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INTERNATIONAL PERSPECTIVES ON PRODUCTIVITY AND EFFICIENCY

Review Article on *Industrial Efficiency in Six Nations* by Richard E. Caves (MIT Press, Cambridge, MA, 1992) and *Competitiveness, Convergence, and International Specialization* by David Dollar and Edward N. Wolff (MIT Press, Cambridge, MA, 1993).

One of the very few findings on which economists of all political leanings concur is that productivity and efficiency represent the key to international competitiveness and rising living standards. A thorough understanding of these concepts is consequently a very important objective of economic research. The two volumes discussed in this review article, *Industrial Efficiency in Six Nations* by Richard E. Caves and Associates and *Competitiveness, Convergence, and International Specialization* by David Dollar and Edward N. Wolff represent major contributions to such an understanding.

The two books under review address two conceptually distinct, but closely related concepts—efficiency and productivity. This review article is organized around four core questions. First, what do we mean by the concepts of productivity and efficiency? Second, how do we measure productivity and efficiency? Third, how do we interpret differences in productivity and efficiency? Fourth, what are the policy implications of differences in productivity and efficiency?

I. Overview

The volume by Richard E. Caves (of Harvard University) and Associates on efficiency represents the second major publication in an international research project whose elements are: (1) the use of recently developed statistical techniques for measuring technical efficiency, (2) the development of hypotheses about why and where technical inefficiency can exist, and (3) the testing of the determinants of technical inefficiency on a cross-section of industries. The first publication in the project was *Efficiency in U.S. Manufacturing* (Caves and Barton, 1990), which estimated technical efficiency at the plant level for four-digit U.S. manufacturing industries through the estimation of stochastic frontier production functions. This publication represents the extension of the project to other countries.

The volume consists of 12 chapters, divided into two major sections. The first section includes chapters on efficiency in manufacturing industries in five countries (Japan, Korea, Australia, U.K., and Canada),[1] The second section features chapters on technical efficiency over time in Korea, the intraindustry

[1]The authors of the six country chapter are Akio Torii (Japan), Seong Min Yoo (Korea), David G. Mayes and Alison Green (U.K.), Chris Harris (Australia), Richard Caves (Australia), and John Baldwin (Canada).

dispersion of plant productivity over time in the U.K., differences in efficiency between large and small Japanese enterprises, and an analysis of productivity growth and technical efficiency in the OECD. The majority of the contributors to the volume (five out of nine) are non-academics, which reflects the major role governments have played in supporting the project.

The volume by David Dollar of the World Bank and Edward N. Wolff of New York University on productivity, competitiveness and convergence represents an extension of earlier work by the authors on productivity issues in general and convergence in particular (Baumol, Blackman, and Wolff, 1989; Dollar and Wolff, 1988). The first chapter provides an excellent self-contained summary of the main ideas and issues which follow. The main empirical findings are laid out in the next three chapters, which examine deindustrialization by investigating trends in industrial output and exports among OECD countries; look at labor convergence in the manufacturing sector and in specific manufacturing industries; and decompose labor productivity convergence at the industry level into a part attributable to capital accumulation and a part attributable to technological advance. The remaining chapters then address whether the convergence trends found in manufacturing are typical for the whole economy; how the pattern of productivity convergence has affected wages and the return to capital; the relationship between productivity changes and shifts in the pattern of international trade, focusing on U.S. and Japanese exports and the extension of the analysis beyond the developed world to examine the pattern of productivity convergence in the newly industrialized countries (NICs). The concluding chapter focuses on the implications of the findings for maintaining the U.S., and other industrial countries, as high-productivity, high-income economies.

II. Definitions of Productivity and Efficiency

Any analysis of productivity and efficiency issues must begin by defining the two concepts. Efficiency can be defined as going as far as possible in the satisfaction of wants within resource and technological constraints (Reiter, 1987). It can be expressed by the concept of Pareto optimality. An efficient state exists if it is not possible to make anyone better off within the given constraints by changing to another state of affairs that also satisfies the applicable constaints. The level of efficiency, consequently, is relative to maximum feasible output.

In terms of the standard production possibilities curve, efficient positions are represented by points on the production possibilities curve where it is not possible to produce more output without more input. Inefficient positions are represented by points within the curve, i.e. it is possible for existing inputs to produce more output.

Figure 1 shows the concept of a natural measure of technical (in)efficiency. The ray OA goes from the origin O to point A on the production possibilities curve. All points on the ray between O and A, such as point B, are inefficient. The degree of inefficiency can be represented by the ratio BA/OA. Inefficiency indexes for all points inside the production possibilities curve can be calculated by drawing a ray intersecting the point between the origin and the production possibility curve.

