EFFECTS OF CHANGES IN FACTOR ENDOWMENTS ON FACTOR PRICES

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I. Introduction

Changes in factor prices may be analyzed by virtue of the demand for and supply of the factor in the factor markets. However, as long as the demand for factor is a derived demand, changes in factor prices are affected by conditions of the goods market. Under the framework of general equilibrium, factor markets as well as goods market should be cleared. If there happens to be an exogenous change in any market, it will cause excess demand or excess supply in both market.

Existing general equilibrium models that have been used to examine the changes in factor price can be classified into the Heckscher-Ohlin -Samuelson (H-O-S) model and the standard specific factor (S-F) model[1]. The H-O-S model assumes that all factors are perfectly mobile over the regions while the S-F model assumes that the production of each good requires a specific factor and a mobile factor which is commonly used in the production of all goods. The H-O-S model emphasizes the long-run property of the general equilibrium in that factor prices are affected by factor substitution while the S-F model can be considered as the short-run approach in that the forces of excess demand and excess supply dominate in determining factor prices.

In examining factor prices in economies where agriculture has considerable importance, the S-F model seems to be more adaptable since land is usually assumed to be region-specific factor. According to the standard S-F model, however, only two goods are produced by

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[1] Refer to Jones and Neary (1984) for a summary of the literature.

three factors, two of which are specific to each industry and the third is mobile. Therefore the standard S-F model cannot reflect the case where more than one mobile factor and specific factor are required to produce each good.

The purpose of this study is to analyze the changes in factor prices corresponding to the changes in factor supply or factor movements. Since rural and urban lands are specific to each region in most underdeveloped countries, we will utilize the modified four -factor, three good S-F model which can be considered as an alternative in the intermediate-run.

II. The Model[2]

1. Assumptions

We begin with the following assumptions.
First, there are two regions, urban and rural, in a country. Second, there is only one sector, farming (F) in the rural area while two sectors, manufacturing (M) and service (S) exist in the urban area. Third, all three goods use two mobile factors, capital (K) and labor (L), as well as a region-specific factor. Thus, the farming sector uses rural land (R) which is specific not only to the farming sector but also to the rural region, while manufacturing and services use urban land (U) which is region-specific but is mobile intersectorally between two sectors, M and S, within the urban region. Fourth, each sector has a different production function under CRTS and there exist perfect competition and full employment in the economy.

2. The 4 x 3 Specific Factor Model

Suppose the production functions for farming (F), manufacturing (M) and services (S) are given, respectively, by

$$F = F(K_F, L_F, R_F)$$
$$M = M(K_M, L_M, U_M)$$

[2] The derivation of the model in this section is mainly based on Eor (1992).

$S = S(K_S, L_S, U_S)$

where the subscripts indicate the sectors in which the factor is used. It is assumed that marginal products are positive but decreasing, while the second cross partials of output with respect to factors are positive, i.e., any marginal product is increased by an increase in the usage of another factor.

Full employment requires that

$$\Sigma_j K_j = K \text{ for } j = F, M, S,$$
$$\Sigma_j L_j = L \text{ for } j = F, M, S,$$
$$\Sigma_j U_j = U \text{ for } j = M, S \text{ and}$$
$$R_F = R$$

Four factors and three commodities in this model raise the computational complexity of differentiating full employment and competitive pricing conditions. They can be reduced by using the properties of the GNP function. The commodity prices are exogenous since the economy is assumed to be small and open. Maximization of GNP subject to the constraints imposed by technology and full employment implies the existence of a GNP function, G(P,V), where P and V are vectors of commodity prices and factor endowments, respectively. That is,

$$P = (P_F, P_M, P_S) \text{ and } V = (K, L, R, U).$$

Let w_i be the price of factor i.
Then the properties of the GNP function are

(T1) $G_{V_i} = \partial G / \partial V_i = w_i$;
(T2) $w_{ik} \equiv \partial w_i / \partial V_k = \partial^2 G(P,V) / \partial V_i \partial V_k = \partial^2 G(P,V) / \partial V_k \partial V_i = \partial w_k / \partial V_i \equiv w_{ki}$;
(T3) $\partial^2 G(P,V) / \partial V_i^2 = \partial W_i / \partial V_i \equiv w_{ii} < 0$;
(T4) $\Sigma_k w_{ik} V_{kj} = 0$, for i,k = K, L, R, U and j = F, M, S.[3]

[3] Property (T1) is proved by Woodland (1982, pp 127~8); (T2) follows from (T1) and the symmetry of the cross partial derivatives of the GNP function; (T3) follows from the concavity of G(P,V) in V and the fact that $w_{ii} \neq 0$ when the number of factors exceeds the number of goods. Dalal(1985) established and proved property (T4).

