REFLECTIONS ON ECONOMIC GROWTH IN ASIA AND THE PACIFIC

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I. INTRODUCTION

This chapter had its start as a simple exposition of certain attributes of the process of economic growth. The focus was partly general, and partly concentrated on rapidly-growing, newly-industrializing countries of East and Southeast Asia. One of the principal conclusions of that early version of the chapter was the importance of changes in total factor productivity (TFP) in explaining why some countries grew more rapidly than others, and why for a given country some periods exhibited more rapid growth than others.

This conclusion caused something of a stir at the conference where it was given, mainly because it ran counter to the "new wave" interpretation that has emerged from recent work by Lau and Kim (1994), and also by Young (1995). This work has received wide dissemination, particularly via a semi-popular article in *Foreign Affairs*, by Krugman (1994), which cited work by Kim-Lau and by Young. As a result of the reaction at the conference, I had hoped to recast my paper entirely, so as to include a full analysis of all three of the mentioned papers. But as time moved

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on it became clear that I would have to defer that task to some future occasion. What I will do here might be called a partial recasting of my conference paper, including the presentation of hypotheses as to why Kim-Lau and Young might have obtained the results they did, side-by-side with reasons as to why I prefer both the traditional growth-accounting methodology and my own two-deflator method to a methodology based on econometric regressions.

II. ELEMENTS OF GROWTH ANALYSIS

It is strange, but many people do not know that most modern growth analysis follows from the following simple equation:

$$\Delta y_n = \bar{w}\Delta L + \bar{\rho}\Delta K + R \qquad (1)$$

where:

- y = real net output,
- L = the employed labor force (ideally in man-hours)
- K = the real capital stock (ideally expressed in the same quantity units as y).
- $\bar{w}$ = the average wage, say, of the preceding period,
- $\bar{\rho}$ = the net-of-depreciation rate of return to capital.

This procedure imputes to incremental labor the average real wage of existing labor, and to incremental capital the average real return to the existing capital stock. If output is defined on a gross-of-depreciation basis, as in GDP, the equation remains essentially the same, but the return to capital must then be expressed gross of depreciation, that is, as $(\bar{\rho} + \delta)$ rather than just $\bar{\rho}$. I will for simplicity use net output in this initial exposition, and thus keep depreciation accounting issues in the background.

A little manipulation will turn Equation 1 into Equation 1', where the growth rate of output is expressed as the sum of an explained portion (share of labor times rate of growth of labor, plus share of capital times rate of growth of the capital stock) and a residual (R/y) measured in percentage points of output, per year or other period.

$$\begin{aligned}\frac{\Delta y}{y} &= \frac{L\bar{w}}{y}\frac{\Delta L}{L} + \frac{K\bar{\rho}}{y}\frac{\Delta K}{K} + \frac{R}{y}\\ &= s_L\frac{\Delta L}{L} + s_K\frac{\Delta K}{K} + \frac{R}{y}\end{aligned} \qquad (1')$$

This is the form in which most people learn the basic growth equation. They often think of it as being derived from a Cobb-Douglas production function ($y = A_t L^{s_L} K^{s_K}$) that is homogeneous of first degree ($s_L + s_K = 1$), with R/y being the

periodic percentage shift of A_t. Of course, Equation 1' can be derived in that way, but it also can be obtained by differentiating with respect to time any production function that is homogeneous of degree one.

I want to note at this point that when writing the basic equation in its initial form, Equation 1, I made no statement about production functions, nor any assumption about homogeneity. Equation 1 can (and I think most fruitfully, should) be interpreted as a simple statement assigning or attributing certain assumed contributions to labor and capital. This builds in a belief that its market return is a pretty good standard approximation to the marginal product of a factor—good enough to be the best assumption for wide and general use.

This way of interpreting Equation 1 simply throws any deviation between factor reward and true marginal product into the residual. That is what R in (1) will reflect, among other things,

$(MP_L-\bar{w})\Delta L + (MP_K-\bar{\rho})\Delta K$. Such differences can be due to taxes, to monopoly markups, and perhaps to other distortions, some of them difficult to ascertain or interpret. But economies of scale, much in our news of late, are subject to a very easy and convenient interpretation. It is well-known that when economies of scale exist, they typically give rise to differences between marginal products and factor rewards. It is quite appropriate, therefore, to interpret economies of scale as one out of many sources of real cost reduction. And I have argued, and will continue to argue in this chapter, that it is both wise and sound economics to try to build a conceptual framework for growth analysis in which, ideally, all sources of real cost reduction end up as contributing to the residual R, with as little as possible contamination from other elements. If this is the objective, then, of course, real cost reductions that stem from economies of scale actually *belong* as part of the residual.

Disaggregation is widely recognized as a good way to "clean up" an exercise in growth analysis and thus to sharpen our interpretation of the residual. I will consider here two types of disaggregation—one by the operations being done, which means by sectors, industries, firms, activities, and so forth, and the other by the characteristics of the factors being employed. In the first case a shift of capital, say, from the housing sector to the corporate sector will contribute to GDP because the marginal product of corporate capital is much higher (mainly for tax reasons) than that of housing capital. An aggregative growth equation like Equation 1 will not capture this as a part of growth "explained" by the capital factor, but a disaggregated equation like Equation 2 will.

$$\Delta y_N = \Sigma_j \bar{w}_j \Delta L_j + \Sigma_i \bar{\rho}_i \Delta K_i + R' \qquad (2)$$

Here ΔK_i might be minus 10 billion units for housing, where $\bar{\rho}_i$ is 5 percent; while ΔK_i is plus 10 billion units for the corporate sector, where $\bar{\rho}_i$ is 15 percent. In this case the shift of 10 billion would cause an increase of output of 1 billion, which would be measured as part of $\Sigma_i \bar{\rho}_i \Delta K_i$, and not as part of R'.

(This example also reveals the clue for dealing with tax distortions. They pose no problem for growth analysis if wages and rates of return are measured gross of the relevant taxes.)

Similarly, GDP will increase if 1,000 workers move from $20,000 jobs in Hawaii to $50,000 jobs in Alaska. Regardless of whether these differences come from distortions (say a strong union in Alaska) or are equalizing differences (for the rigors and beauties of the respective climates), the increment of output of $30 million will be counted as part of $\Sigma_j \bar{w}_j \Delta L_j$ in Equation 2, but would figure as part of R, in Equation 1.

In the above I am thinking of the wage differential (between $20,000 and $50,000) as applying to labor of identical quality in the two places (i.e., no change in human capital is involved). We now turn to a case where human capital investment is of the essence. Suppose we are considering the growth of a country over a five or 10 year period, during which the number of draftsmen fell by 1,500 and the number of engineers grew by a like amount. If the annual earnings of these two categories were $20,000 and $50,000, respectively, then an increase of $45 million in output would be attributable to the "human capital improvement." This increment would be accounted for within the global summation $\Sigma_j \bar{w}_j \Delta L_j$, and would not appear as part of the new residual R', but if the crude procedure of Equation 1 were used, the human capital improvement would be captured as part of the "old" residual R, in the calculation of which the average quality of labor is presumed to remain constant.

I hope these examples lead readers to appreciate how a sufficiently disaggregated framework of type of Equation 2 could leave us with a residual R' that represented, in principle, all the elements of real cost reduction that had occurred during the period being analyzed, and very little (or nothing at all) else.

One way of accomplishing such disaggregations has been pioneered by Dale Jorgenson and his associates. Their efforts have led to a breakdown of labor by two genders, five educational categories, 20 industrial categories plus 10 groups for occupation, eight for age, and two for employment status, in their work for the United States. I do not have the corresponding count for their work on other countries, but it is easy to see from the U.S. example how monumental a task is involved in going down this road. Not only is the task a huge one in terms of sheer work; its data requirements are such that many interesting cases of productivity analysis simply cannot be pursued, for want of data.

I have always been an advocate of the approach followed by Jorgenson and his collaborators.[1] However, an appreciation of the huge difficulties of implementing this approach on a wide scale has led me to turn to what I call the two-deflator approach, which will be expounded in the next section.

III. THE TWO-DEFLATOR APPROACH

The two deflator approach is characterized: (1) by the use of a single "numeraire-cum-deflator" $\bar{p}_d$ (usually the GDP deflator or the consumer price indexes) to deflate all nominal flows that enter into an exercise in growth analysis, and (2) the use of a "standard worker" as the basic unit in which labor is measured and the measurement of any worker's labor quantum by his total earnings divided by w^*, the (real) wage of the standard worker.

