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GROWTH THEORY AND ACCOUNTING FOR GROWTH OF THE TAIWANESE ECONOMY

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Abstract

A growth accounting and an econometric exercise are used to provide insights into the evolution of the Taiwanese economy over the period 1966-96. The approach links the GDP function of a multiple sector neoclassical growth model to growth accounting and, subsequently to the estimation of the parameters of this function. The growth accounting results show that the contribution of total factor productivity (TFP) to growth in GDP averaged about 32 percent over the period, and this contribution increased as the economy approached its long-run equilibrium during the decade of the 1980s, with evidence of some departure during 1991-96. Growth in TFP increased output growth in industry and services while growth in skilled labor benefited all sectors. Growth in capital stock increased the growth of the industrial sector the most, followed by services, but the effect on agricultural output growth was negative. Growth in TFP and capital stock appear to have increased the capacity of the industrial and service sectors to pull resources from agriculture.

Key Words: Economic Growth, Productivity, Technological Change

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1 Introduction

This study focuses on the sources and evolution of economic growth of the Taiwanese economy over the period 1966-1996. Most of the previous growth accounting studies (Young, 1995; Collins and Bosworth, 1996, etc.) have tended to ignore whether an economy is in transition to a steady state, and they have tended to treat an economy as producing one aggregate good, an exception being that of Kohli (1997). The former omission tends to over estimate capital' s contribution to growth when an economy is not in long-run equilibrium, while the latter cannot account for the inter-sectoral competition for resources (such as the flow of labor out of agriculture and the sectoral competition for capital) as the economy grows. To provide empirical insights into linkages between the contribution of factors to economic growth and changes in the sectoral composition, we develop an analytical linkage between a two-sector Ramsey growth model and the gross domestic product function (GDP).

We exploit the envelop properties of this function in two ways. First, we adapt the growth accounting methodology using the GDP approach developed by Diewert and Wales (1992) and used by Kohli (1994, 1997) and others (Govindan et al., 1996) to account for growth contributions from level effects of sectoral prices, factor endowments, and rate effects from growth in total factor productivity (TFP). These results are compared to the results obtained in a frequently cited paper of Young (1995). Second, we fit the gradients of the inter-temporal GDP function to annual data to obtain estimates of Stopler-Samuelson and Rybczynski "like" elasticities, and elasticities of technological bias. Outputs are aggregated into three sectors-agriculture, industry, and service. Inputs are aggregated into two primary factors of production-labor and capital where account is taken of changes in factor quality over the period.

The Taiwanese economy is of particular interest because of what can be learned from its rather spectacular performance. The economy's GDP has grown at an average annual real rate of about 8.2 percent over the 1966-96 period. At the sectoral level, agricultural output has grown at a negative rate of about 2.4 percent, while industrial and service sector output have grown at about 9.4 and 8.8 percent, respectively. The economy has experienced relatively high rates of growth in capital stock, averaging about 11.4 per cent per annum, and growth in the quantity of quality adjusted labor of about 3.3 percent per annum. The share of services in GDP has also grown while agriculture has contracted to about 3 percent of GDP. The results from the growth accounting exercise show that growth in total factor productivity (TFP) averaged 2.58% per annum, which accounts for about 32% of the country' s average annual growth in real GDP. Relating these results to an index measuring the extent to which the economy departs from its long-run steady state equilibrium, we find the reasonable result that during the earlier periods, the Taiwanese economy was relatively distant from its long run equilibrium. In this case, the dramatic rate of growth in capital stock, possibly in response to other shocks such as growth in TFP, is considerably higher than its growth in long run equilibrium. Capital's contribution to GDP growth in the earlier period is thus disproportionately higher than is the contribution of TFP. Previous studies have not accounted for capital's contribution to transition growth, thus tending to overstate its contribution to growth and to understate the importance of growth in factor productivity.

The econometric estimates of the parameters of the GDP function in translog form allow us to investigate the technological biases within the Taiwanese economy, and to provide insights into the forces of structural transformation as the economy has grown over the study period. The estimated elasticities together with the empirical data on the relative share of factor endowments and relative output prices help to understand the underlying forces inducing resources to flow from the rural sector to industry and services, and their contributions to economic growth and factor returns. In general, these results suggest that the evolution of the economy is characterized by growth in factor productivity which increased output growth in industry and services, and growth in skilled labor which benefited all sectors. Growth in capital stock increased the growth of the industrial sector the most, followed by services, but the effect on agricultural output growth was negative. Growth in TFP appears to be capital using. Therefore, growth in TFP and capital stock appears to have increased the capacity of the industrial and service sectors to pull resources from agriculture.

The rest of the paper is organized as follows. Section 2 shows the linkage between a two-sector growth model and an intra-temporal GDP function. Section 3 draws upon the properties of this function to develop the empirical basis for the non-parametric growth decomposition analysis, and then the parametric analysis. Data sources and their construction are presented in Section 4. The results and implications of the empirical analysis are presented in the three parts of Section 5. The first part presents the results of the growth accounting exercise, the second discusses the Stopler-Samuelson and

Rybczynski like results from estimating the parameters of the translog GDP function, and the third reports the key insights obtained from combining the parameter estimates with the evolution of the exogenous variables to explain how the economy evolved over the period. Summary remarks conclude the paper.

2 A Two-Sector Ramsey Model And The GDP Function

2.1 Household

Consider a two sector Ramsey economy in which households provide labor service in exchange for wages w, receive interest income r on assets a, consume goods c_1 and c_2, and save by accumulating additional assets, $\dot{a}$. Since each household's overall utility function is expressed as a weighted sum of all future flows of utility, it is convenient to distinguish the inter-temporal from the intra-temporal allocation problem by constructing an aggregate consumption good $\mathbf{c}$ as a composite of the per capita consumption of the two goods $c_j = C_j/L(t)$, $j = 1, 2$ where $L(t)$ denotes population which grows according to $L(t) = e^{nt}$. In this framework, the household faces a two-level utility maximization problem. It maximizes an inter-temporal utility function by choosing aggregate consumption c and saving, while at the second level, it chooses c_j given c. More formally, the household's inter-temporal optimization problem is to maximize overall utility U

$$U = \int_0^\infty u\left[\mathbf{c}(t)\right] e^{(n-\rho)t} dt \tag{1}$$

subject to the inter-temporal budget constraint

$$\dot{a} = w + a\left(r - n\right) - \mu(P)\mathbf{c} \tag{2}$$

a transversality condition, and the stock of initial assets $a(0)$ per capita. The parameter ρ is the rate of time preference, P is the price of good 2 in terms of good one, and $\mu(P)$ is the shadow price of aggregate consumption $\mathbf{c}$. The function $u(c)$ is assumed to be increasing in $\mathbf{c}$, concave and to satisfy Inada conditions. The intra-temporal problem is to choose c_j to minimize expenditure E,

$$\mu\left(P\right)\mathbf{c} \equiv \underset{\{c_1,c_2\}}{Min}\ E = c_1 + Pc_2 \mid \mathbf{c} = h\left(c_1, c_2\right) \tag{3}$$

where $h(\cdot)$ is a "constructed" CRS technology, $h'(\cdot) > 0, h''(\cdot) < 0$, mapping the two final goods into the composite good $\mathbf{c}$. For given $\mathbf{c}$, the Hicksian demand function for good 2 is obtained from Sheppard' s lemma, i.e., $c_2 = \partial(\mu(P)\mathbf{c})/\partial P$ and $c_1 = E - Pc_2$.

If $u(\mathbf{c}) = ln\mathbf{c}$, we obtain from the first order conditions of the household's optimization problem characterizing the consumption over time:

$$\frac{\dot{E}}{E} = \frac{\dot{\mathbf{c}}}{\mathbf{c}} + \frac{\dot{\mu}}{\mu} = r - \rho \tag{4}$$

2.2 Production

The economy is initially endowed with $L(0)$ units of labor (normalized to unity) and capital $K(0)$, and CRS technologies

$$\widehat{y}_j = l_j f^j\left(\hat{k}_j\right), \; j = 1, 2 \tag{5}$$

where output per effective unit of labor in the j-th sector is $\widehat{y}_j = Y_j/AL$, $A \equiv e^{xt}$; the share of labor and the amount of capital per effective worker employed in the j-th sector is $l_j = L_j/L$, and $\hat{k}_j = K_j/AL_j$, respectively. Technology is presumed to satisfy Inada conditions, and $f^{j\prime} > 0$ and $f^{j\prime\prime} < 0$.

