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INTERSECTORAL ALLOCATION AND ECONOMIC GROWTH: THE CASE OF KOREA

DONG-JU KIM*

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1. INTRODUCTION

Rapid industrialization has been one of the most conspicuous characteristics of the Korean economic growth. The employment share in the agricultural sector changed from 57.9% in 1965 to 24.9% in 1985 and the proportion of GNP originating in the agriculture declined from 42.5% to 15.0% in the same periods. This high rate of sectoral transfromation has been closely linked to the rate of economic growth. Real GNP in Korea increased at an average annual rate of about 9.3% in 1963~73, 8.2% in 1973~81, and 8.4% in 1981~86.

This paper presents a dynamic model of sectoral transformation and confronts the data for Korea. Endogenous technology and resource migration functions are among the important elements of the model. The intersectoral resource transfer equations were allowed to take account of the differentials in wage rates and the rate of returns, the sizes and the prospects of the two sectors.

Given the limits to factor mobility, sectoral transformation occurs under the conditions of disequilibrium in a comparative sense and a shift of labor and capital from less productive sector to more productive sector can accelerate growth. Disequilibrium phenomena are considered to be more significant for the developing or transitional economies than for the mature, industrial economies. So, this study is developed to allow the presence of wage-gaps and factor market distortions to affect the resource allocations.

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2. FRAMEWORK FOR ANALYSIS

The economy is assumed to consist of agriculture and nonagriculture. The technology and the resource allocation between the two sectors are predetermined at any given time. The effect of resource allocation and technology on output is summarized by the production functions. These are assumed to be homogenous of degree one.

$$y_a = A_a l_a^{1-\alpha} k_a^{\alpha} = A_a l_a^{1-\alpha} (\phi_a k)^{\alpha}$$
$$y_n = A_n l_n^{1-\beta} k_n^{\beta} = A_n l_n^{1-\beta} (\phi_n k)^{\beta} \tag{1}$$

where l_i is the fraction of manhours; ϕ_i is the fraction of capital stock(k) devoted to the production of the good i (c_i); A_i is Hicks neutral technology in sector i.

The quantities of labor and capital allocated to each sector are fully employed:

$$l_a + l_n = 1, \qquad \phi_a + \phi_n = 1 \tag{2}$$

The quantities demanded are determined by the demand equations. The demand for final consumption is given in equation(3). Let c represent per capita consumption and p the price ratio of output of the agricultural sector(p_a) in terms of output of the nonagricultural sector(p_n)

$$c_a = D_a(p, c)$$
$$c_n = D_n(p, c) \tag{3}$$

Per capita consumption is given by

$$c = pc_a + c_n \tag{4}$$

Here it is assumed that agriculture is a net importer and that nonagricultrue is a net exporter. Accordingly, there are two sources of supply for agricultural products, production (y_a) and import(m_a), and they are used for consumption (c_a) and investment (i_a). The products of nonagriculture are used for consumption (c_n), investment (i_n), and net export (x_n).

$$i_a + c_a = y_a + m_a$$
$$c_n + i_n + x_n = y_n \tag{5}$$

Investment in each sector is determined by :

$$i_a = \dot{k}_a + \delta_a k_a = \dot{\phi}_a k + \phi_a \dot{k} + \delta$$
$$i_n = \dot{k}_n + \delta_n k_n = \dot{\phi}_n k + \phi_n \dot{k} + \delta_n k_n \tag{6}$$

Where δ_i is the depreciation rate in sector i and note that $k_i = \phi k$. The law of motion for ϕ_i is given in equation (10) and that of $\dot{k}$ is given by equation(11) below.

Then imports and exports are given as residuals:

$$m_a = -y_a + c_a + i_a$$

$$x_n = y_n - c_n - i_n \tag{7}$$

Having determined the quantities of exports and imports, foreign savings(f) are determined:

$$f = pm_a - x_n \tag{8}$$

The analysis assumes that Korea can be treated as a small open economy in the sense that it is a price taker in world markets. The prices of exported good(p_n) and imported good(p_a) are given:

$$p_n = p_n^* E(1+s_n), \qquad p_a = p_a^* E(1+t_a) \tag{9}$$

Where p^*'s are foreign prices, E is the nominal exchange rate, and s_n is the subsidy rate on exports, and t_a is rate of protection. Then the dynamics of the model can be described as follows.