Since we were dealing with labor disaggregation at the end of the last section, we here continue on that subject by elaborating first on point 2).

A. The Labor Deflator (w^*)

Let us suppose, initially, that it is our objective to get an absolutely ideal breakdown of labor into categories, and using that breakdown to define labor's contribution to growth as $\Sigma_j \bar{w}_j \Delta L_j$. Now this idealized breakdown would be much finer than Jorgenson's. Wages differ not only by industry, broad occupational groups, gender and age, but by many other dimensions. There are cheap lawyers and expensive lawyers, high-quality CPAs side-by-side with accountants of only moderate skill. If we now consider the wages bill of any entity (firm, industry, sector, economy) as consisting of $\Sigma w_{jt} L_{jt}$, (where t represents the time period), and we divide this by the wage of a standard worker w^*_t, we get

$$L^*_t = \Sigma L_{jt}(w_{jt}/w^*_t) \qquad (3)$$

L_{jt} would here measure the man hours worked by a given narrow category of workers, and (w_{jt}/w^*_t) would measure their contribution per man hour, as a multiple or fraction of that of the standard worker. A highly skilled medical specialist might represent 20 standard labor units, an ordinary medical practitioner might represent 10, an average nurse might represent 3, a very experienced nurse might count as 5, the nurse's aide might count as 2, the hospital orderly as 1, and the sweeper perhaps as only 2/3 of a standard labor unit.

It does not matter how many different relevant labor categories there might be in the entity under study; there may be 10, or there may be 1,000. When we divide the wages bill by w^* we are counting each individual worker on the basis of his or her wage, as contributing the number of labor units represented by that particular (w_j/w^*).

The growth equation for real net domestic product corresponding to Equation 1 and Equation 2 would now look like

$$\Delta y_N = w^* \Delta L^* + \rho \Delta K^* + R^* \qquad (4)$$

Here w^* and L^* are as defined above, while K^* is the capital stock obtained using the single numeraire-deflator $\bar{p}_d$ and R^* is the unexplained residual that emerges when the two-deflator approach is used.

We are here concentrating on the first term in Equation 4. It can quickly be seen by differentiating Equation 3 that

$$w^*\Delta L^* = w^*\Sigma_j(w_j/w^*)\Delta L_j + w^*\Sigma_j L_j\Delta(w_j/w^*) \tag{5}$$

In the happy event in which the relative wages (w_j/w^*) of the different categories do not change, this reduces to:

$$w^*\Delta L^* = \Sigma w_j\Delta L_j, \text{ when } \Sigma L_j\Delta(w_j/w^*) = 0. \tag{5'}$$

As can be seen, Equation 5' does not require that each and every (w_j/w^*) remain unchanged, only that their weighted sum is zero.

I am most of the time quite content to work with the assumption that the weighted average of the wage premia (w_j/w^*) does not change very much. But one should nonetheless address the question of how to interpret the change in the weighted average premium if it is significant. Quite obviously if $\Sigma_j L_j\Delta(w_j/w^*)$ is positive, that fact makes labor's contribution to growth larger, and the residual correspondingly smaller. If the residual is interpreted as a grab-bag for all sorts of real cost reductions, then the increase in real labor costs (relative to the standard real wage w^*) operates as an offsetting force to whatever other real cost reductions are taking place. In short, the residual R^* can still be interpreted as reflecting net "real cost reductions," if one counts the rise in the average wage premium as an increase in real cost.

It should be clear from the above that the use of the standard labor unit to obtain L^* produces genuinely *desired* results in giving us $\Sigma_j(w_j/w^*)\Delta L_j$ as a part of $w^*\Delta L^*$, and where it gives us more than this, the results are not hard to interpret and are fully compatible with the view that R^* is mainly a reflection of net real cost reductions. At the same time one quickly sees how the results one would get from this analysis would be different, if one chose the basic labor unit differently.

Consider a simple case in which we have just three categories of labor, unskilled, skilled, and professional. Suppose, too, that in the period in question the skill premiums increase. Let me assume that if we choose the middle category as our standard unit of labor, the summation $\Sigma L_j\Delta(w_j/w^*)$ comes out to be exactly zero. The contribution of labor is then represented by Equation 5', and there is no term contributing to the change in real costs.

If we instead choose unskilled labor as our standard unit the second term in Equation 5 will be positive. More of the increase in output will be counted as due to increased labor, less will be attributed to a net reduction in real costs.

By the same token, if we choose professional labor as our standard unit, the second term in Equation 5 will be negative. Now the reduction in "value" of skilled and unskilled labor, relative to the professional wage (now the standard) will increase the size of the residual R^* and should be interpreted as one more "real cost reduction."

Readers should recognize that the underlying reality does not change. What we have above are three different ways of reflecting the same reality depending on our choice of the standard labor units. This type of problem is typically present whenever one can choose among alternative numeraires, alternative types of index number, and so forth. If we calculated GDP or real personal income in terms of a sugar-price numeraire, we would have highly volatile time series for real output and real income. It would be very wasteful to do it this way because we would end up explaining most of the changes in output and income, thus calculated, in terms of what happened to the relative price of sugar! To see ordinary cyclical fluctuations properly we would first have to correct for the vagaries of the sugar market. But note—if we did so, and did so properly—we should come out in the end with the same analysis of, say, cyclical movements. I repeat, the choice of numeraire does not change the underlying reality or its true explanation, but it can make our task of analysis much easier (if we choose the numeraire well) or much more cumbersome and difficult (if we choose the numeraire badly).

So, when we go to apply the two-deflator method, we should try to make a wise and artful choice of the standard labor unit. One easy choice would be to define w^* as $\bar{w} = \Sigma_j w_j L_j/\Sigma_j L_j$. But according to this definition there would never be any change in the measured average quality of labor. If we want to capture the genuine change in quality of labor, we should aim for a standard unit that somehow maintains roughly the same quality through time. In our early work with the two-deflator method, we selected the average wage of male textile workers. This is reported by the ILO for many countries, and has the advantage that textile workers not only are relatively low-skilled in every country, but also are of skill levels that are at least somewhat comparable across different countries.

Our early experiments using the textile wage produced mixed results. What appears to have happened is analogous to the sugar-numeraire story. In some countries there may in a particular year have been a very sharp adjustment in the relative wages of textile workers, perhaps due to a new nationwide union contract, perhaps to some new labor legislation that had a disproportionate effect on textile wages. This type of event is probably what created unwanted "noise" in our time series.

In our second round of exercises we used a hypothetical labor category that always had annual earnings equal to two-thirds of the current year's per capita GDP. There are no capricious jumps in this series, and one can take comfort in the fact that those who earn 2/3 of a year's GDP are overwhelmingly poor, low-skilled, and with relatively low levels of formal education. This series, however, suffers to some degree from the defect of $\bar{w}$ as a measurement of w^*, in that there can easily be an upward (or downward) drift of skill level in the sequence of annual sets of workers characterized by earnings equal to 2/3 of a per capita GDP.

Our third round of exercises has barely begun. Here we are attempting to select a substantial band of industries, all of which are like textiles in typically employing labor of quite low skill. The idea is to take, say half a dozen or more such industries (textiles, apparel, footwear, etc.) and work with the median of the wages reported by the ILO for these different categories. The use of several industries helps insulate the resulting measure from the "sugar problem;" the use of the median further insulates against extreme fluctuations.

Whatever choice is made for the standard labor unit, one must bear that specific choice in mind when interpreting the results. But note too that whatever choice is made for w^*, the expression $w^*\Delta L^*$ always includes the first term of Equation 5, which is the exact disaggregated measure that incorporates attributing to each new worker a marginal product equal to his or her corresponding wage, and dealing with compositional shifts (including those due to education and training) in exactly the same way. This term taken by itself provides a solution to the disaggregation problem which is far more detailed and refined than even Jorgenson's heroic efforts gave us.

One of the significant uses of w^* is to permit one to quickly divide the labor contribution into a part ($w^*\Delta N$) due to the increment of "raw labor power," or "brute force," (here N represents the labor force measured ideally in simple man hours or man years, unadjusted for skill), and a second part $w^*(\Delta L^*\text{-}\Delta N)$ due to the increment of human capital, very broadly interpreted. This latter component includes the greater market productivity that stems from education and training, and it also incorporates increases due to improvements in aptitude, and to the greater scarcity value of some skills or employment. At the same time it also builds in the loss of market value of specific skills (like super-accurate typing, which lost much of its marketability when easy correction became possible on the word processor).