Firms, behaving competitively in output and factor markets, receive revenue for output which exhausts payments to labor and capital. The cost function per effective worker in the $j - th$ sector is given by

$$g^j(\widehat{w}, r)\,\widehat{y}_j \equiv \underset{\{L_j, K_j\}}{Min} \quad l_j\left(\widehat{w} + r\hat{k}\right) \mid \widehat{y}_j = l_j f^j\left(\hat{k}_j\right) \tag{6}$$

where $\widehat{w}$ is the wage per effective worker.

2.3 Intra-Temporal equilibrium

For any period t, given the level of per capita composite consumption $\mathbf{c}$ and capital per effective worker $\hat{k}$, equilibrium in the product market is given by two equations expressing the zero profit conditions obtained by setting unit costs from (6) to output prices. The factor market clearing conditions are expressed by equating the sectoral demand for labor and capital to the level of total labor and capital available at any point on the equilibrium path to the steady-state. These equations are obtained by applying Sheppard's lemma to (6) for $j = 1, 2$. As in the simple Heckscher-Ohlin framework[2], the solution to these equations yields supply functions in terms of output per effective worker

$$\widehat{y}_j = y_j \left(P, \hat{k} \right) \tag{7}$$

If we presume that good 1 is both a consumption good and an investment good, then equilibrium requires that the supply of good 2 equals final demand of good 2 at all points on the path to long-run equilibrium, i.e.,

$$\frac{\partial \left(\mu \left(P \right) \widehat{\mathbf{c}} \right)}{\partial P} = \widehat{c}_2 \left(P, \widehat{\mathbf{c}} \right) = y_2 \left(P, \hat{k} \right) \tag{8}$$

where aggregate consumption is now expressed in units per effective worker. This equation can be solved implicitly as a function of P,

$$P = \mathbf{P} \left(\widehat{c}, \hat{k} \right) \tag{9}$$

Given equilibrium $\widehat{c}$ and $\hat{k}$, The GDP function per effective work can be obtained from (7) and (9) as

$$g\hat{d}p = \tilde{G}(P, \hat{k}) = y_1 \left(P, \hat{k} \right) + P y_2 \left(P, \hat{k} \right) \tag{10}$$

or expressed in "level" terms as

$$GDP = G(P, K, AL) \tag{11}$$

Note that the gradients of (11) yield supply and factor rental rate functions from which Stopler-Samuelson and Rybczynski effects can be inferred. These effects are estimated and discussed later.

2.4 The Steady State Equilibrium

The representative household must end up with zero net debt, therefore the assets per person equal the capital per worker. The steady-state equilibrium requires, from (4)

$$\frac{\dot{\widehat{E}}}{\widehat{E}} = r - x - \rho = 0$$

[2] See for example, Woodland (1982, Chapter 7).

from the budget constraint

$$\dot{\hat{k}} = \widehat{w} + \hat{k}\,(r - n - x) - \mu(P)\widehat{\mathbf{c}} = 0$$

from the evolution of prices (9)

$$\frac{\dot{P}}{P} = 0$$

and the transversality condition

$$\rho > n$$

In the steady state, endogenous level variables, such as output and capital, can be shown to grow at the rate $x + n$, e.g.,

$$\frac{\dot{K}}{K} = x + n \tag{12}$$

2.5 Growth Accounting

As in the static framework, the gradient vector of (11) yields sectoral supply and factor rental rate functions. Taking the derivative of equation (11) with respect to time and dividing both sides by GDP, growth in total factor productivity (TFP) (Solow's residual) can be expressed as

$$\frac{T\dot{F}P}{TFP} = (1 - S_K)\,x = \frac{\dot{G}}{G} - S_2\frac{\dot{P}}{P} - (1 - S_K)\,\frac{\dot{L}}{L} - S_K\frac{\dot{K}}{K} \tag{13}$$

where S_2 and S_k are the shares of good 2 and capital, respectively, in GDP. Then, at any point on the transition path to the steady state, we obtain the contribution of the respective factor as the ratio of its effect on growth to total growth in GDP. In the case of capital, c_k, we have:

$$c_k = \frac{S_K\left(\dot{K}/K\right)}{\dot{G}\,/G} = \frac{S_K\left(\dot{K}/K\right)}{S_2\left(\dot{P}/P\right) + (1 - S_K)\,(n + x) + S_K\left(\dot{K}/K\right)} \tag{14}$$

and similarly for contribution from growth in labor c_L and growth in total factor productivity c_A.

Following Robertson (1998), defining the proportion of transitional growth as

$$\gamma = \frac{\left(\dot{K}/K\right) - (n+x)}{n+x} = \frac{\left(\dot{\hat{k}}\ /\hat{k}\right)}{n+x} \tag{15}$$

permits expressing the growth in capital as

$$\frac{\dot{K}}{K} = (1+\gamma)(n+x) \tag{16}$$

Note from (12), that in the steady state $\gamma = 0$. Substituting (16) into (14), we obtain the contributions of capital as a function of the extent to which the economy is not in its long-run steady state equilibrium:

$$c_k = \frac{S_K (1+\gamma)(n+x)}{S_2 \left(\dot{P}/P\right) + (n+x)(1+\gamma S_K)} \tag{17}$$

The contributions of labor c_L and factor productivity growth c_A can be similarly expressed.

Differentiating (17) with respect to γ shows the changes in contributions when an economy is on the transitional path to its long-run equilibrium. For the case where capital is below its steady state level, i.e., $\hat{k} < \hat{k}^*$, and $\dot{p}/p$ relatively small,

$$\frac{\partial c_K}{\partial \gamma} > 0, \quad \frac{\partial c_L}{\partial \gamma} < 0, \quad \frac{\partial c_A}{\partial \gamma} < 0 \tag{18}$$

These results indicate that the greater the distance $\hat{k} < \hat{k}^*$ the larger is the contribution of capital to growth and the smaller are the contributions of labor and TFP. In other words, the proportional contribution of capital to growth diminishes and the proportional contribution of technological progress increases as an economy approach its long-run equilibrium. A comparison of the contribution of capital to growth over time and/or across countries is more insightful if comparisons are made relative to γ since otherwise, capital may appear be a larger determinant of growth than is actually warranted.

3 Empirical Implementation

3.1 Translog GDP Function and Growth Accounting

The empirical specification of (11) for the case of a three sector economy is the translog form:

$$\ln G(p,v;t) = \alpha_o^t + \sum_j \alpha_j^t \ln p_j + \sum_m \beta_m^t \ln v_m + \frac{1}{2}\sum_j \sum_i \alpha_{ji} \ln p_j \ln p_i + \frac{1}{2}\sum_m \sum_n \beta_{mn} \ln v_m \ln v_n$$

$$+ \sum_j \sum_m \gamma_{jm} \ln p_j \ln v_m + \frac{1}{2}\delta t^2, \quad i,j = A,N,S;\ m,n = K,L \qquad (19)$$

with restrictions

$$\sum_j \alpha_j^t = 1; \quad \sum_m \beta_m^t = 1; \quad \sum_i \alpha_{ji} = 0; \quad \sum_n \beta_{mn} = 0; \quad \sum_j \alpha_{ij} = 0;$$

$$\sum_m \beta_{nm} = 0; \quad \alpha_{ji} = \alpha_{ij}; \quad \beta_{mn} = \beta_{nm}; \quad \sum_i \gamma_{im} = 0; \quad \sum_m \gamma_{im} = 0$$

where agriculture, industry and service sectors are indexed A, N, and S, respectively. Notice that the first order parameters are time dependent.