Intersectoral resources transfers are:

$$\dot{l}_a = \Phi(\omega) l_n^b (1-l_n)^{1-b}$$

$$\dot{\phi}_n = \Phi_k(\gamma) \phi_n^c (1-\phi_n)^{1-c} \tag{10}$$

Equation(10) takes the account of differentials in the wage rate (ω), the rate of return (γ), and the sizes of the agriculture and nonagriculture sectors in labor and capital. Transfer of resources should increase with l_a and ϕ_a due to the large supply.
In addition, resource transfers depend on prospects in the nonagricultural sector, as measured by l_n and ϕ_n. A given rate of transfer will be absorbed more easily with larger absorbing sector. These are formulated in such a way as to maintain constant returns to scale (See Mundlak 1979 and Shin 1990).

The law of capital accumulation may be written as:

$$\dot{k} = i - \delta k \tag{11}$$

where δ is the depreciation tate and i is investment. Investment is assumed to depend on the expected rate of return to capital and on the change in output as an accelerator.

$$i = i(r, Dy) \tag{12}$$

where r is the rental price of capital and Dy is the first difference of per capita income.

Given the foreign prices, exchange rate, import tariff, and export subsidy, an equilibrium is obtained. If there are distortions in factor markets, wage rates and tate of returns need not to be same between the two sectors, Intersectoral differences in wage and rate of return need not to be same between the two sectors. Intersectoral differences in wage and rate of return leads to factor flows. These flows along with the overall expansion of the capital stock, change the resource allocation in time t+1. This new allocation and technological change increase output, and the system reaches a new equilibrium in time t+1. The description of the equations actually used to fit the model is given in section 2.

3. EMPIRICAL IMPLEMENTATION OF THE MLDEL

Some of the variables are determined within the system by using empirical equations whose coefficients are estimated from the past data. This section explains the procedures used and estimates the empirical equations of the model. The resource transfer equations, technology evolution, consumption and investment behavior, and production functions are estimated for the period 1965~1985.

Resource Transfer Equations: The employment share in the agricultural sector has decreased from 57.9% in 1966 to 24.9% in 1985, while the share of capital devoted to the production of the agricultural goods has changed from 7.6% to 6.4% during the same periods as shown in Table 1.

Table 1. Shares of Labor and Capital Employed in Agriculture[a]

Year	1966	1970	1975	1980	1985
l_a	57.9	50.4	45.9	34.0	24.9
ϕ_a	7.6	9.6	10.4	8.4	6.4

[a] Data from Major Statistics of Korea and Pyo (1988).

The labor migration equation (10) is:

$$\dot{l}_n = b_0(\omega-1)^{b_1} l_n^{b_2} (1-l_n)^{1-b_2}$$

That is, $\Phi(\omega)$ in equation (10) was specified as $b_0(\omega-1)^{b_1}$. Migration is formulated in terms of income differentials (ω) between the agricultural and non-agricultural sectors and the relative sizes of the two sectors(l_n and l_a). This formulation is arranged so as to bring in a final nonlinear estimation dividing by $l_a(1-l_n)$.

$$\frac{\dot{l}_n}{1-l_n} = b_0(\omega-1)^{b_1} \left(\frac{l_n}{1-l_n}\right)^{b_2} \tag{13}$$

This equation was first estimated from a country cross-section data for 99 countries between the periods of 1960 and 1978. The simple annual average was used for $\dot{l}_n$ and the income variable was measured as the ratio of the average productivity between the two sectors, where average labor productivity was obtained by dividing the gross domestic product originating in each sector by the employment in that sector. The intercept (b_0) was estimated from the Korean data restricting b_1 and b_2 to the values obtained from the cross country data. This is due to the difficulty of extracting the effect of income differentials for the short period time series data, in which the spread in the systematic component of the income differential is small relative to the spread in its transitory component. The difference between the two intercepts can be considered as the country effect for Korea. Table 2 presents the estimation results, Regression 1 is estimated without correcting the first order serial correlation and regression 2 with first order serial correction.

