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The Tyranny of Numbers or the Tyranny of Methodology: Explaining the East Asian Growth Experience

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This paper applies the theory and insights of Maurice Scott's New View of Economic Growth (1989) to challenge the analysis and conclusions of Alwyn Young's widely acclaimed paper, "The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience" (1995), which purports to show that growth in the East Asian NICs was mainly due to factor accumulation, with little technical change or total factor productivity growth. It is argued that Young's empirical findings result from the inappropriate, albeit widely adopted, practice of subtracting depreciation from gross investment in measuring the contribution of investment to growth.

Key Words: Tyranny of Numbers; Tyranny of Methodology; East Asian Growth.
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1. INTRODUCTION

One of the most widely cited applications of the Solow growth accounting methodology is Alwyn Young's (1995) "The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience." Although the author describes his paper as "boring and tedious," it purports to do no less than to bring the East Asian NICs "from the top of Mount Olympus down to the plains of Thessaly." This done by showing that the growth of the Asian Tigers was unremarkable because it was mainly due to factor accumulation, with relatively little total factor productivity growth (TPFG). In a subsequent paper, Young (2003) does the same for China's post-1978 growth experience, showing that "with minimal sleight of hand, it is possible to transform the recent growth experience of the People's Republic of from the extraordinary into the mundane." The argument seems to be that any country can achieve rapid growth by high rates of saving and investment, but for growth to be truly exceptional it

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must come about from TFPG, which in growth theory is mainly ascribed to technology change.

Unfortunately technology change can not even be defined, much less measured. Its contribution to growth, following the growth accounting method, is therefore derived as the residual of growth not accounted for by labor and capital accumulation. An accurate measure of the contribution of technology change requires accurate measurement of the growth of factor inputs, taking into account changes in the quality of capital and labor over time. Much effort has been given in the literature and in Young's work to measuring changes in the quality of the labor input due to increasing educational attainment of the work force, structural changes in employment and changes in labor force participation rates, all of which serve to whittle down the residual.

Growth accountants have not given the same effort to measuring changes in the quality of capital assets over time. The conventional growth accounting methodology implicitly assumes that capital goods are homogeneous and that investment therefore simply reduplicates the capital stock. Since the capital stock is treated as homogeneous over time, depreciation is taken to be the replacement of worn out capital goods with new ones that are virtually the same. Only on this assumption does it make sense to interpret a dollar of new investment as contributing to growth the same as a dollar of depreciation subtracts from growth, as is the conventional practice.

An important reason why firms invest—indeed must invest in order to survive—is because technology change renders capital assets obsolete. When capital becomes obsolete (i.e., no longer generate profit) it must be scraped whether it is worn out or not, and it must be replaced by new and improved machines in order to maintain the value of the firm. Depreciation due to obsolescence reduces the value of a firm's capital, but it does not entail a social cost since it represents an income transfer from the firm to other agents in the economy as a result of the relative price changes (importantly rising real wages) that technology change brings about.[1] In other words, when capital depreciates because of obsolescence it is wrong

[1]This point has long been recognized as the following quotations from Scott (1989, p.33) reveal. Kuznets (1974, p.156) asks "In what sense does obsolescence justify a deduction from capital, from the standpoint of society, however much it may be justified by business firms as protection against loss of relative competitive position vis-à-vis newcomers who can reap the differential advantage of their newness?" And he answers: "There is something absurd in a procedure that reduces the value of a capital good that is physically otherwise unimpaired because there has been technical progress." Ruggles and Ruggles (1956, p.1140 write: "Technological progress frequently does destroy the earning power, and thus the money value, of already existing capital goods, and this type of obsolescence should and does enter into the depreciation allowances of businessmen. But technological progress causes no real loss to the economy as a whole." Usher (1980, p.105) makes the same point: "Obsolescence, for example, can be looked upon as the result of a transfer of wealth from owners of old types of machines to owners of new

to consider that a dollar of depreciation reduces output as much as a dollar of new investment adds to it.

