



A Vision of the Growth Process

Arnold C. Harberger

The American Economic Review, Volume 88, Issue 1 (Mar., 1998), 1-32.

Stable URL:

<http://links.jstor.org/sici?sici=0002-8282%28199803%2988%3A1%3C1%3AAVOTGP%3E2.0.CO%3B2-6>

Your use of the JSTOR archive indicates your acceptance of JSTOR's Terms and Conditions of Use, available at <http://www.jstor.org/about/terms.html>. JSTOR's Terms and Conditions of Use provides, in part, that unless you have obtained prior permission, you may not download an entire issue of a journal or multiple copies of articles, and you may use content in the JSTOR archive only for your personal, non-commercial use.

Each copy of any part of a JSTOR transmission must contain the same copyright notice that appears on the screen or printed page of such transmission.

The American Economic Review is published by American Economic Association. Please contact the publisher for further permissions regarding the use of this work. Publisher contact information may be obtained at <http://www.jstor.org/journals/aea.html>.

The American Economic Review
©1998 American Economic Association

JSTOR and the JSTOR logo are trademarks of JSTOR, and are Registered in the U.S. Patent and Trademark Office. For more information on JSTOR contact jstor-info@umich.edu.

©2003 JSTOR

A Vision of the Growth Process[†]

By ARNOLD C. HARBERGER*

One of the great pleasures of belonging to my generation of economists is that we were

[†] Presidential Address delivered at the one-hundred tenth meeting of the American Economic Association, January 4, 1998, Chicago, IL.

* Department of Economics, University of California, Los Angeles, CA 90095. This paper is but one step in a sequence of writings and other presentations on the process of growth. In this work I have been greatly helped by a number of research assistants—Luis Alvarado and Harald Beyer in the early stages, Alfonso Guerra and Edgar Robles in the middle phase, and Enrique Flores and Leonardo Torre in the final stage, as this paper was being prepared. Readers will note that this paper also draws on Ph.D. dissertation work done by Beyer, Robles, and Torre. In the course of the evolution just referred to, I have made presentations at, and received valuable comments from, a number of different forums—seminars at Clemson University, Stanford University, Texas A&M University, and UCLA in the United States, plus several abroad—the Catholic University of Chile, the University of Chile and the Centro de Estudios Público (CEP) in Santiago, the Center for Argentine Macroeconomic Studies (CEMA), the Instituto Torcuato Di Tella, the Universidad de San Andrés, and the Instituto Superior de Economistas del Gobierno (ISEG) in Argentina, as well as the Instituto Tecnológico Autónomo de México (ITAM) in Mexico. In addition, there were conference presentations organized by Cornell University, the East-West Center (University of Hawaii), the Association of Asian Economists (Kuala Lumpur, 1996), the Western Economic Association (Seattle, 1997), the Econometric Society (Latin American meetings, Santiago, 1997), and the Argentine Political Economy Association (Bahia Blanca, 1997).

I want to make special note of a conference on capital formation and economic growth, organized by Michael J. Boskin and held at the Hoover Institution in October 1997. This conference was attended by a veritable galaxy of serious students of growth, a fact which motivated me to write a very long paper (Harberger, 1998) probing issues of methodology in the measurement and analysis of growth, as well as the more substantive matters emphasized in the present paper. I take this opportunity to refer readers to that paper (forthcoming in a volume edited by Boskin) for more detailed treatment of methodological issues. I also want to give special thanks to Zvi Griliches, Dale W. Jorgenson, and Paul Romer, as well as to my colleagues Sebastian Edwards, Jean-Laurent Rosenthal, and Carlos Végh, each of whom gave that paper a very careful reading and provided me with extremely useful comments. Finally, I want to give special thanks to Lorraine Grams, who has performed miracles translating handwritten scrawls faxed from four continents into the paper you see before you.

able to witness the birth and the subsequent evolution of the modern approach to the analysis of economic growth. The centerpiece of that approach is probably growth accounting, but we should never forget that growth accounting is firmly rooted in economic theory.

My way of telling the story goes like this: Many, maybe even most, economists expected that increments of output would be explained by increments of inputs, but when we took our best shot we found that traditional inputs typically fell far short of explaining the observed output growth. Our best shot consisted in attributing to each factor a marginal product measured by its economic reward. Thus:

$$(1) \quad \bar{p}\Delta y = \bar{w}\Delta L + (\bar{p} + \delta)\Delta K + R.$$

Here:

Δy = change in output (GDP);

ΔL = change in labor input;

\bar{p} = initial general price level;

\bar{w} = initial real wage;

\bar{p} = initial real rate of return to capital;

δ = rate of real depreciation of capital;

ΔK = change in capital stock; and

R = “the residual” of growth unexplained by increases in traditional inputs.

Many economists are probably more familiar with a variant of (1)

$$\begin{aligned} (1') \quad (\Delta y/y) &= (\bar{w}L/\bar{p}y)(\Delta L/L) \\ &+ [(\bar{p} + \delta)K/\bar{p}y](\Delta K/K) \\ &+ (R/y) = s_\ell(\Delta L/L) \\ &+ s_k(\Delta K/K) + (R/y). \end{aligned}$$

In whichever form, the measured residual typically accounted for an important fraction of the observed output growth, quite often half or more.



Arnold Hauberg

This result came as a surprise to the profession, though perhaps less so to those who reached it, or something very like it, by an alternative route. They were the people who came at the problem out of a tradition of measuring labor productivity, and at some point complemented output per worker with a measure of output per unit of capital, and finally joined the two to create a measure of total factor productivity (TFP). The idea of total factor productivity increasing through time was less a shock to these people than the “growth residual” was to those who approached its measurement along the lines of equation (1) or (1'). See Moses Abramovitz (1952, 1956) and Solomon Fabricant (1954).

In any case, as the newly discovered residual loomed large in our professional thinking, our discussion centered on two potential explanations: “human capital” and “technical advance.” (See Robert M. Solow, 1957.) These can be thought of as complementary explanations, at least up to a point, with technical advance representing truly new ways of doing things, and the accumulation of “human capital” representing increases in the “quality” of the typical human agent. It was not long before attempts were made to quantify the contribution of improved labor quality. These came as part of a general move toward disaggregation of the two factors, which can be represented by:

$$(2) \quad \bar{p}\Delta y = \sum_i \bar{w}_i \Delta L_i + \sum_j (\bar{p}_j + \delta_j) \Delta K_j + R'.$$

Here the index i can vary over all sorts of education and skill groups as well as categories like gender, age, occupation, region, etc. All these are items that may signal a different market wage. In a similar vein, the index j would appropriately vary over categories like the corporate, noncorporate, and housing sectors where, for tax if for no other reasons, different (gross-of-tax) rates of return would presumably prevail, even in a full equilibrium.

In an equation like (2), the presumed marginal product of each category of labor is measured by the wage \bar{w}_i . Average quality can be measured by $Q_t = \sum_i \bar{w}_i L_{it} / \sum_i L_{it}$, and the contribution of change in quality to Δy_t between t and $t + 1$ can be calculated as $L_t \bar{w}_t (\Delta Q_{t+1} / Q_t)$. Thus, the contribution of quality change

is already built into the first summation in (2), but can be separately identified if we so choose.

A focus on human capital could lead us to a slightly different way of breaking down $\sum w_i \Delta L_i$. Here we could choose some “basic wage” w^* , ideally the wage of some well-defined category of relatively unskilled labor. Then we could divide the remuneration w_i of any given category into a part w^* which was a reward for “raw labor” and another part $(w_i - w^*)$ which we would identify as the reward to the human capital of a typical worker of type i .

Using a framework like (2) has long been the standard for careful professionals. Pioneered by Zvi Griliches (1960, 1963), it was utilized by Edward F. Denison (1967) and John W. Kendrick (1973, 1976, 1977), among others. This approach has been further developed and carried to a high art by Dale W. Jorgenson and Griliches (1967), Jorgenson et al. (1987), and Jorgenson (1995).

The main point to be made here is that once the residual is measured using a framework like (2) or its equivalent, the direct, measured contribution of human capital is captured in the labor term $\sum \bar{w}_i \Delta L_i$. By direct contribution I mean what people are paid for. Doctors earn more than nurses, and engineers more than draftsmen. These and similar differences are captured in $\sum \bar{w}_i \Delta L_i$, which can be positive even if $\sum \Delta L_i$ is zero, just from an upward reshuffling of the same labor force. A truly accurate measurement of type (2) would capture all the subtle differences of quality that exist in a modern labor force and would give each a weight corresponding to the (gross-of-tax) earnings that demanders are observed to pay. We may do this imperfectly, but, in concept at least, the residual R' as measured by (2) does not contain any elements of quality change or any direct contributions of human capital to growth. This is a quite important point for it permits us to zero in on the residual as representing “technical change,” “TFP improvement,” and “real cost reduction.”

There is no analytical reason to prefer one of the above three terms over another, in referring to the residual R' . But I am going a bit out on a limb to say that a term like “technical change” leads most economists to think of inventions, of the products of research and de-

velopment (R&D), and of what we might call technical innovations. On the other hand, TFP improvement, once purged of the changes in the quality of labor and/or the direct contributions of human capital, makes one think of externalities of different kinds—economies of scale, spillovers, and systematic complementarities. And finally, real cost reduction, to my mind, makes one think like an entrepreneur or a CEO, or a production manager.

I think it would be perfectly fair to characterize my presentation today as a paean in praise of “real cost reduction” as a standard label for R' . Labels do not change the underlying reality, but they may change the way we look at it and the way we think about it. They also can lead us to understand it better. Thinking in terms of real cost reduction has certainly done all this for me, as I have tried to sort out the many puzzles and complexities that surround the process of economic growth.

Let me try to take you down the path I traveled. In the first place, real cost reduction (RCR) is probably on the mind of most business executives, production managers, etc., at some point or another in any given week, let alone in any given month or year. It is a major path to profit in good times, and a major defense against adversity in bad times. Most U.S. firms that have downsized in recent years did so with RCR in mind. So, too, did the firms that computerized their payrolls and other accounts. And so also did those who shifted to what they considered more modern management techniques. I recall going through a clothing plant in Central America, where the owner informed me of a 20-percent reduction in real costs, following upon his installation of background music that played as the seamstresses worked. And then there is the story of two Chilean refrigerator firms that ended up as parts of a single conglomerate at one point. The new management reduced the number of models from something like 24 to two, making agreements to import other models while exporting these two. The end result was that output more than doubled, while the labor force was cut to less than half, and even the capital stock (at replacement cost) was significantly reduced. This sounds like (and is really) economies of scale, but they would not be detected by our usual measures, as both labor force and

capital stock went down. And we all have seen cases where, say, an office’s real costs were reduced when a martinet of a manager was replaced by someone more reasonable. But we have also seen cases where real costs were reduced when a very lax manager was replaced by someone more strict.

It has long been my song that there are at least 1001 ways to reduce real costs and that most of them are actually followed in one part or other of any modern complex economy, over any plausible period (say, a decade). Once one accepts this proposition as true, the question then arises: Why would anybody try to settle on just one underlying cause of real cost reduction? The answer, I think, is *mind-set*—the framework in which one is thinking at the moment. The pioneer writings of the recent endogenous growth literature can, I think, be said to reflect a kind of annoyance at something like R or R' being considered exogenous. There was an urge to surmount that inelegance by somehow making the residual endogenous. And in a simple growth model that meant generating a feedback from the rest of the model to the residual. A 1001 feedbacks would be out of the question, but one feedback would work just fine. Thus Paul Romer (1986) focused on a feedback through “knowledge,” with the stock of knowledge shifting production functions all over the economy; Robert E. Lucas, Jr. (1988) focused on “human capital,” not on its direct and remunerated productivity, but on the externalities that each increase in the stock of human capital were presumed to generate. These single feedbacks achieved the limited purpose of endogenizing R or R' within a specified model, but they did not represent very well the multifaceted nature of real cost reduction as we observe it in actuality. And, in point of fact, both the cited authors in their more recent writings display a deep recognition of the subtlety and complexity of the growth process, not really capable of being captured through a simple feedback mechanism. (See Romer, 1990, 1994a, b; Lucas, 1993.)

So, real cost reduction is multifaceted and everywhere around us. Where does that get us? Or how can we get anywhere in the face of such complexity? The next step is to recognize that in spite of its complexity, real cost reduction can be reduced to a single metric, and can

TABLE 1—GROWTH BREAKDOWN TREATING REAL COST REDUCTION AS ADDITIVE

Industry	TFP growth over period (1.0 = 100 percent)	Absolute amount of real cost reduction [(1) × (4)]	Cum. sum of (2)	Initial value added	Cum. sum of (4)
	(1)	(2)	(3)	(4)	(5)
1	0.800	\$80b.	\$80b.	\$100b.	\$100b.
2	0.600	\$120b.	\$200b.	\$200b.	\$300b.
3	0.500	\$150b.	\$350b.	\$300b.	\$600b.
All the rest	0.107	\$150b.	\$500b.	\$1,400b.	\$2,000b.

be made *additive*. For a quick appreciation of this, assume that total factor productivity grew by 80 percent in one industry over a decade, by 60 percent in another industry, and by 50 percent in a third. If their initial value added amounted to \$100 billion, \$200 billion, and \$300 billion, respectively, then the real cost reduction of the first was \$80 billion, that of the second was \$120 billion, and that of the third \$150 billion. So we can say that, measured at initial prices, the real cost reduction of the three together was \$350 billion over the decade in question. I truly think that the notion of real cost reduction being additive in this way came to my mind, and is easily seen by others, just as a consequence of the label. The idea of additivity does not follow nearly so easily from the labels “technical advance” and “total factor productivity.”

Anyway, this vision of the growth process opens up many new vistas and gives us many new challenges. To me, it gives *life* to the residual, viewed as real cost reduction, in a way that remote macroeconomic externalities never did. It gives the residual *body*, in the sense that the number of dollars saved by real cost reduction is a tangible and measurable quantity. It gives the residual a *name* (real cost reduction), an *address* (the firm), and a *face* (the face of the entrepreneur, the CEO, the production manager, etc.) And, finally, we shall see that there can be vastly different *expressions* on that face, even as we move from firm to firm in a given industry, as the TFP experience of a period moves from sharply positive to devastatingly negative.

I. Yeast versus Mushrooms: Part I

Table 1 is based on the numerical example just given, plus the information that the remaining industries (say, in the economy) together had an initial value added of \$1,400 billion and experienced real cost reduction of \$150 billion over the period. Setting out data in the format of Table 1 allows us to make statements like “15 percent (\$300 b./\$2,000 b.) of the industries (measured by initial value added) accounted for 40 percent (\$200 b./\$500 b.) of the real cost reduction (RCR) of the period” and “30 percent (\$600 b./\$2,000 b.) of the industries accounted for 70 percent (\$350 b./\$500 b.) of the period’s RCR.”