3. Comparative Statics

The effects of changes in factor supplies on factor prices can be identified by obtaining comparative static results of the parametric changes in factor supplies in our model. Factor i and j are defined as friends (enemies) if $w_{ij} > 0$ (<0), as Ruffin (1981) did.

Using (T4) we obtain

$$w_{ik}K_M + w_{iL}L_M + w_{iU}U_M = 0 \quad (1)$$
$$w_{ik}K_S + w_{iL}L_S + w_{iU}U_S = 0 \quad (2)$$
$$w_{iK}K_F + w_{iL}L_F + w_{iR}R_F = 0 \quad (3)$$

for i = K, L, R, U.

Equations (1)-(3) can be solved for w_{iL} and w_{iR} and w_{iU} in terms of w_{iK} to yield

$$w_{iL} = (-w_{iK})(K_M U_S - K_S U_M)/(L_M U_S - U_M L_S) \equiv -w_{iK}(D_2/D_1) \quad (4)$$
$$w_{iU} = w_{iK}(K_M L_S - L_M K_S)/(L_M U_S - U_M L_S) \equiv w_{iK}(D_3/D_1) \quad (5)$$
$$w_{iR} = (-w_{iK})\{K_F(L_M U_S - U_M L_S) - L_F(K_M U_S - K_S U_M)\}/R(L_M U_S - U_M L_S)$$
$$= (-w_{iK})(K_F D_1 - L_F D_2)/RD_1 \quad (6)$$

where $D_1 = L_M U_S - U_M L_S$, $D_2 = K_M U_S - K_S U_M$ and $D_3 = K_M L_S - L_M K_S$.

Substituting K, L, R and U for i yield

$$w_{KL} = -w_{KK}(D_2/D_1) \quad (7a)$$
$$w_{KU} = w_{KK}(D_3/D_1) \quad (7b)$$
$$w_{KR} = -w_{KK}(K_F D_1 - L_F D_2)/RD_1 \quad (7c)$$
$$w_{LU} = -w_{LL}(D_3/D_2) \quad (7d)$$
$$w_{LR} = w_{LL}(K_F D_1 - L_F D_2)/RD_2 \quad (7e)$$

From equations (1)-(3) we can derive

$$w_{UR} = w_{UU}(L_F D_2 - K_F D_1)/RD_3 \quad (7f)$$

Equations (7a)-(7f) can be analyzed in terms of the factor extremity condition as follows:

Factor k is a middle factor while factor h and r are extreme factors if

$V_{hM}/V_{hS} > V_{kM}/V_{kS} > V_{rM}/V_{rS}$ or

$V_{rM}/V_{rS} > V_{kM}/V_{kS} > V_{hM}/V_{hS}$,

for h, k, r = K, L, U.

Thus the results of the above comparative statics can be summarized as follows:
(1) As long as labor or capital is the middle factor in the urban area, exogenous increase in labor (capital) causes the price of capital (wage rate) to rise.
(2) As long as capital or urban land is the middle factor in the urban area, increase in capital (urban land) will raise the price of urban land (capital).
(3) As long as labor or urban land is the middle factor in the urban area, exogenous increase in labor (urban land) will raise the price of urban land (wage). These findings are consistent with Ruffin's(1981) theorem.[4]
(4) The price of rural land is affected not only by the factor intensities but by the relative magnitude of factor employments in each sector.

III. Empirical Application to South Korea

In order to apply the comparative static results to South Korean case, we need the data on sectoral factor endowments which are not readily available. Relative friendship elasticities of Clark and Thompson (1986) enables us to obtain the results.