In this paper we demonstrate in theory and empirically that if capital assets are mainly scraped because of obsolescence rather than wear and tear (and there is much evidence to that effect) then one should use gross investment instead net investment to measure the contribution of capital accumulation to growth and doing so all but eliminates the residual. Dethrowning the sacred TPGF residual should not require a revolution—if heterogeneous labor and capital inputs were accurately measured and aggregated using their respective relative prices (marginal products) there should not be a residual to attribute to technology change, policy reforms or any the other factors, aside from measurement error, to which it is ascribed.[2]

The central thesis of this paper derives from Maurice Scott's provocative and much ignored study A New View of Economic Growth (1989). A simplified version of Scott's theory is presented followed by a case study of the growth of the manufacturing sector in Taiwan. We demonstrate that Young's conclusion that the Asian Tigers experienced relatively little TPFG or technological change is simply not warranted.[3] Using Taiwanese data comparable to those used by Young, it is shown here that when investment's contribution is fully counted, there is no residual growth to be attributed to TFPG or technological change. The same data are used to estimate an endogenous growth equation based on the insights of Scott's "New View." These estimates indicate that there is no systematic output growth in Taiwan's manufacturing sector that cannot be accounted for by investment and the growth of quality-adjusted employment. The implication is not that technology change did not occur, but rather that it cannot be measured independently of the contribution of investment.

types of machines, labor, or consumers. The loss to the firm is genuine but the loss to the economy is counterbalanced by gains elsewhere."

[2]If improvements in the efficiency of the economy resulting from policy reforms are not captured in the residual, then were do they show up in growth accounting? Again, they do not show up at all because they are reflected in higher real marginal products (rate of return) of the factors which are used to compute the aggregate contributions of factor accumulation to growth.

[3]This should be obvious, since the level of technology in the East Asian NICs is as high as it is anywhere. It follows therefore that either the East Asian countries have been changing technology, contrary to the conclusions of Young's growth accounting, or the rest of the world has been busy catching up with East Asia, which is of course absurd.

2. THREE PREMISES

Scott's arguments about the proper interpretation of depreciation and the basis of his endogenous growth equation rest on three fundamental premises, all of which have solid empirical foundations.

Premise one: Without investment there is no growth. Scott argues that growth comes about by firms changing the way they do things, and that invariably involves a cost. The cost of changing economic arrangements in terms of consumption foregone is investment. What is called technical change is just one of the ways in which economic arrangements are changed and, like all the others, involves a cost, or, in other words, investment. Technical change and investment are for practical purposes inseparable.[4]

Premise two: The return to investment does not diminish as the stock of cumulative investment increases. Constancy of the rate of return to investment is one of the widely noted "stylized facts" about growth.[5] There is no reason to assume diminishing returns to the stock of cumulative investment, Scott argues, because investment changes the world, and in the process it creates and reveals new investment opportunities.

Premise three: Depreciation is mainly the result of relative price changes (obsolescence), and as such should not be subtracted from gross investment to estimate the contribution of increases in capital to growth. The view that capital is scrapped because of obsolescence rather than because of physical deterioration has been long established and widely accepted.[6] When depreciation results from relative price changes, the losses from it must be matched by reciprocal gains elsewhere in the economy. Obsolescence is, therefore, not a social cost.

3. DEPRECIATION AND THE RESIDUAL

To understand why depreciation due to obsolescence is not a social cost and therefore should not be subtracted from gross investment in assessing the contribution of investment to growth, consider a representative firm in a steadily growing economy.

[4]Scott (1989, chapter 5) reviews the empirical literature on technical change, which reveals that all major technological advances have involved substantial cost. Together with the fact that technical change generally comes about by adapting existing techniques rather than inventing things de novo, this suggests that the distinction in conventional growth theory between expenditures for innovation (e.g., R&D) and those for imitation (i.e., capital accumulation) is invalid (Scott, 1992).

[5]Constancy of the rate of profit on capital is one of Kaldor's (1958) six "stylized facts" about long term economic growth and is still widely cited in modern growth theory textbooks (e.g., Jones, 1998).

[6]See footnote 1.