Out of the term $w^*(\Delta L^*\text{-}\Delta N)$ we can also separate what we call a "maintenance component" $w^*[(L^*\text{-}N)/N]\Delta N$, that endows new labor units (ΔN) with the preexisting average "human capital contribution" $[(L^*\text{-}N)/N]$. The remaining piece of $w^*(\Delta L^*\text{-}\Delta N)$ can then be interpreted as the "quality improvement component," once again very broadly construed.

B. The Price Deflator ($\bar{p}_d$)

We now turn to the price deflator, $\bar{p}_d$. This has two classes of implications, one that applies quite generally, and a second that applies most especially to disaggregated (e.g., sector, industry, or firm level) growth analyses.

Both these implications stem from a single fundamental insight, which in my own case followed quite naturally out of thirty-odd years of work in the field of

economic project evaluation. When we study a project *ex post*, and try to ascertain its net present value (or its internal rate of return), we start with all the nominal outflows and inflows of funds associated with the project, and then convert them into real terms by deflating by a single numeraire price index. Simple capital theory tells us that we have to measure the invested amounts and the subsequent returns on the investment in the same units. Thus, if we use the GDP deflator, we invest "GDP baskets" and measure our reward in terms of "GDP baskets." If we use the CPI, we then measure both the investment and the reward in terms of consumer baskets.

Since most growth analysis at the aggregate level is carried out in terms of real GDP as stated in the country's national accounts, the deflator for "product" in those analyses is the implicit deflator of the GDP. But since most growth analyses also work from a capital stock built up on the basis of real investment as stated in the national accounts, capital in those studies is expressed in terms, not of the GDP deflator but of the implicit investment deflator. One of our options in applying the two-deflator approach is to build up our capital stock K* from the annual series on nominal investment, turned into comparable units by deflating each year's investment by that year's GDP deflator.

The above procedure brings the two-deflator approach as close as it can get to the traditional approach. The only difference lies in the use of a different capital stock series—K^* measured in "GDP baskets" in place of the traditional K measured in investment baskets. In many cases the price levels of the two baskets will move very closely together, with the two growth analyses yielding results that are virtually the same.

We move a further step away from the traditional approach when we use the consumer price level as our numeraire, $\bar{p}_d$. Now we re-express real GDP in consumer baskets, and simultaneously build up a capital stock series measured in consumer baskets. Again, in many cases the difference with respect to traditional growth analysis will not be great, but now there are two ways in which differences can emerge.

Differences with the traditional method are likely to grow in importance as we disaggregate more and more. The reason is that the relevant price index of an entity's product is less and less likely to be similar to the CPI (or GDP deflator) as one disaggregates more and more, while at the same time the real wages that that entity pays are less and less likely to move in proportion to w^*, and its capital assets are more and more likely to have price movements different from the broad indexes.

Proper "traditionalists," trying to do a growth analysis of, say, IBM would try to build up a proper price index of the investment goods bought by IBM, plus another of the products IBM produces, or of IBM's value added. That task would in all likelihood turn out to be incredibly difficult, for IBM does not buy "typical" investment goods, nor does it sell "typical" final products. But because of the difficulties of getting the right information, the traditionalists might well end up deflating IBM's investment by the investment deflator from the national accounts, and IBM's product or value added by some other readily available index. In each of these cases the chosen index would probably be an extremely poor approximation to the relevant true index, creating error, bias, and "noise" in the results. At least if they are at all perfectionist in their work, traditionalists, once they realized the problems, would probably end up agonizing over them, perhaps even abandoning the quest. Could this be the reason why we have so few serious growth analyses at the individual firm level?

In contrast to the troubles that lie in wait for traditionalists as they move to more and more disaggregated units, only pleasures await users of the two-deflator method. Let us say we choose the CPI as our numeraire. We would then take as IBM's product its value added, and would deflate that by the CPI. (Note that the age-old problem of whether to define product as output or as value added virtually evaporates; this is because under the two deflator method we would deflate both final product *and* purchased inputs by the same numeraire.) Then we would take IBM's gross investment expenditures, including investment in cash for working capital. We would deflate that series by the CPI, and use the deflated investment amounts to build up a series on capital stock measured in consumer baskets.

The great satisfaction for two-deflator users is that, once the CPI is decided upon as the numeraire, that is the *right* unit in which to express all the relevant financial flows. If our product receipts are $\Sigma_i p_i X_i$, we express them in real terms by dividing by $\bar{p}_d$. Then looking at the change in real output over a period we take:

$$\Delta\Sigma_i(p_i/\bar{p}_d)X_i = \Sigma_i(p_i/\bar{p}_d)\Delta X_i + \Sigma_i X_i \Delta(p_i/\bar{p}_d) \quad (6)$$

The first term in the right hand side of Equation 6 is the absolutely correct version of what the traditionalists seek, but in fact can only approximate very roughly. The second term is in principle not counted in a standard production-function framework, but *is* counted when we use the two deflator approach. The question is *should it be counted*? **Answer**: if you take a very narrow production-function point of view, perhaps not, but if you view the problem from the standpoint of basic economics and elementary capital theory, then surely yes.

The basic point is that it is just as "economic" to invest in minerals in the ground that may yield 10 percent through real appreciation as it is to invest in wheat fields that yield 10 percent, via an annual crop. There is no way in which one can say that returns to investment through real product-price increases or losses through real product-price decreases should be counted differently from returns that stem from "quantities of output" produced. Once this point is realized, it becomes apparent that, in measuring the economic return to investment (social as well as private) the second term of Equation 6 genuinely "belongs" as part of the measure of output. If this term is positive, it will mean that "our" (two-deflator) change in output is bigger than what traditionalists would measure, and our residual R^* would on that account be larger than the traditional (disaggregated) residual R'.

We could replicate the previous story with respect to purchased inputs other than labor. Here a rise in their relative price produces a reduction in output vis-à-vis the traditional measure, and in the end leads to R^* being smaller (on that account) than R'.

To summarize, if one takes an idealized residual R', obtained via a perfectly complete disaggregation in a traditional production-function framework, one moves from there to the two-deflator residual R^* by adding a term $\Sigma_i X_i \Delta(p_i/\bar{p}_d)$ in the different outputs X_i of the entity being studied, by subtracting a term $\Sigma_h F_h \Delta(p_h/\bar{p}_d)$ in the different (non-labor) purchased current inputs F_h, and finally by subtracting a term $w^*\Sigma_j L_j \Delta(w_j/w^*)$. Each one of these "new" components of the residual fits in neatly with the idea that R^* measures real cost reduction. A rise in the real cost either of labor or of other purchased inputs is obviously an offset to real cost reductions generated by new inventions, by economies of scale, or simply by finding better ways of organizing the processes of production, financing, accounting, sales, distribution, and so forth. By the same token a rise in real product prices helps, in the same way that rises in real costs hurt. A rise in real product price can be counted as a real cost reduction by defining the latter as a fall in "real cost per real dollar's worth of product."

Thus the two-deflator approach produces a rather neat package—a growth analysis whose components are in principle easier to measure than those of the traditional approach, and whose measurement is in the overwhelming majority of cases vastly more accurate than that of the traditional approach. There are conceptual differences between the two approaches, but the two-deflator approach yields residuals that are if anything easier to interpret (as reflecting real cost reductions of all kinds) than are those coming from traditional analyses.[2]

IV. TFP EXPLAINS A SIGNIFICANT PART OF DIFFERENCES IN NATIONAL GROWTH RATES

A. Using Traditional Growth Accounting

Table 1 presents results derived from a study of the sources of growth that Professor Victor J. Elias (1991) prepared for the World Bank as a background paper for the 1991 World Development Report. In it he derived, using what I have called the traditional approach, estimates of the rate of growth of total factor productivity for 96 countries during the period 1950-1987. I have divided the 96 countries into three equal groups of 32, representing, respectively, low-income, middle-income and high-income countries. Within each group, the countries with the 10 highest rates of growth and those with the 10 lowest rates of growth were selected. Their average (mean and median) rates of growth were recorded, along with their average rates of TFP increase (measured in percentage points of GDP growth per year). In the last row of each panel of Table 1, the differences between "typical"

Table 1. Comparison of Annual Average Rates of Real GDP Growth and of TFP Increase (Ninety-Six Countries for the Period 1950-87)