Define factor friendship elasticity (factor endowment elasticity of factor price),

$$e_{hi} = (V_i/w_h)w_{hi}, \text{ for } h,i = K, L, R, U.$$

That is, elasticity e_{hi} measures the response of the price of factor h to a change in the endowment of factor i.

Then the relative friendship elasticity is defined as

[4] Ruffin (1981) found out that if there are three factors and two goods produced in a competitive, small open economy operating under CRTS, an increase in the supply of an extreme factor will benefit the middle factor and hurt the other extreme factor when a change in any factor supply affects factor prices.

$$E_{hi} = e_{hi}/e_{hh} = V_i w_{hi}/V_h w_{hh} \qquad (8)$$
$$\text{for } h.i = K, L, R, U.$$

That is. the relative friendship elasticity E_{hi} is the ratio of the cross endowment elasticity of the price of factor h (caused by a change in the endowment of factor i) to the own endowment elasticity of the price of factor h (caused by a change in the endowment of factor h). Note that the relative friendship elasticities are standardized with respect to their own elasticities, and

$$E_{hi} > (<) 0,$$

if factor h and i are enemies (friends) since $e_{hh} < 0$.

Equation (8) implies that

$$E_{KK} = E_{LL} = E_{RR} = E_{UU} = 1.$$

After some calculations we have

$$E_{KL} = -S_L B_2/S_K B_1 \qquad (9)$$

where S_i is factor i's share in the economy.

Similarly,

$$E_{KR} = S_R(f_{LF}B_2 - f_{KF}B_1)/S_K f_{RF} B_1 \qquad (10)$$
$$E_{KU} = S_U B_3/S_K B_1 \qquad (11)$$
$$E_{LR} = S_R(f_{KF}B_1 - f_{LF}B_2)/S_L f_{RF} B_2 \qquad (12)$$
$$E_{LU} = -S_U B_3/S_L B_2 \qquad (13)$$
$$E_{UR} = S_R(f_{LF}B_2 - f_{KF}B_1)/S_U f_{RF} B_3 \qquad (14)$$
$$\text{for } B_1 = f_{LM}f_{US} - f_{UM}f_{LS},\ B_2 = f_{KM}f_{US} - f_{UM}f_{KS} \text{ and}$$
$$B_3 = f_{KM}f_{LS} - f_{LM}f_{KS}$$

Note that

$$E_{LK} = e_{LK}/e_{LL} = (K/L)(w_{LK}/w_{LL}) = (K/L)(-D_1/D_2) = 1/E_{KL},$$
$$E_{RK} = e_{RK}/e_{RR} = (K/R)(w_{RK}/w_{RR}) = (K/R)\{R_F D_1/(L_F D_2 - K_F D_1)\}$$
$$= 1/E_{KR}$$

$$E_{RL} = e_{RL}/e_{RR} = (L/R)(w_{RL}/w_{RR}) = (L/R)\{(R_F D_2/K_F D_1 - L_F D_2)\}$$
$$= 1/E_{LR}$$
$$E_{UK} = e_{UK}/e_{UU} = (K/U)(w_{UK}/w_{UU}) = (K/U)(D_1/D_4) = 1/E_{KU},$$
$$E_{UL} = e_{UL}/e_{UU} = (L/U)(w_{UL}/w_{UU}) = (L/U)(-D_2/D_4) = 1/E_{LU}$$
$$E_{RU} = e_{RU}/e_{RR} = (U/R)(w_{RU}/w_{RR}) = (U/R)\{R_F D_3/(L_F D_2 - K_F D_1)\}$$
$$= 1/E_{UR}.$$ [5]

Let the revenue share of the jth good in GDP be denoted by $y_j = P_j X_j/Y$. Then,

$$S_K = y_F f_{KF} + y_M f_{KM} + y_S f_{KS}$$
$$S_L = y_F f_{LF} + y_M f_{LM} + y_S f_{LS}$$
$$S_R = y_F f_{RF}$$
$$S_U = y_M f_{UM} + y_S f_{US}$$

and the GDP accounting identity implies

$$\Sigma_i S_i = 1, \text{ for } i = K, L, R, U.$$

In order to obtain factor friendship patterns through the relative friendship elasticities, we need only sectoral and aggregate factor shares. The compensation of employees in the national account is considered as the payments to labor in the manufacturing and service sectors. Thus, the labor shares in both sectors are calculated by the ratios of the compensation of employees to the GDP in each sector. These data come out of the *Yearbook of National Accounts Statistics* issued by the United Nations in 1983 and 1990. In contrast, the labor share in the farming sector is derived directly by the data on the survey of production costs of agricultural products. These are from the *Results of Production Cost Survey of Agricultural Product*, issued by the Ministry of Agriculture, Forestry and Fisheries, South Korea, in 1980 and 1988. The aggregate labor share (S_L) calculated as the ratio of total compensation of employees ($w_L L$) to the GDP (Y).