I stumbled on this way of presenting data on real cost reduction in the course of writing a background paper (Harberger, 1990) for the World Bank’s *World Development Report* of 1991. Once I saw it, I immediately embraced it, because it helped me communicate to others what I call the “yeast versus mushrooms” issue. The analogy with yeast and mushrooms comes from the fact that yeast causes bread to expand very evenly, like a balloon being filled with air, while mushrooms have the habit of popping up, almost overnight, in a fashion that is not easy to predict. I believe that a “yeast” process fits best with very broad and general externalities, like externalities linked to the growth of the total stock of knowledge or of human capital, or brought about by economies of scale tied to the scale of the economy as a whole. A “mushroom” process fits more readily with a vision such as ours, of real cost

TABLE 2—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 percent)	Absolute amount of real cost reduction [(1) × (4)]	Cum. sum of (2)	GDP by industry 1958	Cum. sum of (4)
	(1)	(2)	(3)	(4)	(5)
Lumber & Wood Products	0.72	2.51	2.51	3.50	3.50
Railroad Transport	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	<u>22.71</u>	15.20	<u>40.80</u>
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	<u>42.64</u>	9.00	<u>88.60</u>
Trade	0.33	24.93	<u>67.57</u>	76.40	<u>165.00</u>
There follow 18 more industries the combined results of which are	0.03	7.53	75.10	239.80	404.80

Notes: Top 10 percent (these percentages are contributions to GDP of industries ranked according to their present rate of TFP growth over period) of industries account for 30 percent of total TFP contribution.

Top 22 percent (these percentages are contributions to GDP of industries ranked according to their percent rate of TFP growth over period) of industries account for 52 percent of total TFP contribution.

Top 40 percent (these percentages are contributions to GDP of industries ranked according to their percent rate of TFP growth over period) of industries account for 70 percent of total TFP contribution.

Sources: Kendrick and Grossman (1980). GDP data from U.S. national accounts.

reductions stemming from 1001 different causes, though I recognize that one can build scenarios in which even 1001 causes could work rather evenly over the whole economy.

Personally, I have always gravitated toward the “mushrooms” side of this dichotomy. I remember being impressed, when I first saw some early industry estimates of TFP improvement, by their tendency to industry concentration. For years I told my students that the 1920’s were the decade of cars and rubber tires, the 1930’s the decade of refrigerators, the 1940’s that of pharmaceuticals (especially antibiotics), and the 1950’s that of television,

with telecommunications and computers taking over in recent decades. But these were just impressions, not based on any systematic approach. My real turnaround came in the course of writing my 1990 paper, where I presented a series of tables based on Kendrick and Elliot S. Grossman’s (1980) work. Table 2 is an example.

Table 2 has the same format as Table 1. Column (1) presents the familiar measure of the percentage by which TFP grew, or real costs were reduced, during the period in question (note that the percentages apply to the period 1958–1967 as a whole; they are not annual

rates). To turn these percentages into dollar amounts of real cost saving over the period, one multiplies them by base-period real GDP [col. (4)]. The results are shown in column (2). Columns (3) and (5) are the cumulative sums of columns (2) and (4), respectively. Working with these figures one can make statements like those at the bottom of the table—i.e., the top 10 percent of industries accounted for 30 percent of total real cost reduction; the top 22 percent of industries (measured by initial value added) accounted for more than half of total real cost reduction.

Readers will notice that at the foot of each column in the table is an entry referring to 18 additional industries, which together accounted for only 10 percent of the total TFP contribution, while their combined share of initial output was almost 60 percent of the total.

Using the analogy with yeast and mushrooms, the results of my calculations using the Kendrick-Grossman data pointed very clearly to a “mushrooms” interpretation. Not only were the contributions to RCR highly concentrated in a relatively few industries, these industries also were very different as one shifted from decade span to decade span. The top four branches in percentage of real cost reduction during 1948–1958 were Communications, Public Utilities, Farming, and Miscellaneous Manufacturing. In 1958–1967 they were Lumber, Railroad Transport, Textile Mills, and Electrical Machinery. In 1967–1976 they were Finance, Insurance & Real Estate, Apparel, Communications, and Chemicals. Only Communications appears twice among these 12 listings.

Now to my mind, this already brings evidence to bear on a number of possible hypotheses concerning the nature of TFP improvement. Certainly some ways of interpreting a generalized externality due to improved education would be hard to justify using evidence like this. Strong links of the residual term to R&D expenditures¹ would suggest a high degree of persistence among the leaders in TFP improvement. So also (probably) would economies of scale associated with the scale either of the firm or of the industry.

Such economies are not likely to jump wildly around from one industry to the next, from period to period. One would expect them to embody characteristics of the productive process that would be relatively stable over time; hence they should show a reasonably high degree of persistence, over time, in terms of the TFP experience of particular industries.

No economist can look at Table 2 without thinking of its close analogy with a Lorenz curve. That, indeed, was the next step I took in trying to represent the degree of concentration of real cost reduction. Figure 1 (drawn from Edgar Robles, 1997), shows the quasi-Lorenz curves for a 20-industry breakdown of the U.S. manufacturing sector over four successive five-year periods.

What strikes one immediately about Figure 1 is the characteristic “overshooting.” I have marked with the first vertical line the point where the rising curve crosses 100 percent on the vertical axis. The interpretation is that in 1970–1975 the cumulative real cost reduction of just 25 percent of manufacturing industries (measured by initial value added) was equal to the total RCR for manufacturing as a whole. After that there are other industries producing another 40 percent of the total, but their contribution is offset by still other industries with negative RCR during the period.

Corresponding to the 25-percent figure for 1975, we have around 12 percent for 1975–1980, 48 percent for 1980–1985, and 40 percent for 1985–1991. These are the fractions of manufacturing industry which by themselves were able to account for the full amount of real cost reduction during the respective period, in manufacturing industry as a whole.

The second vertical line in each panel of Figure 1 marks the maximum point of the curve. The interpretation is that about 64 percent of industries enjoyed real cost reduction during 1970–1975, with the remaining 36 percent suffering real cost increases (declining TFP). For the subsequent periods, the corresponding figures are 65(35) percent, 78(22) percent, and 82(18) percent. Here the first figure is the percent of industries enjoying real cost reductions; the figures in parentheses represent those experiencing declining TFP.

Some interest attaches to the ordinate of the maximum point on each curve. In the first period, TFP growth ended up accounting for close

¹ For a review of the current status of analysis of R&D expenditures and their impact on economic growth see Griliches (1994).

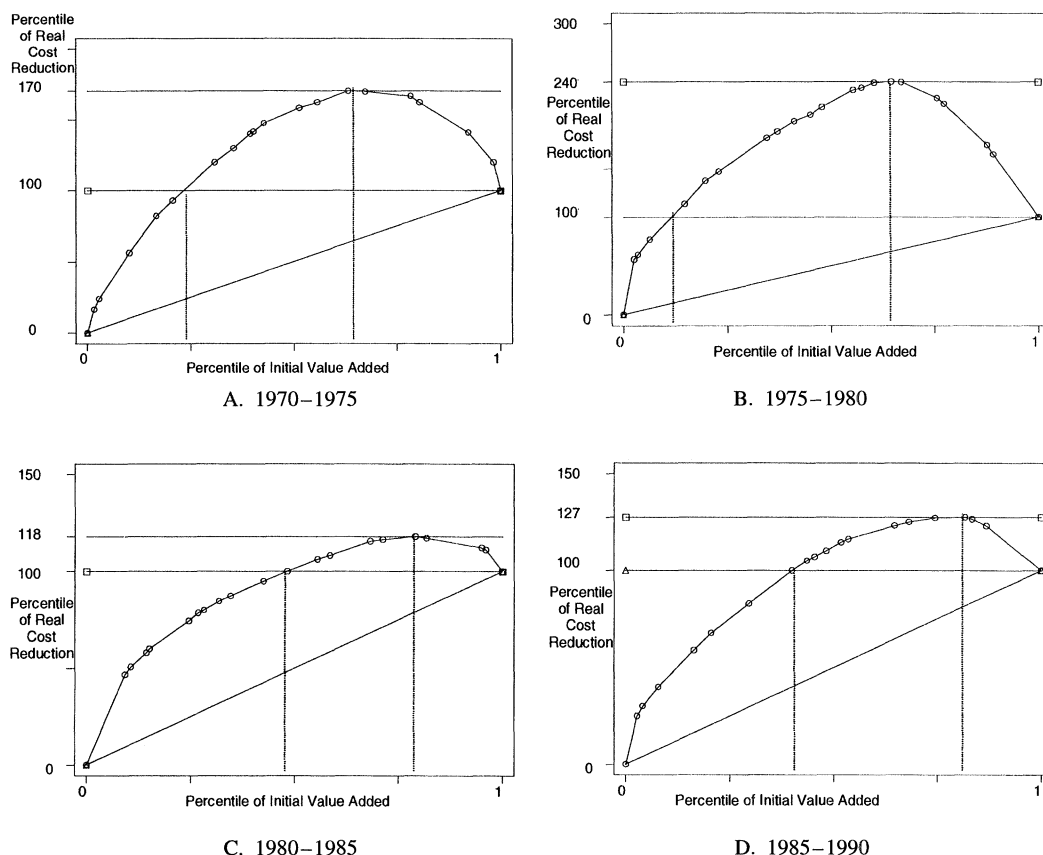


FIGURE 1. PROFILES OF TFP GROWTH AMONG U.S. MANUFACTURING BRANCHES

to 170 percent of the RCR for total manufacturing. In 1975–1980 this figure was about 240 percent, in 1980–1985 only about half that, and in 1985–1991 a little more than 125 percent. The trouble is that when the aggregate TFP contribution is relatively small, the cumulative total of the positive contributions is a large multiple of that aggregate, while when the aggregate is large, this multiple tends to be smaller. Thus, for 1970–1975 and for 1975–1980, the total RCR in manufacturing as a whole was only about 2.3 percent of initial manufacturing value added. In contrast, the total RCR for all manufacturing was almost 10 percent of initial manufacturing value added in 1980–1985, and about 7.5 percent in 1985–1991.

The problem obviously becomes greatly compounded if the real cost reduction for the aggregate (in this case total manufacturing) turns out to be negative. Special conventions would have

to be established to make clear the interpretation of Lorenz-like diagrams in such cases.

I believe I have hit on a felicitous way of solving all these problems, and at the same time creating an even better, clearer visual representation of the degree of concentration or dispersion of real cost reduction among the components of an aggregate. The idea is simply to relabel the vertical axis of the Lorenz-like diagram, making it represent an annual growth rate. For simplicity, think of a 30-degree line as representing 1 percent per annum of TFP growth. The rest of the vertical axis would be calibrated accordingly. Thus, by looking at the slope of a simple chord, we could visually assess how rapid was the TFP growth of the aggregate in question.

Figure 2 is presented simply for didactic purposes. Here we have a hypothetical industrial branch made up of four industries, A, B,

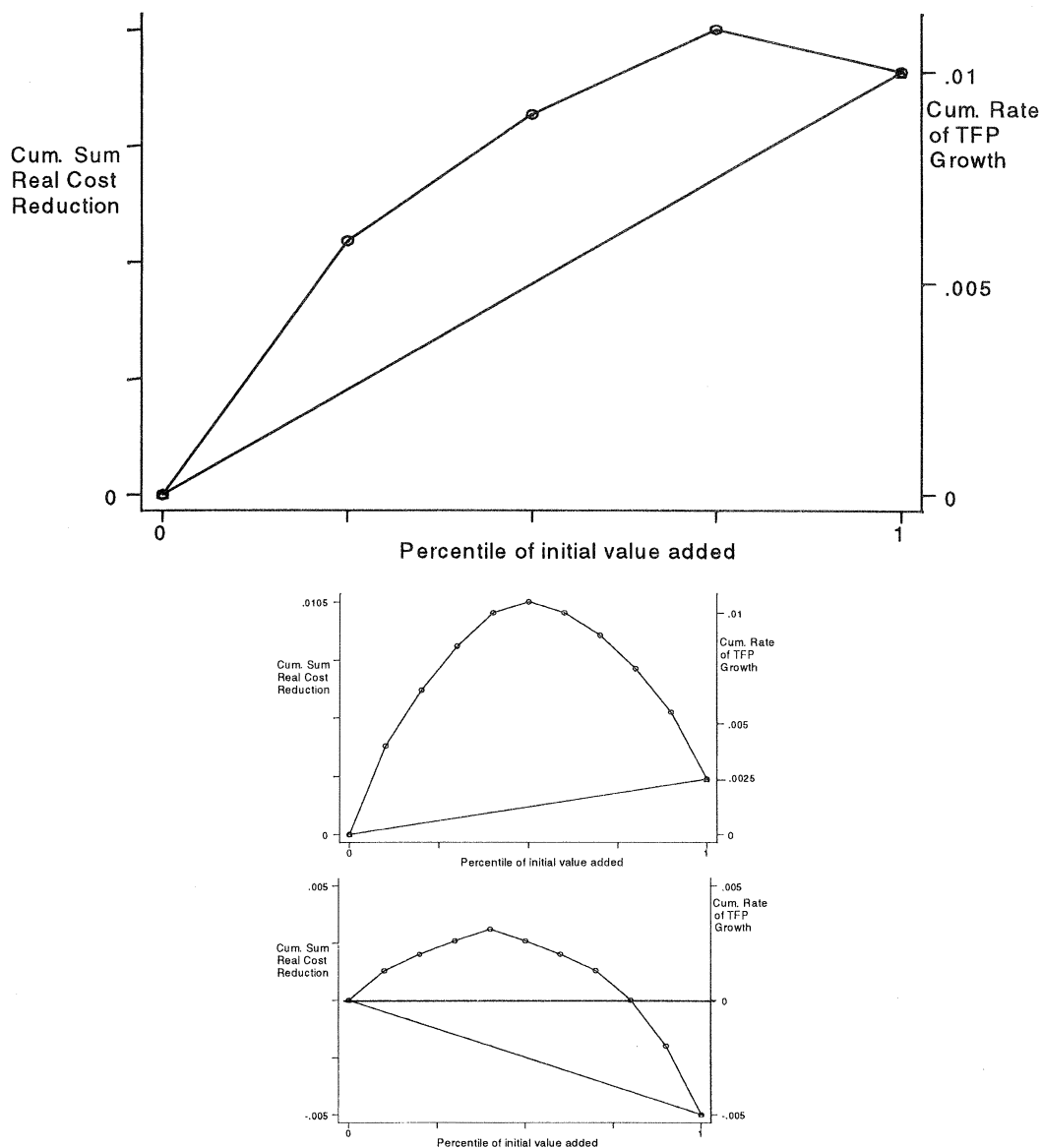


FIGURE 2. ILLUSTRATIVE TFP GROWTH PROFILES (SUNRISE-SUNSET DIAGRAMS)

C, and D. First, we order the industries in descending order, according to their rates of TFP increase in the period. Then we calculate cumulative real cost reduction (a real dollar amount) and plot it against cumulative initial real value added. Then we scale the vertical axis so as to comply with whatever metric we have decided upon for the TFP growth rate (in

the example, a 30-degree line representing a 1-percent annual TFP growth rate), and the horizontal axis so as to add up to 100 percent.

