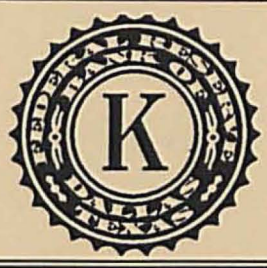

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Growth and Equity with Endogenous Human Capital:
Taiwan's Economic Miracle Revisited

by

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ABSTRACT: We adopt an endogenous growth model to reexamine the major determinants of economic growth, income distribution and their dynamic interactions in a newly-industrialized country, Taiwan, 1964-1986. 3SLS estimations from a four-equation system indicate that human capital evolution was crucial in achieving Taiwan's economic miracle: the rapid human capital accumulation enlarged the labor income share, which, coupled with an increased use of progressive labor income taxes, led also to a more equitable distribution of income. This finding therefore supplements, in part, the Kuznets hypothesis in explaining the development processes in several newly industrialized economies in general and in Taiwan in particular.

JEL CLASSIFICATION: O15, O40, O53.

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GROWTH AND EQUITY WITH ENDOGENOUS HUMAN CAPITAL: TAIWAN'S ECONOMIC MIRACLE REVISITED

1. Introduction

This paper presents an endogenous growth model for a small open economy with significant trade surplus and active government development strategies to reexamine the major determinants of economic growth and income distribution. This analysis provides better interpretation for the intertwined relationship between growth and equity, an important economic issue that by far have not been fully addressed by the well known models (e.g., Kuznets 1955; Solow 1956; and, Blinder 1974).[1]

In traditional growth studies, economists have emphasized the role of two major factor inputs, physical capital and labor. Output growth is considered to depend merely on exogenous shifts in population and technology. Recently, Lucas (1988) questions that this conventional approach to studying economic growth may leave more than half of output growth unexplained. In order to improve the understanding of the underlying endogenous forces promoting economic development, "new growth" theorists have proposed several alternatives to the conventional models, such as the endogenous fertility choice argument advanced by Becker, Murphy and Tamura (1990), the endogenous technological evolution postulated by Romer (1990), and the endogenous human capital accumulation or learning process emphasized by Lucas (1988, 1993), to name but a few. These contributions have generated additional interests in, and rich implications on, empirical studies for public policy analysis (e.g., King and Rebelo 1990) and cross-country comparisons (e.g., Romer 1989 and Barro 1991).

Lucas's endogenous human capital formation model is particularly suitable for studying the economic development of Taiwan because of its special emphasis on education. Between 1964 and 1986, Taiwan's achieved remarkably an economic miracle as represented by both measures of the "operative efficiency" and the "distributive equity." For example, Taiwan's per capita real GDP grew at 6.54 percent and its household income distribution index measured

by the ratio of the highest 20 percentile to the lowest 20 percentile decreased from 5.33 in 1964 to 4.55 in 1986.[2] In this period, per capita real gross capital stock (owned by the private and public enterprises) grew at 8.87 percent, while employment per capita only grew at 1.38 percent. Based on the traditional neoclassical growth theory, this mismatch of the two major factor inputs should not have generated a rapid growth of output. Previous studies based on the traditional neoclassical model had not provided a satisfactory explanation for Taiwan's economic miracle because of the failures in taking account explicitly of the improvement in labor skill over time. To assess this possibility, an index of the fraction of population completing higher (college/university) education in Taiwan was constructed and is referred to as a labor skill index. This labor skill index in Taiwan from 1964 to 1986 was observed to have grown at an annual rate of 6.64 percent. As a result, effective labor growth rate (per capita employment embodied with the labor skill index) was estimated 8.02 percent per year. This rate is very close to the physical capital growth rate and thus conforms to the common growth property as predicted by the endogenous growth model delineated in this paper.