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[5] The result of $E_{hi} = 1/E_{ih}$ requires $e_{hi}/e_{hh} = e_{ii}/e_{ih}$,
or $e_{hi}\, e_{ih} - e_{ii} e_{hh} = 0$, which implies
$w_{hi}(V_i/w_h)w_{ih}(V_h/w_i) - w_{ii}(V_i/w_i)w_{hh}(V_h/w_h) = 0$, or $w^2_{hi} - w_{ii}w_{hh} = 0$.
This would hold if the GNP function is concave (but not strictly concave) in any pair of (V_i, V_j). But it is hard to find any theoretical proof of this concavity in case of more than two factors. We simply derived the relationship using our assumption and definitions of factor friendship elasticity.

Payments on capital are calculated from sectoral capital stock multiplied by its rental rates in the manufacturing and service sectors. The data on these are from the sectoral capital stock estimated by Pyo (1988), and the real interest rates in the curb market surveyed by the Bank of Korea.[6] The capital share in the farming sector is also derived directly from the *Result of Production Cost Survey of Agricultural Product*, the Ministry of Agriculture, Forestry and Fisheries, South Korea, in 1980 and 1988. Aggregate capital share (S_K) is derived by the ratio of total payments to capital ($w_K K$) to the GDP (Y).
Rural and urban land shares can be derived as residuals from the labor and capital shares.

Table (A-1) in appendix shows the result of the empirical application to South Korea from 1970 to 1987. As discussed above, the signs of the elasticities are opposite to the sign patterns of factor friendship. That is, positive (negative) elasticities imply that the two factors are enemies (friends). Note that the magnitude of the relative friendship elasticity, E_{ij}, is the response of factor i's price to the change in endowment of factor j relative to the response of factor i's price to the change in its own endowment. Thus, it is meaningless to compare the quantities of one row with those of any other row in the matrix of relative friendship elasticities.

According to the factor extremity condition, labor is the middle factor in the urban region during the 1970-1978 period excluding 1973, and urban land becomes the middle factor in 1973 and 1979.[7] Also, in the 1980's, capital becomes a middle factor in the urban region.

The results of the empirical application can be summarized as follows:
(1) When labor is the middle factor (i.e., when capital or urban land is used most intensively in the manufacturing sector relative to the

[6] Refer to Pyo, H. K., 1988, "Estimates of capital stock and capital/output coefficients by industries: Korea (1953-86),"*International Economic Journal* 2(3), 92-3. Also, Cho, Y. J., 1990, "The financial policy and financial sector developments in Korea and Taiwan," in J. K. Kwon (ed) *Korean Economic Development*, Greenwood Press, New York.

[7] By definition, $f_{hM}/f_{hS} > f_{kM}/f_{kS} > f_{rM}/f_{rS}$ is
$(w_h V_{hM}/P_M X_M)/(w_h V_{hs}/P_S X_S) > (w_k V_{kM}/P_M X_M)/(w_k V_{ks}/P_S X_S) > (w_r V_{rM}/P_M X_M)/(w_r V_{rs}/P_S X_S)$
By multiplying $P_M X_M/P_S X_S$ yields
$V_{hM}/V_{hS} > V_{kM}/V_{kS} > V_{rM}/V_{rS}$.

service sector) as in most 1970's, E_{KL} has negative sign which implies that an exogenous increase in capital (labor) raises wage (rental price of capital) via excess demand for labor. In contrast, E_{KR} and E_{KU} are positive, so an increase in capital (urban and rural land) lowers rental prices of land (rental price of capital) via excess supply of rural and urban land caused by increased capital. Exogenous increase in labor supply results in excess demand for rural and urban land and thus raises the rental price of both rural and urban lands in this period. Positive E_{RU} implies that rural and urban lands are enemies so they have the same direction of changes in prices in this period.