In the lower panel of Figure 2 I give examples to show how these diagrams cope with the problems of a low TFP growth rate (the overshoot for the case of 0.25-percent growth would show up peaking at over 400 percent in

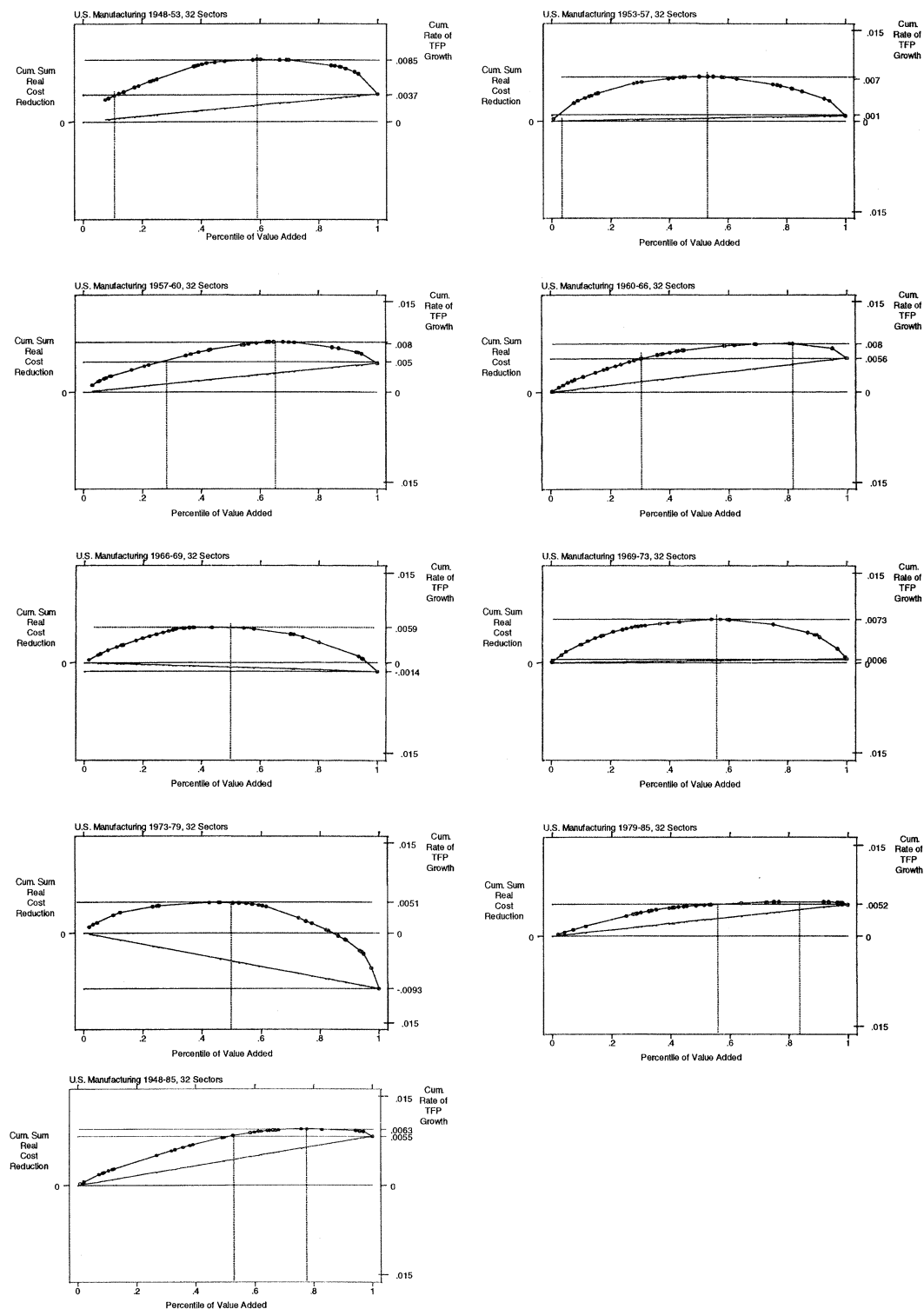


FIGURE 3. TFP GROWTH PROFILES FOR U.S. MANUFACTURING

a Lorenz-type diagram) and of negative TFP growth (where it is hard to even conceptualize a Lorenz-type picture).

I first presented these diagrams before a large audience at the Western Economic Association meetings in Seattle (July 1997), and for that presentation coined the label of “sunrise diagrams” on their analogy with the sun rising over a hill. That same evening Yoram Barzel suggested that where the aggregate slope is negative, we apply the term “sunset diagrams,” which I immediately accepted.

Figure 3 presents a set of sunrise-sunset diagrams based on Jorgenson et al. (1987 pp. 188–90). These cover 32 industrial sectors (their 35 minus Agriculture, Trade, and Government Enterprises). I think the utility of sunrise-sunset diagrams needs no further championing once these pictures are examined and digested. Practically all variants are represented in these real-world cases: low TFP growth with a huge overshoot (1953–1957 and 1969–1973); negative growth with large and moderate overshoots (1966–1969 and 1973–1979); moderate growth with small (1979–1985), medium (1960–1966), and large (1948–1953) overshoots.

One striking fact that emerges from this set of pictures is how variable across periods is the negative contribution of the losers. If the losers had only contributed zero change in TFP, we would have had cumulative TFP contributions of about 0.8 percent per annum in 1948–1953, in 1957–1960, and in 1960–1966. And the other periods would not have been much different: about 0.7 percent in 1953–1957 and in 1969–1973, 0.6 percent in 1966–1969, and 0.5 percent in 1973–1979 and 1979–1985. Instead of this narrow range of cumulative contributions, we have an actual distribution that goes from –0.9 percent in 1973–1979 through around 0.1 percent in 1953–1957 and 1969–1973 to over 0.5 percent in 1960–1966 and 1979–1985.

Does this not suggest that we make a major research push trying to improve our understanding of the phenomenon of negative TFP growth? What syndromes characterize the firms and industries experiencing it? How much of it stems from external shocks like international prices? How much of it from competition within the industry? How much of it represents firms struggling to survive, yet experiencing

output levels well below their previous peaks (and presumably below installed capacity)? How much of it represents things like “labor hoarding” as firms go through periods of adversity?

II. Yeast versus Mushrooms: Part II

I hope that in the previous section I have made a convincing case concerning: (a) the usefulness of sunrise-sunset diagrams, (b) the aptness of the “yeast versus mushrooms” dichotomy, and (c) the pervasiveness with which the mushroom side of that dichotomy seems to come out ahead when the GDP is broken down into industries or industrial branches for TFP analysis. The grand design that emerges from the studies reported here, and from just about all the other industry breakdowns that I recall having seen, is that: (i) a small-to-modest fraction of industries can account for 100 percent of aggregate real cost reduction in a period; (ii) the complementary fraction of industries contains winners and losers, the TFP contributions of which cancel each other; (iii) the losers are a very important part of the picture most of the time, and contribute greatly to the variations we observe in aggregate TFP performance; and (iv) there is little evidence of persistence from period to period of the leaders in TFP performance.

The above results are, I think, very interesting (in the sense of piquing our curiosity), very strong (in terms of their implications about the nature of the growth process), and very robust (in the sense that they have wide applicability over different data sets analyzed by different authors using at least somewhat different methods). But these results, so far, are quite compatible with what I might call an “industry view” of the TFP story. This is the way I, myself, looked at the growth process until quite recently—a vision that was reflected in my stories about rubber tires and autos in the 1920’s, refrigerators and other household appliances in the 1930’s, pharmaceuticals in the 1940’s, etc. The image that I had in mind was one of yeast within each industry and mushrooms between industries—a commonality of TFP experience by firms within an industry, depending on that industry’s

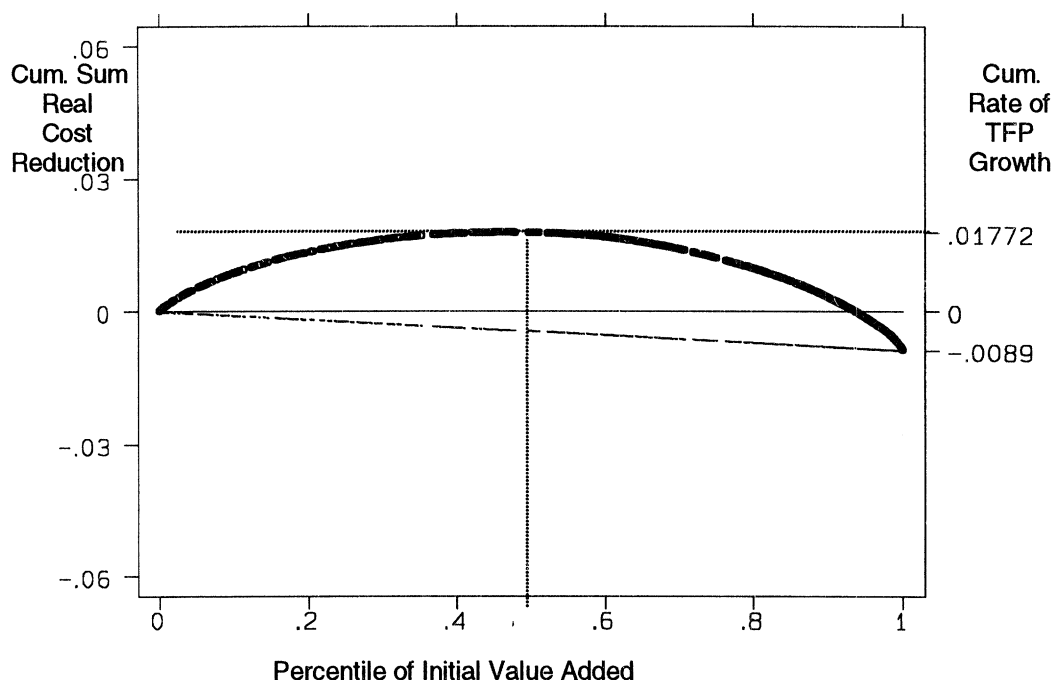


FIGURE 4. TFP GROWTH PROFILE IN MEXICAN MANUFACTURING SECTOR (1892 ESTABLISHMENTS, 1984–1994)

luck in the technological draw, side by side with highly diverse experience between industries because the distribution of technical advances had wide dispersion, even for periods as long as a decade.

Getting access to data at the firm level permits one to explore whether this view is compatible with the actual experiences of firms and industries. We are just in the early stages of this exploration, but I think the result is quite clear already; namely, the “mushrooms” story prevails just as much among firms within an industry as it does among industries within a sector or broader aggregate. I will present here only a taste of the evidence from the United States (on which our systematic work just recently got started). Our massive evidence comes from the Mexican manufacturing sector, for which Leonardo Torre (1997) has analyzed data from a sample of over 2,000 firms. A small fraction of these firms were lost owing to missing data, but some 1,900 firms remained in the sample that Torre finally worked with. These firms were divided into 44 branches of industry, so that on average we have about 43 firms per branch.

There are really too many ways to present such a mass of information as is contained in Torre’s study. What I will do here is give the aggregate picture in Figure 4, and then show in Figures 5A–C three fast-growing branches, three of around median growth, and three from among the slowest-growing branches.

To complement these figures, I finally present, in Figures 6A–D, certain summary statistics from the sunrise-sunset diagrams of the 44 branches that Torre studied. Here Figure 6A gives the distribution of average rates of TFP growth among the 44 industries. Figure 6B shows the distribution of peak cumulative contributions, i.e., what the TFP contribution would have been had all the negatives been zeros. Figure 6C displays the percentile of firms (by initial value added) marking the borderline between positive and negative TFP growth. And finally, Figure 6D shows, for branches with positive TFP growth, the percentile of firms which, by themselves, account for 100 percent of the industry’s TFP growth.

This evidence almost seems to replicate, for firms within an industry, what was found in the previous section for industries within the

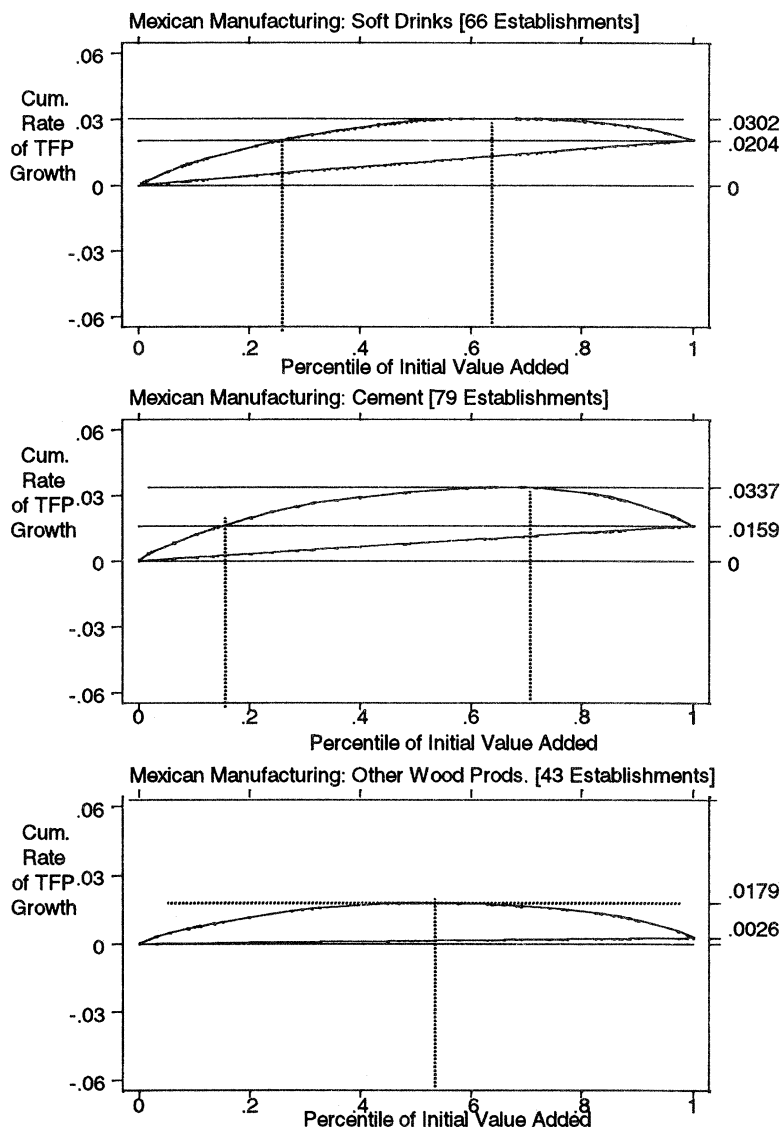


FIGURE 5A. TFP GROWTH PROFILES FOR FAST-GROWING BRANCHES (MEXICAN MANUFACTURING, 1984-1994)

economy—rampant overshooting of sunrise-sunset diagrams, great influence of firms with negative TFP growth in determining the TFP outcome for an industry, and a small or moderate fraction of firms accounting for 100 percent of the TFP growth of an industry (when that growth is positive), with the complementary fraction being winners and losers whose efforts end up just offsetting each other. It re-

mains to try to give some interpretation to those results.