Table 2. Estimates of Migration Equation[a]

Regression	b_0	b_1	b_2	ρ
Cross country				
R−1	0.0148(0.0010)	0.1044(0.0568)	0.4406(0.0420)	−
Korea(ω_1)				
R−1	0.0367(0.0058)	0.1044	0.4406	−
R−2	0.0364(0.0082)	0.1044	0.4406	0.28(0.24)
Korea(ω_2)				
R−1	0.0351(0.0056)	0.1044	0.4406	−
R−2	0.0349(0.0079)	0.1044	0.4406	0.29(0.24)

[a] Numbers in parentheses are standard errors.

Here, $\omega_1 = \frac{P_n Y_n}{L_n} / \frac{P_a Y_a}{L_a}$ and $\omega_2 = \frac{1-\beta}{1-\alpha} \frac{P_n Y_n}{L_n} / \frac{P_a Y_a}{L_a}$ were used for income differentials. The country effect for Korea(0.0367) is about three times as big as the world average (0.0148) as shown in the first columm.

Table 3 and Figure 1 present the wage differentials between the two sectors. The average difference for the world as a whole was 5.29, whereas those differences were 2.65 for ω_1 and 3.62 for ω_2. These differences may however be affected by measurement problems of agricultrual output and human capital differences between the sectors.

Table 3. Income Differentials[a]

Year	1966	1970	1975	1980	1985	Average
ω_1	2.62	2.84	2.58	2.89	2.09	2.65
ω_2	4.07	4.23	3.21	3.44	2.57	3.62

[a] $\omega_1 = \frac{P_nY_n}{L_n} / \frac{P_aY_a}{L_a}$ and $\omega_2 = \frac{1-\beta}{1-\alpha} \frac{P_nY_n}{L_n} / \frac{P_aY_a}{L_a}$

Wage Differentials

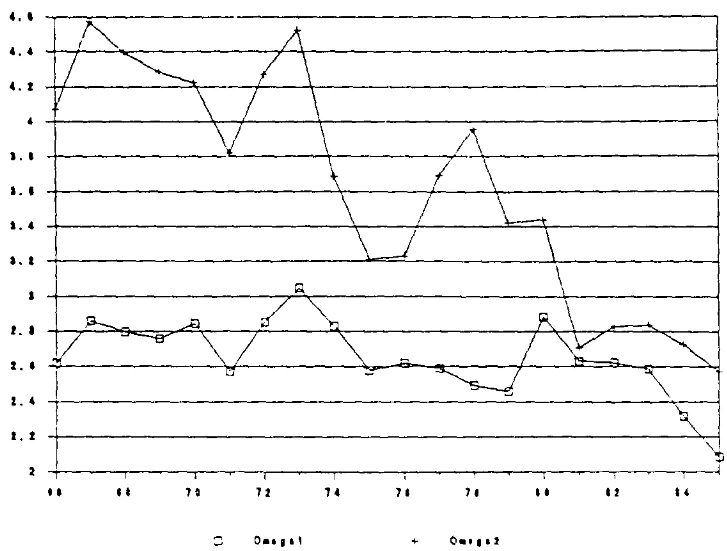

Figure 1

Income Differentials

Meanwhile, the share of capital devoted to the production of each sector has showed little changes so that ϕ_n is set to zero and the average value of 0.08 is used throughout the sample periods.

Production and Evolution of Technology:

The shares of capital measured as the share of non-wage income in total sectoral income are plotted in Figure 2 for each sector. As summarized in Table 4, the share of capital averaged 52.36 percent in agriculture and 34.58 percent in nonagriculture.

Table 4. Sectoral Capital Income Shares[a]

Sector	Average	S.D.	Maximum	minimum
Agriculture	52.36	3.25	58.16	46.08
Nonagriculture	34.58	4.57	42.31	23.68

[a] Computed as one minus labor share.