The objectives of this paper are to evaluate the effects on Taiwan's economic growth of (i) the endogenous human capital evolution (through its impact on productivity or skill level of workers), (ii) export enhancement (through its impact on the exportability of manufactured goods), and (iii) fiscal policy instruments (including public enterprise investment, government consumption and the aggregate tax rate). In addition, the impacts of economic growth and human capital formation on income in Taiwan are also investigated through a four-structural-equation econometric model using the three-stage least square (3SLS) method. The estimates show that human capital evolution played the most dominant role in driving the economic growth of Taiwan; and also the effects of export enhancement and public enterprise investment on output growth are significant and positive. However, other fiscal variables were of little importance. As a consequence of a rapid human capital accumulation, the labor income share in Taiwan was not only increasing over time, but far exceeding those observed in the main OECD countries. This, along with a shift in government tax structure from sales taxes and

customs duties to a more progressive personal (labor) income tax, contributed to a more desirable pattern of family income distribution. Thus the economic miracle in Taiwan is far more clearly explained and the Kuznets conflicting puzzle between growth and distributional goals are better comprehended.

The paper is organized as follows: Section 2 presents a new growth model with endogenously accumulated physical and human capital and summarizes the theoretical implications for the empirical study; Section 3 describes the variables and the econometric model, while Section 4 discusses empirical estimates on the structural equations using the annaul data for Taiwan covering the period from 1964 to 1986; and Section 5 concludes the paper with recommendations for future research.

2. The Theoretical Background

By incorporating a net trade component and an active government sector into the endogenous growth framework of Lucas (1988), a continuous-time, balanced growth model is delineated below, for a small open economy with infinitely-lived perfect-foresighted agents, to analyze the interaction between economic growth and income distribution.

First denote by c^*, k and L, on a per capita basis, effective consumption, physical capital and effective labor, respectively. Let $c^* = c^{\beta} g^{1-\beta}$, where c and g represents, respectively, (per capita) private consumption and (per capita) government spending and β is a substitution factor between private and government consumption.[3] Let $L = h\ell$, where h and ℓ represents the human capital skill level and the fraction of time allocated to work, respectively. For simplicity, leisure (such as recreation, reading and sleeping, etc.) is assumed inelastic and hence the fraction of time $1 - \ell$ is allocated to the accumulation of human capital (including education and on-the-job training). Following the existing literature, the representative agent's preference is assumed time-separable with a (constant) subjective rate of time preference ρ. The instantaneous utility function u is assumed to have with a constant intertemporal elasticity of substitution of consumption, α^{-1}. Moreover, the production technology f is assumed to take

the standard CES form with a (constant) elasticity of substitution, $(1-\sigma)^{-1}$. To be specific, we assume $u(c^*) = (c^{*1-\alpha} - 1)/(1-\alpha)$ and $f(k, h\ell, h^*) = A[\gamma k^\sigma + (1-\gamma)(h\ell)^\sigma (h^*)^\delta]^{1/\sigma}$, where A, γ and δ are positive constant parameters. Notably, h^*, denoting the average human capital skill level of the economy, measures the Lucasian external effect from human knowledge and labor skill spillover.[4]

The representative agent's optimization problem is

$$\max_{\{c,\ell,k,h\}} U = \int_0^\infty u[c^*(t)]e^{-\rho t}dt \qquad (P1)$$

subject to

$$c(t) + \dot{k}(t) + x(t) = [1 - \tau(t)]f[k(t), h(t)\ell(t), h^*(t)] - nk(t) \qquad (1)$$

$$\dot{h}(t) = \phi(1 - \ell)h(t), \qquad (2)$$

where x measures the exogenous (per capita) net export demand (which is consistent with the Taiwan data), τ denotes the income tax rate, n represents the (constant) rate of population growth, and ϕ indicates the maximal growth rate of human capital. Equation (1) is a budget constraint that allocates after-tax net real income to consumption, investment, and net exports. Equation (2) specifies the endogenous evolution of human capital, analoguous to that developed by Lucas (1988).