III. "Just Errors" or "It's a Jungle Out There?"

The first question that will enter the mind of many economists on looking at the evidence presented so far is: how much of what

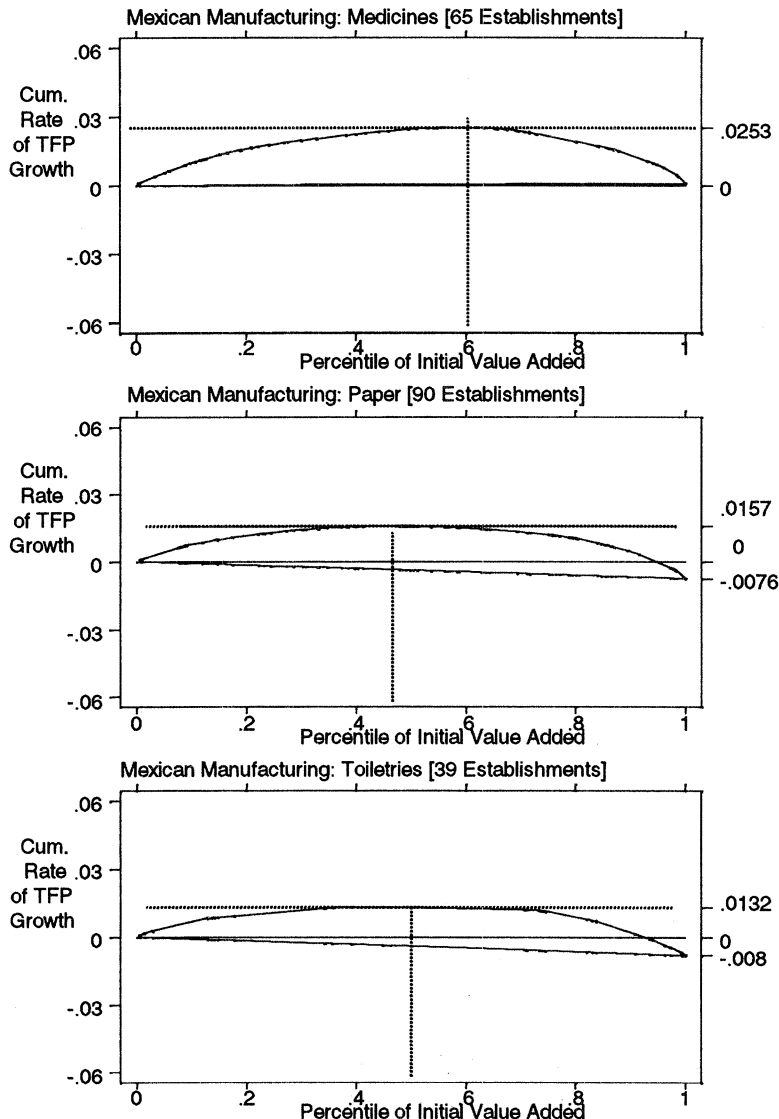


FIGURE 5B. TFP GROWTH PROFILES FOR MEDIUM-GROWING BRANCHES (MEXICAN MANUFACTURING, 1984–1994)

we have seen and emphasized might simply be the result of errors of observations? This is by no means a frivolous question. For one can actually create frequency distributions of rates of TFP increase which contain exactly the same information as the sunrise-sunset diagrams previously presented. The only trick is to count as the unit of frequency not one firm (out of an industry aggregate) or one industry (out of some larger aggregate)

but, instead, say, 1 percent of the total value added of the aggregate. Thus a firm with 20 percent of the value added of an industry would appear with 10 times the weight of a firm accounting for 2 percent of the value added of that industry. In such a chart, the cumulative frequency (say, 68 percent) above $\Delta TFP = 0$ would represent the projection on the horizontal axis of the maximum point on a sunrise diagram. Its

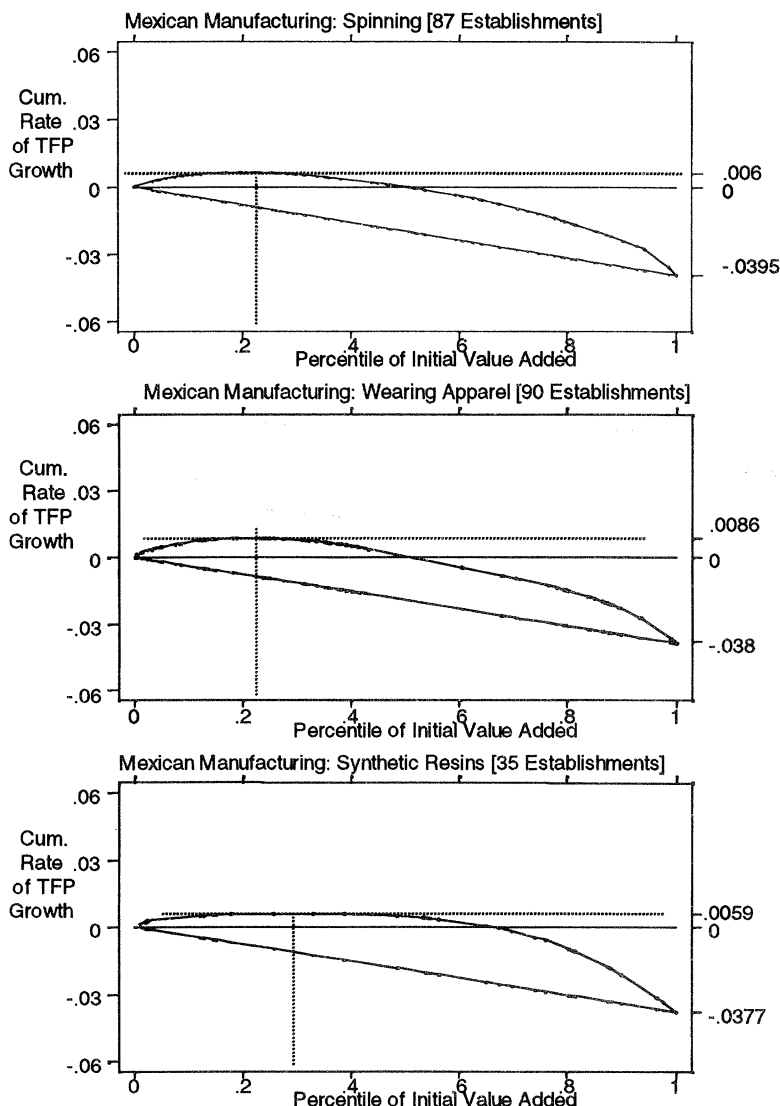


FIGURE 5C. TFP GROWTH PROFILES FOR SLOW-GROWING BRANCHES (MEXICAN MANUFACTURING, 1984–1994)

complement (32 percent) would represent the initial value added associated with negative TFP performance during the period.

If, then, all the information could be generated by a properly designed frequency distribution of rates of TFP growth, could it not all be the result of chance alone—more specifically, of errors of measurements? I really think not—my favorite quip on this is that “white noise does not sing a tune.” That is, if we can rationalize what we see in terms of an

analytical framework which embodies well-established economic principles and sensible presumptions about underlying relationships and facts, this is itself strong evidence against the white noise hypothesis.

Nonetheless, we have to face the fact that errors of observation of some magnitude certainly do exist, and we must recognize that they can cloud our perceptions and bias our results. What I am going to do here is consider frequency distributions of firms. TFP is mea-

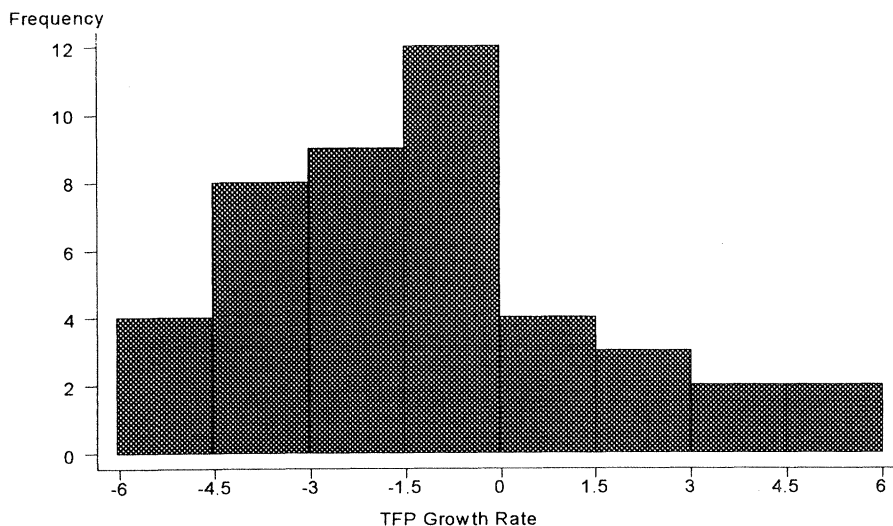


FIGURE 6A. AVERAGE ANNUAL TFP GROWTH RATE: MEXICAN MANUFACTURING 1984–1994
FREQUENCY DISTRIBUTION, 44 INDUSTRIAL BRANCHES

sured in two ways—one using value added by a set of firms on the one hand, and the other using “output” by those same firms, measured through dividing value added by separate estimated firm-by-firm price (of value added) indexes p_j . For these purposes we can conveniently think in terms of *logarithms*, so let:

v_j = observed value added of firm;
 p_j = estimated firm-level price index;
 $y_j = v_j - p_j$ = estimated output;
 $v_j = T_j + e_j$ [T_j = true value added];
 $p_j = \pi_j + u_j$ [π_j = true price index]; and
 $q_j = T_j - \pi_j$ [true output of firm].

We would like to have data on \dot{q}_j and its variance

$$\sigma_{\dot{q}}^2 = \sigma_{\dot{T}}^2 - 2\sigma_{\pi\dot{T}} + \sigma_{\pi}^2.$$

If we simply work with observed value added as our quantity variable, we get

$$\sigma_v^2 = \sigma_T^2 + \sigma_e^2 \text{ (assuming } \sigma_{Te} = 0 \text{)}.$$

If we worked with the measured y_j , we get

$$\sigma_y^2 = \sigma_T^2 + \sigma_e^2 + \sigma_u^2 + \sigma_{\pi}^2 - 2\sigma_{T\pi}$$

(assuming \dot{u} and \dot{e} to be strictly random).

My presumptions are as follows:

- (i) We can estimate value added quite accurately at the firm level. Hence the presumption that σ_e^2 is small.
- (ii) In most industries, there is considerable variety among the firms and their products. Hence, except in cases of industries with very homogeneous products, we should not expect σ_{π}^2 to be small. Hence, I expect $\sigma_{\pi}^2 > \sigma_e^2$.
- (iii) Finally, we have the presumption that, at least at the level of firms within an industry, $\sigma_{\pi\dot{T}} < 0$. We know that firms choose to operate in regions of the demand curve where they consider the elasticity facing them to be greater than one. But also, in an analysis of the growth process, one would expect the big gains in value added to accrue to those firms in an industry which were passing along to consumers some of the fruits of current or past real cost reductions.

These three presumptions lead me to the conclusion that σ_v^2 is likely to understate the true variance of output σ_q^2 (because $-2\sigma_{\pi\dot{T}} > 0$ and $\sigma_{\pi}^2 > \sigma_e^2$), and that σ_y^2 is likely to overstate σ_q^2 (only the covariance terms with \dot{e} and \dot{u} , which were assumed to be zero, could make it otherwise). And since Torre worked with real

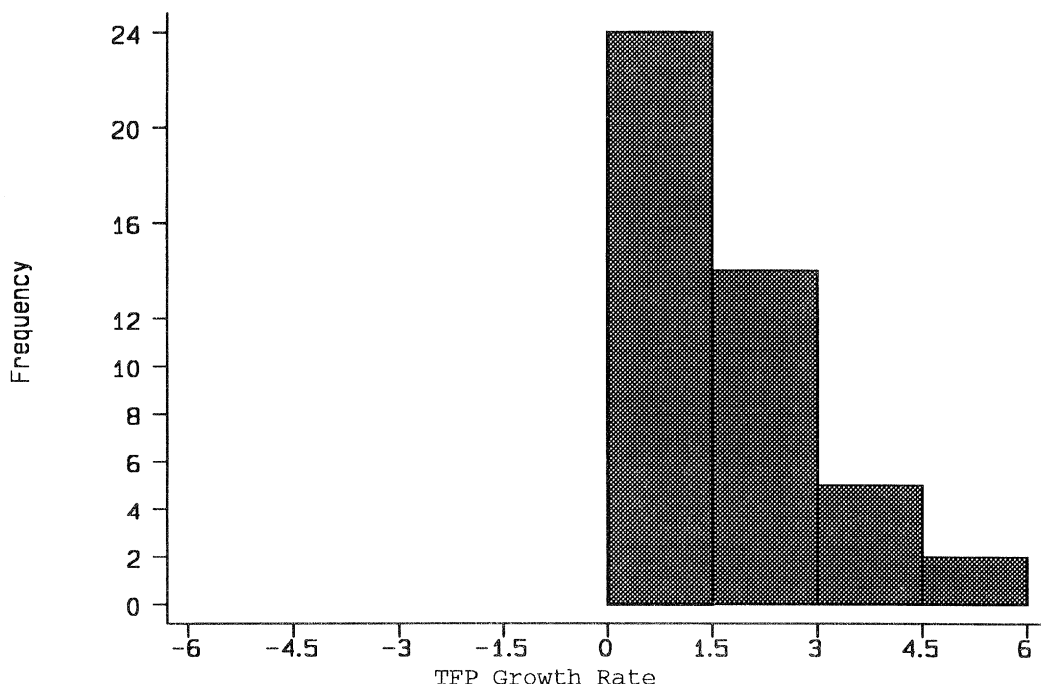


FIGURE 6B. MAXIMUM AVERAGE ANNUAL TFP GROWTH RATE (MAX. ORDINATE OF TFP PROFILE):
MEXICAN MANUFACTURING, 1984–1994
FREQUENCY DISTRIBUTION, 44 INDUSTRIAL BRANCHES

value added as his quantity variable, this suggests that, if anything, the substitution of the “true quantity variable” q for observed value added v would have given results with greater dispersion of TFP, and consequently greater overshooting in his sunrise-sunset diagrams.