		Average Rate of GDP Growth 1950-87	*Average Rate of TFP Increase 1950-87*	*Ratio of Differences*
A. For Thirty-Two Low-Income Countries[a]				
10 Highest Rates	Median	4.8	1.08	
of FDP Growth	Mean	5.1	1.13	
10 Lowest Rates	Median	2.0	0.0	
of GDP Growth	Mean	1.9	0.22	
Difference in	Medians	2.8	1.08	0.39
Difference in	Means	3.2	0.91	0.28
B. For Thirty-Two Middle-Income Countries[b]				
10 Highest Rates	Median	5.9	1.71	
of FDP Growth	Mean	6.3	1.63	
10 Lowest Rates	Median	3.9	0.90	
of GDP Growth	Mean	3.4	0.85	
Difference in	Medians	2.0	0.81	0.41
Difference in	Means	2.9	0.78	0.27
C. For Thirty-Two High-Income Countries[c]				
10 Highest Rates	Median	6.9	2.94	
of FDP Growth	Mean	6.7	2.87	
10 Lowest Rates	Median	3.2	1.21	
of GDP Growth	Mean	3.2	1.09	
Difference in	Medians	3.7	1.73	0.47
Difference in	Means	3.5	1.78	0.52

Notes: a. These are the 32 lowest-income means Countries of the 96 covered in Table 4 of Prof. Elisa's study. Elias, *op. cit.a.*
b. These are the middle of the 96 Countries covered in Table 4 of Prof. Elias's study. Elias, *op. cit.a.*
c. These are the 32 highest-income Countries of the 96 covered in Table 4 of Prof. Elias's study. Elias, *op. cit.a.*

high-growth and "typical" low-growth countries are recorded. Thus, for the 10 highest-growth low income countries the median growth rate was 4.8 percent per year, while the 10 low-growth countries had a median growth of just 2 percent per year. Of the difference of 2.8 percent per year between these two averages, a full 39 percentis accounted for by the difference of 1.08 percent per year (= 1.08% for the high-growth countries minus zero percent for the low-growth countries) in median levels of TFP growth. Table 1B does the same for middle-income countries, where the difference in TFP growth accounts for 41 percent of the difference in GDP growth as between the low-growth and the high-growth subsets. Finally, Table 1C presents a similar exercise for the high-income countries, with the result that 47 percentof the difference in median GDP growth rates is accounted for by the differences in median rates of TFP growth. These data clearly support the importance of TFP improvements in accounting for the difference between success and failure in the search for the secrets of economic growth.

B. Using the Two-Deflator Approach

In Table 2, I report some results from the application of the two-deflator approach to selected Latin American countries, a list largely determined by the ready availability of the necessary data. The time span covered is from 1960 to 1992, but for some countries the data limitations required shortening this span, at the beginning and/or at the end.

The data are organized into subperiods of four or five years' duration. For those exercises the price numeraire ($\bar{p}_d$) was the GDP deflator, and the standard worker was defined as one earning, in each year, a w^* equal to 2/3 of that year's per capita GDP. The labor contribution is, in the notation of the previous section $w^*\Delta L^*/y_g$ and the capital contribution is $(\rho+\delta)\Delta K^*/y_g$. A depreciation factor δ appears because we are working with gross, not net, domestic product. In deriving K^*, we used $\delta = .025$ for structures, $\delta = .08$ for machinery and equipment, and $\delta = 0$ for inventories. Initial period capital stocks were estimated using $I_{gt} = (\gamma+\delta)K_{t-1}$, where I_{gt} is gross investment in, say, machinery, at time t and γ is the rate of growth of output in period t. This assumes that in the base period the capital stock was growing at the same rate as output. (To reduce the amount of "noise" in this calculation, it was typically made for a three or four year period.) The data on TFP increase given in Table 2 are percentage rates of GDP growth attributable to TFP. In the notation of the last section, they represent R^*/y_g, averaged over the four or five-year period in question.

Table 3 places the data of Table 2 into a format similar to that of Table 1.

The results of this exercise were surprising even to people like myself who feel very comfortable with the idea that real cost reduction is a vital force in the day-to-day workings of a market economy, and can even be the dominant force. What we see here for the high-growth countries, is that TFP improvement accounted for more than a third of the observed growth rate, while for the low-growth countries it was negative. Indeed, of the 13 low-growth episodes reported in Table 3, 10 had negative TFP contributions. These facts combine to make *differences* in TFP growth the overwhelmingly dominant "explainer" of *differences* in GDP growth rates.

In Table 4 we present data similar to those of Table 2, but for five East Asian countries. These data are compressed in Table 5 into the top nine periodic episodes (measured in terms of GDP growth) and into the bottom nine by the same criterion.

The results of Table 5 are very similar to those of Table 3. They show that one of the main factors that distinguishes episodes of high growth from episodes of low growth is differences in the contemporaneous rate of total factor productivity improvement.

V. EXERCISE USING ALWYN YOUNG'S DATA

Table 6 presents some data drawn from Alwyn Young's (1995) study of economic growth in the four East Asian "tigers." The methodology he uses is basically the

Table 2. Rates of Return and Sources of Growth Selected in Latin American Countries ($\bar{p}_d$ = GDP Deflator)

Period	*Net Rate Of Return*	*GDP Growth*	*Labor Contribution*	*Capital Contribution*	*Residual*
A. Colombia					
1960-64	10.01%	4.99%	2.02%	1.43%	1.53%
1964-69	10.46%	5.13%	1.80%	1.46%	1.87%
1969-74	11.81%	6.54%	1.37%	1.47%	3.70%
1974-79	12.34%	5.01%	1.96%	1.57%	1.48%
1979-84	10.66%	2.45%	1.52%	1.68%	–0.75%
1984-88	11.21%	4.50%	0.11%	1.57%	2.82%
B. Costa Rica					
1960-64	8.59%	5.19%	2.25%	1.38%	1.56%
1964-69	9.47%	7.46%	1.96%	1.63%	3.87%
1969-74	9.98%	7.14%	1.12%	2.43%	3.70%
1974-79	8.83%	5.55%	2.07%	1.96%	1.52%
1979-84	6.91%	0.31%	0.98%	1.53%	–2.21%
1984-88	5.67%	4.13%	2.19%	1.41%	0.53%
1988-92	5.33%	4.52%	–0.43%	1.48%	3.47%
C. Ecuador					
1960-64	12.17%	3.72%	2.51%	1.69%	–0.47%
1964-69	10.71%	4.49%	2.46%	1.52%	0.52%
1969-74	14.07%	12.51%	0.08%	2.75%	9.58%
1974-79	16.21%	7.43%	2.41%	4.27%	0.75
1979-84	13.44%	3.37%	0.80%	2.70%	–0.13%
1984-88	12.18%	4.37%	2.08%	1.63%	0.65%
D. Mexico					
1960-64	20.65%	7.27%	1.86%	2.96%	2.46%
1964-69	20.09%	6.87%	1.93%	3.43%	1.51%
1969-74	18.43%	8.82%	2.23%	2.99%	1.60%
1974-79	15.95%	6.14%	1.87%	3.25%	1.02%
1979-84	15.35%	2.51%	–0.40%	3.11%	–0.20%
1984-88	14.52%	0.97%	0.38%	1.81%	–1.22%
1988-92	15.30%	3.20%	0.26%	2.28%	0.68%
E. Panama					
1969-74	10.78%	4.86%	2.92%	3.47%	–1.54%
1974-79	7.06%	3.76%	0.97%	2.05%	0.74%
1979-84	8.04%	4.83%	1.79%	1.90%	1.15%
1984-89	6.09%	–1.11%	1.13%	0.19%	–2.43%
1988-92	7.31%	7.48%	0.16%	1.05%	6.27%
F. Peru					
1969-74	11.55%	5.32%	1.89%	1.48%	1.94%
1974-79	11.59%	–0.11%	0.19%	1.19%	–1.49%
1979-84	10.49%	2.19%	1.34%	1.81%	–0.97%
1984-89	9.76%	0.80%	1.70%	1.62%	–2.52%
G. Venezuela					
1960-64	14.07%	7.67%	1.30%	1.51%	4.85%
1964-69	14.98%	4.34%	2.05%	2.58%	–0.28%
1969-74	12.99%	5.36%	0.51%	3.37%	1.48%
1974-79	10.72%	5.01%	3.87%	3.54%	–2.20%
1979-84	7.33%	–1.02%	0.82%	1.06%	–2.71%
1984-88	8.29%	3.55%	1.82%	0.74%	1.19%

Table 3. Comparison of Annual Average Rates of Real GDP Growth and of TFP Increase (41 Periods in 7 Latin American Countries)

		Average Rate of GDP Growth In Period	*Average Rate of TFP Increase In Period*	*Ratio of Differences*
13 Highest Rates	Median	7.14	2.46	
of GDP Growth	Mean	7.25	3.26	
13 Lowest Rates	Median	2.19	–0.97	
of GDP Growth	Mean	1.61	–0.93	
Difference in	Medians	4.95	3.43	.69
Difference in	Means	5.64	4.23	.75

same as that used by Jorgenson for the United States and other countries. Labor is cross-classified on the basis of "up to seven attributes, i.e., sex, age, education, industry, income, hours of work, and class of worker (i.e., employee, self-employed, etc." (Young, 1995, p. 653) Since both the Jorgenson method and the two-deflator approach aim at garnering the benefits of a high-level of disaggregation, one can say, in a sense, that the two methodologies, are "kissing cousins."