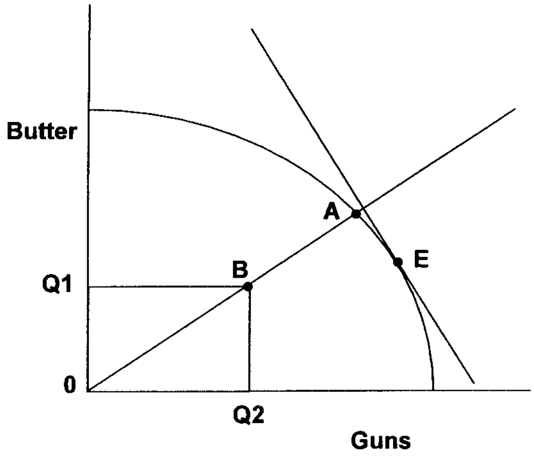

Figure 1

Labor productivity can be defined as the quantity of output produced with a given level of labor input, irrespective of the quantity of other inputs used or the efficiency of their use. Labor productivity of a firm or country, that is the level of output actually produced by the employed workforce, may or may not correspond to a position on the production possibility curve. Indeed, any point on or inside the production possibility curve has a level of labor productivity associated with it.

Aggregate labor productivity is defined as the summation of the output of the various goods produced, with prices used to aggregate heterogenous goods, divided by the summation of the labor input needed to produce each good. In Figure 1, the labor productivity at point B is represented as $P^1Q^1 + P^2Q^2/L^1 + L^2$ where Ps and Qs refer to the respective prices and quantities of the goods produced and Ls refer to the quantity of labor input. Points closer to the production possibility curve than point B do not necessarily represent higher levels of labor productivity. Although output may be greater, so is employment. The labor productivity level will only be greater at say point A than at point B if the percentage increase in output in going from B to A is greater than that of employment. In fact, if, for example, physical strength is a determinant of labor productivity and employers hire the strongest workers first, output per worker will be greater at point B (where employment is lower) than at point A.

The concept of total factor productivity represents the ratio of output to an index of a combination of inputs, usually labor and capital. Like labor productivity, it relates output to an indicator of inputs. While increases in the capital stock normally increase labor productivity, they do not necessarily have the same effect on total factor productivity, since the additional capital stock also increases total factor input.

The concept of economic efficiency or inefficiency has been a central concern of economists. However, economists have often defined the concept to refer to allocative efficiency which arises from the operation of the price mechanism (a situation of allocative inefficiency is represented by point A in Figure 1, in comparison to point E where the slope of the relative prices of the two goods is tangent to the production possibility curve). A more common sense concept of efficiency is technical efficiency. Technical inefficiency exists when firms can produce more with given outputs, or need less factor input to produce a given output.[2] Economists often analyze how to move along the production frontier to greater allocative efficiency, even though gains from allocative efficiency are usually estimated to be very small. However, moving firms *to* the production frontier is what can produce really significant output gains. Economists have traditionally downplayed this concept of inefficiency as its existence is inconsistent with the assumption of profit maximization, which implies all opportunities for profit are fully exploited.

Technical efficiency can also be defined in a dynamic sense as the rate at which the production possibility curve moves out over time. This type of efficiency gain may in fact dominate both static technical efficiency and allocative efficiency in importance.

According to Caves, two developments have made production or technical inefficiency a subject for serious empirical inquiry. First, research has shown that market failures, such as information costs and asymmetries, agency problems, and contract and bargaining costs, can severely limit utility-maximizing economic decision-makers from achieving first-best efficiency. Second, research methodologies have been developed for measuring technical inefficiency.[3] In particular, stochastic frontier production functions (SFPF) can now be readily estimated from data on establishments and enterprises.

III. Measurement of Productivity and Efficiency

In the Caves approach, efficiency is measured in relative terms. Plant labor efficiency is represented by the ratio of output per unit of labor in a given plant to the production possibilities frontier of the industry, which can be proxied by the plant (or group of plants) in the industry with the highest labor productivity level, that is the best-practice plant. Of course, differences in capital-labor ratios may account for much of the inter-firm labor productivity difference. A comparable concept exists for capital efficiency. Efficiency in an industry is represented by the average productivity levels in relation to the technical production possibilities frontier, again proxied by the productivity leader(s). If productivity levels of the majority of firms are close to that of the leader, the industry is relatively efficient. On the other hand, if there is a large gap between average productivity levels and the best-practice plant, the industry is relatively inefficient.

Efficiency measures are greatly influenced by whether national or world standards are used. In a country where the best-practice plants are below the world

[2]Technical inefficiency is also known as *X*-inefficiency, a term coined by Leibenstein (1966).

[3]Farrell (1957) first made operational the measurement of technical inefficiency through linear programming techniques, which infer the best-practice production function from reported input–output combinations of some small number of the most efficient units. However, this method makes severe and unrealistic demands on the accuracy of the data, a condition relaxed by the development of the stochastic frontier production function (SFPF). Key references on the SFPF are Aigner, Lovell, and Schmidt (1977), Forsund, Lovell, and Schmidt (1980), Lee and Tyler (1978), and Meeusen and van den Broeck (1977).

leader, a switch from a national to a world perspective to measure efficiency will produce a greater level of inefficiency.