SECTORAL CAPITAL INCOME SHARES

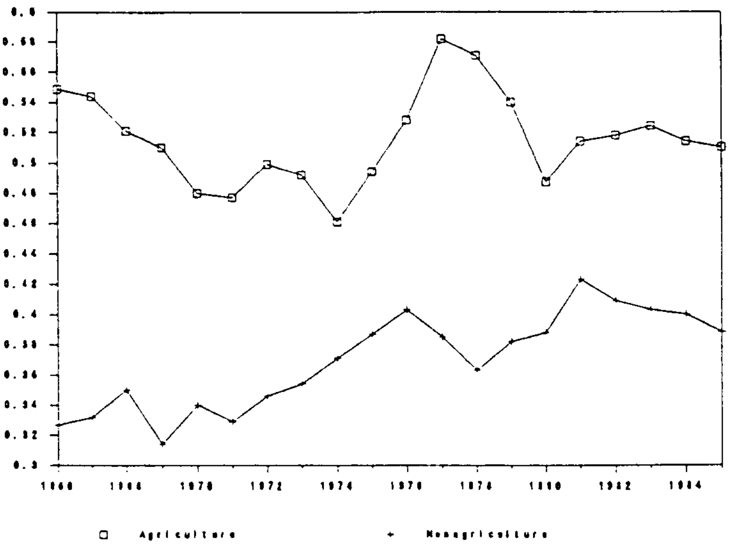

Figure 2

The Sectoral Capital Income Shares

It is often assumed that technology is exogenously given but this study considers the possibility that technology is endogenous. Technology is assumed to very with state variables following Mundlak(1990).

$$ln(A_a) = \pi_{a0} + \pi_{a1} ln(k_a) + \pi_{a2} ln(y_a^*) + \pi_{a3}\sigma_a \qquad (14)$$
$$ln(A_n) = \pi_{n0} + \pi_{n1} ln(k_n) + \pi_{n2} ln(y_n^*) + \pi_{n3}\sigma_n$$

Where y^* is the historical peak of y defined as $y_t^* = max(y_{t-i})$, $i < t$. Thus y^* represents the net effects of the various forms of human capital, institutiona and organization which are referred to as technology and cannot be measured directly(Mundlak 1991). σ is the standard deviations of the sectoral prices in the past three years.

The capital income share in each sector is:

$$\alpha = a_0 + a_1 ln(k_a) + a_2 ln(y^*_a) = a_3\sigma_a \qquad (15)$$
$$\beta = b_0 + b_1 ln(k_n) + b_2 ln(y^*_n) = a_3\sigma_n$$

where α and β are production elasticities for capital in agriculture and nonagriculture and are equal to capital income share in the Cobb-Douglas case.

The capital labor ratio, k, uncertainty about future conditions measured by the standard deviations of sectoral prices in the past three years(σ), and the peak of output, y^*, are expected to be related to the slope and the level of the production function, Table 5 presents the estimation results for the shares (Equation 15) and Table 6 for the levels (Equation 14).

Table 5. Estimates of Capital Income Shares[a]

	Agriculture		Nonagriculture	
Variables	Estimates	t-Stat.	Estimates	t-Stat.
Constant	-3.0892	(-4.43)	-0.8804	(-1.89)
$ln(K/L)$	-0.0977	(-3.39)	0.1888	(2.04)
$ln(y^*_i)$	0.8260	(5.07)	-0.0640	(-1.11)
σ_i	-0.5859	(-2.75)	-0.0787	(-1.89)
R^2	0.87	–	0.81	–
D.W.	1.81	–	2.07	–

[a] Numbers in parenthesis are t-Statistics.

The coefficient of y^*_i is positive for agriculture indicating that the trend of the technological progress was labor saving. On the other hand, a negative coefficient in the nonagriculture indicates a capital saving trend, though it is statistically not significant. The positive sign of the coefficient of K/L in the nonagriculture sector indicates that the labor share decreased, and negative sign in the agriculture sector indicate that the labor share increased. In other words, the elasticity of substitution was greater than unity in the nonagricultural sector and was less than unity in the agricultural sector. Volatility of prices had a negative effect on the capital share in both sectors.

Table 6. Estimates of Level of Technology[a]

Variables	Agriculture Estimates	Agriculture t-Stat.	Nonagriculture Estimates	Nonagriculture t-Stat.
Constant	11.2965	(4.56)	15.2242	(8.54)
$ln(K/L)$	-0.1207	(-1.61)	-2.1686	(-6.34)
σ_i	4.0854	(2.87)	0.3515	(0.27)
$ln(y_i^*)$	-1.4543	(-2.61)	1.2507	(6.19)
R^2	0.83	–	0.83	–
D.W.	2.04	–	1.11	–

[a] Numbers in parenthesis are t-Statistics.