I was accordingly quite pleased to see in Table 6 that we really don't have anything to argue about, in terms of the main contention of this chapter. Comparing Tables 5 and 6 (which, readers should recall, have only two sample countries, Taiwan and Korea, in common) one notes that the average rates of TFP increase are about one percentage point higher for the fast-growing group in Table 5 than in Table 6. The averages differ by less than one percentage point for the respective slow-growing group. And our earlier conclusion, that differences in TFP growth account for a significant fraction of differences in GDP growth, remains intact.

Perhaps this is a good point at which to address the issue of a likely bias in our procedure, due to errors of measurement. This bias would stem from the fact that an error in measurement of output growth would automatically be reflected in an error of like amount in the calculated contribution of TFP to growth. And if there were errors in both elements of a difference in rates of GDP growth, the same "error component" would appear as part of the corresponding difference in rates of TFP increase.

How does this possibility of bias affect our story and our conclusions? I feel that for plausible magnitudes of measurement error, we do not have a serious problem. Consider that a typical result from one of our measurements would be a difference in GDP growth rate of 4 percentage points, combined with a difference in rates TFP increase equal to 2 percentage points. For this case our measured "ratio of differences" would be 0.50.

Now suppose that there existed an error of measurement equal to half the observed difference in rates of TFP increase. If this difference were overestimated by 1 percentage point, the "corrected" difference in GDP growth rates would be 3

Table 4. Rates of Return and Sources of Growth Selected Asian Countries ($\bar{p}_d$ = GDP Deflator)

Period	Net Rate Of Return	GDP Growth	Labor Contribution	Capital Contribution	Residual
A. Malaysia					
1970-74	22.67%	13.09%	0.51%	5.34%	7.24%
1974-79	19.83%	7.22%	1.47%	4.55%	1.21%
1979-84	16.64%	6.87%	1.76%	5.77%	–0.66%
1984-89	12.11%	4.70%	2.01%	2.56%	0.14%
1989-91	12.97%	9.22%	1.47%	4.43%	3.32%
B. Japan					
1960-64	19.61	10.26%	0.43%	8.02%	1.80%
1964-69	14.75%	10.63%	0.38%	5.75%	4.50%
1969-74	11.53%	5.99%	2.55%	4.49%	-1.06%
1974-79	6.13%	4.60%	1.32%	2.06%	1.22%
1979-84	6.01%	3.86%	0.45%	1.78%	1.63%
1984-88	5.88%	4.30%	0.28%	1.63%	2.39%
C. Korea					
1960-66	28.36%	7.33%	0.92%	4.41%	2.00%
1966-70	22.93%	8.53%	1.86%	6.37%	0.30%
1970-75	17.91%	7.84%	0.95%	4.65%	2.25%
1975-80	16.59%	10.03%	2.06%	5.15%	2.82%
1980-85	12.23%	9.13%	0.55%	3.62%	4.97%
1985-88	11.54%	11.03%	1.07%	3.49%	6.46%
D. Taiwan					
1960-64	20.27%	9.08%	1.58%	3.49%	4.02%
1964-69	20.55%	9.76%	0.93%	4.85%	3.97%
1969-74	20.80%	10.27%	1.26%	6.15%	2.86%
1974-79	15.54%	10.31%	1.02%	4.75%	4.53%
1979-84	13.20%	7.21%	1.63%	3.34%	2.25%
1984-89	15.94%	9.08%	0.86%	2.77%	5.44%
1989-94	14.44%	6.51%	0.95%	3.13%	2.43%
E. Thailand					
1970-74	16.13%	7.19%	1.22%	3.35%	2.62%
1974-79	14.82%	8.47%	1.72%	3.71%	3.04%
1979-84	14.06%	5.60%	0.81%	3.58%	1.41%
1984-89	14.59%	9.03%	0.17%	4.22%	4.64%
1989-93	16.78%	9.81%	–0.70%	7.43%	3.07%

percentage points, and the "corrected" difference in rates of TFP increase would be one percentage point. So the "corrected" ratio of differences would be .33.

If the error were in the opposite direction, the "corrected" difference in rates of GDP growth would be 5 percentage points, while that of TFP improvement would be 3 points. Here the "corrected" ratio of differences would be .60.

The likelihood, of course is that the measurement error will be positive, owing to the fact that our initial classification selects entries according to whether their GDP growth rates are high or low. So there is a presumption that a proper correction for measurement error would move our ratios of differences downward. Yet a quick exercise, hypothetically attributing to error up to a third or a half of the observed difference in rates of TFP increase, and making a corresponding adjust-

Table 5. Comparison of Annual Average Rates of Real GDP Growth and of TFP Increase (29 Periods in 5 East Asian Countries)

		Average Rate of GDP Growth In Period	Average Rate of TFP Increase In Period	Ratio of Differences
9 Highest Rates of GDP Growth	Median	10.27	4.53	
	Mean	10.60	4.14	
9 Lowest Rates of GDP Growth	Median	5.60	1.41	
	Mean	5.51	1.12	
Difference in	Medians	4.67	3.12	.67
Difference in	Means	5.09	3.02	.59

Table 6. Comparison of Annual Average Rates of Real GDP Growth and of TFP Increase (Alwyn Young's Estimates)[a] (18 Periods In Four East Asian Countries)

		Rate of GDP Growth (%)	Rate of TFP Growth (%)	Ratio of Differences
A. Five Highest Rates of GDP Growth				
Korea[b]	1966-70	14.4	1.3	
Singapore	1966-70	13.0	4.6	
Taiwan[b]	1966-70	11.1	3.4	
Hong Kong	1961-66	10.9	3.5	
Korea[b]	1985-90	10.7	2.6	
Median Growth Rate		11.0	3.4	
Mean Growth Rate		12.0	3.1	
B. Five Lowest Rates of GDP Growth				
Taiwan[b]	1980-91	7.8	3.3	
Korea[b]	1960-66	7.7	0.5	
Singapore	1980-90	6.9	–0.5	
Hong Kong	1986-91	6.3	2.4	
Hong Kong	1981-86	5.8	0.9	
Median Growth Rate		6.9	0.9	
Mean Growth Rate		6.0	1.3	
C. Differences				
in Medians		4.2	2.5	0.60
in Means		5.1	1.8	0.35

Notes: a. Source: Alwyn Young, "The Tyranny of Number: Confronting the Statistical Realities of the East Asian Growth Experience," *Quarterly Journal of Economics*, August, 1995, pp. 641-80.
b. For Korea and Taiwan, Young does not present data on the whole economy. These data, which exclude agriculture and the armed forces, are the most fully aggregated series that he presents.

ment to the corresponding difference in rate of GDP growth, suggests, that a range of "ratios of differences" of say 0.33 to 0.75 might be shifted downward to something like 0.20 to 0.60. I believe that if modern growth analysis based on growth accounting is sufficiently accurate to give broadly meaningful results, then our principal conclusion can stand without modification.

VI. SOME COMMENTS ON ECONOMIES OF SCALE AND TIME-SERIES REGRESSION ANALYSIS

As mentioned earlier, I had no opportunity to do a serious analysis of the work by Lau and Kim (1994). The main point to be noted, however, is that their results are based not on growth accounting but on econometric regressions. The key difference arises out of the fact that in growth accounting we get from the basic data an estimate of the marginal product of each factor in each period. Usually these estimates take the real wage w_j of any labor category j as representing its marginal product and the real rate of return ρ_i received by any particular type of capital i as representing its marginal product.