Diewert and Morrison (1986) have shown for the theoretical productivity index

$$R_{t,t-1} = \frac{G(p,v;t)}{G(p,v;t-1))}$$

of the function (19), the following *Laspeyres*

$$R_L^t = \frac{G(p^{t-1},v^{t-1};t)}{G(p^{t-1},v^{t-1};t-1)} \qquad (20)$$

and *Paasche*

$$R_P^t = \frac{G(p^t,v^t;t)}{G(p^t,v^t;t-1)} \qquad (21)$$

indexes are of special interest. Both indexes measure the percent change in GDP that occurred solely due to improvement in technology or in the efficiency of production activities between period t-1 and t. The numerator of R_L^t and the denominator of R_P^t are unobservable so that neither are empirically feasible. However, Diewert and Morrison (1986) showed that the geometric mean of these two productivity indexes is precisely equal to the translog implicit output index divided by the translog input index between period t-1 and t.

Given (19), the geometric mean of R_L^t and R_P^t is

$$R_{t,t-1} = \frac{a_{t,t-1}}{b_{t,t-1}c_{t,t-1}} \tag{22}$$

where growth in GDP (i.e., $1 + \dot{GDP}/GDP$) is

$$a_{t,t-1} = \frac{p^t \cdot y^t}{p^{t-1} \cdot y^{t-1}} \tag{23}$$

and the effect of prices and input levels are, respectively:

$$\ln b_{t,t-1} = \frac{1}{2}\left(\sum_j \frac{p_j^t y_j^t}{p^t \cdot y^t} + \sum_j \frac{p_j^{t-1} y_j^{t-1}}{p^{t-1} \cdot y^{t-1}}\right)\left(\ln \frac{p_j^t}{p_j^{t-1}}\right) \qquad j = A, N, S \tag{24}$$

$$\ln c_{t,t-1} = \frac{1}{2}\left(\sum_m \frac{w_m^t v_m^t}{w^t \cdot v^t} + \sum_m \frac{w_m^{t-1} v_m^{t-1}}{w^{t-1} \cdot v^{t-1}}\right)\left(\ln \frac{v_m^t}{v_m^{t-1}}\right) \qquad m = K, L \tag{25}$$

These indexes can be evaluated using price and quantity data without knowledge of the parameters of (19). Equation (24) is the Tornqvist aggregate real output price index, therefore a/b is an implicit output quantity index, and c is the Tornqvist aggregate fixed input quantity index. Individual real price and input contributions can be disaggregated from equation (24) and (25). These equations are the key components of the non-parametric analysis carried out below. Taking the logarithm of both sides of equation (22), we have the equivalence of Solow' s residual:

$$\frac{T\dot{F}P}{TFP} = \ln R_{t,t-1} = \ln a_{t,t-1} - \ln b_{t,t-1} - \ln c_{t,t-1} \tag{26}$$

Equation (24) is the empirical approximation of the share weighted output price change in (13), while (25) is the empirical approximation of the share weighted input quantity change in (13).

This completes the linkage between the neoclassical growth model and our growth accounting exercise presented below.

3.2 Technological Biases and Elasticities

The envelope properties of (19) imply the net output share equations

$$S_j^t = \alpha_j^t + \sum_i \alpha_{ji} \ln p_i + \sum_m \gamma_{jm} \ln v_m, \quad i,j = A,N,S \tag{27}$$

and the primary input share equations

$$S_m^t = \beta_m^t + \sum_j \gamma_{jm} \ln p_j + \sum_n \beta_{mn} \ln v_n, \quad n,m = K,L \tag{28}$$

where S_j^t and S_m^t are the GDP shares of output j and input m respectively. The time dependent constant terms α_j^t and β_m^t can be replaced by $(\alpha_j + \delta_j t,$ and $\beta_m + \delta_m t)$ where t denotes a trend variable " time". The parameters δ_j, δ_m are referred as technological change biases as Jorgenson (1986) suggested. The time dependent coefficient α_o^t can also be decomposed into $\alpha_o + \theta t$.

Differentiating both sides of (27) and (28) with respect to time, and solving for $\varepsilon_{\cdot t}$,we obtain

$$\varepsilon_{jt} = \frac{\delta_j}{S_j} + \frac{\partial \ln G(\cdot)}{\partial t} \tag{29}$$

$$\varepsilon_{mt} = \frac{\delta_m}{S_m} + \frac{\partial \ln G(\cdot)}{\partial t} \tag{30}$$

where $\partial \ln G(\cdot)/\partial t = \tau$ is aggregate productivity growth. Given the translog form, the rates of technological biases can be defined as

$$\zeta_{jt} = \varepsilon_{jt} - \frac{\partial \ln G(\cdot)}{\partial t} = \frac{\delta_j}{S_j}, \quad j = A,N,S \tag{35}$$

$$\zeta_{mt} = \varepsilon_{mt} - \frac{\partial \ln G(\cdot)}{\partial t} = \frac{\delta_m}{S_m}, \quad m = K,L \tag{36}$$

These elasticities, along with the implicit supply and factor rental rate elasticities are estimated and discussed in empirical analysis section of the paper.

4 Sources of Data

Data on the Taiwanese economy were obtained for the period 1966 to 1996. Sectoral current and constant dollar values of GDP were obtained from the

Statistical abstract of National Income in Taiwan Area, Republic of China , 1951-1997. The economy was aggregated into three major sectors: agriculture (A), industrial (N), and service (S) sectors. The agricultural sector includes crops, livestock, forestry, and fisheries. The industrial sector includes mining, manufacturing, construction, electricity, gas and water industries, and the service sector consists of commerce, transportation, communication, government service, finance, insurance, business service and others.

Wages of workers corresponding to gender and educational attainment were obtained from the *Survey of Manpower Utilization*. However, these data are only available since 1978. Facing a similar problem, Fei, Ranis and Kuo (1979) drew upon the original tabulation sheets of the 1966 *Survey of Personal Income Distribution* and estimated wages by gender and education[3]. We utilized their results. Labor force data were obtained electronically from *Taiwan Economic Data Center* (TEDC) [4]. To account for changes in the quality of the labor force, data on gender, educational level and employment status were obtained from the various issues of *The Yearbook of Manpower Survey Statistics, Taiwan Area Republic of China*.

Data on different types of capital formation in current and constant prices were also obtained electronically from TEDC. Again, the price of each type of investment good was the price deflator obtained by dividing the current dollar to constant dollar values. Estimates of the stock of imported equipment was obtained from *Taiwan Statistical Data Book*. Using the methodology suggested by Jorgenson et al (1987), these data were adjust to account for changes in the quality of the labor force and capital services[5].

5 Results and Discussion

5.1 Accounting for Growth

The results from applying (23 to 25) to the data, and comparisons with previous studies are reported in Table 1. As can be seen, the rate of growth in Taiwan's real GDP averaged 8.17% per annum over the 1966-96 period. Over this period, the price of services relative to agriculture and manufacturing tended to rise, and contributed about 0.22 percent to growth in GDP

[3]We thank Dr. Chang-Tai Hsieh for his generous sharing of the wage data.

[4]Web site of TEDC: 140.111.1.22/moecc/rs/pkg/tedc.htm

[5]These data are available from the authors upon request.

on average. However, the effect of changes in all output prices on growth was negative and small, averaging a mere -0.02 % per annum. Growth in the quantity of quality adjusted labor and capital accounted for roughly 70 percent of the average annual growth in GDP over the period. Prior to 1980, growth in capital contributed substantially to GDP growth, accounting for almost half of the average annual rate of output growth. Capital's contribution reached a low point in the first half of the 1980's, and rose modestly thereafter, but not to the levels seen in the initial periods. Overall, capital accounted for about 40 percent of the annual average rate of growth in GDP. TFP growth rose noticeably starting in the late 1970s, reaching a high of about 3.8 percent per annum over the 1986-90 period. Growth in TFP since the late 1970s has been a major force which partially compensated for the effect of the decline in capital's contribution.