The signs of levels are always opposite of the signs of slopes and, therefore, the uncertainty measured by the standard deviation of the sectoral prices has a positive effect on the level of technology in both sectors, while the peak variable shows negative effect in agriculture and positive effect on nonagriculture. The increase in the capital-labor ratio shows a negative effect on technology due to the decrease in the rate of return on capital.

The elasticity of output with respect to state variable z can be calculated as:

$$E_{ai} = \frac{\partial ln(y_a)}{\partial ln(z_i)} = \frac{\partial ln(A_a)}{\partial ln(z_i)} + \frac{\partial \alpha}{\partial ln(z_i)} ln(k_a)$$

$$E_{ni} = \frac{\partial ln(y_n)}{\partial ln(z_i)} = \frac{\partial ln(A_n)}{\partial ln(z_i)} + \frac{\partial \beta}{\partial ln(z_i)} ln(k_n)$$

This is holding k constant. For a more general expression, see Mundlak (1991). Table 7 presents the elasticities of output with respect to σ and y^* for each sector.

Table 7. Elasticities of Output[a]

Year	Agriculture σ_a	Agriculture y^*_a	Nonagriculture σ_n	Nonagriculture y^*_n
1966	1.9	1.6	-0.1	0.9
1970	1.6	2.1	-0.2	0.8
1975	1.2	2.6	-0.2	0.8
1980	1.0	2.9	-0.2	0.8
1985	1.0	3.0	-0.3	0.7
Average	1.3	2.5	-0.2	0.8

[a] Elasticity with respect to sigma is semi-elasticity.

The elasticity of output with respect to the price uncertainty is positive in agriculture and negative in the nonagriculture. The fact that the profit function is convex in prices implies that producers prefer a spread in prices to stability. It is, however, important to note that this result is based on the assumption that producers know in advance what the price will be. Otherwise, they can not take advantage of the spread. In Korea, the government buys the major cereals at a specified price, which is determined by many factors including political ones and it is usually fixed percentage increase of the previous year's price. Therefore, it is not surprising that the elasticity of output with respect to the price uncertainty was positive in the agricultural sector. The elasticities of output with respect to the peak variable are positive in both sectors, and the magnitude in agriculture is three times as large as that in nonagriculture.

Consumption and Investment :

The estimation of consumption function is formulated to include a wealth variable measured as the economy's per capita stock of capital, $k = K/L$ and the consumption lagged three periods, The latter is included to allow for partial adjustment. Table 8 presents the estimation of the consumption function. Last year's consumption had a strong positive effect on the present consumption and the coefficient on per capita stock of capital was positive but with lesser degree of effect. R-1 presents the full regression. R−2 on wealth, and R−3 on ragged consumption or random walk with drift. Then, the consumption for each sector can be obtained by using the equations (3)

The investment function is formulated as:

$$i = -2448E^{3}r + 0.714Dy \tag{16}$$

where r is the rental cost of capital measured as the capital income divided by the capital stock and Dy is the first difference of the per capita income and shows the acceleration effect. R^2 is 0.93, D. W. is 1.44, and the t-Statistics are -5.05 for r and 3.63 for Dy.

Table 8. Total Consumption Per Capita[a]

Variable	Const	$\frac{K}{L}$	C^p_{-1}	C^p_{-2}	C^p_{-3}	R^2
Coefficient(R−1)	174.853	0.059	0.589	-0.044	0.078	0.9
t-Stat.	(3.39)	(1.27)	(2.33)	(-0.14)	(0.32)	−
Coefficient(R−2)	171.388	0.255				0.79
t-Stat.	(3.10)	(8.36)				−
Coefficient(R−3)	84.830		0.92			0.92
t-Stat.	(2.25)		(14.92)			−

[a] $\frac{K}{L}$ is the economy's per capita stock of capital

4. SIMULATING THE PATH OF THE KOREAN ECONOMY

The model was confronted with the data for Korea during the period of 1965~1985. The simulated values are presented in the figures below and compared with the actual observations. The key variables and their composition between the agricultural and nonagricultural sectors are plotted in Figures 3−4. Although the structural equations need to be substantiated more fully, the model in its present form provides a good fit to the data. The actual share of agricultural employment changed from 57.9 percent to 24.9 percent, and the share of nonagricultural employment increased from 42.1 percent to 75.1 percent. The simulated share of agricultural employment changed from 57.9 percent to 23.1 percent, and the share of nonagricultural employment increased from 42.1 percent to 76.9 percent.