On the other hand, labor productivity is measured in absolute terms. In sectors where output is homogeneous in physical terms, labour productivity at the plant, firm and industry level is measured by units of output per unit of labor input. In industries producing heterogeneous products, prices must be used to aggregate the different types of output, and labor productivity is expressed in dollars of output (either value added or gross output) per unit of labor input. To compare trends in labor productivity levels over time, current dollar output must be deflated to obtain constant dollar or real measures of output.

As total factor productivity is determined by more than one input measured, its measurement is more complex than partial productivity measures like labor productivity. Labor and capital, which are measured in different units, must be aggregated into one factor input before being divided into output to determine total factor productivity. Consequently, total factor productivity levels cannot be expressed in absolute form, but are expressed in index form. Indexes of labor and capital are weighted by their respective factor shares to form a total input index.

The volume by Dollar and Wolff contribute greatly from both a theoretical and empirical perspective to our understanding of productivity measurement. Wolff and Dollar define their total factor productivity (TFP) index as the ratio of a sector's (country's) value added (Y) to a weighted average of employment (L) and gross capital stock (K):

$$\text{TFP} = Y/[\alpha L + (1-\alpha)K]$$

where α is the wage share. For international comparisons, the TFP index is normalized so that the U.S. TFP index in the base year equals 1.0. International comparisons require that both output and capital stock data be measured in common units and in constant prices. Purchasing power parities are used to convert variables expressed in national currency into U.S. dollar equivalents. While it is relatively straightforward to develop time series TFP indexes for each country, comparing indexes across countries in the base year is more difficult. This is done by calculating absolute levels for labor and capital productivity, indexing these levels relative to levels in the U.S. (U.S. = 100), and then weighting these partial productivity indexes by factor shares to obtain a TFP index relative to the U.S.

A major contribution of the volume by Dollar and Wolff is the introduction into the literature of a new productivity data set, called the Dollar–Wolff data base. It is largely derived from data from the United Nations Yearbook of Industrial Statistics, but also includes data from other sources, including Eurostat, the OECD, and national statistical agencies. Dollar and Wolff are to be highly commended for putting together this data set, a time-consuming task undervalued by many economists.

The data base challenges the conventional wisdom in a number of areas. For example, it shows that output per hour in Canadian manufacturing in 1986 was 93 percent of American level and that Canada was the productivity leader among 12 industrial countries in nine of 28 manufacturing industries. Past studies have found that the gap between the Canadian and American manufacturing productivity level was much greater. For example, Rao and Lemprière (1992), using data from the U.S. Department of Labor, show that real value added per hour in Canadian manufacturing in 1985 was only 81 percent of the U.S. level. Intuitively, the Dollar–Wolff estimates are more compelling. Since it is widely accepted that there is little gap between productivity levels in Canadian and American non-manufacturing industries, it is difficult to see why a large gap should exist in manufacturing. Historically, tariff barriers could have accounted for the gap, but these barriers have been reduced or eliminated over the past several decades. Hopefully, this new finding will stimulate researchers to review their estimates to explain the discrepancy.

A second challenge to conventional wisdom arising from the new data set, at least in the eyes of the general public, is the weakness of Japanese manufacturing productivity levels. It is widely believed that Japan's relatively low aggregate productivity level is explained by low service sector productivity, with manufacturing productivity levels high by international standards. The Dollar and Wolff data base show that this is not the case as in 1986, value added per hour in Japanese manufacturing was only 65 percent of that in the U.S. Perhaps more surprisingly, Japan was not the productivity leader in any of 28 manufacturing industries, including transportation equipment and electrical products and in only two of 28 industries (iron and steel and petroleum refining) were Japanese productivity levels higher than those in the U.S.

Comparison of productivity levels across countries requires the computation of purchasing power parities and appropriate output deflators. Due to the difficulty of these calculations, the Bureau of Labor Statistics releases no official estimates of productivity levels, although unofficial estimates are made available to researchers. The estimates that are available are generally produced by independent researchers. These estimates often exhibit considerable variability, which means that there is a high degree of uncertainty associated with them. Indeed, Dollar and Wolff themselves present divergent estimates. For example, they show that while the Dollar–Wolff data set puts the Japanese productivity level in manufacturing in 1986 at 65 percent of that in the U.S., the OECD data base puts the number (in 1985) at 79 percent, a significant difference. The bottom line is that international productivity level comparisons should be interpreted very cautiously since they can be subject to such a wide margin of error, due largely to different assumptions about PPPs.

