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STRUCTURAL AND TECHNOLOGICAL CHANGES IN THE AGRICULTURAL SECTOR OF TAIWAN, 1951-1976: A TIME-VARYING PARAMETER APPROACH

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In the literature of aggregate production and economic development, most of the discussions are based on homogeneous production functions with constant returns and neutral technological progress (Solow, 1956, 1957; Amano; Ferguson; Uzawa; and Fei and Ranis). This approach may have many drawbacks in the measurements of aggregate production due to changes occurring in the following production elements over time: (1) the quality and combinations of inputs of production; (2) the mixture of aggregate outputs; and (3) social capital investments and structure.

The value of Taiwan's agricultural output increased nearly threefold in 1951-1976, in real terms. During this period, labour supply went through surplus in the early 1950s, to seasonal shortages in the 1960s, and to real shortages in the 1970s due to the rapid development occurring in its industrial sector. Mechanization, adoption of newly developed varieties of crops, livestock, fertilizers, and pesticides, and better education for farm operators and labourers have not only improved the quality of inputs of agricultural production, but also have changed the forms of inputs as well as the mixture of outputs.

In order to estimate Taiwan's aggregate production function with time series data, assumptions have to be made about the moments when technological changes occurred if traditional ordinary least squares method is to be used. In addition, continuous technological changes over time have to be approximated by several discrete time segments as if one had perfect knowledge about the occurrences of technological changes, which may cause problems in estimating degrees of freedom.

In this study, an aggregate agricultural production function is estimated by means of the Cooley-Prescott procedure, which demonstrates that the changes in parameters can be specified in an econometric model. The aggregate production function can be specified in the time-varying parameter framework

$$(1) \quad Y_t = K^{\alpha_1(t)} L^{\alpha_2(t)} \exp[\alpha_0(t)],$$

where Y_t = per hectare production in year t in 1,000 constant Taiwanese dollars,

k = capital inputs per hectare in year t in 1,000 constant Taiwanese dollars,

L = labour input per hectare in year t in 1,000 man-days, and

α's = the parameters to be estimated.

In addition,

$$(2) \quad \alpha_i(t) = \alpha_i^p(t) + \mu_i(t)$$

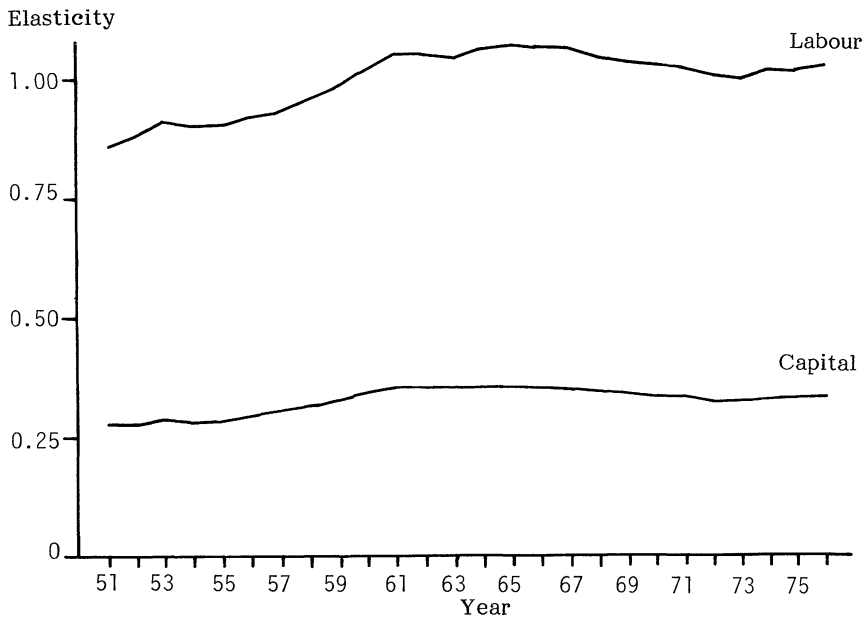
$$(3) \quad \alpha_i^p(t) = \alpha_i^p(t-1) + \nu_i(t) \qquad i=0,1,2$$

where α^p = the permanent component.

Error μ measures the transitory component. Equation 3 gives the dynamic path of the parameters showing the permanent adjustments over time and ν is the error associated with the permanent change. With this method no prior specification of the time path is required except for that of the Marovian process shown in the above equations. In the absence of prior information for Σ_ν and Σ_μ, the covariance matrix of coefficients from OLS estimates is used to approximate both.