The actual output per capita originating in agriculture changed from 163.6 thousand won in 1980 price to 190.2 thousand won, and the actual share of GDP in agriculture decreased from 42.5 precent to 14.8 percent. The actual output orginating in the nonagricultural sector changed from 221.34 thousand won to 1,093.5 thousand won, and the actual share increased from 57.5 percent to 85.2 The simulated output per capita originating in the agriculture changed from 163.6 thousand won in 1980 price to 189.68 thousand won, and the simulated share of GDP in agriculture decreased from 42.5 percent to 15.4 percent. The simulated output originating in the nonagricultural sector changed from 221.3 thousand won to 1,040.4 thousand won and the simulated share increased from 57.5 percent to 84.6 percent. Actual and simulated values of per capita output, consumption and investment are plotted in Figure 4.[1]

1) Other figures are available upon requests.

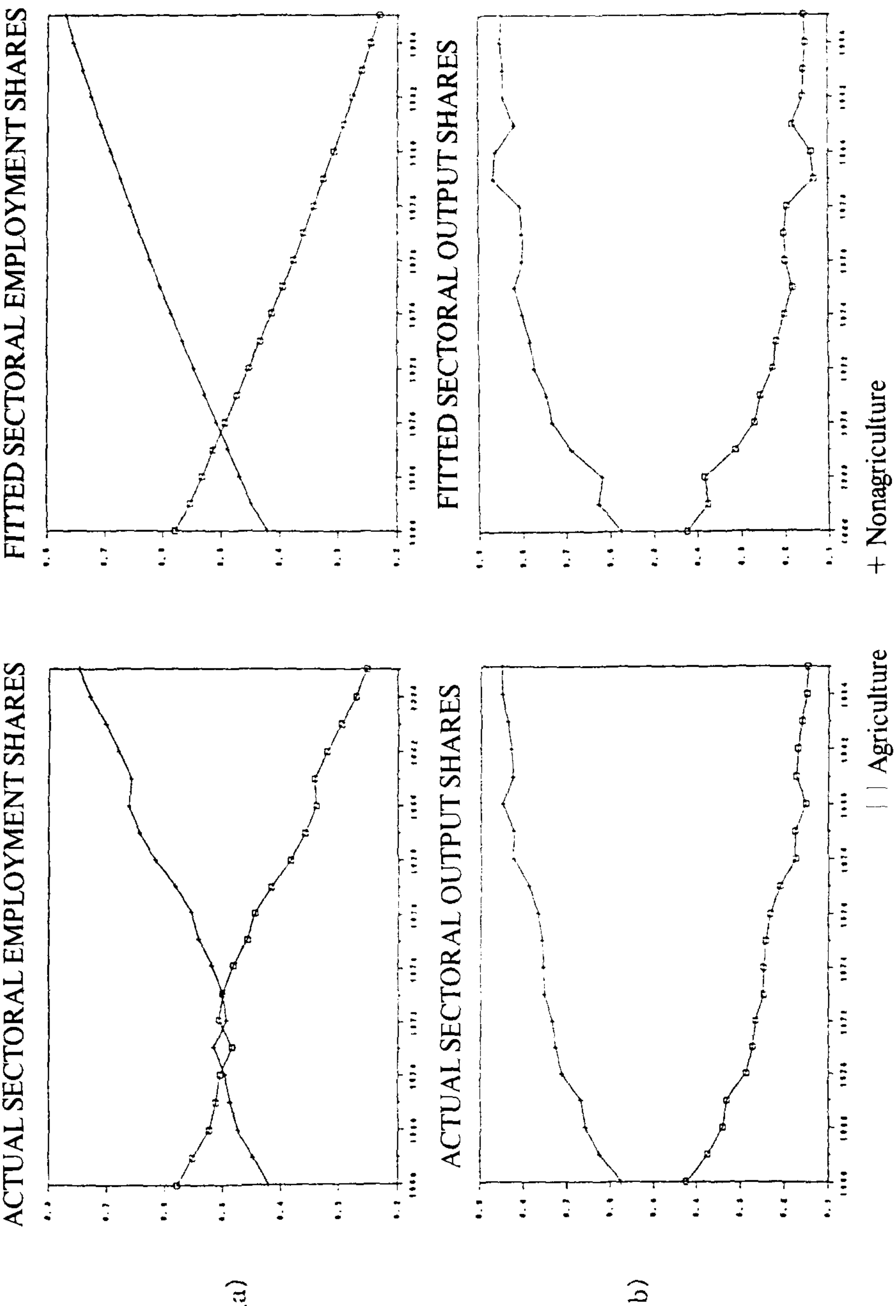

Figure 3
Sectoral Employment(a) and Per Capita Output(b) shares

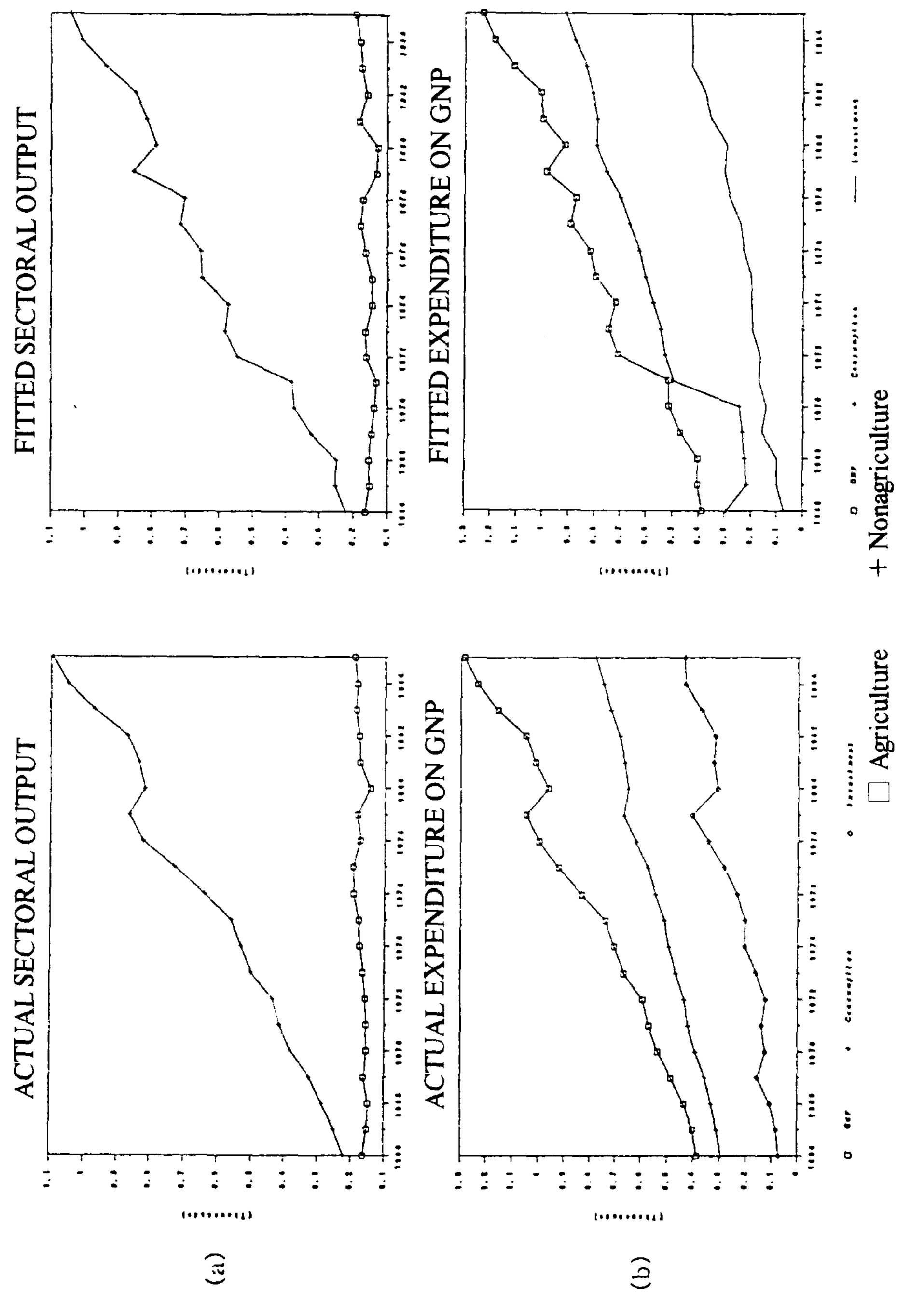

Figure 4
Sectoral Per Capita Output(a) and Expenditures on GNP(b)

5. CONCLUDING REMARKS

Many studies on intersectoral transformation have been carried out using a static model. An explicit framework containing dynamic extensions was developed to confront the data for Korea over the period of 1965–1985. The framework allowed production to vary in response to the prevailing economic environment. For example, the factor share varied greatly over the sample periods and such variation is interpreted to reflect largely, but not exclusively, variations in the implemented technology.