The measures of TFP growth obtained by others differ due to different methodologies, different periods studied and different treatment of the data used. Therefore, a direct comparison of these results is not too meaningful. Nevertheless, our results correspond rather closely to those reported by Young (1995) in his frequently quoted paper " The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience". He suggested that rapid increases in employment were the primary sources of GDP growth of these East Asian economies[6]. He states, "Neoclassical growth theory, with its emphasis on level changes in income and its well-articulated quantitative framework, can explain most of the difference between the performance of the NICs and that of other postwar economies". However, he does not specifically relate neoclassical growth theory to his growth accounting exercise.

Table 2 extends the growth accounting results reported in Table 1 . Row (16) reports the proportion of transition growth γ from equation (15). The results suggest that the economy was relatively distant from its long-run equilibrium in the late 1960s. Following the decline in the rate of capital accumulation, the economy appears to have roughly converged to its long-run equilibrium during the 1981-85 period, only to depart somewhat in later periods but never reaching departures of the earlier period. This pattern suggests that the aggregate return to capital per worker exceeded its long-run

[6]Drawing on Young' s results, Krugman (1994) further claims that the East Asian miracle is not miraculous at all because this kind of input- intensive type of economic growth cannot last forever.

level thus inducing a relatively rapid but declining growth in capital stock through the late 1970s. As equation (17) suggests, and can be seen in the Table 2, Row (12), capital's contribution (c_K) was relatively high during this earlier period (ranging from an annual average of 54 to 37%), but declined as the economy approached its long-run equilibrium. The decline in growth of capital stock also roughly corresponds to the decline in γ, suggesting that capital's growth was slowed in part by diminishing returns. As can be seen from Table 1, the rate of productivity growth in the past one and half decades has been at historically high levels. In the mid 1980s it appears that a resurgence in the rate of growth in TFP may have lessoned the rate of diminishing returns to capital experienced in the late 1970s. As growth in TFP occurred, growth in capital stock that exceeded 8.5 percent per year followed through the end of the study period.

What proportion of the observed pattern of growth in capital stock is due to a transitional component and what proportion is due to a steady state component? In terms of the analytical framework, the former component results from capital accumulation purely induced by high capital returns, and the latter is from the growth in factor productivity and population. The contributions of transitional growth and steady state growth are presented, respectively, in rows (18) and (19) of Table 2. The results show that the contribution of transitional growth to overall growth of GDP is smaller than the contribution from the steady state component. The transitional component was relatively high during the first decade of the period when the country's capital stock per effective worker was relatively far below its level in long-run equilibrium. During this period, the transitional component accounted for an average of about 27 and 32 percent per annum over the 1966-70 and 1971-75 periods respectively, and then rising again during the last decade. Nevertheless, most of capital's contribution to growth in GDP is attributable to growth in TFP and the quantity of quality adjusted labor. Overall, these results show that the farther the economy is from its steady state, the larger the contribution of capital stock to growth, while the closer it is to the steady state, the larger is the contribution of the TFP to growth. As the economy approaches its steady-state rate of growth, the contribution of TFP to growth increases leaving it as the primary source of output growth in the long-run.

5.2 Direct, Own Elasticities And Technological Bias

The previous nonparametric approach allows us to measure economy-wide productivity growth without knowing the parameters of the GDP function. However, without estimates of these parameters, inferences cannot be made regarding the sectoral evolution of output and factor returns induced by growth in factors and by the relative growth in sectoral factor productivity. Specifically, we are interested in identifying the technological biases as defined in Section 3.2 with respect to outputs and inputs.

The parameters of equation (19) were estimated by fitting, simultaneously (19), and the accompanying share equations (27) and (28) to the data using an iterative version of Zellner' s (1962) method for seemingly unrelated regressions. To avoid singularity of the variance-covariance matrix of this system, one equation from each subsystem was omitted. Initial efforts showed that the estimated GDP function failed to be convex for data points in the late 1960s. In order to satisfy the convexity assumption, we imposed this property locally for the year 1966 by using the reparameterization proposed by Wiley, Schmidt and Bramble (1973). The results from this exercise is reported as " Regression 1" in Table 3. The low Durbin- Watson' s statistics obtained however suggest that the residuals may be autocorrelated. To deal with this problem, we assumed that the disturbance terms of the system follow a first-order autocorrelation process and thus applied the AR 1 procedure to the estimation. We refer to this result as " Regression 2". Finally, the analytical framework suggests that even for a relatively open economy as Taiwan, capital and perhaps the prices of services may be jointly determined with the evolution of output and factor payments. "Regression 3" reports the results from fitting the model to data where the intensity of capital (i.e. the per worker capital) and the relative price of service to industry are treated as endogenous variables. This problem is addressed using an instrumental variables technique[7], and fitting the model to data using a three stage nonlinear least squares estimator. Overall, the model appears to fit the data well with relative consistency across estimators. The ensuing discussion draws upon the results of Regression 3.

[7]. The instrumental variables included: population, relative price of agriculture to industry, openness index, ratio of foreign investment to GDP, ratio of income tax to GDP, ratio of saving to GDP, interest rate, tariff rate, trade surplus, time index, time index square and the population of three major trading partners of Taiwan: United state, Japan, and Hong Kong.

Table 4 reports the complete set of elasticity estimates based on the results from "Regression 3," Table 3. Estimated elasticities are reported as a mean over the entire period (the last column of Table 3), and for each five year increment. The first block presents the various own and cross price elasticities of output supply. E_{jk}, denotes the elasticity of price p_k on the supply of output y_j, $j, k = a$ (agriculture), n (industry), s (service). Notice that all own price elasticities are positive, and most of the cross price elasticities are negative.

The own price elasticities of the agricultural sector rise rather dramatically over time suggesting that the sector has become more responsive (elastic) to output price changes. Interestingly, this result is consistent with an earlier study by Shun-Cheng Lee (1982) using farm level panel data over the period 1966-78 to estimate the parameters of short and long-run trans-log cost functions. He found that the liberalization of fertilizer, water and land policy caused agriculture to become more capital intensive, and the sector's demand for factors of production became more price elastic.

The own price elasticity of supply for the industrial and service goods are positive and relatively constant over the period. In the case of the industrial sector, own price elasticity ranges from 0.45 to 0.28 while that for the service sector ranges from 0.38 to 0.32. In the case of Indonesia (Govindan et al., 1996) corresponding elasticities evaluated at the mean of the data are 0.17 and 0.26 for the industrial and service sector, respectively. The cross prices elasticities are generally negative, suggesting that sectors must compete for resources. The strongest substitution effect is shown by the service price on the supply of agricultural goods. Over 1966-1996, on average, one percent of increase in the price of service goods causes a 0.78 percent of decrease in agricultural supply. In general, the price effect of agriculture on the other sectors is minor. The rise in the absolute value of the cross-price elasticity between agriculture and the industrial sectors suggests that as capital deepening has occurred in the industrial sector, and as agriculture's share of the economy has declined, the importance of intermediate product linkages between the sectors has declined.

The second part of the table contains the elasticities that show the responses of factor rental rates to own and cross-factor supplies. Own elasticities are of the expected sign. The rental price of capital is more sensitive to its supply than is the corresponding case for labor. On average, a one percent increase in the amount of capital will decrease the rental price of capital by nearly 0.60 percent, which is more than twice the effect of an increase in the supply of labor on wage. This result implies that wage is relatively inelastic to change in the supply of labor compared to capital rental price. In comparison to other studies, Kohli (1994) finds for the case of the US, elasticities of -0.50 and -0.67 for labor and capital respectively, while Govindan et al. (1996) find values of -0.46 and -0.59 for the case of Indonesia. Thus, while we find a similar relationship for the case of capital, wages appear to be affected less negatively by an increase in the quantity of quality adjusted labor. The positive cross quantity elasticities of inverse factor demand indicate that the two factors of production are substitutes. On average, the impact of an increase in the supply of labor on the rental rate of capital is more than that of an increase in the supply of capital on the wage of labor. This result is consistent with the previous observation that demand for labor is more inelastic than that for capital.