A recent Bureau of Labor Statistics (BLS) publication (U.S. Department of Labor, 1994) demonstrates the sensitivity of productivity estimates to PPP assumptions. It produces three sets of estimates of real GDP per employed person for each year (see Table 1). The estimates are based on purchasing power parities (PPPs) benchmarked to 1985 and 1990 OECD/Eurostat studies. The BLS concluded that there was no compelling reason to select one set of PPPs over another. The 1990 benchmark results were also aggregated using two different methods—the Greay-Khamis (GK) method and the Elteto–Koves–Szulc (EKS) method.[4]

[4]The EKS method provides PPPs for each pair of countries that are close to the PPPs that would be obtained if each pair of countries had been compared separately. With the GK method, countries are treated as members of a group, with each country weighted according to its share of the GDP for the group and common prices are defined as prices which are characteristic of the group overall. See OECD (1992)

TABLE 1

BLS ESTIMATES OF GDP PER EMPLOYED PERSON FOR 1992

	1985 PPPs (GK method)	1990 PPPs (EKS method)	1990 PPPs (GK method)
		(U.S. = 100)	
Canada	92.1	86.6	88.5
Japan	75.6	76.4	80.7
Korea	43.8	43.9	43.9
Austria	74.1	84.0	84.6
Belgium	85.4	93.6	97.9
Denmark	69.3	73.1	78.9
France	88.0	95.6	97.9
Germany	79.6	89.1	90.8
Italy	87.2	93.0	95.5
Netherlands	78.0	80.2	83.3
Norway	82.6	74.8	78.9
Sweden	68.7	70.3	73.0
U.K.	71.4	73.7	75.6

Source: Supplementary Tables to *Comparative Real Gross Domestic Product Per Capita and Per Employed Person, Fourteen Countries, 1960–1992*, Office of Productivity and Technology, Bureau of Labor Statistics, U.S. Department of Labor, March, 1994.

The BLS data show that for the same year (1992) estimates of real GDP per worker can vary greatly. In the case of five countries (Austria, Belgium, Denmark, France, Germany) out of the 13 countries for which relative estimates are available, estimates varied by 10–11 percentage points. In only one country (Korea) was the variation less than 4 points. Moreover, there was no pattern to the variation, with use of the 1990 benchmark (either EKs or GK method) increasing the relative productivity level (compared to the 1985 benchmark) for some countries and decreasing it in for others. Country ranking are also affected. For example, based on 1985 PPPs, Canada ranked second after the U.S. in terms of output per person employed (92.1 percent of the U.S. level), well ahead of third-place France (88.0 percent). Based on 1990 PPPs (GK method), Canada fell to sixth place (88.5 percent), now behind second-place France (97.9 percent), Belgium (96.7 percent), Italy (95.5 percent) and Germany (90.8 percent).

Most international productivity comparisons, including those of Dollar and Wolff, are couched in terms of output per worker based because of the greater availability of data on employment than on hours. However, output per hour is clearly preferable. Average weekly hours actually worked differ across countries because of differences in the standard work week for full-time employees, the relative importance of part-time workers, the use of overtime, the number of holidays and length of vacation and the rate of absenteeism.

Total hours data can change drastically productivity level worker rankings. Japanese workers on average work 11.1 percent more hours per year than American workers so that relative to the U.S., output per hour levels are lowered by this amount. Conversely, annual hours worked in the other countries were less than in the U.S. (France (9.0 percent), Germany (11.7 percent), Sweden (18.9 percent) and Norway (22.7 percent)), with the result that output per hour was

TABLE 2

LABOR PRODUCTIVITY, CAPITAL–LABOR RATIOS AND TOTAL FACTOR PRODUCTIVITY, 1985

	Labor Productivity	Capital–Labor Ratio	Total Factor Productivity
		(U.S. = 100)	
Australia	96	89	101
Canada	95	91	100
Denmark	73	80	80
Finland	74	102	74
Germany	95	99	95
Japan	78	58	96
Norway	105	109	101
Sweden	82	92	85
U.K.	72	61	87

Source: Tables 5.1, 5.3, and 5.5 in Dollar and Wolff, based on the OECD data base.
Note: Total factor productivity based international average unadjusted wage share.

greater, relative to the U.S., than output per worker (BLS, 1994). Indeed, based on the 1990 PPPs and the GK aggregation method, output per hour in 1992 was actually higher in France (107.6 percent of the U.S. level), Germany (102.8 percent) and Norway (102.2 percent) than in the U.S.

According to the statistics compiled by Wolff and Dollar, the U.S. does not have the highest level of total factor productivity (see Table 2). In 1985, this honor belonged to Australia and Norway. It is high levels of capital per worker, not greater efficiency in the use of labor and capital which explain the high income in the U.S. A country that has very high levels of capital per worker may use that capital inefficiently, but it still helps labor to produce large quantities of output. It is this high labor productivity which produces a high standard of living.