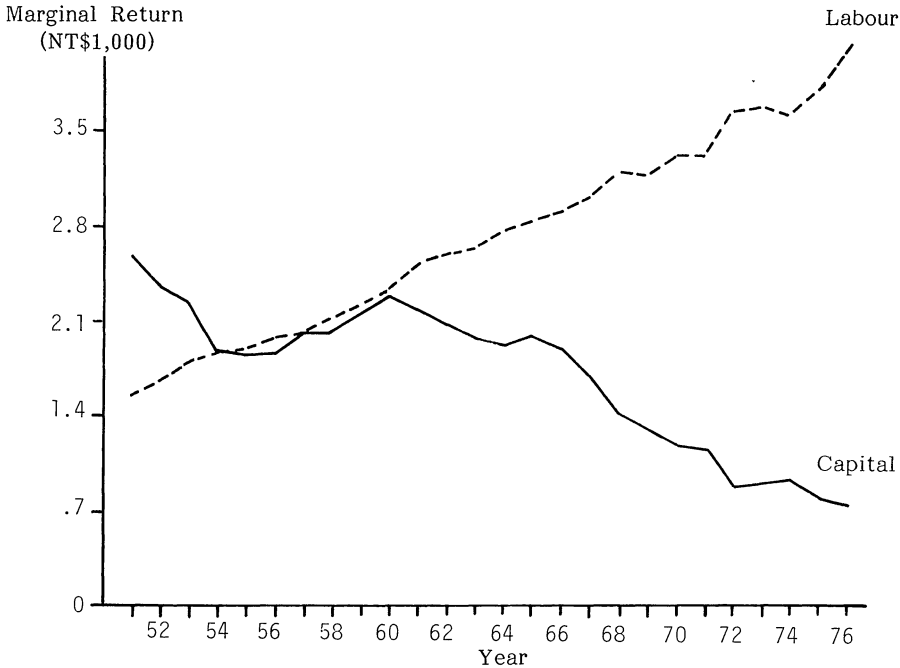
The estimated output elasticity of capital increased from 0.28 in 1951 to 0.36 in 1961-1966, then decreased to 0.34 in 1976. The estimated output elasticity of labour increased from 0.86 in 1951 to 1.03 in 1960, then to 1.08 in 1965 and 1966, and decreased back to 1.03 in 1976 (figure 1). The hypothesis of constant returns to scale can not tested directly. However, the difference between the sum of $\alpha_1(t)$, $\alpha_2(t)$, and unity ranges from 0.14 to 0.44, which is very close to the standard error of estimated output elasticity of labour. This result suggests that the hypothesis of constant returns to scale can not be rejected.

Figure 1. Dynamic Path of Output Elasticities of Labour and Capital



The marginal product estimates shown in figure 2 indicate that in 1951-1953 the labour input was relatively abundant when compared with capital, and the marginal return to labour was lower for capital. In 1954-1960, the estimates show that marginal returns to capital and to labour were about equal. After 1960, capital inputs were relatively abundant when compared to labour input. This result may reflect the fact that during the 1960s and 1970s the industrial sector of Taiwan's economy was expanding rapidly and absorbed a large quantity of rural labour. Expansion in the industrial sector created seasonal labour shortages in the 1960s and real labour shortage problems in the 1970s. In order to adjust, farmers used more capital inputs relative to labour. This adjustment decreased marginal returns to capital and increased returns to labour as shown in figure 2.

Figure 2. Estimated Marginal Returns to Labour and Capital



Hicks defined technological progress as capital intensive, neutral, or labour intensive according to whether the marginal rate of technical substitution of capital for labour diminishes, remains unchanged, or increases at the originally prevailing capital:labour ratio. The estimates of $\alpha_1(t)$ and $\alpha_2(t)$ provide some information about the technological changes in Taiwan's agricultural sector in 1951-1976. If the capital:labour ratio is fixed, the locus of $\alpha_2(t)/\alpha_1(t)$ over time provides information about the path of technological changes in Taiwan's agricultural sector. Figure 3 shows the locus of $\alpha_2(t)/\alpha_1(t)$.

The results in figure 3 show that the technological change in the early 1950s was labour intensive, in the late 1950s it became capital intensive, then became labour intensive again during the 1960s, and in the 1970s it became neutral. These changes coincide with the growth path of Taiwan's agriculture. During the 1950s there were important innovations in production methods; for example, success in breeding new varieties of crops and livestock, and increased applications of fertilizer, herbicides, and pesticides increased the intensity of capital inputs, which induced a capital intensive technological change. In the 1960s the introduction of mushrooms, asparagus, and other vegetables increased the intensity of labour input which resulted in a labour intensive technological change. In the late 1960s, due to labour shortage, farmers changed from small farm production to large scale commercial production. As a consequence, change became neutral.