One can use somewhat different types of attribution in growth accounting work. For example, I have long been dubious of attributing to new investment in activity i a real rate of return of 37 percent per annum, simply because that activity currently has measured annual real returns to capital equal to 37 percent of its measured real capital stock. My instinct leads me in such cases to want to estimate the rate of return (say, 10 percent or 15 percent or 20 percent) that that particular activity might be using as its target rate of return on new investments, and to use that rate of return as our first-approximation guess as to what new capital investments will likely yield. This procedure would implicitly take the excess of the observed 37% over the target rate of return as being either the result of good luck on past investments, or of windfalls due to relative price changes, and so forth. It would *not* consider that 37% was *the* rate of return on capital in a standard production function sense, such that the next tranche of capital would yield 37 percent, the one after that, maybe 36%, the one after that, 35 percent, and so on.[3]

When actual factor rewards are used in growth accounting as the basis for attributing factor marginal productivities, one might consider that an implicit assumption of constant returns to scale is being made. Certainly, any production function that is homogeneous of degree one will tend to produce (under competition) marginal productivities of individual factors that are equal to their respective wages or other factor rewards.

However, one can do growth accounting for an aggregate of firms that we call an industry without accepting the idea that that "industry" possesses a "production function." There may be thousands of different products (as in chemicals or pharmaceuticals), each made in its own special way. Maybe each one of them has a production function, but one doesn't need to press one's luck to stretch that concept beyond where it easily and naturally fits.[4]

The fact is that to analyze the growth of the chemical and/or pharmaceutical industry we do not need to use the idea of a production function. All we need is estimates of ρ_i to apply to the various ΔK_i, and estimates of w_j to apply to the various ΔL_j. If these ρ_i and w_j were derived on the basis of actual factor rewards, then, if there do exist economies of scale, these effects will be found in the residual term; that is, increases in scale will lead to increases in TFP. Since I find highly appealing the idea of a residual term that encompasses all sorts of real cost reductions, I am quite happy to have any possible effects of economies of scale embedded, along with other real cost reductions, in the residual.

A person who was quite convinced that a given activity enjoyed significant economies of scale could build them into a growth accounting exercise by attributing to L_j a contribution equal to $w_j(1+\lambda)$, and to ΔK_i a contribution equal to $\rho_i(1+\lambda)$. ($\lambda = 0.1$ would mean that a 10 percent increase in all factors would in this activity lead to an 10 percent increase in output.) Ideally, there would be evidence to back up the choice of λ—evidence that would convince readers, independently of the growth accounting exercise itself, that economies of scale of a certain degree were present in one case, of a different degree in another, and probably of no degree at all in most cases.

For myself, I believe that economies of scale are pervasive, in the sense that nearly all activities experience them up to a point, but that they play themselves out rather quickly as scale becomes larger. I am of the generation that long ago was taught that long run average cost curves were U-shaped, that is, that each type of activity had an optimal scale, indicated by the bottom of the U. But certainly by the late 1940s this vision was being replaced by one in which the long run average cost curve had a falling segment, but instead of bottoming out and quickly rising, it leveled off in a long flat segment, perhaps ultimately followed by a rise, perhaps not. With this change the idea of an "optimal scale" was supplanted by one of a "minimum efficient scale"—the point where the LRAC curve flattened out. Survivorship ratios and other measures were used to give us an idea of where this minimum efficient scale was located, for specific activities.

I still believe in the revised vision, just described, of economies of scale. To me, they characterize many activities, but only up to a point. They can be an important source of real cost reduction in the early stages of growth of a small firm, yet alongside this firm will be others that from the day of their birth were in the flat range of LRAC (i.e., beyond the minimum efficient scale).

In contrast, I resist the idea of massive, pervasive and general economies of scale (and even more so of widespread or general diseconomies of scale). When someone asserts their existence, I want to ask, where specifically are they located? What is their nature and extent? What evidence exists that would lead me to believe that economies of scale are really at work, and not just the continuing efforts of thousands or millions of businessmen to find new ways of reducing real costs?

I am here pursuing the issue of economies of scale with more fervor than usual, only in part because they play an important role in the Kim-Lau paper. Quite apart from that paper, I have long been troubled by the role or roles that economies of scale play in the modern literature on endogenous growth. That literature arose because its authors were not content with interpreting growth-accounting residuals as the result of millions of tries at reducing real costs, each meeting with its own degree of success or failure. For growth to be endogenous, the models needed a feedback explaining R or R^* as the consequence of other forces encompassed within the models. In general, this meant a single feedback mechanism per model, with the mechanism reflecting economies of scale of one kind or another, but always at the aggregate level. Thus we have economies of scale associated with the scale of the economy itself, with the total stock of human capital, with the growth of the urban sector within the overall economy, and so forth.

I am troubled by these models and the role of economies of scale in them, not because I do not believe in each of the mentioned kinds of economies of scale, but because I believe in *all* of them, and many hundreds of other types of real cost reductions.

In challenging those who believe in the idea that economies of scale are mainly a macro-phenomenon, I want to emphasize the additive nature of the residual in economic growth analysis. Equations like Equation 2 and Equation 4 can in principle be measured at the most micro level, then added up to constitute the GDP of an industry, a sector, or of the whole economy. I believe we get great insights when we measure them at the micro level. I believe we can appreciate why TFP growth was high for autos in one decade, for refrigerators in another, for pharmaceuticals in another; for television manufacturing in yet another. We can check our observations against the history of the different industries, decade-by-decade, to verify the plausibility of our TFP measures. We can learn more about the sources of growth by digging into the archives of individual firms that produced great TFP advances at particular times.

The above conveys something of a vision of the growth process, in which in addition to investment in physical capital and the expansion of the labor force together with its improvement in quality, we have the constant driving search for real cost reductions, by businessmen, managers, entrepreneurs, and so forth, all over the world. Out of this search come thousands or millions of real cost reductions of many different types and from many different sources. Once one has this view more or less confirmed by many observations at the micro level, the $64,000 question is, how can all these thousands of sources and types of real cost reduction somehow collapse into just one big macro story, driven not by the thousands of entrepreneurs, but by the simple growth of GDP, or of overall human capital, or of the country's total urban economy, as our endogenous growth models seem to assert?

As stated earlier, Kim and Lau use regression techniques as the basis for assigning marginal products to labor and capital in the growth equation. When they finish, they find there is very little growth left to be explained. The factors of production explain nearly all of it, if one counts as part of their contribution the elements due to economies of scale.

The measurement of economies of scale in a regression framework is typically implicit. Since output is typically the dependent variable, it cannot itself be used as a measure of scale. So if one were fitting a Cobb-Douglas function, one would capture economies of scale if the coefficients of $\log L$ and $\log K$, in explaining variation in $\log y$, added up to more than one.

I am skeptical of the use of regression techniques in growth analysis for several reasons. The main one is that, to the degree that technical advance, real cost reduction, TFP improvement, and so forth, really exist and are important, they imply that production functions themselves, at micro- and macro-levels, are undergoing important shifts. Why should we expect these shifts to be so nicely regular that the production function at the end of our period is in some sense or other "the same" as the production function at the beginning. Modern steel processes are very different from those of 50 years ago (and, by the way, have smaller minimum economic scale)—*should* they somehow fit on the same overall production function for steel, with maybe just a shift of its constant term?

I am skeptical too because of the upward trends of nearly all the key time series in most growth analyses. Output is growing, the labor force is growing, the physical capital stock is growing. If human capital is represented as a separate variable, it too is growing; if it is not so represented, the separate educational categories of the labor force L_j are typically also growing. Multicollinearity abounds; it is practically a natural part of most cases of growth analysis. Stick in a simple trend variable, and it typically will explain almost everything. Add capital and labor to trend (or trend to labor and capital), as explanatory variables, and most or all of the probability levels of the separate coefficients will typically fade into insignificance. Even without trend, capital and labor will often fight each other for explanatory power over output movements, leading to coefficients that seem totally implausible to most economists.

If my broad vision is even roughly correct, turning to estimation in terms of first differences will not help either. Labor force growth is typically quite similar from one year to the next; capital stock growth is less steady, but its big movements are cyclical, and inform us more concerning deviations from the mainline growth path than about the characteristics of that growth path itself.