Labor productivity is not, however, efficiency. The contribution of the Caves volume lies in the measurement of efficiency. Indeed, it is the first study that has attempted to measure technical efficiency through the estimation of stochastic frontier production functions. To ensure comparability of results with the earlier U.S. study (Caves and Barton, 1990), the studies used the translogarithmic (translog) production function, a similar set of rules for editing data, either volume of output or value added as measures of plant output, and either 1977 or 1978 as the year of study (but small establishments were included in some studies and excluded from others). A taxonomy of possible determinants of efficiency levels was developed, which included competitive conditions, organizational factors, structural heterogeneity and product differentiation, dynamic disturbances, and regulation, each proxied by a number of variables.[5]

[5]For example, competition was proxied by concentration ratios, import competition, and export-shipments ratios; organization by scale of typical plant, inbound diversification, outbound diversification, multiplant operation, subcontracting, foreign investment, union membership and part-time employment; structural heterogeneity by interplant dispersion of capital intensity, capital intensity, interplant dispersion of materials–labor ratio, intraplant diversity of industry's products, intraindustry diversity of plant scale, product differentiation, nonproduction workers, regional dispersion, and fuel intensity; dynamic disturbances by research and development expenditures, technology imports payments, technology exports receipts, productivity growth, output growth, and variability of output growth; and public policy by tariff protection and regulation of entry.

The SFPF formulates the production function for statistical estimation as

$$y = f(x) \exp(v - u), \tag{1}$$

where y is output, x is a vector of inputs, and the error term is composed of two elements. The usual normally distributed v represents random disturbances, measurement errors, and minor omitted variables. The other component $u \geq 0$ represents some one-sided distribution of technical efficiency beneath the frontier. A particular data point may lie above the estimated regression plane because of a "lucky" random component or measurement error or it may lie below the plane either due to an unlucky draw or because it is technically inefficient. If the model correctly identifies an industry's inefficiency, the residuals from its fitted production function will be negatively skewed. The moments of the residuals yield the estimated standard deviations of v and u components of the composed residuals from which measures of technical efficiency are calculated. These measures become dependent variables in the regression models to test hypotheses about technical efficiency.[6]

The study reached broad four conclusions. First, technical efficiency is a topic fit for serious economic analysis and deserves more attention than it is currently receiving. Second, the stochastic frontier production function has both strengths and weaknesses. Its major strength is that it allows one to relate possible causes of inefficiency with interindustry differences in efficiency. Third, the static measurement of efficiency can be integrated with the dynamic microanalysis of productivity growth and efficiency changes. Fourth, the SFPF must be used with caution as it does not always outperform simpler and cheaper measures. In particular, for intertemporal analysis, it reveals less than approaches that track the productivity of individual establishments over time. As Caves says (p. 25), "the statistical frontier production function belongs in the research arsenal, but in some battles it will yield to other weapons."

Caves' attempt to make the issue of technical inefficiency a central concern of economists is to be lauded. There is no doubt that technical inefficiencies can be substantial and that knowledge of their magnitude and causes is useful information. Indeed, reduction in technical inefficiency within an industry is generally much more important for overall productivity growth than expansion of the best-practice frontier of the leading firms because of the high proportion of firms that are behind the productivity leaders. Economists in general and industrial organization economists in particular have too long ignored this issue because of their *a priori* assumption of profit maximization.

However, the jury is still out on the overall contribution of the stochastic frontier production function to our understanding of technical efficiency. Indeed, given limited resources, the study of the dispersion of productivity levels among firms at both the national and international levels (i.e. the second moment of the residuals) may be more cost effective and fruitful.

[6]Caves stresses that the procedure does not always work because, in at least two cases, residuals cannot be calculated. A type I failure occurs when the skewness of the residuals is positive. This implies that the data lie above the estimated regression plane. A type II failure occurs when the third moment of the residuals is large relative to the second.

A great strength of the book is the "respect for the hazard of undue complexity," and the recognition that more sophisticated technique does not necessarily generate greater understanding. For example, the chapter on Canada by John Baldwin, unlike the other country chapters, does not use the SFPF approach because of lack of data on plant-level capital stock. Using data on output per person employed, Baldwin assumes that some fraction (10 to 40 percent) of each industry's total output emanates from efficient plants and then calculates average efficiency as the ratio of the weighted average of productivity for the remaining plants that are deemed inefficient relative to the corresponding productivity level for plants assumed on the frontier. A key virtue of this method is its simplicity. Caves appears perfectly willing to adopt the dispersion of plant productivity levels within an industry approach over the SFPF approach if it can be shown to be more productive, and it can be argued that the volume would have been improved if more chapters had included data on the dispersion of establishment productivity level data in an industry and compared these data to the measures of technical inefficiency generated by the SFPFs for the industry. In particular, such a comparison is a useful check on the robustness of the SFPF results.