The above demonstration should be taken as merely suggestive. It is not important to me that Torre’s results underestimate the variability of the different firms’ TFP experience. It is only important that measurement error should not be the principle determinant of those results. On this I feel very confident. In my view, it really is “a jungle out there,” with winners and losers in every period—good as well as bad.

As I have noted earlier, we are only just beginning a systematic study of TFP among U.S. firms, so I can offer no display comparable to Torre’s.

However, Robles (1997) did examine the experience of 12 firms in the U.S. oil industry. His results are summarized in Figure 7. But

Robles tells basically the same story as Torre. Three firms out of the 12 were more than sufficient to generate the real cost reduction experienced by the total group. Half (or almost half) of the firms had negative TFP growth in each period. And the cumulated amount of this negative TFP growth was sizeable when measured against the total TFP performance of the industry.

What I see in TFP performance is quite analogous to what I see in the stock market pages of the newspaper. There are winners and losers every day, every month, and every year. The gains and losses come from all sorts of causes. World price shocks can drive firms into negative TFP performance if the consequent output reductions are greater than the reductions of inputs. So, too, can cyclical or secular declines in demand, including those caused by the successful actions of competitors.

When firms are under stress, they typically fight to stay alive. Maybe they fight for too long in some cases, in the sense that less of society’s resources would be wasted if they

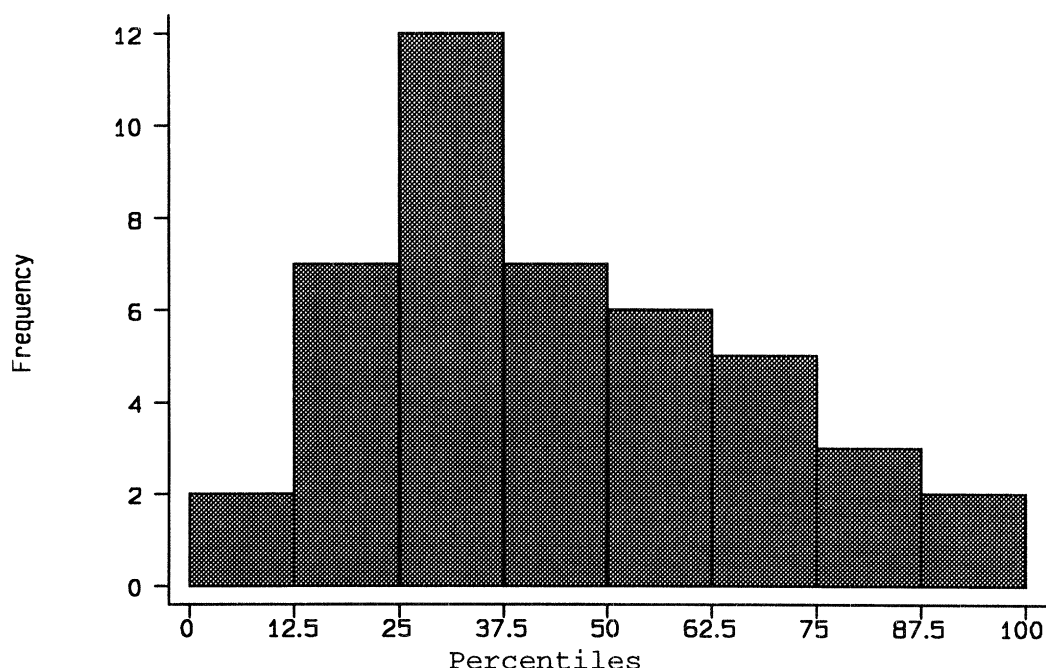


FIGURE 6C. PERCENTAGE WITH POSITIVE TFP GROWTH: MEXICAN MANUFACTURING 1984–1994
FREQUENCY DISTRIBUTION OF PERCENTILES, 44 INDUSTRIAL BRANCHES

were to quit earlier in response to a challenge that turns out to be deadly. But they do not recognize the challenge as deadly, so they keep struggling to survive. I believe this is part of the nature of entrepreneurs, CEOs, and business leaders in general. They would not be where they are, doing what they are doing, if they were ready to quit at the first sign of a challenge. They are fighters by nature, and they probably would not have achieved success if they were not.

Firms with negative TFP growth may even be innovators. New challenges come and different firms think of different ways to respond to them. Some (like Intel and Microsoft) end up winners; others (Montgomery Ward and Apple?) end up losing. But it may not be that they just waited passively and tried to fight to survive in the face of negative shocks. They may have had quite innovative ideas, with decent prior probabilities of success, but in the end success did not come. Thus, negative TFP performance can, and I believe often does, come simply from “backing the wrong horse.”

To me, Joseph A. Schumpeter’s vision (1934) of “creative destruction” captures much of the story. What he is saying is, yes, it’s a jungle out there, but the processes of that jungle are at the core of the dynamics of a market-oriented economy. They are what got us to where we are, and they hold the best promise for further progress in the future.²

In my opinion, Schumpeter saw through to the essence of the problem, but it is not wise for us to be fatalistic in accepting his vision. We cannot lose by making a major effort to understand the process of TFP improvement where it happens—at the level of the firm. This is all the more true because of the

² The idea of creative destruction has come up in recent literature, in a context of formal modeling as distinct from this paper’s focus on growth accounting and the intuitive economic interpretation of its results (see Gene M. Grossman and Elhanan Helpman, 1991, 1994; Philippe Aghion and Peter Howitt, 1992). For an econometric study emphasizing the variability of performance among firms, see Jacques Mairesse and Griliches (1993 pp. 200–04).

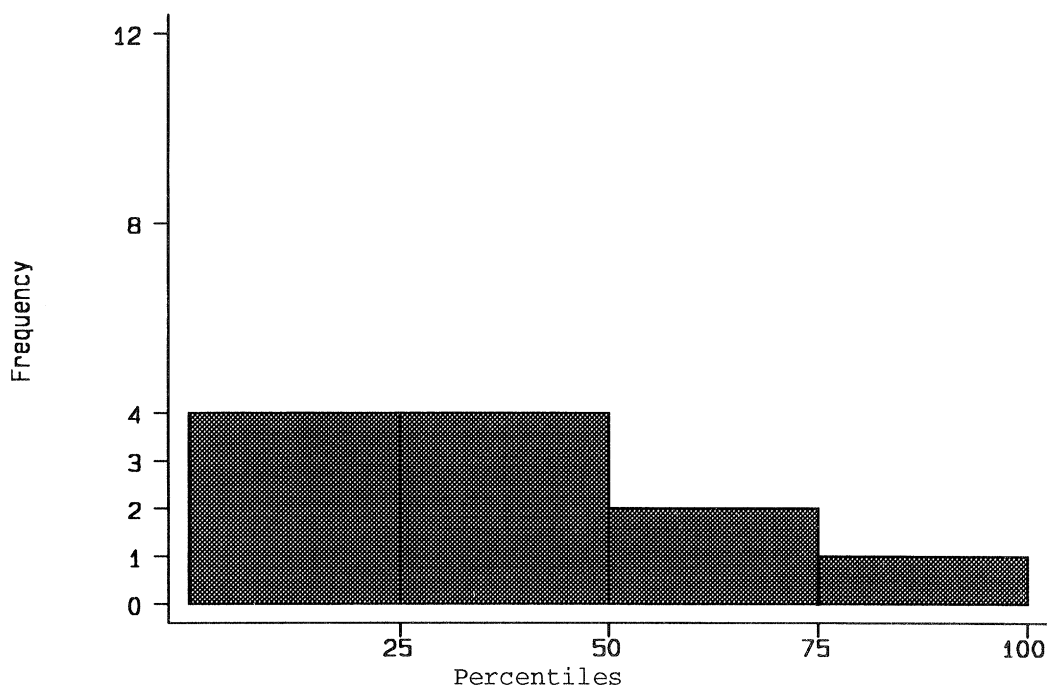


FIGURE 6D. PERCENTILE WHERE CUM. SUM TFP CONTRIBUTION = 100 PERCENT:
MEXICAN MANUFACTURING 1984–1994

pervasiveness of negative as well as positive TFP performance among the components of almost any aggregate. By learning more about this aspect of the aggregate picture, we may stumble upon ways to “accentuate the positive and eliminate the negative” parts of the TFP story. But that is too quixotic a goal to take as the point of focus right now. To me, the present task is simply to get hold of the huge mass of information that is available at the firm level and squeeze it hard enough to wring out as much understanding and as much insight as we can.

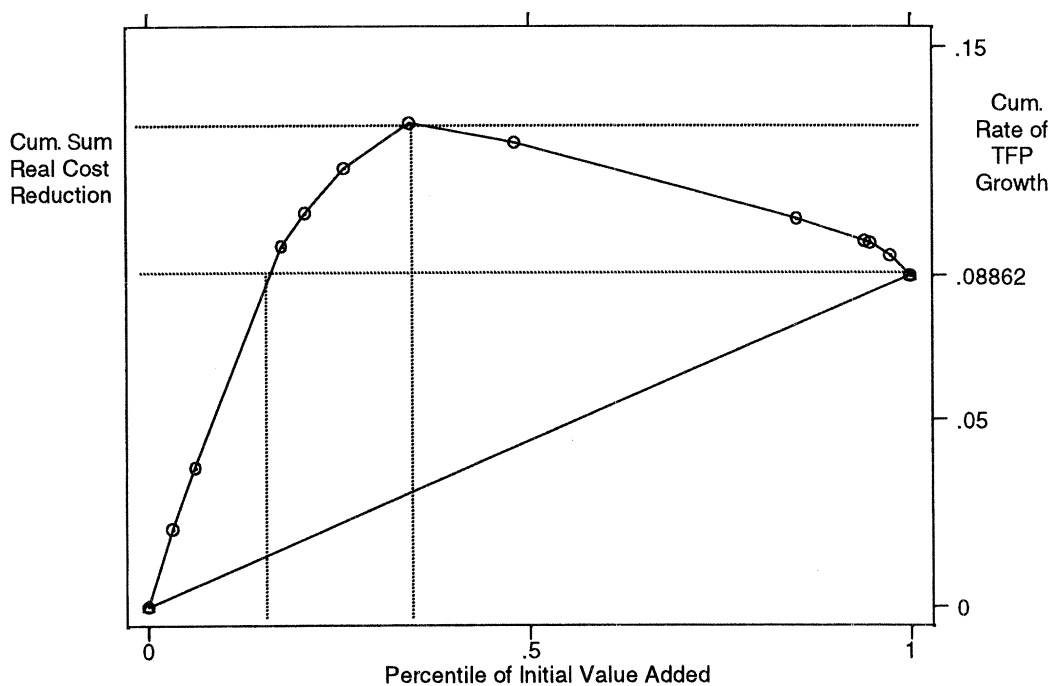
IV. Some Observations on Methods and Research

What I am about to say in this section is not meant to consist of direct implications of what has gone before. Instead, I think of the earlier parts of this paper as building a case for a certain vision of the economy, and of how the forces of growth work within it. This vision in turn leads one to think in different ways not

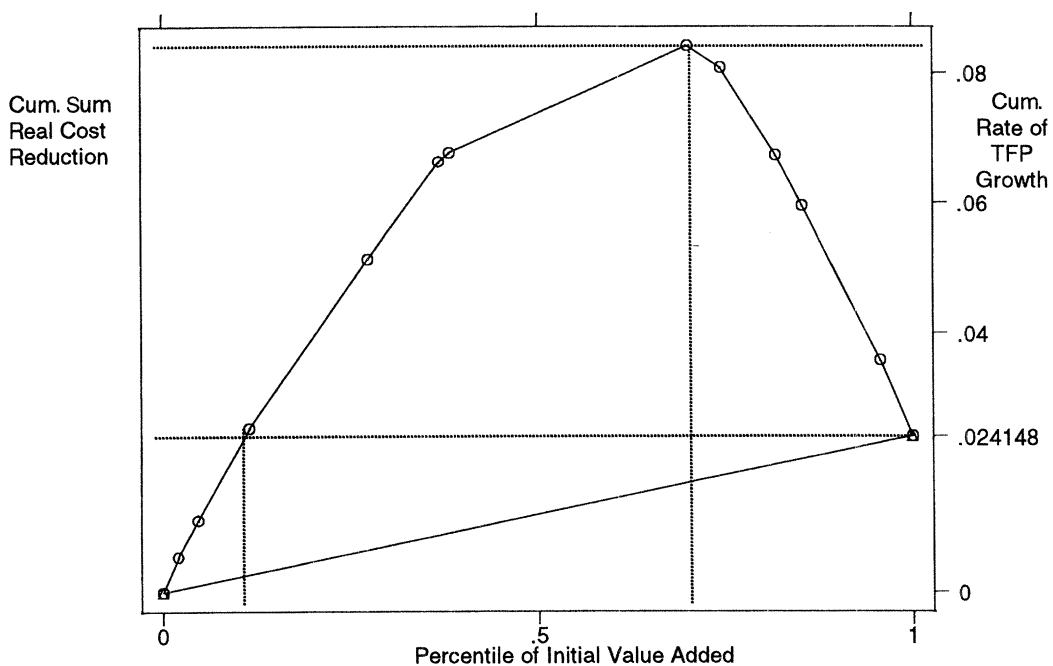
only about the growth process itself but about how we, as economists, might best advance our study and understanding of it, and how policies might be molded so as better to promote it.