Of more interest are the Rybczynski - like elasticities which show the supply response to change in the amount of primary inputs. Estimates of these elasticities are reported in the third block of Table 4. In a Heckscher-Ohlin 2×2 economy, the Rybczynski theorem essentially states that the industry which uses a factor relatively intensively will expand more than proportionately to an increase in the factor' s supply, while the other industry will shrink more than proportionately. However, this theorem does not generalize for the three by two economy modeled here, although it can be shown that the sector using an input intensively will expand relative to other industries, unless production is joint. Specifically, the parameter estimates suggests that the net supply elasticities of the agriculture and service sectors with respect to labor (1.25 and 0.94, respectively) are larger than the elasticities with respect to capital (-0.25 and 0.06); however, the reverse is the case for industrial sector, that is, the industrial sector is more responsive to changes in capital than labor (0.67 v.s. 0.33). This implies that, all else constant, output growth of all three sectors benefited from the 3.3 percent average annual increase in the quantity of quality adjusted labor (see $\dot{L}/L$, Table 2). Agriculture benefited the most since its relative labor intensity increased over the period, followed by the service sector. The industrial sector is capital intensive, and it benefited the least. Since the share of the service sector in the economy is relatively large, as we see in the next section, this 3.3 percent annual increase is a major factor contributing to of the economy.

Counteracting this positive effect on agriculture, however, is the Rybczynski effect of growth in capital stock. This elasticity is negative which indicates that the growth in the country's capital stock tends to "pull" resources from the agricultural sector. In other words, since the technology of agricultural sector is relatively labor intensive, an increase in the stock of capital benefits the sectors which use capital relatively intensively and change the input combination of the agricultural sector in a way which, all else constant, cause production to fall. The effect of growth in capital stock on the output of the service sector is positive, but small.

The Stolper-Samuelson - like (S-S) elasticities are reported in the last part of the Table 4. According to S-S theorem, in a standard 2×2 Heckscher-Ohlin model, the rental rate of a factor will rise more than proportionately to a rise in the output price of the industry which use this factor relatively intensively. Again, this theorem does not hold for the case of joint production nor does the proportionality condition in the three by two economy modeled here. The S-S effects suggest that, from the Rybczynski elasticities, if the agricultural and service sectors use labor intensively relative to capital, while the industrial sector uses capital intensively relative to labor, then an increase in the relative price of agricultural and service goods should have a greater impact on the rental rate of labor than on that of capital. In contrast, an increase in the price of industrial goods should have a larger impact on capital rental rates than on wage.

On average, nominal wages respond positively to the increase in output prices, but they respond most positively to an increase in the output price of services. The capital rental rate responds negatively to an increase in the price of agricultural output, and positively otherwise; it is most sensitive to an increase in the price of industrial goods. A one percent increase in the price of agricultural output causes the wage rate to rise 0.15 percent, on average over the period, while causing the capital rental price to fall 0.08 percent. A rise in the price of service sector output likewise causes the wage to rise relative to the capital rental rate (0.66 percent v.s. 0.11 percent). In light of the price trends reported in Table 2, and as we show in the next section, all else constant, the rise in the price of services is associated with a relatively large rise in the wage rate while the increase in the price of industrial goods has been a major factor mitigating the observed decline in the rental rate of capital. Viewing the S-S elasticities of agricultural price on wage over time, the results reported suggest the impact of agricultural price on wage declines (from 0.26 percent to 0.10 percent) over the period while that of the service price on wage increases modestly (from 0.64 percent to 0.73 percent). The S-S impact of industrial prices on capital rental prices increase with time.

To summarize, the S-S effects cause nominal wages to rise the most from an one percent rise in the price of services, followed by an one percent rise in the price of industry and agriculture, in that order. Overall, we observe in the data a relative rise in the price of services, growth in capital and quality adjusted labor. Given the SS and Rybczynski elasticities, these trends, as we show in the next section, have tended to favor the service and manufacturing sectors of the economy relative to agriculture. Next, we turn to the estimates of the parameters associated with technological change.

To the extent that time is a proxy variable for growth in factor productivity, the rate of TFP growth is reported in Row τ of Table 5. The results suggest that productivity growth steadily increased throughout the period. The average productivity growth over the period is 2.75%, which closely approximates the estimate of 2.58% obtained from the nonparametric approach (Row 7, Table 2). However, the econometric estimates are lower than the growth accounting estimates during the early years of the period, and higher during the latter years. The econometric measure also provides an estimate of the effect of economy-wide technological change on each sector. These semi-elasticities of output supplies and input rewards with respect to time are reported in the first panel of Table 5. The effect on output supply tends to favor the service sector (ε_{st}), and to be biased against agriculture (ε_{at}) and, in earlier periods, against the industrial sector. On the input side, technological progress clearly benefits nominal wages (ε_{lt}) relative to the rental rate of capital (ε_{kt}).

The lower two panels of Table 5 contain estimates of these technological biases computed as the difference between the semi-time elasticities and the economy-wide technological progress index.With regard to output, we find that the indexes are negative for agricultural and industrial sectors and positive for service sector. Thus, technological change is pro-service, but anti-agriculture and anti-industrial good biased, all else constant. In terms of factor rental rates, we find technological progress to be pro-labor, and anti-capital biased. Of course, this does not imply that growth in sectoral factor productivity has been negative, merely that relative to the mean rate of 2.75%, productivity growth has not had neutral effects on output growth or on the growth in factor rental rates.

5.3 Total Effects on Output and Factor Rental Rates

Drawing upon the estimated elasticities, Table 5 extends the above discussion by evaluating the level and rate effects on growth in output and nominal factor rental rates from changes in the explanatory variables, evaluated at their mean annual rate of change observed over the period of the study[8]. Those factors contributing positively (negatively) to output growth, all else constant, appear as positive (negative) values in the table. In the case of agriculture, the factor contributing most positively to mitigating its observed average annual - 2.42 percent decline in output is the rise in its own price. However, the rise in own price was not sufficient to overcome the effects of the rise in the prices of services and manufacturing which leaves agriculture's terms of trade marginally negative with the net effect on growth in output being slightly negative on average for the period. The second factor is the growth in the quantity of quality adjusted labor, the most important component of which is the growth in skilled workers. This component accounts for over 80 percent of the total labor effect. The negative impact of capital on agricultural output arises from the Rybczynski effects discussed above. Together, the level effects of changes in prices and resources has had a slight negative effect on growth in agriculture's output. Finally, economy-wide growth in factor productivity did not favor agriculture. Economy-wide growth in TFP appears to have encouraged resources to depart the sector. At this level of analysis, this appears to be the dominant feature explaining the average annual decline of 2.42 percent in agricultural output over the period.

In the case of industrial sector output, its terms of trade effects have also been slightly negative overall. However, almost 90 percent of its annual average rate of growth in output, net of the price effects, is attributable to the level effects of growth in labor and capital stock. Since the sector is relatively capital intensive, the growth in capital stock accounts for a far larger effect on output than growth in labor. In contrast to agriculture, growth in factor productivity accounted for about 11 percent of the sectors growth in output, net of the slightly negative terms of trade effects.

[8] These estimates are given by the following for supply

$$\dot{y}_j/y_j = \sum_k E_{jk}\left(\dot{p}_k/p_k\right) + \sum_m E_{jm}\left(\dot{v}_m/v_m\right) + \varepsilon_{jt}$$

and

$$\dot{w_m}\ /w_m = \sum_j E_{mj}\left(\dot{p}_j/p_j\right) + \sum_n E_{mn}\left(\dot{v}_n/v_n\right) + \varepsilon_{mt}$$

for factor rental rates where prices $(\dot{p}_j/p_j)$ and resources $(\dot{v}_n/v_n)$ are evaluated at the mean of the data. It should be kept in mind that p_s and v_k are also endogenous variables.

The service sector has also experience high annual average rates of output growth. In this case, terms of trade effects have been small but positive. Due to Rybczynski effects, growth in labor has accounted for the largest component of growth with, once again, the growth in skilled labor accounting for the far largest component of the total labor effect. Total level effects account for 46 percent of the sector's annual average rate of growth over the period. Growth in factor productivity accounts for the remaining 54 percent of output growth. This factor surely increased the sector's ability to compete with the other sectors of the economy for factors of production, and notably labor from agriculture.