Table 7. Fitting a Cobb-Douglas Function to Time Series Data: Key Results (Fitted Equation: $\log y = \alpha + \beta_K \log K^* = \beta_\ell \log L^*$)

Country and Period		Coefficients β_K	β_ℓ	Sum $\beta_K + \beta_\ell$	D.F.	R^2
Colombia	1960-88	0.76	0.53	1.29	26	0.984
		(0.18)	(0.32			
Costa Rica	1960-92	0.64	0.66	1.30	30	0.973
		(0.14)	(0.31)			
Ecuador	1960-88	0.84	0.06	0.90	26	0.984
		(0.08)	(0.23)			
Japan	1960-88	0.79	–0.37	0.42	26	0.997
		(0.02)	(0.10)			
Korea	1960-88	1.02	–1.42	–0.40	26	0.997
		(0.05)	(0.33)			
Malaysia	1970-91	0.78	–0.32	0.46	19	0.986
		(0.09)	(0.26)			
Mexico	1960-92	0.31	1.27	1.56	30	0.993
		(0.04)	(0.10)			
Panama	1970-92	0.59	0.29	0.87	20	0.942
		(0.16)	(0.38)			
Peru	1970-92	0.58	0.29	0.87	20	0.942
		(0.18)	(0.38)			
Taiwan	1960-94	0.74	0.56	1.30	32	0.994
		(0.08)	(0.32)			
Thailand	1970-91	0.90	–0.58	0.32	19	0.990
		(0.40)	(0.20)			
Venezuela	1960-88	0.81	0.11	0.92	26	0.935
		(0.34)	(0.65)			

Note: a. Standard errors in parentheses below coefficients.

VII. AN EXERCISE IN TIME SERIES REGRESSION ANALYSIS

Having thus unburdened myself of some general points of view concerning economies of scale and on the use of regression techniques in growth analysis, I now turn to a simple experiment. In it I will estimate simple Cobb-Douglas functions using the data on y, K^* and L^* that underlie the calculations of Tables 2 and 4. The fitted equation is $\log y = \alpha + \beta_k \log K^* + \beta_\ell \log L^*$. Table 7 presents the key results.

The results of Table 7 are so absurd as to be laughable! No economist worth his salt would even dream of drawing a serious inference about the nature of production functions, or of making a serious prediction about the consequence of changes in factor employment, on the basis of any one (let alone all) of the above regressions! They tell us nothing of relevance in these respects.

I believe, however, that we can understand the results of Table 7 in the light of my earlier comments. All the signs of acute multicollinearity are present.

The R^2's are, with just one exception, enormous, yet more often than not, the labor coefficient is insignificant at the 0.10 level. Four cases yield negative coefficients for labor! Where economies of scale are shown, they are absurdly high, by any standard. Where diseconomies of scale are shown, they too are absurdly high in most cases. The sum of the coefficients just may be flirting with plausibility in the cases of Ecuador, Panama, and Venezuela (recall that we have neglected the land factor, whose economic use undoubtedly in fact increased over the period in these countries).

Suffice it to say that this type of result should serve as a fire alarm to alert economists to the severe troubles that await attempts at growth analysis using regression methods.

Turning to first difference regressions did nothing to solve the problem. Here two sets of regressions were run, one with, and other without a constant terms.

Table 8A. Concentration of TFP Growth Among U.S. Industries 1948-1958 (Columns (2) to (5) in Billions of 1948 Dollars)

	TFP Growth Over Period (1.0 = 100%) (1)	Absolute Contrib. of TFP Growth [(1) × (4)] (2)	Cum. Sum of (2) (3)	GDP by Industry 1948 (4)	Cum. Sum of (4) (5)
Communication	0.69	2.63	2.63	3.80	3.80
Public Utilities	0.69	2.97	5.60	4.30	8.10
Farming	0.59	13.65	19.25	23.30	31.40
Miscellaneous Manufacturing	0.43	0.73	19.98	1.70	33.10
Electrical Machinery	0.36	1.58	21.56	4.40	37.50
Food and Kindred Products	0.35	3.53	25.08	10.20	47.70
Instruments	0.33	0.36	25.44	1.10	48.80
Mining	0.31	2.92	28.36	9.40	58.20
Construction	0.31	3.54	31.90	11.50	69.70
Tobacco	0.31	0.52	32.42	1.70	71.40
Railroad Transport	0.2?	2.40	34.82	8.80	80.20
Chemicals	0.27	1.15	35.97	4.30	84.50
Apparel	0.25	0.92	36.89	3.70	88.20
Lumber and Wood products	0.24	0.76	37.65	3.10	91.30
Finance Insurance & Real Estate	0.24	6.43	44.08	26.90	118.20
There follow 15 more industries whose combined results are	0.06	19.21	63.29	121.70	239.90

Top 13%[a] of industries account for 30% of total TFP contribution
Top 30%[a] of industries account for 52% of total TFP contribution
Top 49%[a] of industries account for 70% of total TFP contribution

Note: a. These percentages are contributions to GDP of industries ranked according to their percent rate of TFP growth over period.

Source: John W. Kendrick and Elliot S. Grossman, *Productivity in the United States: Trends and Cycles*, Baltimore: Johns Hopkins University Press, 1980.

Table 8B. Concentration of TFP Growth Among U.S. Industries 1958-1967 (Columns (2) to (5) in Billions of 1958 Dollars)

	TFP Growth Over Period (1.0 = 100%) (1)	*Absolute Contrib. of TFP Growth [(1) × (4)]* (2)	*Cum. Sum of (2)* (3)	*GDP by Industry 1948* (4)	*Cum. Sum of (4)* (5)
Lumber and Wood Products	0.72	2.51	2.51	3.50	3.50
Railroad Transpot	0.63	5.52	8.03	8.70	12.20
Textile Mill Products	0.61	2.49	10.52	4.10	16.30
Electrical Machinery	0.55	5.10	15.66	9.30	25.60
Transport Equipment	0.46	7.05	22.71	15.20	40.80
Chemicals	0.44	3.97	26.68	9.10	49.90
Public Utilities	0.42	4.65	31.33	11.00	60.90
Petroleum and Coal	0.41	1.27	32.60	3.10	64.00
Rubber and Products	0.41	1.23	33.83	3.00	67.00
Mining	0.41	5.20	39.03	12.60	79.60
Communication	0.40	3.61	42.64	9.00	88.60
Trade	0.33	24.93	67.57	76.40	165.00
There follow 18 more industries whose combined results are	0.03	7.53	75.10	239.80	404.80

Top 10%[b] of industries account for 30% of total TFP contribution
Top 22%[b] of industries account for 52% of total TFP contribution
Top 40%[b] of industries account for70% of total TFP contribution

Note: b. These percentages are contributions to GDP of industries ranked according to their percent rate of TFP growth over period.

Source: John W. Kendrick and Elliot S. Grossman, *Productivity in the United States: Trends and Cycles*, Baltimore: John Hopkins University Press, 1980.

Of the resulting 24 regressions, the coefficient of $\Delta\log L^*$ was *negative* in fully 19 (both regressions for Ecuador, Japan, Korea, Malaysia, Panama, Peru, Taiwan, Thailand, and Venezuela, plus the no-constant-term regression for Colombia). The coefficient of $\Delta\log K^*$ was negative (−1.78) in the Colombia regression with a constant term, which was 0.06, implying a trendwise growth of 6% per year with no help from the basic factors! This leaves only two countries. For Costa Rica, R^2 was below 0.09 in both regressions. For Mexico the constant term was −.016, with a standard error of .0088, when it was present, along with a coefficient of 1.14 (0.33) for $\Delta\log K^*$. Without a constant term, capital's coefficient fell to 0.59, with labor's rising to 0.67.

It may be that it was results like these on time series regressions for individual countries that led Kim and Lau to turn to panel data, using time series data from several countries to fit a single production function (with separate constant terms for each country). This, to me, is yet another primrose path. If it makes no sense to fit the same demand function for money, or for sugar, or for meat to data from different countries, how can it make sense to fit the same aggregate production function, even with different constant terms?

VIII. INSIGHTS INTO THE GROWTH PROCESS

I realize I have been making some pretty strong assertions about the nature of the growth process and the role of many different types of real cost red uction in it. As a consequence, I feel impelled to share with readers some of the evidence that led me to these views. Table 8, like Table 1, is drawn from my 1990 paper, "Reflections on the Growth Process." It draws its data from Kendrick and Grossman's 1980 *Study of Productivity in the United States*. The key trick of the table is to convert TFP growth from percentage points per year into constant dollars, which of course are additive. The conversion is made by multiplying each industry's percentage TFP growth in a decade by its base period contribution to GDP. The result is the constant-dollar measure of the extra product that TFP improvement brought to that industry in that decade. Such contributions from different industries can be added , and their sum over the whole economy would presumably be the constant-dollar increment to GDP that was brought about by the total TFP improvement over the course of that decade.