The flow of gross profit (Π) to the firm is:

$$\Pi = P \cdot Q - W \cdot L \tag{1}$$

where P is the output price, and for a representative firm can be taken as the numeraire ($P = 1$), Q is output[7], W is the (real) wage rate and L is employment. In a steadily growing economy, in which real wages are steadily increasing, a firm can remain profitable if only continually undertakes to raise Q or lower L, which inevitable entails a cost, i.e., investment. The relevant measure of the flow of profit is therefore net profit (π) or what Scott calls "take-out" to avoid confusion with the accounting concept:

$$\pi = \Pi - I = Q - W \cdot L - I = Q(1 - s - \lambda) \tag{2}$$

where I is gross investment, s is the rate of investment (I/Q), and λ is the labor share of value-added. It is apparent from (2) that for given values of s and λ, the flow of net profit grows at the rate of growth of output (value-added).

If the firm is on a steady growth path, then the value of the firm is the present value of the future stream of net profit (V), which is equivalent to the accumulated sum of past net investment (K) when there are no windfalls:

$$\begin{aligned} V_T &= \int_T^{\infty} \pi \cdot e^{(g-r)t} \cdot dt = \frac{\pi}{r-g} \\ &= \int_0^T (I_t - D_t) \cdot dt = K_T \end{aligned} \tag{3}$$

where r is the discount rate, which in steady-state equilibrium is equivalent to the return on investment, g is the rate of growth of output and profit, and D is depreciation, defined as the minimum investment required to keep the present value of the firm (equivalently the capital stock) constant ($D = ICdK$).

Depreciation due to obsolescence diminishes the value of capital, but it does not diminish the contribution of new investment to growth. Therefore, in deriving a growth equation the relevant ratio is not net investment to capital ($\frac{I-D}{K}$), but instead gross investment to capital ($\frac{I}{K}$). Using the forward-looking definition of the capital stock:

$$\frac{I}{K} = \frac{sQ(r-g)}{\pi} = \frac{s(r-g)}{1-\lambda-s} \tag{4}$$

[7]Output of the firm is measured by value added. As is the convention, intermediate inputs are ignored or assumed to be in fixed proportion to output.

The rate of return (r) is the discount rate that equates the present value of an increase in the perpetual flow of profit to the increase in the investment rate that brings it about, and is given by:

$$r = \frac{g - \lambda g_L}{s} \tag{5}$$

Substituting (5) into (4) and solving for g we get:

$$g = (1 - \mu)\frac{I}{K} + \mu g_L \quad \text{where} \quad \mu = \frac{\lambda}{1 - s} \tag{6}$$

This formulation bears a striking resemblance to Solow's famous growth equation:[8]

$$g = (1 - \lambda)\frac{I - D}{K} + \lambda g_I + g_A \tag{7}$$

where g_A is the growth of technology or total factor productivity, and in the growth accounting framework is measured as a residual.

The two growth equations are different in three respects: first, in Solow's equation, the contributions of investment and growth of labor are weighted by the factor income shares $[\lambda, (1 - \lambda)]$, while in Scott's they are weighted by the factor income shares adjusted by the rate of investment $[\mu, (1 - \mu)]$; secondly, Solow's equation contains a residual (g_A), while Scott's has none; and, finally, depreciation is netted out of gross investment in the Solow equation, but not in Scott's.

The key differences in the two models are the treatment of depreciation and the presence or absence of a residual. It can be shown in the simple framework of the representative firm that is used here that depreciation and the residual are one and the same. Assuming that capital does not deteriorate physically before it becomes obsolete, depreciation is the amount of investment required to compensate for economic obsolescence and thereby preserve the value of capital assets:

$$D = I - dK = \frac{s(r - g)Q - g(1 - \lambda - s)Q}{r - g} \tag{8}$$

where: $I = sQ$, $K = \frac{\pi}{r-g} = \frac{Q(1-s-\lambda)}{r-g}$, $dK = \frac{g(1-s-\lambda)Q}{r-g}$

Using $g = g_W + g_L$ (for $\Delta\lambda = 0$), (8) simplifies to:

$$D = \frac{W \cdot L \cdot g_W}{r - g} \tag{9}$$

[8]Equation 7 is obtained by differentiating the constant returns to scale (Cobb-Douglas) production function $Q = AK^{(1-\lambda)}L^{\lambda}$, where $dA/A = g_A$.

which indicates that depreciation is the present value of increments to the wage bill due to rising real wages.[9] Depreciation is, in other words, an income transfer between owners of capital and labor and as such is not a social cost.