A second issue is the appropriate spatial reference for analysis of efficiency issues. The Caves volume takes a country focus. In other words, the productivity gap between the national industry leader and other firms are calculated. If there is little dispersion, then the country is deemed to enjoy a high level of technical efficiency. Yet one can doubt the usefulness of the concept of technical efficiency in a national context when large gaps exist in productivity levels between countries. A country with small variance in productivity levels within the country may simply be a country where most firms are "equally bad," if the country's productivity levels (including that of the industry leaders) are well below world levels. The natural reference point for technical efficiency in the sense of Figure 1 is the international leader, not the national leader, and studies that compare a country's productivity levels to those in other countries (e.g. McKinsey, 1992, 1993 and 1994) offer greater insights on efficiency than those which fail to put a country's efficiency performance in an international context.

In theory, stochastic frontier production functions could be estimated with data pooled across countries. This would provide useful information on the international variance of productivity levels. In reality, data incomparability may have made pooling of the data inappropriate. In any case, a long-term objective should be the estimation of technical efficiency beyond the country level.

IV. Explanations of Differences in Productivity and Efficiency

Efficiency differences among firms reflect the differential application of the factors that determine productivity. In other words, certain firms have lower levels of output per worker or output per unit of capital than industry leaders because they have older equipment, less motivated workers, less advanced technology, or less effective organizational structures.

The welfare implications of labor productivity levels and changes are relatively straightforward whereas those associated with efficiency measures and changes in the measures can be ambiguous. The higher the labor productivity level, the better off society is in the sense it can attain higher levels of production and consumption. Increased labor productivity is the basis of improved living standards.

Efficiency measures in the Caves sense, which are based on the dispersion of firm productivity levels in relation to the productivity leader, bear no direct relationship to productivity levels and hence to economic welfare. For example, a high productivity, high living standard country like the U.S. may have low levels of efficiency because of a large productivity gap between the productivity leader and the average firm.

Changes in efficiency in the Caves sense are also ambiguous from a welfare point of view. When increased efficiency arises from an improvement of the productivity levels of firms below the productivity leaders, it is associated with an improvement in welfare due to the increased productivity level. In contrast, when efficiency improvements come from a fall in the productivity levels of the productivity leader, welfare falls due to the lower productivity level. Equally, decreased efficiency in the Caves sense may be associated with either increasing or decreasing productivity levels and hence welfare. A productivity advance for the productivity leader not experienced by other firms may lower efficiency in the Caves sense even though it raises productivity. A fall in productivity for the majority of firms relative to the leader lowers efficiency, productivity and welfare.

A key objective of the Caves volume was to identify factors explaining technical efficiency and to determine the robustness of the results across countries. The most dramatic regularity of the results concerned domestic producer concentration. In every country, high concentration was found to be hostile to technical efficiency. Perhaps surprisingly, international competition raises efficiency less robustly than domestic competition.

The overall results of the Caves volume were somewhat disappointing in terms of the international robustness of the determinants of technical inefficiency. Of the 72 bilateral tests on inefficiency determinants conducted between the U.S. and the five countries of the study, less than half (34 or 47 percent) revealed that the same factor was statistically significant in both countries (Table 3). Clearly, with the exception of competition, there is little robustness across countries in the importance of various factors in the determination of technical inefficiency.

The main contribution of Dollar and Wolff lies in their analysis of international productivity convergence. They argue the debate about declining U.S.

TABLE 3

INTERNATIONAL ROBUSTNESS OF RESULTS OF INTERINDUSTRY DETERMINANTS OF TECHNICAL EFFICIENCY

	U.S.-Japan	U.S.-Korea	U.S.-U.K.	U.S.-Canada	U.S.-Australia
Tests made in both countries	19	14	13	16	12
Tests with same results	8	8	5	7	6
Proportion of tests with same results	42	57	38	44	50

Source: Caves (1992), Table 1.2.

competitiveness in fact concerns the extrapolation of convergence into the future. International competitiveness is defined in terms of relative productivity and income levels. Two scenarios are possible. First, the current situation continues indefinitely. Productivity growth rates in certain countries outside the U.S. continue at a faster pace than those in the U.S., with the result that American productivity levels are eventually surpassed. This would represent a situation of declining U.S. competitiveness. A second scenario is that productivity growth rates in countries that are currently experiencing faster productivity growth than the U.S. level off as the American level is approached due to the phenomenon of convergence. The aggregate American productivity level may be attained by other countries, but it is never surpassed, and U.S. competitiveness does not decline.

Consequently, Dollar's and Wolff's objective is to ascertain which scenario is more likely. As they note:

> "Our contribution to the [convergence] debate is to delve, more deeply than in any previous work, into the sources of the productivity convergence that had been observed up through the end of the 1980s. A more thorough understanding of the sources of productivity convergence should enable us to assess the probability that trend will continue. Furthermore, this knowledge should also be useful in shaping public policy aimed at improving a nation's productivity and competitive standing." (p. 6.)