The last two columns of Table 5 show that the growth in nominal wages averaged almost 13 percent per annum over the period while nominal capital rental rates fell at an annual average rate of about 2.7 percent. Rising output prices contribute positively to growth in both rates, but the rise in the price of industrial sector output, all else constant, clearly had a mitigating effect on the observed decline in the nominal capital rental rate. The growth in the quantity of quality adjusted labor has had small negative effects on the growth in nominal wages, although this growth, particularly skilled labor, clearly contributed to augmenting the productivity of capital and hence, to further mitigating the decline in the capital rental rate.

The growth in capital stock had a relatively small impact on the growth in nominal wages because the service sector is labor intensive and accounts for a relatively large share of the economy. The growth in capital stock (an endogenous variable) is associated with a relatively large effect on reducing the rate of return to capital. This result is consistent with the convergence of the economy to its long-run equilibrium ($\gamma \rightarrow 0$) and suggests, all else constant, diminishing returns to additional capital. Together however, level effects appear to have had little impact on reducing the decline in the rental rate of capital. The -116 percent of the rate effect can be interpreted as encouraging the growth in capital stock to such an extent as to be an important explanation for the decline in capital's rental rate. Finally, growth in factor productivity has had a relatively large positive affect on the growth in nominal wages. Thus, in this sense, growth in factor productivity has been labor saving and capital using.

Further insight into the evolution of the economy can be gleaned by considering the decline in the labor/capital ratio over the period of the study (Figure 1). Given the driving force of factor productivity growth, which favored growth in output of services and industry, in that order, the growth in capital relative to labor contributed in a major way to the growth in output of the capital intensive industrial sector over the period. The relative growth in capital stock also contributed to the growth of nominal wages and the decline in the nominal capital rental rate. Growth in wages and the Rybczynski effects of growth in capital stock encouraging the migration of labor out of agriculture. The labor intensive service sector's access to growth in quality adjusted labor was also partially induced by relatively favorable terms of trade over the period (Figure 2), which also help to increase labors nominal wage. Thus, of the two major sectors of the economy, services benefited the most from growth in quality adjusted labor, while manufacturing benefited the most from growth in capital. Growth in factor productivity surely induced growth in capital stock which, together with growth in factor productivity, were the major contributors to the 12.6 percent average annual growth in nominal wages over the period.

6 Concluding Remarks

This study focused on the sources and evolution of growth of the Taiwanese economy over the 1966-96 period. The economy was aggregate into three sectors, agriculture, industry and services, and two quality adjusted factors, labor and capital. The approach linked the GDP function of a multiple sector neoclassical growth model to growth accounting and, subsequently to the estimation of the parameters of this function. In general, the evolution of the Taiwanese economy is characterized by growth in factor productivity which increased output growth in industry and services, and growth in skilled labor which benefited all sectors. Accompanying these sources of growth were high rates of growth in the country's stock of capital during the earlier periods which then declined to levels approximating long-run equilibrium during the decade of the 1980s, with some divergence during the 1991-96 period. Growth in capital stock increased the growth of the industrial sector the most, followed by services, but the effect on agricultural output growth was negative. Growth in TFP and capital stock appears to have increased the capacity of the industrial and service sectors to pull resources from agriculture.

More specifically, the growth accounting results shows that, on average over the period, the order of importance in contributing to growth are growth in capital stock, growth in factor productivity, and growth in the quantity of quality adjusted labor. During the first decade of the period, approximately

30 percent of capital's contribution was due to the adjustment to long-run equilibrium, the remaining proportion to steady-state growth. The economy appeared to be in approximate long-run equilibrium during the 1980s. Since then, growth in capital stock has tended to increase, leaving about 13 percent of capital's contribution due to transitional dynamics. For the most part, estimates of Harrod neutral technological change has tended to rise from the early 1970's through about 1990, then declining to about 3.4 percent per annum over the 1991-96 period.

The econometric model fit the data well. Own price elasticities of supply for agriculture, industry and services are positive, and cross price elasticities are negative with own and cross price elasticities for agriculture showing a clear trend over the period. Own wage to changes in the quantity of quality adjusted labor, and the capital rental rate to changes in capital stock are negative, with positive cross elasticities. Rybczynski elasticities indicate that the agricultural sector is labor intensive while the service sector is relatively labor intensive. The industrial sector is capital intensive, but, all else constant, its output is not affected negatively by increases in the economy's quantity of labor. Consequently, changes in the quantity of quality adjusted labor have positive effects on the output of all three sectors of the economy, with relatively strong effects on increasing the output of agriculture and services and smaller effects on the industrial output. Increases in the stock of capital have strong positive effects on industrial sector output, modest positive effects on the output of services but negative affects on agricultural output. The Stopler-Samuelson elasticities show that nominal wages respond most positively to an increase in the prices of services, and to respond almost equally to increases in the price of industrial and agricultural output. The rental rate of capital is most responsive to an increase in the price of industrial sector output, while rather unresponsive to change in agricultural and service prices.

Using time as a proxy, growth in TFP was found to have relatively nonneutral effects on growth in sectoral output. The semi-elasticity of growth in TFP to agricultural output is negative, and positive for the other two sectors, but favoring growth in the output of services relative to output of the industrial sector. The semi-elasticity of growth in TFP to growth in nominal wages is positive and negative with respect to capital's rental rate.

The broader implications of these results to the evolution of the economy were obtained by combining the elasticity estimates with the observed changes in the data. These results show that changes in the country's sectoral terms of trade, while small overall, tended to favor the growth in output of the service sector. These changes also encouraged the growth in nominal wages, and to mitigating the observed decline in the capital rental rate. Growth in the quantity of quality adjusted labor positively affected the output growth of all three sectors with agriculture benefiting the most, followed by the service and manufacturing sectors. Of the total labor effects, growth in skilled labor was most important. Growth in capital contributed to output growth in the industrial sector the most, and to the service sector. Growth in labor had relatively small negative affects on growth in labor wage but relatively large positive effects on slowing the decline in capital's rental rate. Growth in capital stock led to a rather large decline in capital's rental rate, as did growth in factor productivity. Growth in factor productivity accounted for an average of 11 percent of the growth in industrial output, and for about 54 percent of the average annual growth in service sector output. Apparently, growth in TFP and capital stock increased the capacity of both the industrial and the service sector to pull resources from agriculture.

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Table 1. Accounting For Growth in Real GDP,
Average Annual Rates in Percent, 1966-96

	Real GDP Growth	Static effects on GDP Growth Due To					Rate effect
		Agricul. Price	Indust. Price	Service Price	Labor	Capital	TFP Growth
Period (%)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1)1966-70	10.08	-0.55	-0.32	0.65	3.08	5.33	1.89
(2)1971-75	8.70	0.44	-0.26	-0.21	2.99	4.71	1.02
(3)1976-80	8.67	-0.11	-0.20	0.36	2.70	3.21	2.70
(4)1981-85	7.50	0.03	0.22	-0.22	2.17	1.79	3.51
(5)1986-90	8.00	-0.06	-0.24	0.34	1.66	2.51	3.79
(6)1991-96	6.08	0.12	-0.53	0.42	1.43	2.07	2.58
(7)1966-96	8.17	-0.02	-0.22	0.22	2.34	3.27	2.58
(8)Young 1966-1990	8.90				3.64	3.16	2.60
(9)Kim&Lau 1953-1990	8.70				1.13	6.79	0.78
(10)Hsieh 1966-1990	8.70						3.46
(11)Worldbank 1960-1989	9.20						3.76