4. ACCOUNTING FOR THE GROWTH OF TAIWANESE MANUFACTURING

If the above argument is correct, then the residual obtained from the application equation (7) should disappear when the same data are applied to equation (6). This is what is explored here, using Taiwanese data on manufacturing. Focusing on the manufacturing sector avoids problems that arise when applying the growth accounting framework at the level of aggregate GDP, since the underlying growth theory is not relevant to some components of GDP (e.g., the public sector). In addition, it avoids empirical complications that arise from inter-sectoral resource transfers.

In applying the growth accounting framework, regardless of whether based on equation (6) or (7), it is essential to make adjustment for changes in the quality of labor due to increases in education attainment of the labor force.[10] Since the productivity of workers with a secondary education is higher than that of those without it, as is apparent from the fact that they are paid more, an increase in their share in the work force raises output in the same way an increase in the number employed does.[11] In measuring employment, therefore, those with and those without a secondary education should weighted according to their relative productivity.

As an approximation, a quality-adjusted measure of the manufacturing labor force (L_A) is constructed as follows:

$$L_{A_t} = (1 + \omega \cdot \theta_t) L_t \tag{10}$$

where L is the number employed in manufacturing, θ is the proportion of workers with a secondary education or higher, and where ω is the proportionate difference in the marginal productivity of workers with and without a secondary education or higher.[12]

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[9] In this version of the model, changes in relative prices arise solely from changes in real wages, and hence changes in real wages are the sole cause of obsolescence, but in practice it may arise from any relative price change.

[10] No adjustment is made for the shift from rural to urban employment since the focus is the manufacturing sector which is predominantly in the urban sector.

[11] Note, over the period of estimation, 1960 to 1995, the share of workers with a secondary education or higher increased more than three-fold, from about 18 percent in 1960 to about 68 percent in 1995.

[12] From the evidence available on wages by level of educational attainment, the productivity of those with a secondary education is taken to be 50 percent higher than those without a secondary education (i.e.,$\omega = .5$).

Here we have assembled the data on value added growth, capital accumulation and quality adjusted employment growth comparable to those used by Young in "The Tyranny of Numbers." To show how closely comparable they are, Young's results for Taiwan manufacturing are presented in Table 1 and compared those obtained from the data set assembled for this paper. The growth rates of output, capital and labor, in each period, for two data sets, are within about one to two percent of each other, with one exception.[13] Not surprisingly therefore, the two sets of calculations of TFPG, following the same procedures, are almost identical.

TABLE 1.

Total Factor Productivity (TFP) Growth Calculations (annual percentage changes)

	g	$(I-D)/K$	g_{LA}	g_A	g_A/g	λ
Young's original results (p. 661)						
1966-70	16.8	20.7	7.8	3.1	0.184	0.558
1970-80	12.1	14.5	10.0	0.1	0.008	0.556
1980-90	7.1	7.9	1.2	2.8	0.389	0.613
1966-90	10.8	13.1	5.9	1.7	0.157	0.579
Our data with Young's methodology						
1966-70	17.3	20.0	12.7	1.4	0.079	0.558
1970-80	12.1	14.6	8.9	0.6	0.055	0.556
1980-90	7.1	7.7	2.6	2.5	0.356	0.613
1966-90	9.5	12.5	5.4	1.1	0.117	0.579
Our data with Scott's methodology (using I/K and μ)						
1966-70	17.3	30.0	12.7	0.3	0.015	0.75
1970-80	12.1	24.6	8.9	−0.7	−0.059	0.75
1980-90	7.1	17.7	2.6	0.7	0.102	0.75
1966-90	9.5	22.5	5.4	−0.3	−0.036	0.74