Does productivity convergence represent a general phenomenon, or is it confined to only a small number of countries? Dollar and Wolff take the view, correct in my opinion, that convergence is not an automatic process that occurs in all countries regardless of local conditions. The countries with the lowest per capita income do not automatically enjoy the highest productivity growth rates. Rather, convergence can best be viewed as an opportunity whose realization depends on several other factors or pre-conditions—adequate savings rates, an outward trade orientation, a certain minimum level of educational attainment of the population. Once these factors are controlled for, backward countries do indeed grow faster than more developed ones. As it is the OECD countries that are more likely to possess the pre-conditions for growth, it is this group of countries that constitutes the "convergence" club of the postwar period. From this perspective, convergence is not a general phenomenon or law of economic development or growth.

At the economy wide level, there are two basic possible sources of productivity convergence across countries—shifts in employment at the industry level and industry-specific productivity growth. It is possible that industry-specific productivity levels are the same in the two countries, and that the difference in productivity levels reflects the greater concentration of employment in low productivity level activities, like agriculture. As the employment structure in the low aggregate productivity moves toward that of the productivity leader, through the shedding of jobs in low productivity and employment growth in high productivity industries, the aggregate productivity level moves toward that of the productivity leader. In this case, the source of productivity difference was differences in employment structure, not industry-specific differences in productivity levels.

Alternately, industry-specific productivity levels may differ between countries. Here movement toward the aggregate productivity level of the productivity leader arises from faster productivity growth at the industry level in the low productivity country. Changes in the structure of employment have no impact on aggregate productivity.

A major finding by Dollar and Wolff is that productivity convergence among OECD countries has nothing to do with shifts in employment at the industry level. Rather, it entirely reflects catch-up in industry-specific productivity levels. It should of course be noted that industry-specific productivity growth is determined by both industry-specific factors, such as investment, and economy-wide factors such as the general level of health and education of the workforce. In terms of explaining productivity growth, attention has traditionally focused on the industry-specific factors, and neglected economy-wide factors.

At the industry level, there are two sources of productivity convergence—capital accumulation and technological advance. Dollar and Wolff find that technological catch-up was particularly important until the mid-1970s, and in industries and countries well behind the U.S. This result is consistent with the advantages of backwardness. Since the mid-1970s, productivity convergence has been increasingly associated with capital accumulation. Dollar and Wolff note that the U.S. productivity lead after World War II was an aberration based on particular historical experiences. It was almost inevitable that the world would return to a more normal state where there are a number of advanced countries whose productivity levels are close together.

Second, the authors do not attempt to explain the reasons for differences in total factor productivity levels across countries. Given the book's stress on technological convergence, the reader tends to assume that differences in technologies explain such discrepancies. Yet other factors, in particular differences in the skills of the workforce, can also account for international differences in the efficiency of resource use. The authors unfortunately do not develop this point. What is the role of human capital in explaining both differences in productivity levels across countries and in the productivity convergence process? Is there convergence in levels of educational attainment just as there is convergence in levels of technology, and if so what proportion of total productivity convergence does it account for? It is interesting to note that the international growth accounting literature of the 1960s and 1970s (see, for example, Denison (1967)) found human capital played a major role in explaining differences in both productivity growth rates and levels across countries. Hopefully, these past insights can be integrated into more recent analysis.

Third, the authors do not adequately discuss the relative merits of the various measures of convergence they present. In my view, by far the most useful measure is the average/leader ratio, as it presents information on the actual gap between the leader and the average. Yet, in the discussion, the superiority of this measure to the coefficient of variation measure is not noted. This latter statistic is flawed as a measure of convergence. A lower coefficient, which is taken as a trend toward convergence, may in fact only reflect less variation in observations around the mean, and tells nothing about the relationship between the leader and average.

Fourth, a surprising finding is that Hong Kong, in contrast to Korea, Brazil and Singapore, the other Third World countries analyzed, has experienced little convergence toward American productivity levels. Dollar and Wolff show that the ratio of Hong Kong to U.S. value added per worker in manufacturing rose only from 0.12 in 1973 to 0.14 in 1986 (0.22 to 0.26 with PPP exchange rates). Given the flourishing of the Hong Kong economy such a result is very surprising and merits further explanation. It is also at variance with other analyses of the Hong Kong economy, which have found productivity growth greatly superior to that in the U.S., hence implying convergence. For example, Young (1993) found that aggregate output per worker in Hong Kong over the 1971–91 period advanced at a 4.8 percent average annual rate, compared to only 0.9 percent for the U.S.

