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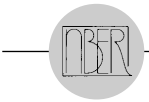

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New Developments in Productivity Analysis

Edited by **Charles R. Hulten, Edwin R. Dean, and Michael J. Harper**

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Since this volume is a record of conference proceedings, it has been exempted from the rules governing critical review of manuscripts by the Board of Directors of the National Bureau (resolution adopted 8 June 1948, as revised 21 November 1949 and 20 April 1968).

Contents

Prefatory Note

This volume contains revised versions of most of the papers and discussions presented at the Conference on Research in Income and Wealth entitled "New Directions in Productivity Analysis," held in Silver Spring, Maryland, on 20–21 March 1998. It also contains some material not presented at that conference.

Funds for the Conference on Research in Income and Wealth are supplied by the Bureau of Labor Statistics, the Bureau of Economic Analysis, the Federal Reserve Board, and the Bureau of the Census; we are indebted to them for their support. This conference was supported by the National Science Foundation under grant SBR-9730608.

We thank Charles R. Hulten, Edwin R. Dean, and Michael J. Harper, who served as conference organizers and editors of the volume, and the NBER staff and NBER and University of Chicago Press editors for their assistance in organizing the conference and editing the volume.

Brent R. Moulton
Matthew Shapiro
Robert Summers

Volume Editors' Acknowledgments

The editors of this volume, who also served as the organizing committee for the CRIW conference that took place on 20–21 March 1998, gratefully acknowledge the financial support of the National Science Foundation through grant SBR-9730608. We thank Kirsten Foss-Davis and other members of the NBER conference department for their work in making the conference possible. In preparing these proceedings for publication, we relied greatly on the expert assistance of Helena Fitz-Patrick and other members of the NBER editorial staff as well as staff members of the University of Chicago Press. Finally, we thank two anonymous referees for their comments on the volume.

Introduction

Charles R. Hulten, Edwin R. Dean, and Michael J. Harper

The Conference on Research in Income and Wealth (CRIW) last met to discuss "new developments" in productivity analysis in November 1975 at a meeting organized by John W. Kendrick and Beatrice N. Vaccara. Discussions of productivity were dominated at that time by the methodological debate between Edward Denison, on the one hand, and Dale Jorgenson and Zvi Griliches, on the other. While many of the positions of Jorgenson and Griliches have been widely accepted—notably through the 1983 launch of the multifactor productivity program by the Bureau of Labor Statistics (BLS)—other issues have surfaced. The proceedings of the 1975 conference make no mention of the productivity slowdown that commenced in the early 1970s, but this slowdown became the central concern of productivity analysts over the next two decades.

The focus has shifted again in recent years as the prolonged economic expansion has offered up another conundrum: Why has measured productivity failed to keep up with the boom in a period notable for major innovations in information technology? The New Economy explanation of the recent boom assigns central importance to unmeasured gains in productivity arising from index number issues and from the failure to measure improvements in product quality. The potential importance of these issues is underscored by the recent revisions of government productivity statistics.

Charles R. Hulten is professor of economics at the University of Maryland and a research associate of the National Bureau of Economic Research and chairman of the Conference on Research in Income and Wealth. Edwin R. Dean was formerly associate commissioner for Productivity and Technology, Bureau of Labor Statistics, U.S. Department of Labor. He is currently adjunct professor in the Department of Economics at The George Washington University, Washington, D.C. Michael J. Harper is a member of the staff of the Office of Productivity and Technology of the U.S. Bureau of Labor Statistics.

Data on real gross domestic product (GDP) were revised in 1996 to use an annually chained Fisher Ideal Index number formula. The primary empirical impact of this was to assign the proper historical weights to computer hardware in calculating real GDP. In 1999 a second round of GDP revisions introduced computer software, improved the measures of banking output, and utilized price data that were developed using improved index number methods at the most detailed levels of aggregation. This second round of changes resulted in productivity estimates in the nonfarm business sector that reveal a smaller slowdown in the 1970s and more rapid growth since the mid-1990s. Advocates of the New Economy viewpoint may applaud these data improvements.

The perception that productivity statistics have a systematic downward bias is not universally shared. Environmentalists have argued that the bias may go in the opposite direction, because the measures of output and inputs used in conventional productivity calculations do not account adequately for the depletion of natural resources or damage to the environment. A recent publication by the National Research Council, "Nature's Numbers," suggests major changes in the national accounts to address this problem.

The theory of productivity measurement discussed at the 1975 conference was based on a view of economic growth that evolved largely from research published in the 1950s and early 1960s. The last twenty-five years have seen some basic shifts in the paradigm of growth. One shift emphasizes the endogeneity of macroeconomic productivity change and the importance of market structure. Another emphasizes the investigation of productivity growth at the firm and plant levels of detail, using large-scale microdata sets.

The CRIW met in March 1998 to discuss these developments; the fifteen papers in this volume reflect these deliberations. The first four papers present a summary of the history and the current state of play in the field. The paper by Charles R. Hulten is a biography of the total factor productivity (TFP) residual. It provides an overview of the evolution of nonparametric productivity analysis; discusses the main problems that currently beset the field, such as the difficulty in accounting for quality change; and presents an overall assessment of the strengths and weaknesses of the TFP residual as a tool for understanding the factors underlying long-term trends in economic growth. The paper, which is intended to serve as an introduction to the conference proceedings, provides an illuminating analysis of the survival of the residual as the main workhorse of empirical growth analysis. The paper by Edwin R. Dean and Michael J. Harper provides an overview of the BLS productivity measurement program, the development of which was one of the major milestones in the evolution of the field. This program publishes the official U.S. government productivity statistics. The paper shows that the adoption of theoretical advances by the BLS measurement

program often required interesting judgment calls. A paper by W. Erwin Diewert then discusses which ideas are ready to be adopted by government statistical measurement programs. A paper by M. Ishaq Nadiri and Ingmar R. Prucha rounds out the section by reviewing developments in the econometric analysis of production, with a focus on dynamic interrelated factor demand models. The authors critically examine models based on restrictive simplifying assumptions and simple econometric specifications. They also provide a Monte Carlo study showing the magnitude of the errors that may arise from using simpler econometric specifications when the structure of production exhibits great complexity.