Table 2. Accounting for Transitional Growth, 1966-96

	1966-70	1971-75	1976-80	1981-85	1986-90	1991-96	1966-96
(1) $\dot{GDP}/GDP$	0.1008	0.0870	0.0867	0.0750	0.0800	0.0608	0.0817
(2) $\dot{P}_A/P_A$	-0.0297	0.0354	-0.0117	0.0038	-0.0161	0.0319	0.0023
(3) $\dot{P}_N/P_N$	-0.0080	-0.0062	-0.0045	0.0048	-0.0052	-0.0141	-0.0055
(4) $\dot{P}_S/P_S$	0.0138	-0.0045	0.0077	-0.0046	0.0068	0.0071	0.0044
(5) $\dot{L}/L(=n)$	0.0455	0.0442	0.0382	0.0295	0.0231	0.0189	0.0329
(6) $\dot{K}/K$	0.1642	0.1450	0.1103	0.0674	0.0896	0.0852	0.1135
(7) $\dot{TFP}/TFP$	0.0189	0.0102	0.0270	0.0351	0.0379	0.0258	0.0258
(8) S_K	0.3247	0.3252	0.2913	0.2653	0.2802	0.2432	0.2883
(9) S_A	0.1776	0.1233	0.0911	0.0672	0.0482	0.0358	0.0905
(10) S_N	0.3517	0.4143	0.4491	0.4561	0.4383	0.3815	0.4151
(11) S_S	0.4708	0.4624	0.4598	0.4768	0.5136	0.5827	0.4943
(12) c_K	0.5288	0.5416	0.3707	0.2382	0.3141	0.3408	0.4003
(13) c_L	0.3050	0.3429	0.3120	0.2891	0.2080	0.2356	0.2861
(14) c_A	0.1878	0.1176	0.3117	0.4683	0.4734	0.4239	0.3160
(15) $n+x$	0.0736	0.0594	0.0763	0.0774	0.0757	0.0530	0.0691
(16) γ	1.3751	1.0963	0.5947	-0.0258	0.2964	0.2323	0.6411
(17) x Harrod neutral Tech. Growth	0.0280	0.0152	0.0381	0.0478	0.0526	0.0341	0.0363
(18) Steady State Contribution $= \frac{n+x}{(\dot{GDP}/GDP)}$	0.7298	0.6825	0.8801	1.0309	0.9467	0.8714	0.8461
(19) Transitional Contribution = 1-[18]	0.2702	0.3175	0.1199	-0.0309	0.0533	0.1286	0.1539

Table 3. Parameter Estimates of Translog GDP Function (Eqtn. 19)

	Regression (1)		Regression (2)		Regression (3)	
	coefficient	t-statistic	coefficient	t-statistic	coefficient	t-statistic
α_0	11.7320*	(665.08)	11.7502*	(461.33)	11.7836*	(316.25)
α_a	0.2013*	(17.43)	0.2020*	(28.28)	0.2154*	(23.95)
α_s	0.4742*	(44.86)	0.4677*	(47.46)	0.4659*	(40.23)
β_l	0.6711*	(55.65)	0.6559*	(43.04)	0.6523*	(33.73)
β_k	0.3289*	(27.27)	0.3441*	(22.58)	0.3477*	(17.98)
δ_t	0.0137*	(4.72)	0.0090	(1.79)	0.0005	(0.03)
α_{aa}	0.2425*	(4.84)	0.1675*	(6.87)	0.1699*	(6.44)
α_{ss}	0.4820*	(4.72)	0.3361*	(5.29)	0.4278*	(5.32)
α_{as}	-0.0691	(-1.59)	-0.0975*	(-3.66)	-0.1122*	(-3.45)
β_{kk}	0.0175	(0.46)	-0.1345	(-1.58)	0.0353	(0.35)
γ_{ak}	-0.0887*	(-2.75)	-0.0917*	(-4.06)	-0.0473	(-1.35)
γ_{sk}	-0.2322*	(-6.78)	-0.2000*	(-6.01)	-0.1120*	(-1.96)
δ_{at}	0.0006	(0.29)	0.0010	(0.60)	-0.0031	(-1.15)
δ_{st}	0.0175*	(7.95)	0.0169*	(6.79)	0.0100*	(2.27)
δ_{kt}	-0.0018	(-0.69)	0.0109	(1.53)	-0.0165	(-1.74)
δ_{tt}	0.00092*	(3.88)	0.00004	(0.06)	0.00316	(1.30)
R^2 - agr.	0.8726		0.9771		0.9780	
R^2 - ind.	0.5889		0.8837		0.9246	
R^2 - ser.	0.8668		0.9450		0.9552	
R^2 - L	0.6675		0.8049		0.7453	
R^2 - K	0.6675		0.8048		0.7453	
R^2 - GDP	0.9959		0.9976		0.9907	

* estimated coefficients are significant at 5% level

Table 4. Elasticity Estimates by Subperiods

	1966-70	1971-75	1976-80	1981-85	1986-90	1991-96	1966-96
Price elasticities of output supplies							
E_{aa}	0.1036	0.4433	0.9347	1.7004	3.1550	4.2384	1.0251
E_{an}	0.0267	-0.0382	-0.1898	-0.4410	-0.9451	-1.3800	-0.2439
E_{as}	-0.1303	-0.4051	-0.7449	-1.2594	-2.2099	-2.8584	-0.7813
E_{na}	0.0171	-0.0119	-0.0379	-0.0606	-0.0795	-0.1156	-0.0516
E_{nn}	0.4450	0.3253	0.2947	0.2770	0.2806	0.3541	0.3156
E_{ns}	-0.4621	-0.3134	-0.2569	-0.2164	-0.2010	-0.2385	-0.2640
E_{sa}	-0.0485	-0.1133	-0.1437	-0.1672	-0.1751	-0.1604	-0.1375
E_{sn}	-0.3285	-0.2762	-0.2367	-0.2046	-0.1809	-0.1587	-0.2195
E_{ss}	0.3770	0.3894	0.3804	0.3718	0.3561	0.3192	0.3570
Elasticities of inverse factor demand							
E_{ll}	-0.2680	-0.2698	-0.2420	-0.2171	-0.2418	-0.2014	-0.2370
E_{lk}	0.2680	0.2698	0.2420	0.2171	0.2418	0.2014	0.2370
E_{kl}	0.5694	0.5683	0.5871	0.6014	0.5868	0.6093	0.5902
E_{kk}	-0.5694	-0.5683	-0.5871	-0.6014	-0.5868	-0.6093	-0.5902
Rybczynski elasticities							
E_{al}	0.9351	1.0440	1.2207	1.4686	1.8524	2.2018	1.2533
E_{ak}	0.0649	-0.0440	-0.2207	-0.4686	-0.8524	-1.2018	-0.2533
E_{nl}	0.2074	0.2865	0.3411	0.3833	0.3535	0.3391	0.3287
E_{nk}	0.7926	0.7135	0.6589	0.6167	0.6465	0.6609	0.6713
E_{sl}	0.9165	0.9209	0.9465	0.9684	0.9320	0.9456	0.9384
E_{sk}	0.0835	0.0791	0.0535	0.0316	0.0680	0.0544	0.0616
Stolper-Samuelson elasticities							
E_{la}	0.2579	0.1997	0.1618	0.1311	0.1158	0.0967	0.1540
E_{ln}	0.1031	0.1728	0.2099	0.2366	0.2243	0.1756	0.1908
E_{ls}	0.6390	0.6275	0.6282	0.6323	0.6599	0.7277	0.6552
E_{ka}	0.0398	-0.0173	-0.0672	-0.1122	-0.1139	-0.1571	-0.0775
E_{kn}	0.8373	0.9034	0.9812	1.0558	0.9976	1.0301	0.9704
E_{ks}	0.1229	0.1139	0.0860	0.0564	0.1163	0.1270	0.1072