Since Taiwan's government debt is negligible, one may simply specify the government budget constraint as

$$g(t) = \tau(t)f[k(t), h(t)\ell(t), h^*(t)]. \qquad (3)$$

By Walras's law, (1) and (3) can generate the market clearing condition:

$$c(t) + \dot{k}(t) + g(t) + x(t) = Af[k(t), h(t)\ell(t), h^*(t)] - nk(t). \qquad (4)$$

Given constant growth rates of the exogenous variables, x and g, and a constant distortionary tax rate, τ, one can follow Lucas (1988) to solve for the balanced growth equilibrium of the dynamic system which exhibits common growth among production inputs, output and

consumption.[5] To ensure bounded utility, we follow Barro (1990) to assume that the intertemporal elasticity of substitution is bounded above by unity (i.e., $\alpha > 1$). It can be shown that either net export enhancement or government spending expansion will lead to higher output growth, and that a higher distortionary tax rate will retard economic growth. Moreover, higher human capital implies higher output, which, under this endogenous growth framework, promotes greater human capital accumulation. As a consequence, a sustained growth will result. Furthermore, in the presence of the external effect, the higher human capital is, the larger is the labor income share, measured by $(1-\gamma)(h\ell)^{\sigma}(h^{*})^{\delta}/[\gamma k^{\sigma}+(1-\gamma)(h\ell)^{\sigma}(h^{*})^{\delta}]$. Since labor income distribution is generally more equitable than capital income distribution, one may expect a better pattern of household income distribution to emerge.

3. An Econometric Model

To substantiate empirically the aforementioned theoretical relationships a simultaneous equation model with four structural equations has been constructed under the following four endogenous variables:

YP: Per capita output, measured by real gross domestic product per capita.

ID: Income distribution index, measured by the family incomes ratio of the highest to the lowest 20 percentile; this measure is used only because consistent time-series data on Gini coefficient was not available.

NH: Higher education achievement rate, a proxy for the human capital skill level, measured by the proportion of population (at and over the age of six) completing college and university education.[6]

LS: Labor income share, measured by the percentage of compensation of employees to total labor and capital income.

There are six predetermined variables employed in this simple macroeconometric model:

KS: Per capita physical capital stock, measured by adding/substracting private and public enterprise investment series to/from the 1975 capital stock measure obtained from the

input-output survey.[7] Public enterprise investment is included because it has been devoted to promoting heavy industries and transportation infrastructure, thus improving productivity.

EM: Per capita employment, a raw labor input index, measured by the proportion of labor employed.

TS: Distortionary tax rate, measured by the ratio of labor and capital income taxes to real GDP.

GC: Per capita government consumption.

XR: Export-import ratio.

TR: Ratio of the labor tax rate to the capital tax rate, designed to measure the potential effect of tax structure on income distribution.

In the specification of the output equation, we assume there exists a time-to-build production technology. Output is a function of physical capital (lagged one year), raw labor, human capital, the export-import ratio, government consumption, and the distortionary tax rate. This equation is:

$$ln(YP_t) = a_1 + b_1 * ln(KS_{t-1}) + b_2 * ln(EM_t) + b_3 * ln(NH_t) + b_4 * ln(XR_t) + b_5 * ln(GC_t) + b_6 * ln(TS_t), \quad (5)$$

where 'ln' represents the natural-log operator. The theoretical predictions imply all but the distortionary tax rate contribute positively to output growth: $b_1 > 0$, $b_2 > 0$, $b_3 > 0$, $b_4 > 0$, $b_5 > 0$, and $b_6 < 0$. Since the human capital proxy is not a precise measure, it is difficult to test for the increasing-return-to-scale hypothesis. Specifically, let the true measure of human capital be HH and assume that $HH = NH^m$. Then the production technology exhibits increasing returns in both reproducible capital stocks if and only if $b_1 + m^{-1}b_3 > 1$. However, m cannot be explicitly measured and hence such a test cannot be conducted.[8] Therefore, an increasing return enviroment may be inferred only indirectly through the observation of an increasing labor share.

The income distribution index is expressed as a function of the labor share and the ratio of the labor tax rate to the capital tax rate:

$$ln(ID_t) = a_2 + b_7 * ln(LS_t) + b_8 * ln(TR_t). \quad (6)$$

Our theoretical analysis in Section 2 above suggests that a higher labor share help reduce income inequality. Moreover, labor taxation in Taiwan is more progressive than capital taxation, implying that an increase in TR will improve the overall pattern of total income distribution. Thus, one can expect $b_7 < 0$ and $b_8 < 0$.