(2) When urban land is the middle factor as in 1973 and 1979, both capital and labor become friends of rural and urban land. But capital is an enemy of labor and rural land is an enemy of urban land. Thus, any exogenous increases in capital or labor raises the prices of both lands.

(3) When capital is the middle factor in the urban region, the effects of changes in other factor endowments on the price of rural land are indeterminate if the other mobile factor, labor, is most intensively used in the farming sector.

When rural land is an enemy of the middle factor as in the 1981 -1986 period, exogenous increase in capital raises both the wage rates and rental price of urban land while it lowers the rental price of rural land. In contrast, exogenous increases in labor raises the price of rural land and lowers urban land price. But rural land is a friend of urban land, so their directions of changes in prices are opposite.

When rural land is a friend of the middle factor as in 1980 and in 1987, exogenous increases in capital raises the prices of all other factors while an increase in labor lowers the prices of both rural and urban lands. In this case, rural and urban lands are enemies, too. Note that the relationship of rural land to the middle factor is always the opposite of its relationship to the extreme factors.

IV. Summary and Conclusion

This study extended the number of factors and commodities of the S-F model by utilizing the properties of the GNP function and the relative friendship elasticity formulas. Major findings can be summarized as follows: First, as long as labor is the middle factor, exogenous increases in capital or capital inflow didn't raise the rental price of rural land. Thus, capital inflows from abroad into South Korea didn't contribute to a rise in the price of rural land in the 1970's. In contrast, capital inflow resulted in a soaring price of urban land thereafter.

Second, the price of rural land rose when labor increased exogenously in most years during the sample period. Also, labor migration into the urban region raised the price of urban land until the 1970's. Thus, the rises in the price of urban land can be explained by labor migration in the 1970's and by capital inflows in the 1980's.

Third, rural and urban lands are enemies until 1980, but friends after 1981 excluding 1987. That is, expansion of urban land raised the rental price of rural land during the 1980's.

Fourth, the relationship of rural land to the middle factor is always the opposite of its relationship to the extreme factors. So, for instance, when labor is the middle factor, increase in labor causes the price of rural land to rise but increase in capital or urban land causes it to fall.

From the above discussion the following policy implications can be suggested:

(1) For the stabilization of the urban land price, analyses of the relative factor intensity and extremity is required to find the middle factor and extreme factors.

(2) Since the price of rural land is usually raised by an increase in labor rather than that in capital, restraint of labor out-migration from the rural area will prevent the price of rural land from falling.

(Appendix)

TABLE(A-1) Estimates of Relative Friendship Elasticities

	E_{KL}	E_{KR}	E_{KU}	E_{LR}	E_{LU}	E_{UR}
1970	-1.37	.25	.12	-.18	-.09	2.17
1971	-1.39	.25	.14	-.18	-.10	1.76
1972	-1.47	.21	.26	-.15	-.18	.83
1973	5.81	-1.62	-5.18	-.28	-.89	.31
1974	-2.76	.48	1.28	-.17	-.47	.37
1975	-2.25	.34	.91	-.15	-.41	.38
1976	-2.15	.23	.92	-.11	-.43	.26
1977	-1.79	.14	.65	-.08	-.36	.22
1978	-1.33	.06	.27	-.05	-.20	.23
1979	.95	-.28	-1.70	-.29	-1.76	.16
1980	-.70	-.003	-.29	.01	.41	.01
1981	-.93	.02	-.09	-.02	.09	-.23
1982	-.90	.01	-.11	-.01	.12	-.09
1983	-.93	-.02	-.08	-.02	.09	-.20
1984	-.94	.02	-.08	-.02	.08	-.24
1985	-.90	.02	-.12	-.02	.13	.17
1986	-.86	.01	-.15	-.01	.18	-.07
1987	-.66	-.01	-.40	.01	.60	.02

Note: $E_{ij} = e_{ij}/e_{ii} = e_{ji}/e_{jj} = 1/E_{ij}$ and $E_{ii} = 1$, for a 1i,j.

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