Table 8C. Concentration of TFP Growth Among U.S. Industries 1967-1976 (Columns (2) to (5) in Billions of 1967 Dollars)

	TFP Growth Over Period (1.0 =100%) (1)	*Absolute Contrib. of TFP Growth [(1) × (4)]* (2)	*Cum. Sum of (2)* (3)	*GDP by Industry 1948* (4)	*Cum. Sum of (4)(* (5)
Finance, Insurance and Real Estate	1.14	132.25	132.25	115.60	115.60
Apparel	0.37	2.84	135.09	7.70	123.30
Communication	0.34	6.23	141.32	18.10	141.40
Chemicals	0.31	4.85	146.17	15.70	157.10
Electrical Machinery	0.30	5.99	152.16	19.70	176.80
Food and Kindred Products	0.30	6.62	158.78	22.20	199.90
Tobacco	0.29	1.00	159.78	3.50	202.50
Miscellaneous Manufacturing	0.26	0.92	160.70	3.50	206.00
Paper and Products	0.26	2.11	162.81	8.20	214.20
There follow 21 more industries whose combined results are	0.08	41.52	204.33	495.70	709.90

Top 20%[c] of industries account for 69% of total TFP contribution
Top 30%[c] of industries account for 80% of total TFP contribution

Note: c. These percentages are contributions to GDP of industries ranked accord ing to their percent rate of TFP growth over period.

Source: John W. Kendrick and Elliot S. Grossman, *Productivity in the United States: Trends and Cycles*, Baltimore: John Hopkins University Pres, 1980.

In Table 8, industries are ranked in each decade in descending order of their percentage growth of TFP over the decade. In column (2) this TFP growth is expressed in constant dollars, as explained above. In column (3) the cumulative sum of column (2) is presented. Column (4) simply records the base-year GDP of each industry, while column (5) gives the cumulative sum of column (4). This permits us to make statements like those at the bottom of the table—that is, the "Top 13% of industries account for 30% of total TFP contribution" (Table 8a), or, the "top 20% of industries account for 69% of total TFP contribution" (Table 8c).

The result can be compared to a Lorenz curve. If all industries had equal percentage increases in TFP, the curve would be a straight line, and the two percentages would always be the same. A few industries (in terms of initial GDP) accounting for most of a decade's TFP increase produces a sharply curved "Lorenz curve," with a high "Gini coefficient."

This is what I believe I see in these data. To me it bespeaks causes of TFP increase that are idiosyncratic among industries, not causes that stem from general macroeconomic forces. Moreover, it is to be noted that of the top industries that accounted cumulatively for a third of the TFP contribution in 1948-1958, only one (electrical machinery) is in the top group in 1958-1967. And of this latter top group none repeats (because of the overwhelming dominance of Finance, Insurance and Real Estate) in 1967-1976. As I see it, new things appear on the scene, new inventions are incorporated into productive processes, new management techniques are found. Everybody is trying, but many do not succeed, while a few succeed in a big way. I believe it is our task to learn more about precisely what brought about these big, concentrated real cost reductions that appear to characterize our economic history.

For several years I have told the above story exclusively in terms of industries, with the implication that things went on in a pretty homogeneous way within each industry. I began to change my mind as a result of some initial experiments with growth analysis of U.S. firms. (Ford and General Motors, for example, have very different patterns of TFP improvements.) But I almost totally abandoned my initial view quite recently, as a result of work by Leonardo Torre on a sample of about 2,200 Mexican firms. These firms are divided into some 45 industries, and, true to form, the top third of these industries account for more than two-thirds of the TFP growth of the aggregate. They come as no surprise.

The real surprise in Torre's data was what happened within each industry. Almost invariably, within each industry, the "Lorenz curve" was as sharply curved as that among industries. It wasn't at all true that TFP was spread evenly among the firms in an industry. Rather, the top quarter of the firms (measured in terms of initial value added, and ranked in descending order of percentage increase in TFP) would typically account for two thirds or three quarters of the industry's total TFP contribution. Typically, there were serious loser forms (with negative TFP growth) even in industries that were TFP champions.

I cannot help it! I am driven by this evidence to a much more Schumpeterian view of the growth process than I used to have. I now know much better the meaning of "creative destruction," and I see more clearly than ever the cruel but fruitful dynamics of a market economy. I see too why socialist economies and others with lots of state-owned enterprises run into trouble, especially when they are reluctant to allow losers to go out of business.

In light of this evidence I simply cannot believe that any one or two or three simple causes, like those of endogenous growth theory, really help us understand the forces of real cost reduction and how they work. I feel much more comfortable going back to Schumpeter!

VIII. EPILOGUE

In closing, I want to return to the assertions that "there was no East Asian miracle" and that "incremental labor and capital account for almost all of East Asian growth," with hardly any contribution from improvements in total factor productivity.

Our own data show rates of TFP increase of over 4 percent per annum for our East Asian countries in their periods of rapid growth. This compares with rates of around 3 percent or less for our sample of Latin American countries, in their periods of rapid growth. When growth was slow in the East Asian countries, the TFP contribution averaged over 1 percent per annum; in the Latin American countries it was around minus one percent per annum. In both sets of countries differences in TFP contribution were major factors accounting for the differences in GDP performance, as between low-growth and high-growth periods.

How then, did the above assertions get started? And, once started, how did they survive as long as they have? One very simple reason, I believe, is the habit of many economists to think of the TFP contribution as a fraction of the total growth rate of the period, rather than in terms of percentage points (of productivity increase, or equivalently, of real cost reduction), per annum.

The contribution of TFP is almost bound to look small as a fraction of the growth rate, in a country that saves 30 percent or 40 percent of its GDP, compared with one that saves only 10 percent or 20 percent. Table 5 shows the Asian countries with a TFP increase of a bit over 4 percent, during high-growth periods when the growth rate averaged over 10 percent. So TFP accounted for only 40 percent or so of total growth. This ratio is about the same as for the high-income countries in Panel C of Table 1. But 4 percentage points of GDP improvement per year is far higher than we observe for any category listed in either Table 1 or Table 3.

I have always insisted that it was a mistake to focus on the fraction of the growth rate explained, rather than on the percentage rate of TFP increase itself. It is the latter which is the measure of "cost reduction effort and success," and on this the East Asian countries are clear winners. If at the same time they are also winners in terms of national savings rates, and in terms of the net rate of return that they obtain on invested capital, these are things to be separately applauded. They should not be used so as to belittle the importance of championship TFP performances.

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NOTES

1. See, for example, my "The Cost-Benefit Approach in Development Economics," in *World Development*, vol. II no. 10 (1983) and my "Reflections on the Growth Process," background paper for the *World Development Report, 1991* (mimeo, June, 1990).

2. I should mention that the traditional approach (disaggregated) produces the following dual representation of the residual.

$$R' = \Sigma_i p_i \Delta X_i - \Sigma_h p_h \Delta F_h - \Sigma_j w_j \Delta L_j - \Sigma_i \Delta d_i \Delta K_i$$
$$R' = \Sigma_i K_i \Delta \rho_i + \Sigma_h F_h \Delta p_h + \Sigma_j L_j \Delta w_j - \Sigma_i X_i \Delta p_i$$

The corresponding dual representation for the two-deflator approach is

$$R^* = \sum_i \left(\frac{p_i}{\bar{p}_d}\right)\Delta X_i + \sum_i X_i \Delta\left(\frac{p_i}{\bar{p}_d}\right) - \sum_h \left(\frac{p_h}{\bar{p}_d}\right)\Delta F_h - \sum_h F_h \Delta\left(\frac{p_h}{\bar{p}_d}\right)$$

$$- w^*\Delta L^* - \rho^*\Delta k^* = L^*\Delta w^* + k^*\Delta\rho^*$$

3. The interpretation of the traditional dual representation is that increases in output per unit of output get reflected in increased factor rewards relative to product prices. The interpretation of its counterpart is that real cost reductions measured using the two-deflator approach are reflected either in increased profits or in increased wage payments per standard labor unit.

4. In Harberger (1990) I made some rapid calculations for many different countries based on alternative sets of assumptions. One set was based on $\bar{\rho} = 7.5$ percent, together with a share of labor equal to 60 percent of GDP; the second was based on $\bar{\rho} = 15$ percent together with a share of labor equal to half of GDP. These two sets of assumptions led to two quite different calculated series for *R*, the traditional residual, but they were both fully compatible with the type of conclusion we have been reaching in this chapter.

A lot, too, depends on the purpose for which a concept is used. I have no skepticism regarding the use of aggregate or sectoral production functions in comparative-static tax analysis, but I have lots of skepticism about regression-based measurement of same.

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