In a luncheon address, Robert M. Solow, whose seminal 1957 paper laid the conceptual foundations for TFP measurement, provided remarks assessing both progress in the field and potential future directions. He recommended that more emphasis be placed on his vintage model, an alternative framework for analyzing the role of capital in productivity, which he proposed in 1959.

The next two papers deal with new theoretical developments. The paper by Jeremy Greenwood and Boyan Jovanovic explores alternative models of productivity change. It compares the conventional model of disembodied technical change developed by Solow and by Jorgenson and Griliches with a variety of possibilities organized around the model of embodied technical change, which is extended to include learning and diffusion effects, plant heterogeneity, capital-skill complementarity, R&D, and worker-machine matching. Susanto Basu and John Fernald take up another theoretical issue that has challenged productivity analysis: the problem of short-run procyclical productivity fluctuations. Conventional analysis regards these fluctuations as a nuisance that obscures long-run movements in total factor productivity (also referred to as multifactor productivity.) This paper treats them as potentially interesting macroeconomic variables that need to be understood in their own rights. Several competing explanations are studied, including procyclical technology shocks, the effects of imperfect competition with increasing returns to scale, variable utilization of inputs over the business cycle, and resource reallocations over the cycle.

The next set of papers deals with another major theme in modern productivity analysis: the perception that the answer to productivity puzzles is to be found at the level of firms and plants, rather than at high levels of aggregation. The paper by Lucia Foster, John Haltiwanger, and C. J. Krizan explores this issue in the context of panel data on plant-level production (notably, the U.S. Bureau of the Census's LRD database). Productivity growth at the industry or economy level of aggregation arises from two general sources: productivity improvement at the plant level and the reallocation of resources among plants of different efficiencies. The first effect captures technological and organizational innovations, as well as other factors related to productivity, whereas the reallocation effect cap-

tures the interaction of productivity effects with other factors determining market share. Both are important for understanding the sources of productivity change.

The paper by Denny Ellerman, Thomas M. Stoker, and Ernst R. Berndt also emphasizes the importance of disaggregated productivity measures, but the focus here is on a specific industry: coal mining. Official statistics do not present an accurate picture of technical innovation because they abstract from the heterogeneity of the technologies, production scale, and coal quality. The paper illustrates the importance of industry-specific factors in interpreting and measuring productivity trends.

Martin Neil Baily and Eric Zitzewitz take the most disaggregated view of all. They report on the results of projects carried out by McKinsey and Company with data from client firms. Their focus is on one of the chronic problem areas of productivity analysis: the service sector. They present results for five service industries: the banking sector, telecommunications, retail trade, public transportation, and airlines. A key issue in each area is how to define and measure the output of the industry, which is a necessary step in calculating a productivity ratio. The authors argue that another necessary step in correctly measuring output is to understand the industry from the inside out.

The next two papers deal with international issues. A paper by Nazrul Islam examines alternative approaches to international comparisons of productivity. This is an issue that has occupied productivity specialists for years (see, for example, the paper by Laurits Christensen, Diane Cummings, and Dale W. Jorgenson in the Kendrick-Vacarra volume cited in Islam's paper). However, it has received increased attention in recent years in the literatures on the international convergence of growth rates, the debate over the nature of the East Asian Miracle, and the question of whether capital accumulation or assimilation of technology is the principle engine of growth. Then, a paper by Dale W. Jorgenson and Eric Yip uses the TFP framework and international data to challenge the notion that we have entered a new era of more rapid productivity growth. It is generally believed that productivity improvements are a necessary condition for long-run improvements in living standards, and it is also widely believed that productivity improvements support the recent prosperity in financial markets. The future prosperity of the United States will depend, fundamentally, on how fast productivity can grow.

The final two papers deal with environmental issues. Most conventional analyses of productivity growth make no allowance for production-related environmental factors such as pollution and resource depletion. This has clearly been an active policy issue, and it raises interesting conceptual problems for productivity theory—namely, how to treat outputs and inputs whose prices and quantities cannot be measured, and how to deal with multiple outputs, some of which are "bads" rather than "goods." The

paper by V. Eldon Ball, Rolf Färe, Shawna Grosskopf, and Richard Nehring takes up this problem using a technique not used in conventional studies: distance functions. This approach gives rises to Malmquist indexes that incorporate environmental "bads." The authors apply this approach to pesticides and fertilizer runoff in the U.S. agricultural sector. Frank M. Gollop and Gregory P. Swinand show how to deal with environmental issues within the conventional TFP model. The central issue is to specify production and utility functions correctly in order to include the full environmental consequences of economic activity. Like the authors of the preceding paper, they apply their framework to the farm sector.

Zvi Griliches opened the conference with some brief remarks. Later, he prepared a written version of these remarks, and these are presented as the final paper in this volume. In this paper, Griliches comments on how well his 1967 paper with Jorgenson has held up over the years, and he provides insight into difficult measurement problems that are presently retarding progress in understanding productivity trends. Sadly, Zvi passed away on 4 November 1999. He was one of the seminal intellectual forces of the productivity research community, and he will be greatly missed. This volume is dedicated to the remembrance of his many contributions both to this research area and to others.