Except for the 1980's, Taiwan manufacturing appears, according to the conventional interpretation of growth accounting results, to have made only modest technical progress. Young offers no explanation as to why the 1980s, a period of stagnation in real investment in Taiwan, was a period of exceptionally rapid TFP growth, and of course none will be offered here either, since it is our view that these calculations are wrong and misleading. They are wrong and misleading, it is our contention, because the change in net

[13] The exception is the rate of growth of quality adjusted employment for the period 1966-70, which Young incorrectly reports as 7.8 percent. Young's number is clearly incorrect since employment in manufacturing (unadjusted for changes in educational advancement), as reported in the Taiwan Statistical Databook, 1989 (p.19), went from 633,000 in 1966 to 958,000 in 1970, a compound annual rate of 10.9 percent. Adjusting for changes in educational attainment only serves to raise the number, as in indeed it does in our calculations.

capital understates the contribution of investment to growth by about 10 percent, the rate of depreciation that is assumed using the perpetual inventory method. When gross rather than net investment is used to assess the contribution of capital, with adjustment in the weights used to add the contribution of capital and labor (μ instead of λ), the residual disappears entirely in every period.[14] This does not imply that there was no technological change or productivity growth, only that it cannot be measured because it cannot be separated from the contribution of investment.

5. ESTIMATING AN ENDOGENOUS GROWTH EQUATION FOR TAIWAN MANUFACTURING

Another way of examining whether TFPG or technological change contribute to growth independently of investment is to estimate an appropriate growth equation over time to see if there is any systematic growth left unexplained. The data set used is the same as that used in the growth accounting framework above. Equation (6) can be rewritten as:

$$g = a\rho \cdot s + \mu g_{LA} \tag{11}$$

where a is a constant and ρ is an index of investment efficiency, which will be closely related to the return on investment (r). As for what determines investment efficiency, Scott (1989, p.177) writes:

> The knowledge intelligence, originality, common sense, and effort of businessmen, inventors, and scientists are all highly relevant, as are the economic institutions that influence their perceptions and choices, including the degree of competition, taxes and subsidies, the credit system, and product and factor markets generally.

In estimating (11) the gross investment rate (s) is defined as the average investment rate over the two previous years to allow for the gestation of investment. In addition, dummy variables are introduced to account for the effects of the international oil price shocks in 1974-75 (D_{70}) and again from 1979 to 1991 (D_{80}). The estimation equation is therefore:

$$g_t = a_1 \sum_{i=1}^{2} \frac{S_{t-i}}{2} + a_2 g_{LA,t} + a_3 D_{70} + a_4 D_{80} + e_t \tag{12}$$

[14]Note: $\mu = \lambda/(1-s)$. In computing μ the values for λ are as reported for each period in the table and the values for s are 0.26, 0.26, 0.18, and 0.22 respectively for 1966-70, 1970-80, 1980-90, and 1966-90.

The dependent variable is in first differences and exhibits stationary ($I(0)$).[15] The estimation results for equation (12) are shown in Table 2. The equation fits the data well, explaining about two-thirds of the annual variation in the growth rate of real manufacturing production over the period. The actual and "explained" growth rates of real manufacturing value-added are plotted in Figure 1.

FIG. 1. Actual and explained rates of real manufacturing value-added growth in Taiwan: 1962-95

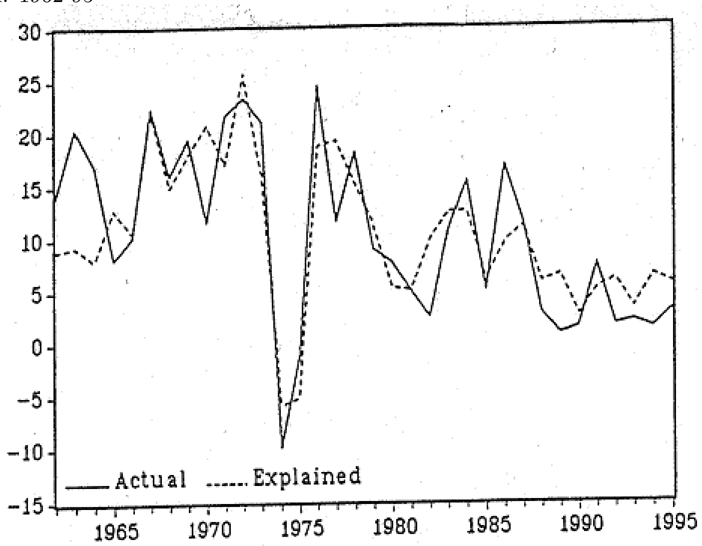


TABLE 2.