(a) *It is always wise to study the components of growth separately.* The rate of investment, the rate of return on capital, the rate of growth of the labor force in numbers or in hours worked, the contribution of human capital or of the increment in average quality of labor, and the residual representing real cost reduction—all these are sufficiently different, and potentially sufficiently disjoint from each other, to merit their being treated separately. I would give special emphasis to the following three points.

- (i) The worthwhileness of measuring the rate of return and emphasizing its role in the growth process.
- (ii) The importance of focusing on investment rather than saving in studying the



A. 1970-1981



B. 1982-1994

FIGURE 7. TFP GROWTH PROFILES FOR U.S. OIL FIRMS

process of growth. Saving is an interesting topic in its own right, but the more “open economy” is the situation being studied, the less saving has to do with investment. Saving takes on great importance in closed-economy models focused on aggregate growth, in which case it is equal to investment. It gets to be almost meaningless as one focuses on the growth of cities and regions, or on firms and industries.

- (iii) The importance of viewing the residual as an umbrella covering real cost reductions of all kinds, and of recognizing that we are closer to home thinking that RCR takes 1001 forms than that it can be well represented by one or two or three aggregate-style variables.

(b) In principle, *the accumulation of human capital by the labor force should be represented in the labor contribution* of the growth equation, or in a bifurcation of this contribution into one due to raw labor, the other to human capital. It is in a term like $\sum_i w_i \Delta L_i$ that one captures the shifting skill composition of the labor force. In particular, we capture here the higher wages that are the fruits of investment in education and training, which are the benefits that the workers themselves perceive. These should be kept separate from any externalities education might have.

It is important to try to keep this internalized part of the story out of the residual, so that we can straightforwardly interpret the residual as real cost reduction.

(c) *To study externalities due to education, training, or human capital, we should not be content with broad generalizations* such as “TFP growth is higher in entities with lots of human capital per worker.” We should try to figure out how this externality works. Is it higher for *firms* with high incidence of human capital? Is it higher for industries or sectors? Or are human capital externalities more spatial in nature, making more efficient the economic life of the cities, provinces, states, or nations which have high concentrations of human capital? And if this is a fruitful trail to pursue, at what type and size of geographical units do these externalities typically work?

(d) The same goes for economies of scale. *We should not be satisfied with vague attributions of economies of scale, say, at the level of the national economy.* Instead, we should pursue the matter. If the economies of scale are national, through what channels do they work, and what evidence do we have to look at to see them in operation? In particular, what is their connection to real cost reductions where they really happen—i.e., at the level of the firm? Economies of scale at the levels of the firm and the industry are easier to visualize. Here, too, however, the task is to check them out—to see if the real cost reductions of firms are linked to the initial sizes of those firms themselves, or of the industries in which they operate, and of the direction (up or down) in which output is moving.

(e) Perhaps most important of all, we should really try to *take full advantage of evidence at the firm level.* I think particularly of identifying considerable numbers of outstanding cases of TFP improvements and TFP decline, and studying them one by one to try to ferret out the sources of their big real cost reductions and real cost increases. You can be pretty sure, if there have been big real cost reductions in a firm, some people in that firm have a pretty good idea of where those reductions came from and how they were accomplished. By capturing this grassroots evidence, we can put some added discipline into our ruminations about the nature of TFP at the aggregate level. We must follow up on the sort of work pioneered by Jacob Schmookler (1966) and Edwin Mansfield (1995). In general, our aggregate story should be compatible with, and comfortably contain, what we see at the grassroots level. In particular our overall picture of TFP improvement should comfortably accept the overwhelming evidence of the “mushrooms” rather than “yeast” nature of the process.

(f) *Special urgency applies to the study of declining total factor productivity at both the firm and the industry levels.* The pervasiveness of declining TFP is perhaps the most profound conclusion to emerge from the empirical links that I have reported here. As a profession, we obviously have been aware of its existence at the industry level for virtually all studies that

give a breakdown by industry reveal it. Yet to my knowledge, we have barely scratched the surface in studying it. I find it hard to think of more fertile soil for future research on the process of economic growth.

(g) I do not think that we gain much by trying to express the relation between policies and economic growth by a series of regressions. *Cross-country growth regressions seem hopelessly naive* to longtime observers of the growth process like myself. To us, there is too much to question in regression lines that draw much of their slope from the differences between Sudan and Switzerland, between Bangladesh and Brazil, or between Ceylon and Canada. In contrast, it seems much more sensible to look at episodes within individual countries and to search for common elements that characterize the passage from bad to good growth experiences within each of the number of countries, and for those elements that seem to describe the good growth experiences on the one hand and the bad ones on the other. I think we can reach in this way a good appreciation of the nature of the growth process, without resorting to the straitjacket of regression lines that seem to draw from comparisons among very disparate countries, lessons that are supposed to be meaningful for countries like Bangladesh, Ceylon, and the Sudan—as well as others at different levels—as each strives to take the next upward step in the climb toward modernization.

My view of cross-country growth regressions is somewhat less negative to the extent that they focus on the components of growth (rate of investment, rate of return, and real cost reduction in particular) rather than on the overall growth rate. There is also a subtle distinction to be drawn between two ways of presenting cross-country regressions—(i) as “explaining” why and how some countries grow faster than others (not recommended), and (ii) as simply summarizing a series of “stylized facts” describing the experience we observe (far preferable, and not just for its being more modest in its claims).

V. Some Policy Implications

In approaching the question of the influence of policy on real cost reduction in particular,

and, to a degree even on economic growth in general, I believe that the key words are “obstructing” and “enabling.” We know from sad experience how easy it is for governments to adopt policies that get in the way of economic growth and even turn it negative. We know, too, that there is no “silver bullet,” no single magic key that by itself opens the door to a paradise of prosperity and growth. Broadly speaking, the easiest starting point for a successful growth experience is a once-prosperous economy that has suffered from bad policies. Releasing that economy from its trammels, correcting an accumulation of past mistakes, can sometimes set in motion a prolonged episode of astounding growth. A shift from policies that obstruct to policies that enable growth seems to lie at the heart of growth “miracles” like those of Taiwan, Spain, Korea, Brazil, Indonesia, Malaysia, and China (among others).

The springboard for the following listing of policy implications is the interpretation of the growth residual as representing real cost reduction and the ready acceptance that in the real world RCR comes in 1001 different forms.

(a) The first key observation is that *people must perceive real costs in order to reduce them*. Hence, policies that impede the accurate perception of real costs are ipso facto inimical to growth. *Inflation* is the most obvious, probably the most pervasive, and almost *certainly the most noxious of such policies*. If I have any expertise based on experience in economics, it has to be in the first-hand observation of processes of serious inflation. So I ask you to take my word for it: the most serious cost of inflation is *not* a triangle or a trapezoid under the demand curve for real cash balances, nor is it the inflation tax. The most serious cost of inflation is *the blurring of economic agents' perceptions of relative prices*. This happens because individual prices adjust in different ways and at very different rates. A high product price and a low input cost normally is an invitation clamoring for new investments to be made. This is not so during a serious inflation, when such a signal can easily turn out to be “here today, gone next month” as both product and input prices continue on their separate paths of adjustment to

the ongoing inflation. Without exception, in my own observations, the higher the rate of inflation, the worse is its effect in blurring agents' perceptions of relative prices. In an inflation at, say, 20 percent to 50 percent per year, people see prices as in a morning haze; in one of 20 percent to 50 percent per month, they see them as in a London fog. Many empirical studies exist showing that serious inflations are seriously inimical to growth. (See William Easterly, 1996.) The clouding of perceptions of relative prices is an important reason why—for it gets in the way of successful real cost reductions at the level of the individual firm.

Inflation also inhibits growth in other, perhaps more obvious ways:

- (i) by diverting energies from more productive activities to the search for mechanisms of inflation protection;
- (ii) by reducing (often very drastically) people's real monetary balances, thus impacting negatively on the real amount of credit the banking system provides to the productive sector; and
- (iii) somewhat related to both (a) and (b), by causing people (both "here" and abroad) to invest abroad some of the funds they would otherwise have invested "here," or (what is very close to the same thing) by accumulating hoards of hard currencies as an inflation hedge.

(b) A second policy implication is, in the words of my friend and longtime collaborator Ernesto Fontaine, *avoid "prices that lie" (precios mentirosos)*. Talking about inflation, we focus on the blurring of the signals that the price system gives; here we focus on its giving wrong signals due to distortions that have been introduced, usually as a direct consequence of government policies. No good can or did come, in terms of economic efficiency, from tariffs of 50 percent and 100 percent and more, giving effective protection often of 200 percent and 300 percent and more. Nor can growth be fostered by heavy-handed price controls and interventions in credit markets.

I am not being a religious purist here—just as big distortions have big costs, small distor-

tions typically have small costs, and all economies are distorted to some degree. The message here is *that economies have to pay the price for the level of distortions they choose to have*, and that one of the important components of that price is that *distortions create situations where what is truly a saving of private costs is not a genuine saving of costs from the point of view of the economy as a whole*.

(c) Just as bad, and often even worse than direct distortions, are the excess costs imposed on an economy by *ill-conceived regulations and bureaucratic hurdles*. Hernando DeSoto (1989) has made the exposure of these trammels in Peru into what has become virtually his life's work. Clear rules of the game are an essential and integral part of a well-functioning market economy, but all too easily these get supplemented by others that make investment, production, marketing, sales, new product development, etc., more costly. Labor laws have been particularly troublesome, often adding artificially to the cost of labor and giving firms a strong incentive to avoid hiring new workers, simply because of the high costs associated with any later dismissal of them.

But there are loads of other items—the *need for approvals*, sometimes a dozen or more, before undertaking some investment or some new venture; regulations that one way or another impede new entry, so as to protect strong vested interests (small retailers being protected against supermarkets in many countries); and the complexity of tax codes and their enforcement, which imposes large compliance costs on business firms and individuals. Somehow, countries interested in promoting growth should find ways of paring their regulatory frameworks down to those rules and requirements that are really justifiable in terms of their costs and benefits to the economy and society at large.

(d) Although *international trade distortions* (tariffs, quotas, licenses, prohibitions, etc.) might be subsumed under points (b) and (c), their importance merits a separate heading. The move to openness (from a protectionism that sometimes bordered on autarchy) has been one of the main hallmarks of the growth miracles of the past half-century [see

Sebastian Edwards (1993) and Anne O. Krueger (1985, 1997)]. Just as inflation has costs beyond the area under the demand curve for real cash balances, so protectionism seems to have burdens that go beyond the standard triangle-trapezoid-rectangle measures of the costs of trade distortions. There are at least two quite natural explanations: first, that openness helps grease the wheels of the international transfer of more modern technologies, and second, that firms that may once have relaxed in ease and comfort behind high protective barriers end up having to sink or swim once forced to compete in a much more open-economy setting. Under either explanation, trade liberalization opens up new paths of real cost reduction, thus providing additional impetus to economic growth.

(e) The recent wave of *privatizations* among both developed and developing economies may have important effects in enabling real cost reductions that otherwise might have been delayed, or not have happened at all. It is, I believe, fair to say that in most countries state-owned enterprises operate under a series of constraints that seriously get in the way of real cost minimization in a comparative-static sense and of real cost reduction in a dynamic sense. These constraints sometimes limit the salaries of executives, sometimes impose onerous conditions on the firm as it employs lower-skilled workers, often limit the capacity of the firm to shut down inefficient lines of production, and almost always make it difficult to fire workers, etc. To my mind, however, perhaps the worst attribute of state-owned enterprises is the ethos that often evolves inside of them—an ethos where middle managers are well advised to “leave well enough alone,” “not rock the boat,” and “not invite trouble.” This ethos flies in the face of a vision of the growth process that gives a huge role to the search for real cost reductions at the grass-roots level, and that recognizes the tumult that accompanies “creative destruction” in all its forms. I thus must applaud the contemporary trend toward privatization. If I harbor any qualms in this connection, they concern the degree to which many privatizations have been carried out in too much haste and with too little care, often motivated by purely fiscal considerations rather than by a general search for

economic efficiency. This may have led to gratuitous transfers of wealth in some instances and to the planting of newly private enterprises in soil that was not properly prepared (e.g., still lacking a sound regulatory framework for electricity rates, or intelligent rules promoting competitiveness in at least some aspects of telecommunications, etc.)

(f) One cannot complete a list like this without mentioning something that most of us simply take for granted—a *sound legal and institutional framework in which individuals are protected against arbitrary incursions on their property and other economic rights*. This very basic point—recently much emphasized by Douglass C. North (1990), Robert J. Barrow and Xavier Sala-i-Martin (1994), Mancur Olson, Jr. (1996), and Barro (1997)—is at least potentially a vital element for a sustained process of successful economic growth. If it is true that spurts of growth have sometimes occurred in the absence of such a framework, it is also true that most cases of sustained growth over long periods of time have benefitted from a sound institutional and legal environment.

(g) Somewhat related to the above is the element of *political consensus concerning the broad outlines of economic policy*. We have learned from experience that very admirable policy reforms can take place, yet end up having little effect. This can happen because a new government comes in and reverses the reform. But it can also happen because people fear that a new government will come in and reverse the reforms later on. At the moment, the Chilean economy is one of the jewels of economic growth (and general economic success) in Latin America. Many people point to the thoroughness and pervasiveness of Chile’s economic reforms over the last two decades or so. But not so many point to the fact that the reform package has remained essentially intact through several changes of ministers, and even more important, through two presidential elections in which the winners came from the opposite side of the political fence from the government that initiated the reforms. The confidence in the economic order of things instilled by this sequential endorsement of the basic framework of economic policy has to be

one of the important reasons for Chile's continued, very impressive economic performance. And it is important, also, in the context of this paper. Living in a world in which real cost reductions are a key dynamic force producing economic growth, we must look to the motivations and preoccupations of those who take the critical decisions at the level of the firm. For these decisions, it is not only important that the policy framework be good now; the expectation that it will stay good in the future is also important. Otherwise, investments will tend to be limited to those with short horizons and payment periods, and much soil, fertile with longer-term economic opportunities, will go unplowed.

VI. A Vision of the Growth Process

Let me now try to summarize my own vision of the growth process—the major elements of which have been presented here. In the first place we have the five standard pillars of growth—the rate of increase in the labor force, the rate of increase in the stock of human capital, the increase in the capital stock (net investment as a fraction of value added), the rate of return which that investment will yield (or can be expected to yield) and, last but not least, real cost reductions stemming from 1001 different sources.

Commenting on these in turn, I would note that increases in the labor force have taken on new meaning in many countries as labor force participation rates (particularly those of women) have increased. Whereas with a constant participation rate, the growth rate of the labor force is just a proxy for the growth rate of population, important increases in labor force participation can lead, just by themselves, to significant increases in measured real income per head.