Figure 3. Dynamic Path of $\alpha_2(t)/\alpha_1(t)$

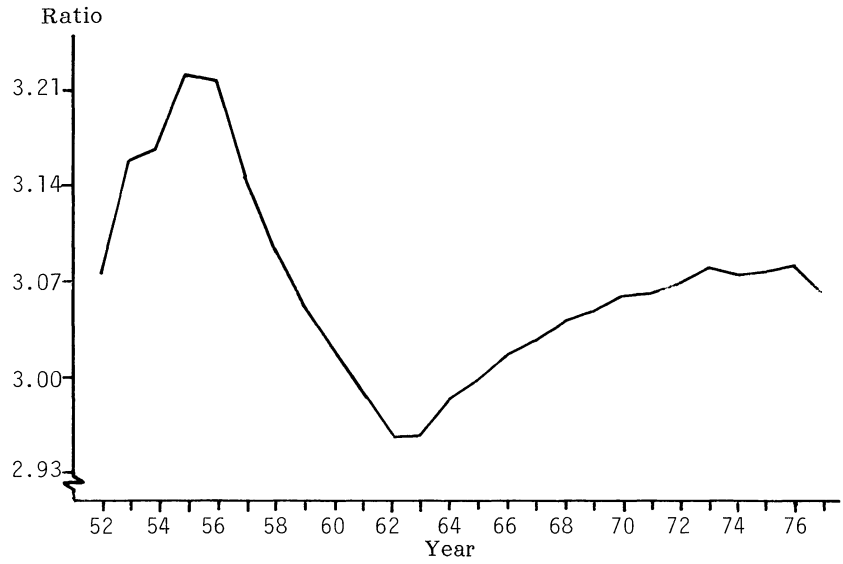
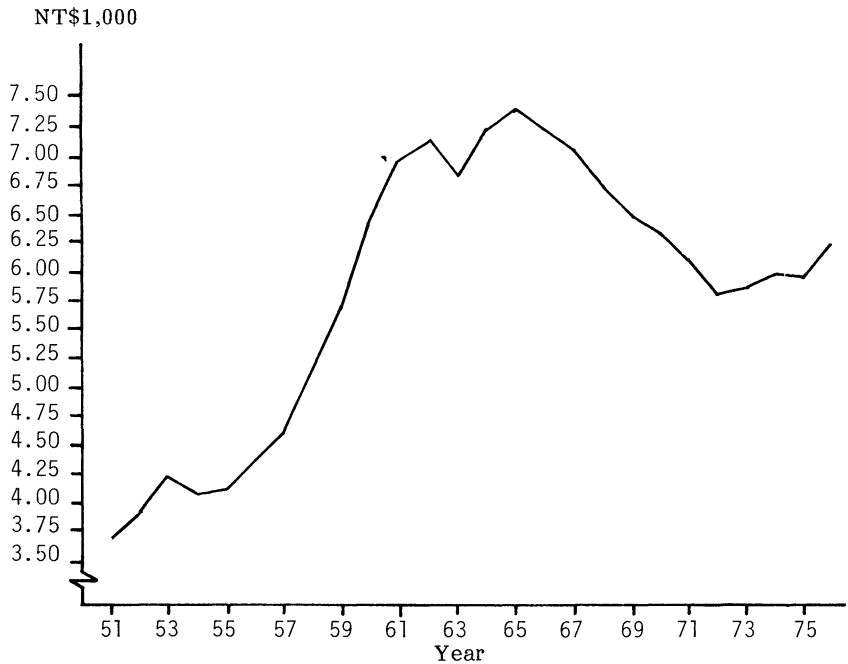


Figure 4. Dynamic Path of Intercept $\text{Exp}[\alpha_0(t)]$



The output response (net of the effects of capital and labour) as a function of time is $\alpha_0(t)$. The effects from these excluded variables are reflected in Exp $[\alpha_0(t)]$ in equation 1 and are illustrated in figure 4. Exp $[\alpha_0(t)]$ increased from 3.714 in 1951 to a maximum of 7.345 in 1965, and decreased to 5.830 in 1972, then increased again to 6.197 in 1976. These changes coincide with the rapid growth in productivity of most commodities before 1965. After 1965, agricultural production had drastic changes. The growth in all commodities slowed due to labour shortage or to loss of acreage from urbanization.

The cumulative effect of all parameters changing is reflected in the degree of permanent to transitory change via γ (Cooley and Prescott, pp. 464-65). The estimated γ was 0.30 with a standard error of 0.21. This estimate suggests that about 70 percent of the technological change in Taiwan's agricultural production was transitory.

Note

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