It was found that the elasticity of substitution was greater than unity in the nonagricultural sector and was less than unity in the agricultural sector. Volatility of prices had a negative effect on the capital share in both scetors. The consumption function included a wealth variable and lagged consumption.

The intersectoral resource transfer equations were allowed to take account of the differentials in wage rates and the rate of returns, the sizes and the prospects of the two sectors. The intercept of the labor flow equation was interpreted as the country mobility effect, which for Korea was estimated to be about three times as big as the world average estimated from a cross-country regression. Although the structural equations of the model need to be substantiated mord fully, the model provided a good fit to the data.

REFERENCES

Balassa, Bela, "Korea's Development Strategy," in *Korea Economic Development*, edited by Kwan, Jene K., 1990

Chenery, Hollis, Robinson Sherman, and Syriquin, Moshe, *Industrialization and Growth : A Comparative Study*, Oxford University Press, 1986.

Chenery, H., and Srinivasan, T., The *Handbook of Development Economics, Amsterdam*, North Holland, 1989.

Johnston, Bruce F. and Peter Kilby, *Agriculture and Structural Transformation*, Oxford University Press, London:1975.

Korea Economic Planning Board, *Major Statistics of Korean Economy*, Seoul, Korea, Various Issues.

Korea National Bureau of Statistics, *Korea Statistical Yearbook. Seoul*, Korea, various issues.

Kwan, Jene K., *Korea Economic Development*, Greenwood Press, 1990.

Leppo, Matti "Regularities of Sectoral Changes in Economic Activity, A Study on the Output and Input Shares of Primary Production, Transforming Industries and Services in Growing Economies, *Suomalainen Tiedeakatemia*, Helsinki, 1980.

Lee, K.S., "An Analysis of Economic Factors of Labor Mobility," Korea Development Research, Mimeo.

Luca, Robert E., Jr, "On the Mechanics of Economic Development," *Journal of Monetary Economics 22*(1988) : 3-42

Matsuyama, Kiminori, "Agricultural Productivity, Comparative Advantage and Economic Growth," Northwestern Working Paper, 1990

Moon, Pal-Yong, and Kang, Bong-Soon, *Trade, Exchange Rate, and Agricultural Pricing Policies in the Republic of Korea*, World Band, 1989.

Mundlak, Y., and Coeymans, J. E., "Endogenous Technology and Sectoral Productivity, Chile 1962-82," , 1991, mimeo.

Mundlak, Y., Cavallo and Domenech, *Agriculture and Economic Growth in Argentina 1913-1981*, IFPRI, Research Report, Nov., 1989.

———, *Agriculture and Economic Growth : Theory and Measurement*, Lecture Notes, University of Chicago, 1988.

———, *Intersectoral Factor Mobility and Agricultural Growth*, IRPRI, Washington, 1979.

Pasinetti, Luigi L., *Structural Change Economic Growth*, Cambridge University Press, Cambridge : 1981.

Pyo, Hak-Kil, "Estimates of Capital stock and Capital/ Output Coefficients by Industries : Korea (1953-1986)," *International Economic Journal*, 1988.

Tolley, G.S., and Thomas, V., The Economics of *Urbanization and urban Policies in Developing Countries*, Washington, D.C., The World Bank, 1987.

———, *Trade, Agriculture and Development*, Editor and Co-Author, Boston, Ballinger Publishing Co., 1973.

———, and S. Smidt, "Agriculture and the Secular Position of the U.S. Economy", *Econometrica*, vol 32, No. 4, 1964.

Torado, M.P., *Economic Development in the Third World*, 4th edition, NY 1989.

World Bank, *World Development Report*, Oxford University Press : various issues.