Estimation Results

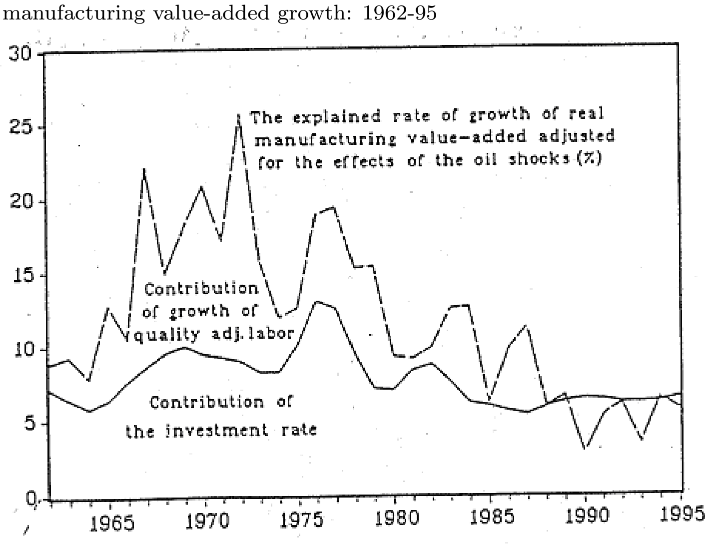
Coefficient	Estimate	Standard Error	t-Statistic
a_1	0.36	0.06	5.74
a_2	0.75	0.16	4.65
a_3	−17.81	3.77	4.71
a_4	−4.03	3.05	1.32
$R^2 = 0.67$ Adj. $R^2 = 0.64$ $D.W. = 2.02$ F-Statistic= 20.87			

The main finding of these results is the statistical significance and overwhelming explanatory power of the investment rate. The estimate of coefficient a_1 suggests a rate of return to investment of about 36 percent. The es-

[15]The adjusted Dickey-Fuller statistic is 3.789, which allows rejection of the null hypothesis of a unit root.

timate of coefficient a_2 is also an extremely precise estimate of $\mu[= \lambda/(1-s)]$ since the national income accounts indicate that the labor share of value added in manufacturing (λ) was about 60 percent, while the average rate of investment in manufacturing (s) was about 20 percent over the estimation period, implying a predicted value for μ of 0.75. Consistent with Scott's theory, the constant term was found not to be statistically different from zero, and was therefore omitted in the estimates reported in Table 2. There is, therefore, no "unexplained residual" to attribute to TFPG or technological change.

FIG. 2. The contributions of investment and quality-adjusted employment growth to real manufacturing value-added growth: 1962-95



As Figure 2 shows, until the early 1970s growth in quality adjusted employment contributed as much to growth of real manufacturing value-added as investment. Thereafter, with surplus rural labor having been absorbed for the most part in the manufacturing sector, investment alone served as the engine of growth in manufacturing. The estimates of coefficients a_3 and a_4 confirm the strong negative, albeit temporary, influence of the oil shocks in the mid 1970s and early 1980s on manufacturing growth in Taiwan.

6. CONCLUSION

The East Asian NICs have made economic history. They have been the first contemporary developing countries to cross the line into the OECD income range. If there were an Olympic event for economic growth these countries would get the gold, silver and bronze. To suggest that their accomplishment is any less because they did it by accumulating physical and human capital at prodigious rates is unwarranted. The argument that they failed to achieve technological change or raise total factor productivity flies in the face of common sense and direct observation. Here we present theoretical arguments and empirical evidence based on a case study of growth of manufacturing in Taiwan that calls into question Young's growth accounting conclusions. Perhaps what we have is a tyranny, not of the numbers, but of the standard methodology used to interpret them.

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