Concerning increases in the stock of human capital, my conviction is that most of their contribution to growth is, on the whole, well measured by market wages, as in the expression $\sum_i w_i \Delta L_i$. This does not deny the existence of externalities due to an increased human capital stock; it simply judges their influence on the growth rate to be modest in comparison with the effects of education, training, learning-by-doing, etc., that can be (and typically are) internalized by those who

receive them. We therefore look for the effects of human capital accumulation mainly in the term $\sum_i w_i \Delta L_i$, and only (via externalities) as one of many elements underlying the growth residual R' .

The rate of investment is a veteran on the stage of growth analysis. What I would emphasize here is the importance of maintaining a clear separation between the rate of investment and the rate of saving. Models (like those of the representative consumer) in which saving and investment are always equal are not much use even for analysis at the national level in our modern, interdependent world. They are even less useful as one goes down to smaller geographical regions, and simply cease to make sense as one studies the growth process at the levels of the industry and the firm.

The rate of return to investment has in many ways been the orphan of our growth analysis, having been masked from view by our typical representation of capital's contribution to the growth rate as $s_k(\Delta K/K)$. Here the rate of return $(\rho + \delta)$ is totally hidden from view. I deeply urge that more of us get into the habit of representing this same term as $(\rho + \delta)(\Delta K/y)$. I want to see more attention paid to the rate of return because it plays such a central role in the motivation of economic agents, and also because changes in it are such an important element in understanding and explaining the growth residual, R' . Table 3 helps explain why I feel this way. This table is adapted from Harald Beyer's (1996) work. He carried out an analysis of the growth experiences of 32 countries ranging from Sri Lanka to the United States on the income scale, and from Iceland to Australia on the geographic scale. In Table 3 we present results for his ten countries with the highest and for his ten countries with the lowest GDP growth rates from 1971–1991. In the second column the calculated average annual rate of return is shown. In the third column we have capital's contribution to the growth rate $[= (\rho + \delta)(\Delta K/y)]$, and in the final column the estimated average annual rate of TFP growth, all over the same time period.

Table 3 shows an unequivocal tendency for fast-growing countries to be experiencing high rates of return as well as high capital contributions and high rates of TFP improvement.

TABLE 3—GROWTH RATES, RATES OF RETURN, AND RATES OF TFP IMPROVEMENT
(SELECTED FROM A SAMPLE OF 32 COUNTRIES, 1971–1991)

Ten fastest-growing countries	GDP growth rate	Rate of return	Capital cont. to growth rate	TFP growth rate
Taiwan	8.83	15.0	3.81	3.68
Korea	8.47	13.2	4.30	2.38
Thailand	7.65	12.5	3.68	2.96
Hong Kong	7.91	20.0	3.56	2.28
Ecuador	5.58	14.0	2.70	0.36
Cyprus	5.12	10.6	2.99	1.92
Zimbabwe	4.62	13.6	2.42	0.97
Colombia	4.43	11.3	1.99	0.74
Iceland	4.35	9.4	1.95	1.77
Ireland	4.12	6.7	1.70	0.36
Median	5.35	12.85	2.84	1.83
Mean	6.10	12.63	2.91	1.74
Ten slowest-growing countries	GDP growth rate	Rate of return	Capital cont. to growth rate	TFP growth rate
Austria	2.87	5.1	1.13	1.29
France	2.80	6.1	1.21	0.99
Germany	2.60	6.3	0.97	1.29
Belgium	2.56	6.8	1.06	1.60
Netherlands	2.52	7.0	1.12	0.83
United States	2.52	9.1	1.20	0.23
South Africa	2.16	7.5	1.58	−0.97
Denmark	2.15	7.5	1.01	0.82
United Kingdom	2.12	9.6	0.95	0.22
Sweden	1.84	4.3	0.66	0.24
Median	2.52	6.90	1.09	0.825
Mean	2.41	6.93	1.09	0.661

Source: Beyer (1996), Tables III.1.1 through III.1.32; also Appendix I for rates of return.

This is all the more interesting because in the calculation of TFP a higher *level* of the rate of return operates to reduce the calculated TFP (i.e., $\Delta\rho$ is a positive component of R' and should presumably be positively correlated with it,³ but R' is found by subtracting $\rho\Delta K$ from Δy ; hence, in a sense, the *level* of ρ

should presumably be negatively correlated with R'). What we are seeing here, in my opinion, is a genuine syndrome in which all sorts of good things go together. Strong real

³ The standard expression for the residual, $R = \bar{p}dy - \bar{w}dL - (\bar{p} + \delta)dK$ has a “dual” representation, which is:

$R = \bar{L}dw + \bar{K}d(\rho + \delta) - \bar{y}dp$. This form simply says that the fruits of real cost reduction have to go somewhere—either to workers ($\bar{L}dw$) or to owners of capital [$\bar{K}d(\rho + \delta)$] or, in the form of lower prices to the activity's customers ($-\bar{y}dp$).

cost reductions and high rates of return create attractive investment opportunities which, when acted upon, bring about a high capital contribution to growth. It should be no surprise that under such circumstances the GDP growth rate itself tends to be high. It should likewise be no surprise that the opposite syndrome—with weak real cost reductions and low rates of return producing fewer interesting investment opportunities—should end up being associated with a low capital contribution and a low GDP growth rate.

Finally, we come to the residual R' itself. To me, the biggest message here is to recognize the *multiplicity of sources* from which it can (and I believe does) come, and the *additivity* that nevertheless is its attribute. I think that the term real cost reduction very neatly captures both these aspects in a way that renders it preferable to terms like TFP improvement and technical advance—preferable not in the sense of a mechanical definition (for which all three are equally good), but in the sense of better conveying the underlying nature of the process to one's listeners or readers.

The next step is to recognize that of the five main pillars, at least three (the rate of investment, the rate of return, and real cost reduction) are key foci of decision-making processes at the level of the firm. I cannot escape the conclusion that the great bulk of the action associated with the growth process takes place at the level of the firm. Hence, I feel we should focus much more study than we have in the past on what happens at this level. And when we are not working at the firm level, we should pay a lot of attention to what happens at lesser levels of disaggregation like industries and industrial branches.

Key insights flow from taking this kind of focus. Few economists are aware of the pervasiveness with which sunrise-sunset diagrams are characterized by overshooting, or of the importance that firms or industries with real cost increases (i.e., reductions in TFP) play in determining the aggregate rates of real cost reduction that we see in such diagrams. Here we have only scratched the surface in digesting the evidence. But I find impressive the degree to which the data of Table 3 seem to point to a growth syndrome in which high rates of return, high rates of investment, high rates of real cost reduction, and high rates of

output growth all go together. I see in this result the likelihood that real cost reductions are the big driving force, generating high rates of return and calling forth high rates of investment and high output growth. This interpretation is compatible with many exercises that I have performed over the years in which I have tried to contrast high-growth with low-growth experiences. In such exercises, as in Table 3, the difference in rates of real cost reduction has typically been a major "source" of the difference in growth rates.

Also impressive in the analysis of the Jorgenson data is the degree to which the varying experiences of U.S. manufacturing in different decades derives from different degrees of bad experience (real cost increases) rather than different degrees of good experience (real cost reduction). It is as if the creative part of Schumpeter's "creative destruction" was more steady (for these decades in U.S. manufacturing) than the destructive part, whetting our (or at least my) appetite to look deeper, inquiring into why this was so.

The Mexican data at the firm level were somewhat more recalcitrant than the Jorgenson data by industrial branch, but they nonetheless give us a clear picture of lots of winners and lots of losers, with the losers being strongly characterized by falling real value added and/or by falling real rates of return.⁴

⁴ Of Torre's observations with negative TFP growth, over three-fourths had negative growth in real value added, and over one-half had falling real rates of return. Less than 15 percent showed increases both in real value added and in their real rate of return. Many of Torre's "anomalies" of negative TFP improvement together with positive real output growth stem from very high rates of return (\bar{p}) being imputed to the observed increases (ΔK) in the capital stock.

This points to a problem that extends to all (or nearly all) growth-accounting frameworks. Implicitly, they assign to new investment a marginal product based on the average observed gross rate of return ($\bar{p} + \delta$) or average observed capital share s_k . This makes little sense in cases where the observed \bar{p} is far above or far below the going market rates. Firms earning 50 percent real return in their historical investments are very unlikely to be "requiring" such a high expected yield on new investments. Similarly, firms going through periods of actual accounting losses may often still be investing, but it is absurd to think they are expecting (or typically getting) negative returns on their new investments (ΔK). There are, I think, good reasons for us to experiment with alternative ways of select-

The role of policy in this vision of the growth process is an “enabling” one. By creating the circumstances where firms can quickly and accurately predict opportunities for real cost reduction and act on them, governments can guide the economy toward an enhanced contribution of RCR to growth. By rationalizing and/or eliminating barriers and controls, they may also lead to an increased pace of investment and increased rates of return. In this view, the connection between good policy and growth is not mechanical, and thus cannot easily be captured in regression-type analysis, but that does not stop it from being of vital importance.

I want to give special weight to another role of “growth-enabling” policy actions, which has to do with how policies, the effects of which might typically be considered to be comparative static, can nonetheless turn out to influence economic growth rates over extended periods of time.

This story begins with a recognition that most developing countries have typically used production techniques that were “backward” in relation to those used by the advanced economies. One way to verify this is to imagine integrally replicating, say, a U.S. factory in India, and manning it there with Indian workers equivalent in skill to their U.S. counterparts. The combination of lower construction costs and much lower operating costs (mainly wages) would permit this hypothetical new Indian firm to undercut the prices of *both* the U.S. firm of which it was a copy *and* the typical Indian firm currently active in the same industry. This says that the typical Indian firm is operating on an “inferior” production function. If, as I believe, the difference in efficiency between U.S. and developing-country firms is typically large, there is much room for quite rapid improvements in the developing countries as they learn how to “adopt and

adapt” already-known techniques from the advanced countries.

I would assume that the incentives for “convergence” are always present, but that they have typically run into barriers and trammels of many kinds in the poor countries of the world. Reducing the barriers and loosening the trammels permits the more rapid convergence to techniques that are closer to the frontier of knowledge.

The way I see the influence of policy in growth, it is simply not true that implementing enabling policies typically permits a quantum jump from the old to the truly modern. It is more accurate to describe it as speeding up what will in any case be a very lengthy process. Personally, I like the analogy to a hydraulic system in which a large vessel with a high water level and lots of water is connected to a much smaller and narrower vessel with a much lower level of water. Physical laws dictate a tendency for the water levels to equalize in the end. But this can take a very long time if the tube connecting the two vessels is tiny, or is clogged by extraneous matter.

The policies that we consider good for growth have the attribute, in this analogy, of removing the extraneous matter and/or enlarging the connecting tube. But even with the best modernizing policies, the tube remains small enough so that it takes many decades for a country to pass from poor to middle income or from middle income to rich. If somehow the hydraulic connection could be made so large as to bring about an almost instantaneous full adjustment of the water level, then we would say that good policies mainly represent level adjustments. But observing even the best of real-world growth experiences, I think we have to conclude that the adjustment is going to be extended over a lengthy period in any event, thus causing the big observable result of better policies to be a higher growth rate over an extended period rather than a discrete jump to a totally different level.

This way of looking at the world also leads to some observations on the current literature dealing with convergence. I have long been mystified by allusions to an ultimate convergence of growth rates among countries, or an ultimate convergence of levels of output per head. To me, the natural convergence is product by product, not country by country. And

ing the rate of return (ρ) imputed to new investments. Arguments can be developed for using arbitrary but “sensible” rates (like 10, 15, or 20 percent), or for applying to investments by individual firms and/or industries rates of return \bar{p} that are obtained not from those specific firms or industries but from broad sectoral (e.g., manufacturing) or economywide averages. I am pursuing these avenues in work that will be reported at a later time.

among products there may be some where current techniques will never be further improved. Those products will have no real cost reductions or TFP improvements in the future, while others will enjoy huge advances of productivity. My guess is that unlucky countries (Bhutan, Nepal, Mongolia?) may always lag way behind the pack, while luckier ones (Taiwan, Argentina, Brazil?) may one day hope to be among the world's leaders. So convergence comes through as a general tendency, and quite surely a general possibility, for the production techniques used in making any given product to improve as enterprises using "backward" techniques learn of better ones, and even more important, learn about how to put them into practice. I do not believe that much more than this can be said of convergence as a real-world force. Wage rates for given types of labor tend toward a rough equality across regions in a country because of the ease of migration in response to perceived wage differences. The forces at work internationally are both weaker and more complex, but the big message here is that the improvement of technique in any one industry does nothing to improve the wages of labor in just that industry. After an improvement, the industry may end up hiring more or less labor, but will presumably choose the amount of labor so as to bring marginal productivity into correspondence with market wages. So technological improvement has an effect on wages via supply and demand in the national labor market, not through any direct link from technical improvement to wages (for given skills, etc.) at the level of the industry or the firm.

As my final point, let me return to the thought that the justification for perfecting the functioning of the market system does not lie only in reducing the efficiency costs associated with each period's operation of the economy. Perfecting a country's economic policy does not only cause it to move from a path at around, say, 90 percent of its potential output to another equal to 95 percent of potential, with the time path of potential output being somehow given in advance. That gain would certainly be a worthwhile gain, and it would amply justify a lot of hard work involved in achieving it. But that gain is still fundamentally comparative static in nature.

What I hope to have evoked in this paper is a sense that the perfecting of economic processes can also in nearly all cases be justified as greasing the wheels of the constant search for new avenues of real cost reduction. To the extent that economic reforms do so, they become vehicles for bringing an economy to a point where, year after year, new, cheaper, and better ways are found of doing things, not just in so-called "production" but also in such mundane areas as merchandising, sales, finance, insurance, and many more.

Some years ago, in a book that I edited called *World Economic Growth* (1984), I wrote an essay called "Economic Policy and Economic Growth," in which I listed "13 lessons" that I thought followed from the papers presented in the volume, recounting the growth experiences of countries as disparate as Ghana and Taiwan, or Japan and Sweden. These lessons—basically focused on thinking about policies in terms of their economic costs and benefits—could easily be read as a reprise of the old comparative-static story. But they were not meant as such—it is quite relevant that they appeared in an essay concerned with world economic growth. The point was that these sensible policies emerged as part of a consensus of serious economists, each an expert in his particular country's history, focusing attention on the process of economic growth.