There has been much soul-searching and teeth-nashing in the U.S. in recent years over the country's supposed economic decline or loss of competitiveness or leadership to competitors, particularly Japan and Germany (see, for example, Kennedy, 1988 and of course Baumol, Blackman, and Wolff, 1989). Dollar and Wolff point out that all countries, including Japan, have self-doubts about their future. Then they note that the concept of country competitiveness is not a well-defined economic term, given that price level and exchange rate adjustment ensure that each country is a low-cost producer of some product. The concept of competitiveness is only meaningful when applied to firms in particular sub-industries. Despite their unease about the application of competitiveness to nations, they realize the concept is going to continue to be used in public debate, and therefore offer the following general definition:

> "A competitive nation is one that can succeed in international trade via high technology and productivity, with accompanying high income and wages. Given this definition, the best overall measure of competitiveness is one that has long been used in international comparison: productivity." (p. 3.)

This conflation of the term competitiveness with productivity performance has become the standard manner in which economists now define competitiveness. For example, it is the approach taken by Michael Porter (1990) and Paul Krugman (1994).[7]

Based on this definition of competitiveness, Dollar and Wolff assert that concerns over any apparent lack of U.S. competitiveness are currently misplaced since the U.S. is still the international leader in terms of productivity levels, even if this may be a surprise to the man on the street. However, such concerns may be pertinent in the future if productivity levels in other countries surpass those in the U.S.

They correctly point out that much of what is perceived as the relative decline of the U.S. is simply the convergence of advanced economies into a more homogeneous group. They note that while the U.S. share of total OECD manufacturing exports has fallen, the U.S. share of total OECD manufacturing output has actually increased, due to above average manufacturing output growth. This is hardly the sign of a manufacturing sector in decline. They also point out that

[7]"We must abandon the whole notion of a "competitive nation" as a term having much meaning for economic prosperity. The principal economic goal of a nation is to produce a high and rising standard of living for its citizens. The ability to do so depends not on the amorphous notion of "competitiveness" but on the productivity with which a nation's resources (labor and capital) are employed . . . . The only meaningful concept of competitiveness at the national level is national productivity." (p. 6.)

the growth of production by American multinational corporations located outside the U.S. has offset at least some if not all of the U.S. loss of export share.

V. Policy Implications

One obvious policy implication which may flow from the above discussion is that society in attempting to maximize productivity growth, should at least pay attention to Caves-type efficiency indicators across industries. Industries that exhibit low levels of technical efficiency may have greater productivity growth potential, at least in the short to medium term, than industries with high levels of technical efficiency because of the greater productivity gap between the leader and the other firms and the large productivity gains associated with the elimination of this gap.

A key question in my opinion not sufficiently developed in the Caves volume is the degree to which this technical inefficiency represents market failure and hence really does have normative implications. This is admittedly a difficult issue. Technical inefficiency can arise from imperfect information and non-optimal but persistent contractual arrangements that can be influenced by public policy, but it also can be due to product differentiation, spatial fragmentation of the market, and capital vintage effects, factors which are not influenced by public policy. While in theory it may be possible to control for the non-public policy amenable factors, in practice, the SFPF methodology is not yet at the point where this is possible. Consequently, the concept of technical inefficiency may have little if any normative content. Without an understanding of the factors behind technical inefficiency, policy-makers should be somewhat cautious about using indicators of technical inefficiency as the rationale for particular policy measures. For example, one may not know whether a situation of increasing technical inefficiency in the Caves sense reflects large increases in the productivity levels of the leading firms (a positive development) or falling productivity of other firms (a negative development).

Dollar and Wolff's analysis of productivity trends has important implications for both trade and industrial policy. They argue that the postwar international growth experience lends strong support to the view of trade as mutually beneficial exchange. Consequently, they stress the importance of an open door policy to foreign trade and investment for a sound international economy.

In terms of industrial policy, they reject the idea that government should attempt to target the development of particular technologies because of the great difficulty of predicting in which areas innovations are going to occur. Rather they argue it makes more sense for government to improve the overall environment for innovation, through, for example, the attention to problems of deteriorating schools and physical infrastructure and to massive fiscal deficits which they claim have taken resources away from productive investment.

VI. Conclusion

The volumes under review make two different, but complementary contributions to the productivity literature. The Caves volume tries to focus attention on the large productivity gains that can be achieved by moving to the production frontier, an area that has traditionally been ignored by economists because of the assumption of profit maximization. The lesson for economists is that much more attention should be focused on technical efficiency in an attempt to move firms closer to the best-practice firms.

The Dollar–Wolff volume focuses attention on the productivity gains that can accrue to countries with productivity levels below that of the world leader as these countries adopt best-practice technology. This productivity convergence has been a major source of productivity growth in the postwar period. The lesson for economists is a positive one—under the right conditions, low income countries can benefit from best-practice technology and see their productivity levels and living standards rise to approach those of the high-income countries.

Taken together, the Caves and Dollar–Wolff volumes make a major contribution to the economics profession's understanding of the concepts of productivity and efficiency and their determinants. Economists of all political leanings can use this understanding in the development of policies to improve productivity levels and living standards.

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