We assume that the current human capital skill level depends on its lagged value because such human capital stocks are build-ups continuously over time. Obviously, within the endogenous growth framework, the human capital stocks depend vitally on current output because the latter not only facilitates but make the accumulation of the former possible. Thus, the human capital equation takes the following form with $b_9 < 0$ and $b_{10} > 0$:

$$ln(NH_t) = a_3 + b_9 * ln(YP_t) + b_{10} * ln(NH_{t-1}). \tag{7}$$

The labor share of national income is mainly driven by the haman capital accumulation:

$$ln(LS_t) = a_4 + b_{11} * ln(NH_t). \tag{8}$$

In the presence of a positive external effect, a higher level of human capital increases labor productivity more than proportionately, which in turn enables labor to receive a larger share of the national product, implying $b_{11} > 0$.

4. Data and Estimates

To empirically test the hypotheses built in the endogenous growth model for Taiwan, annaul data covering the period from 1964 to 1986 was used.[9] As an exploratory analysis of the relationship between real income and household income distribution, we, following Kuznets (1955), regress ID on YP, $(YP)^2$ and $(YP)^3$. The results indicate a zigzag relation between the two indicators: a higher per capita real income may be associated with a more equitable income distribution at the beginning and the final stages of economic development.[10] This differs from the prediction of the Kuznets inverted-U hypothesis. In order to understand why such a relation exists, we also investigated the underlying structure and the process of economic development as well.

To correct for contemporaneous correlation between the error terms in the structural equations, three-stage least square method was used in our estimation. Our preliminary estimates show that government consumption, $ln(GC)$, and the distortionary tax rate, $ln(TS)$, do not add statistically significant explanatory power to physical and human capital in the output regression, and are therefore omitted.[11] The estimates of the structural equations are presented in Table 1.

The system weighted R-square is 0.9955 which, with 75 degrees of freedom, shows promising explanatory power of the model. The Durbin-Watson statistics obtained for individual equations show that autocorrelation is either absent or in the inconclusive range. All coefficient estimates are statistically significant at the 5 percent level, using one-tailed t-test. The results of particular interest include: (i) the estimated coefficient $b_9 = 0.4427$ with a t-value of 2.02 in $ln(NH)$ equation supports the endogenous human capital accumulation proposition; (ii) the estimate, $b_3 = 0.4365$ $(t = 4.57)$ in $ln(YP)$ equation, highlights the role of human capital in driving output growth; and, (iii) the estimates of $b_{11} = 0.0291$ $(t = 2.35)$ in $ln(LS)$ equation and of $b_7 = -0.3340$ $(t = -10.2)$ in $ln(ID)$ equation uphold the hypothesis that human capital accumulation has improved the pattern of family income distribution in Taiwan.

In summary, our findings suggest that human capital evolution played a dominant role in driving the economic growth of Taiwan. Human capital growth accounted for about 44 percent of output growth,[12] while the remaining 56 percent of output growth were resulted from the accumulation of private and public enterprise physical capital, the enlargement of the employment ratio, and the enhancement of exportability. As a consequence of a rapid human capital evolution (at an annual rate of 6.6 percent), the labor income share in Taiwan increased constantly over time (at an annual rate of 1.4 percent).[13] This, together with a shift from other taxes to a more progressive labor income tax, (as indicated by the annual growth rate of TR of 0.6 percent), apparently contributed to a more desirable pattern of household income distribution, thus creating a paradigm of growth with equity, often referred to as the

"economic miracle" on Taiwan.

5. Concluding Remarks

We have employed an endogenous growth model to explain the economic miracle or specifically, the intriguing interaction between output growth and income distribution in Taiwan. We find that human capital evolution played a crucial role in nurturing economic growth while preventing income inequality from widening; thus, the traditional conflicting goals of operative efficiency and distributive equity have been delicately harnessed in Taiwan, through in particular some well designed education and fiscal policies and socioeconomic infrastructure development programs, as far as the period between 1964 and 1986 is concerned.[14]