A few years later, and as the theme of a different concept, John Williamson (1990) coined the term, the "Washington consensus." Williamson listed ten points, covering territory very similar to my 13 lessons. He also produced a pithy summary that captures the essential thrust of both his and my listings: "Macroeconomic prudence, outward orientation, and domestic liberalization." He, too, and the members of the Washington professional establishment whose apparent consensus led to Williamson's list, were not just thinking of comparative-static gains as they reached their conclusions about policy. They were thinking about ways to move economies from slow growth, stagnation, and even in some cases negative growth, to a healthy, prosperous flowering of economic progress. Similar views were more recently affirmed by Stanley Fischer (1993).

To me, the dynamics of real cost reduction are at the very least an important piece of what

people have in mind when they list efficiency-oriented policies as essential ingredients of a program promoting economic growth. It is policies of this type that give the right signals to the CEOs and the managers down the line, that take away trammels that impede their quest for real cost reductions, and that create an environment in which Schumpeter's process of "creative destruction" can work its wonders.

APPENDIX ON METHODOLOGY

The vision of the growth process presented in this paper leads one almost inevitably to some methodological twists—twists which, if they are not new, at least differ in significant ways from what I take to be the most common practice in breaking economic growth down into components.

(a) To measure the real rate of return to capital, one must express the numerator (real dollars of return) and the denominator (the capital stock) in the same units. The most efficient way to do this is to measure both output (value added) and the capital stock in units of the GDP deflator. That way one is sure that the outputs of all the subaggregates in the economy add up to the GDP, and one also satisfies the requirement that the capital and return be measured in the same units. This is also the way cash flows would be deflated in a standard, *ex post* project evaluation. When this is done at the aggregate level the contribution of capital to growth is $(\rho + \delta)\Delta K$ where ρ is an aggregate rate of return to capital, δ the depreciation rate (including obsolescence), and ΔK the net increment to the capital stock in the period in question. At a subaggregate level, the contribution of capital to growth in activity j is $(\rho_j + \delta_j)\Delta K_j$. At both levels, we find that high rates of return are an important component of most successful growth episodes.

(b) To capture the great diversity of the labor factor, we would like to have a very fine breakdown of labor into categories (indexed by i). The labor contribution is then $\sum_i w_i \Delta L_i$, where w_i represents the real wage of category i and ΔL_i the change in hours worked by category i . Since the number of relevant categories of labor is huge, any such breakdown is difficult, and gets more difficult as one disaggregates from economy to sector to branch to

industry and to firm. This Gordian knot can be cut by a simple assumption, similar to what is done in most countries to convert residential construction to real terms. There, one builds a price index of a "standard house" p_h^* , and then obtains a quantum of construction C^* by dividing total construction outlays by the price of the standard house. In the resulting aggregate, each individual residence (i) gets attributed a quantum of housing equal to p_i/p_h^* . In this work I define a standard wage w^* , which I assign to "standard labor" or "raw labor." The excess of anybody's actual wage over w^* is attributed to human capital. The returns to natural ability, as well as to formal education, training, and experience belong there, under this interpretation. High returns due to a distorted wage structure are not appropriately attributable to human capital, but the methodology would nonetheless be correct in attributing to the affected labor a marginal productivity that is measured by the distorted high wage.

The "labor contribution" as measured by $w^*\Delta L^*$ is equal to $w^*(\sum_i (w_i/w^*)\Delta L_i + \sum_i L_i \Delta(w_i/w^*))$. The second term will be zero if the structure of relative wages remains constant, or even if the weighted average premium does not change. Any changes in the weighted average premium will cause the calculated residual to be different from those calculated by other methods.

The "two-deflator method" is characterized by the use of a single numeraire-deflator (say, the GDP deflator), by the treatment of the quantum of output as value added divided by the numeraire-deflator, and by the use of a standard wage w^* and a quantum of labor L^* equal to the wages bill divided by w^* . This is the method used by Beyer (1996), Robles (1997), and Torre (1997) in their work reported in this paper.

It goes without saying that the two-deflator method is rough. But it is also tremendously robust and easily applied. I think of it as being really designed for use at the firm level, where very commonly we can get data in value added, on gross investment, and on the wages bill, but know nothing (from standard sources) about the quantum of output or about the number of total hours worked (or even the total number of employees used). This opening of wide new vistas, of huge new data sets, is what

I consider the strongest argument for the two-deflator approach.

But there are other pluses as well. First, at the aggregate economy level, the two-deflator approach comes very close to the traditional approach. In rate-of-growth terms, we have $(R^*/y) = g_y - s_k g_k^* - s_L g_L^*$, compared with $(R/y) = g_y - s_k g_k - s_L g_L$, where g refers to growth rate, and y to GDP. K^* differs from K in being built up from gross investment deflated by the GDP deflator, while K is built up from gross investment deflated by the investment deflator of GDP. L^* is in principle much more refined than N (number of workers), but its measurement can be influenced by a widening or narrowing skill premium. (R^*/y) likewise differs from Jorgenson's residual $(R'/y) = g_y - \sum_j s_{kj} g_{kj} - \sum_i s_{\ell i} g_{\ell i}$ mainly in his use of different capital deflators for different categories of capital. (The implicit labor breakdown in L^* is much finer even than Jorgenson's, but Jorgenson does not have to contend with the possibilities of widening or narrowing skill premiums—at least not among the labor categories he works with, which are typically broken down by gender, age, education, occupation, industry, and employment status.)

The bottom line is that when Beyer compares his two-deflator results, at the national aggregate level, with those of others using different methods, he finds on the whole only modest differences. [See Beyer (1996); Harberger (1998).]

When one uses the two-deflator method at the industry level, one often has the possibility to adjust the quantity variable so as to make it correspond with that of the more traditional approach. Thus, we may start by using $dy_j^* (= p_j dy_j + y_j dp_j)$ as the quantity variable, and calculate a residual R_j^* using that concept. Then we may get an adjusted residual by taking $R_j^* - y_j dp_j$. This is easy to do so long as we have decent data on dp_j , the relative price of j , which we often do at the branch or industry level. When Jorgenson's residuals are compared with the two-deflator residuals, with and without price adjustment, I find the differences without adjustment to be small enough to be quite acceptable. With adjustment, the degree of agreement between the two approaches is quite notable (85 percent of differences less than one percentage point of per annum

growth). [See Robles (1997); Harberger (1998).]

When one gets down to the firm level, the two-deflator method is in its element. Rarely do we have decent time series on the price index of a firm's output. Treating many firms in one industry, one might then give all of them the same price index—that of the industry. At that point the distribution of adjusted TFP residuals among the firms would end up differing from the original two-deflator distribution only by a constant. When expressed in percentage terms we would have $(R_j^*/y_j^*) = g_{y_j}^* - s_{kj} g_{kj}^* - s_{\ell j} g_{\ell j}^*$ for each firm j without adjustment, while *with adjustment* we would have $R_j^*/y_j =$ the same expression minus $g_{\bar{p}}$, the rate of growth of the *industry's* relative price index (the same for all firms).

So in the great bulk of cases one ends up with something quite like the two-deflator method when working at the individual firm level. The consolation is that the residual terms of individual firms, calculated for the whole economy, add up to a residual term for the aggregate—in the sense that outputs sum to GDP, the L_j^* sum to L^* for the economy, the K_j^* to K^* for the economy, etc. For more details on methodology, see Harberger (1998).

REFERENCES

- Abramovitz, Moses. "Economics of Growth," in Bernard F. Haley, ed., *A survey of contemporary economics*. Homewood, IL: Richard D. Irwin (for the American Economic Association), 1952, pp. 132–78.
- . "Resources and Output Trends in the United States Since 1870." *American Economic Review*, May 1956 (*Papers and Proceedings*), 46(2), pp. 5–23.
- Aghion, Philippe and Howitt, Peter. "A Model of Growth Through Creative Destruction." *Econometrica*, March 1992, 60(2), pp. 323–51.
- Barro, Robert J. "Determinants of Economic Growth: A Cross-Country Empirical Study." Harvard Institute for International Development Discussion Paper No. 579, April 1997.
- Barro, Robert J. and Sala-i-Martin, Xavier. *Economic growth*. New York: McGraw-Hill, 1994.

- Beyer, Harald.** "Sources of Economic Growth: Cross-Country Comparisons." Discussion paper, University of California, Los Angeles, 1996.
- Boskin, Michael J., ed.** *Capital formation and economic growth*. Stanford, CA: Hoover Institution, 1998 (forthcoming).
- Denison, Edward F.** *Why growth rates differ: Post-war experience in nine western countries*. Washington, DC: Brookings Institution, 1967.
- DeSoto, Hernando.** *The other path: The invisible revolution in the third world*. London: Tauris, 1989.
- Easterly, William.** "When Is Stabilization Expansionary? Evidence from High Inflation." *Economic Policy: A European Forum*, April 1996, (22), pp. 65–98.
- Edwards, Sebastian.** "Openness, Trade Liberalization and Growth in Developing Countries." *Journal of Economic Literature*, September 1993.
- Fabricant, Solomon.** *Economic progress and economic change*. Thirty-Fourth Annual Report of the National Bureau of Economic Research. New York: NBER, 1954.
- Fischer, Stanley.** "The Role of Macroeconomic Factors in Economic Growth." *Journal of Monetary Economics*, December 1993, 32(3), pp. 485–512.
- Griliches, Zvi.** "Measuring Inputs in Agriculture: A Critical Survey." *Journal of Farm Economics*, December 1960, 42(5), pp. 1411–27.
- . "The Sources of Measured Productivity Growth: United States Agriculture, 1940–60." *Journal of Political Economy*, August 1963, 71(4), pp. 331–46.
- . "Productivity, R&D, and the Data Constraint." *American Economic Review*, March 1994, 84(1), pp. 1–23.
- Grossman, Gene M. and Helpman, Elhanan.** *Innovation and growth in the global economy*. Cambridge, MA: MIT Press, 1991.
- . "Endogenous Innovation in the Theory of Growth." *Journal of Economic Perspectives*, Winter 1994, 8(1), pp. 23–44.
- Harberger, Arnold C.** "Perspectives on Capital and Technology in Less Developed Countries," in M. J. Artis and A. R. Nobay, eds., *Contemporary economic analysis*. London: Croom Helm, 1978, pp. 42–72.
- . "In Step and out of Step with the World Inflation: A Summary History of Countries, 1952–76," in M. J. Flanders and A. Razin, eds., *Development in an inflationary world*. New York: Academic Press, 1981, pp. 35–46.
- . "Economic Policy and Economic Growth," in Arnold C. Harberger, ed., *World economic growth*. San Francisco, CA: ICS Press, 1984, pp. 427–66.
- . "Reflections on the Growth Process." Working paper, World Bank, 1990.
- . "Studying the Growth Process: A Primer," in Michael J. Boskin, ed., *Capital formation and economic growth*. Stanford, CA: Hoover Institution, 1998 (forthcoming).
- Jorgenson, Dale W.** *Productivity*, Vols. 1 and 2. Cambridge, MA: MIT Press, 1995.
- Jorgenson, Dale W.; Gollop, Frank M. and Fraumeni, Barbara M.** *Productivity and U.S. economic growth*. Cambridge, MA: Harvard University Press, 1987.
- Jorgenson, Dale W. and Griliches, Zvi.** "The Explanation of Productivity Change." *Review of Economic Studies*, July 1967, 34(3), pp. 249–80.
- Kendrick, John W.** *Postwar productivity trends in the United States*. New York: Columbia University Press, 1973.
- . *The formation and stocks of total capital*. New York: National Bureau of Economic Research, 1976.
- . *Understanding productivity: An introduction to the dynamics of productivity change*. Baltimore, MD: Johns Hopkins University Press, 1977.
- Kendrick, John W. and Grossman, Elliot S.** *Productivity in the United States: Trends and cycles*. Baltimore, MD: Johns Hopkins University Press, 1980.
- Krueger, Anne O.** "Trade Policies in Developing Countries," in Ronald W. Jones and Peter A. Kenen, eds., *Handbook of international economics*, Vol. 1. Amsterdam: North-Holland, 1985.
- . "Trade Policy and Economic Development: How We Learn." *American Economic Review*, March 1997, 87(1), pp. 1–22.
- Lucas, Robert E., Jr.** "On the Mechanics of Economic Development." *Journal of Monetary Economics*, July 1988, 22(1), pp. 2–42.

- _____. "Making a Miracle." *Econometrica*, March 1993, 61(2), pp. 251–72.
- Mairesse, Jacques and Griliches, Zvi.** "Heterogeneity in Panel Data: Are There Stable Production Functions?" in Paul Champsaur et al., eds., *Essays in honor of Edmond Malinvaud, volume 3: Empirical Economics*. Cambridge, MA: MIT Press, 1993, pp. 192–231.
- Mansfield, Edwin.** *Innovation, technology and the economy: Selected essays of Edwin Mansfield*. Aldershot, U.K.: Elgar, 1995.
- North, Douglass C.** *Institutions, institutional change and economic performance*. Cambridge, MA: Cambridge University Press, 1990.
- Olson, Mancur, Jr.** "Big Bills Left on the Sidewalk: Why Some Nations Are Rich and Others Poor." *Journal of Economic Perspectives*, Spring 1996, 10(2), pp. 3–24.
- Robles, Edgar.** "An Exploration into the Sources and Causes of Economic Growth in the United States and Fourteen Latin American Countries." Ph.D. dissertation, University of California, Los Angeles, 1997.
- Romer, Paul.** "Increasing Returns and Long-Run Growth." *Journal of Political Economy*, October 1986, 94(5), pp. 1002–37.
- _____. "Endogenous Technological Change." *Journal of Political Economy*, October 1990, 98(5), pp. S71–S102.
- _____. "The Origins of Endogenous Growth." *Journal of Economic Perspectives*, Winter 1994a, 8(1), pp. 3–22.
- _____. "New Goods, Old Theory, and the Welfare Costs of Trade Restrictions." *Journal of Development Economics*, February 1994b, 43(1), pp. 5–38.
- Schmookler, Jacob.** *Invention and economic growth*. Cambridge, MA: Harvard University Press, 1966.
- Schumpeter, Joseph A.** *The theory of economic development*. Cambridge, MA: Harvard University Press, 1934.
- Solow, Robert M.** "Technical Change and the Aggregate Production Function." *Review of Economics and Statistics*, August 1957, 39(3), pp. 312–20.
- Torre, Leonardo.** "Concentration Patterns of the Contribution of TFP to Output Growth: Evidence From the Mexican Manufacturing Sector." Paper presented at the meeting of the Western Economic Association, 1997.
- Williamson, John, ed.** *Latin American adjustment*. Washington, DC: Institute for International Economics, 1990.