Table 5. Rate of Technological Change and Indexes of Technological Biases

	1966-70	1971-75	1976-80	1981-85	1986-90	1991-96	1966-96
Semi-elasticities of output supplies and factor rewards $\epsilon_{it} = \partial \ln y_i(\cdot)/\partial t$, $\epsilon_{mt} = \partial \ln w_m(\cdot)/\partial t$ i=a,n,s;m=k,l							
ϵ_{at}	-0.0133	-0.0138	-0.0140	-0.0183	-0.0329	-0.0414	-0.0229
ϵ_{nt}	-0.0170	-0.0067	0.0039	0.0148	0.0270	0.0361	0.0105
ϵ_{st}	0.0246	0.0319	0.0410	0.0508	0.0623	0.0713	0.0478
ϵ_{lt}	0.0278	0.0346	0.0431	0.0525	0.0657	0.0760	0.0508
ϵ_{kt}	-0.0484	-0.0412	-0.0370	-0.0326	-0.0146	-0.0127	-0.0305
Rate of technological change $\tau = \partial \ln G(\cdot)/\partial t$							
τ	0.0034	0.0102	0.0197	0.0300	0.0424	0.0540	0.0275
Rate of technological bias $\zeta_{jt} = \epsilon_{jt} - \tau$							
Output Sector							
ζ_{at}	-0.0168	-0.0241	-0.0337	-0.0483	-0.0753	-0.0954	-0.0504
ζ_{nt}	-0.0198	-0.0169	-0.0159	-0.0152	-0.0153	-0.0178	-0.0170
ζ_{st}	0.0211	0.0217	0.0213	0.0209	0.0200	0.0173	0.0203
Input Sector							
ζ_{lt}	0.0243	0.0244	0.0234	0.0225	0.0234	0.0220	0.0233
ζ_{kt}	-0.0519	-0.0514	-0.0567	-0.0625	-0.0569	-0.0667	-0.0580

Table 6. Contributions of Prices and Factor Endowment to Predicted Outputs and Factor Returns.

	Supply of			Factor Return of	
	agriculture	industry	service	Labor	Capital
Growth rate	-0.0242	0.0938	0.0883	0.1261	-0.0265
Price					
agriculture	274	-2	-9	8	-13
industry	-61	17	-14	7	176
service	-235	-18	25	30	23
Endowment					
Labor	181	11	35	-6	74
Skill	149	8	26	-5	54
Unsiklled	32	3	10	-2	20
Capital	-166	82	8	21	-243
Domestic	-124	54	5	14	-162
Imported	-42	28	3	7	-81
Total static effect	-8	89	46	60	16
Rate effect	-92	11	54	40	-116
Sum	-100	100	100	100	-100

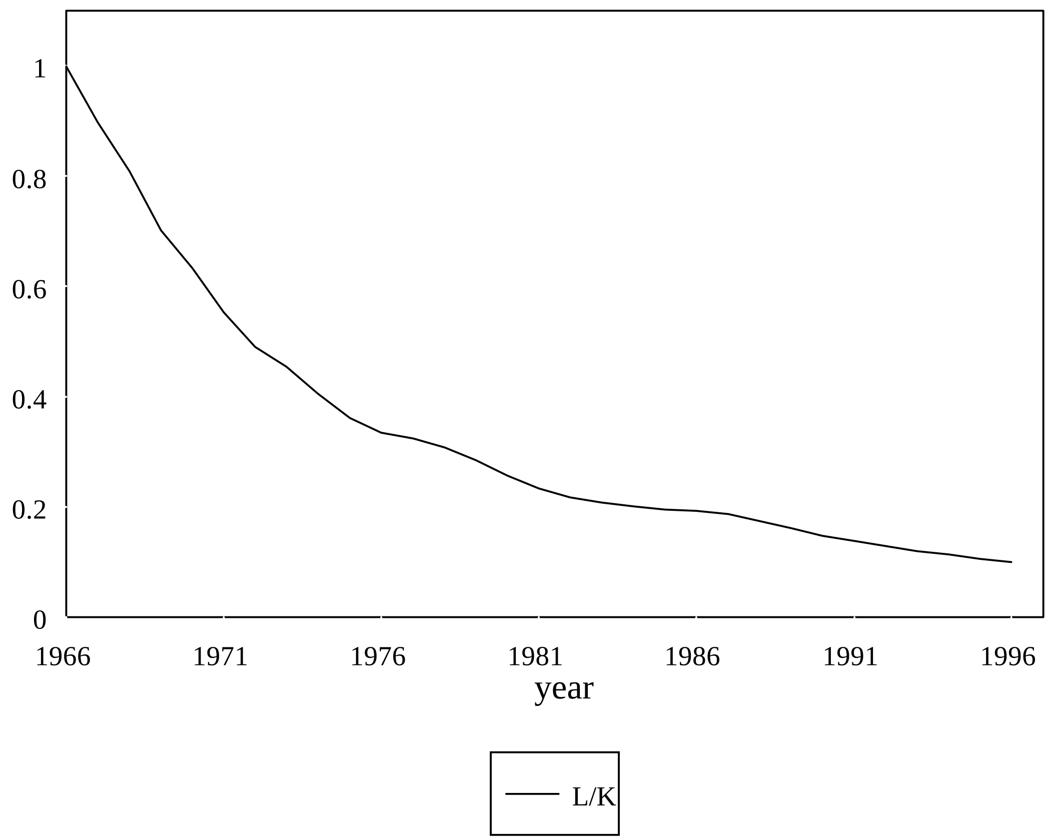

Figure 1: Relative Factor Endowments (1966 =1)

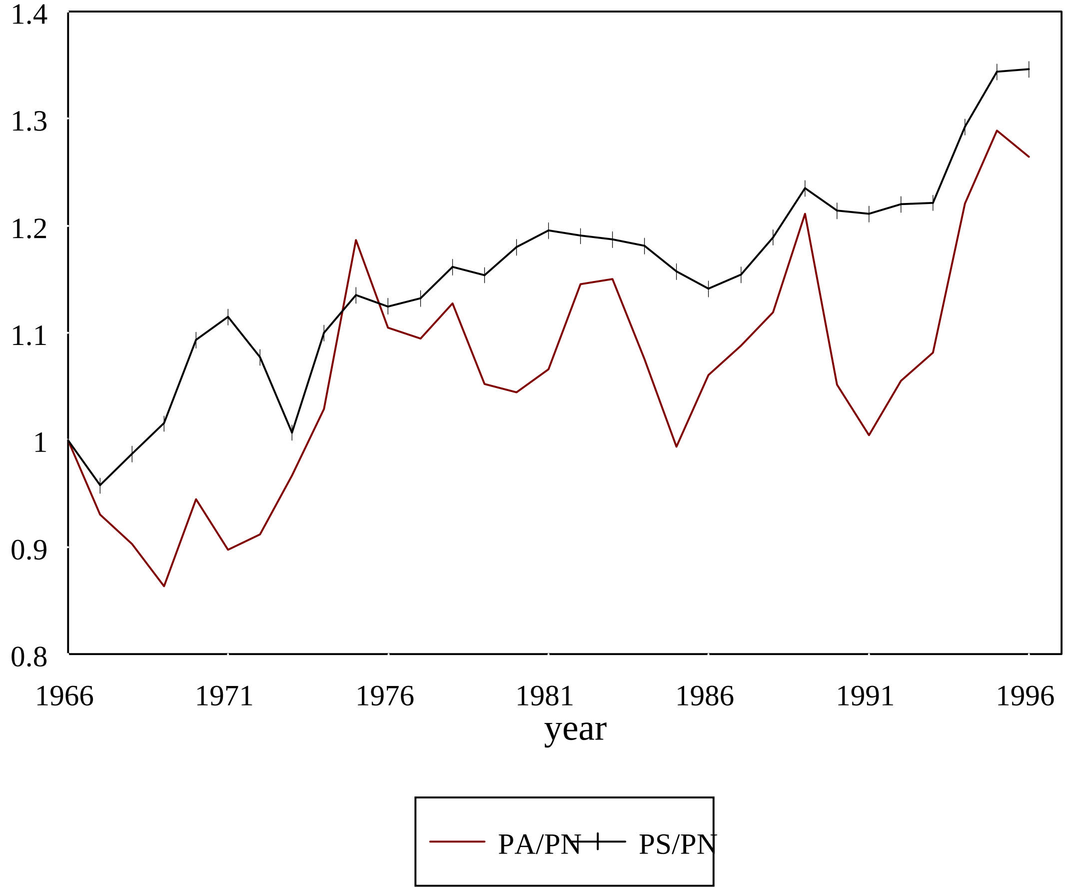

Figure 2: Relative Prices of Outputs (1966 = 1)