This paper lends formal empirical support to the argument by Lucas (1993) that human capital accumulation or continuous learning process has been responsible in making miracles in newly-industrialized economies, such as Taiwan and Korea. The hypotheses that investment in human capital, especially through improved education and increased social mobility, would raise labor productivity as postulated by Schultz (1961), Blinder (1974) and Liu (1975), are further upheld in this study for Taiwan. Along this research line, it might be of interest to (i) study the growth of output by specific industries and (ii) investigate how such industry-specific growth may affect the pattern of income distribution. A major task in any attempt to perform studies similar to this is to construct appropriate industry-specific physical capital stocks and human capital skill indices.[15] Furthermore, since financial market conditions may affect individuals' incentives to invest in human capital, one may incorporate the study of the Taiwanese asset market analaysis recently completed by Huang, Cheng, Chou and Lin (1991), among others, into the real sector of this paper so that the impacts of the newly developed financial market on economic growth and income inequality can be better understood and more scientifically studied.

Footnotes

1. Although the Kuznets hypothesis of an inverted-U relation between income and inequality is supported by cross-country studies such as Ahluwalla (1976), Saith (1985) finds evidence indicating such results are not robust. Moreover, the inverted-U hypothesis has also failed to capture the development pattern of a newly industrialized country like Taiwan, better known as the "Kuznets puzzle."

2. All long-run averaged growth rates are estimated by regressing the logged values of the corresponding variables on a linear time-trend variable.

3. See Barro (1990) for a similar composite good specification.

4. This is a generalization of the functional form used by Lucas (1988).

5. Since the solution technique is analogous to that in Lucas (1988), detailed manipulations are excluded for brevity.

6. To ensure that our NH measure would not rely on demographic factors, we have also studied the age structure and the fertility rate, in addition to this human capital skill index. We find the results to be robust.

7. This is to our knowledge the best measure for the capital stock series; the data is available upon request.

8. Mankiw, Romer and Weil (1990) use the Summers-Heston data to perform a cross-country study for economic growth and conclude that production technology exhibits decreasing returns. However, the validity of their result is based upon the presumption that their high school enrollment rate proxy is the precise measure for the human capital skill index.

9. The selection of the sample is based upon data availability. A detailed description of the data is relegated to the Appendix.

10. The estimated equation is: $ID = 8.1 - 0.12 * YP + 0.0011 * YP^2 - 0.0000033 * YP^3$, where all coefficient estimates are significant at the 5 percent level.

11. The complete estimation results is available upon request.

12. This number is obtained by multiplying the coefficient estimate, $b_3 = 0.4365$, to the ratio of the human capital to output growth rate, 0.0664/0.0654.

13. Taiwan's labor income share in the 1980's was about 85 percent, much higher than those of the major OECD countries (usually in the range between 55 and 75 percent).

14. After 1987, speculations in land and stock markets have widened the income inequality in Taiwan. Nevertheless, there are too few data points to perform a formal test on this possible reverse trend.

15. Suppose that the human capital evolution cross industries is homogeneous. Then even with industry-specific employment and physical capital, diffusion in industrial output growth cannot be explained in an economy where human capital is the main driving force of economic growth.

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Table 1: 3SLS Estimation for the Four-Equation System

A. Dependent Variable: ln(YP)

Explanatory Variable	Estimate	t-value
Constant	(a_1) 3.857	4.56
ln(KS[-1])	(b_1) 0.1859	2.31
ln(EM)	(b_2) 1.1844	4.05
ln(NH)	(b_3) 0.4365	4.57
ln(XR)	(b_4) 0.1219	2.07

Durbin-Watson Statistic=1.00

B. Dependent Variable: ln(ID)

Explanatory Variable	Estimate	t-value
Constant	(a_2) 17.812	11.5
ln(LS)	(b_7) -3.3340	-10.2
ln(TR)	(b_8) -0.4246	-9.38

Durbin-Watson Statistic=1.14

C. Dependent Variable: ln(NH)

Explanatory Variable	Estimate	t-value
Constant	(a_3) -4.106	-1.95
ln(YP)	(b_9) 0.4427	2.02
ln(NH[-1])	(b_{10}) 0.5339	2.55

Durbin-Watson Statistic=1.97

D. Dependent Variable: ln(LS)

Explanatory Variable	Estimate	t-value
Constant	(a_4) 4.399	208.4
ln(NH)	(b_{11}) 0.0291	2.35

Durbin-Watson Statistic=1.46

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