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Volume Title: Measuring Capital in the New Economy

Volume Author/Editor: Carol Corrado, John Haltiwanger and Dan Sichel, editors

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-11612-3

Volume URL: <http://www.nber.org/books/corr05-1>

Conference Date: April 26-27, 2002

Publication Date: August 2005

Title: Introduction to "Measuring Capital in the New Economy"

Author: Carol Corrado, John Haltiwanger, Daniel Sichel

URL: <http://www.nber.org/chapters/c0201>

Chapter pages in book: (1 - 10)

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# Introduction

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As the new economy has developed, intangible assets and high-technology investments are playing an increasingly important role.<sup>1</sup> These developments have raised many important questions about measurement, including how to treat intangible assets in economic accounts and whether we are accurately measuring newer, high-technology capital. Economic researchers, data providers, and policy analysts are interested in answering these questions because the answers can lead to better assessments of the economy's long-run pace of economic growth and rate of technological advance, as well as to improved measures of national wealth.

In April 2002, the Conference on Research in Income and Wealth (CRIW) of the National Bureau of Economic Research (NBER) held a conference at the Federal Reserve Board in Washington, D.C. The purpose was to develop new results in capital measurement and to explore their practical implications for the measurement community. This volume includes the papers presented at the conference, the discussants' remarks, and summary remarks of some of the key conference participants. The papers and

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The views expressed in this introduction are those of the authors and should not be attributed to the Board of Governors of the Federal Reserve System or other members of its staff.

1. We use the term "new economy" broadly to encompass the ongoing changes in the economy, particularly those related to information technology.

comments have undergone review and, in some cases, substantial revision since their presentation at the conference.

The themes of the conference and this volume concern the challenges of how to measure physical capital accumulation and the contribution of intangible assets in an economy that is increasingly dominated by high-technology capital and undergoing change brought about by advances in information technology. Just as Griliches (1994) argued that the fraction of output that is difficult to measure has been growing over time, we argue that the fraction of capital that is challenging to measure has been growing over time as well. Growth of high-tech capital has been extremely rapid in recent decades, and although data are sparse, the growth of intangible capital appears to have been rapid as well.

Substantial attention has already been devoted to some of the measurement challenges regarding high-tech assets. For example, the focus on measuring real investment in computers and on studying the prices of semiconductors for computers has been considerable. Less attention, however, has been devoted to the measurement of the asset accumulation process for high-technology communications capital and for computer software capital; the latter is a major type of intangible asset that the Bureau of Economic Analysis (BEA) has only recently included in its capital accounts. This volume devotes needed attention to the measurement of communications equipment and software capital.

This volume also devotes substantial attention to the measurement of intangible assets not now on the national balance sheet. Relatively little is known about the precise size of these assets, although recent work points to the potentially large magnitude of business spending on intangibles (Nakamura 2001; Lev 2001). Moreover, an extensive literature documents the profitability of business spending on research and development (R&D) and employer-provided training, suggesting that one can broadly argue that intellectual capital, organizational capital, human capital, and human resource practices are crucial assets of successful firms in today's economy (Hall 2000, 2001a,b; Lev 2001).

A growing body of research also emphasizes the complementarities between investment in high-tech capital, including software capital, and the creation of intangibles in the form of network externalities (Shapiro and Varian 1999) and organizational and firm-specific human capital (Brynjolfsson and Hitt 2000). Such complementarities likely exist both in dot-coms and in large manufacturing establishments, although the nature of the complementarity likely differs substantially across sectors and businesses. Although much work remains to be done in this literature, these types of intangible capital and their interaction with other forms of capital also receive considerable attention in this volume. Indeed, the desire to better understand this interaction is a key reason the conference focused on the challenges of measuring capital quality and intangibles. As noted

above, these measurement challenges are similar in that their importance and relevance have grown with the spread of information technology. They are very distinct, however, in the questions addressed: “Are we capturing technological change in our price measures for high-tech assets?” versus “How should we determine the boundary between what is investment and capital and what is not?” Accordingly, the papers in this volume address diverse measurement issues.

Without a doubt, some of the measurement issues highlighted here are controversial. The flourishing U.S. economy of the late 1990s—especially its booming stock market—has been partly responsible for generating the interest in better measuring and understanding the role of capital quality and intangibles in our modern economy. Indeed, a sizable literature attempts to determine how much of the gap between the market value of corporate securities and the value of corporate capital at replacement cost can be explained by intangibles. Although several papers in this volume are skeptical about using market valuations to measure intangibles, the perspective that important inferences about firm performance can be drawn from market valuations receives support in this volume. At the same time, other papers in the volume offer alternative strategies for measuring intangibles based on spending or earnings data.

We recognize that it is vital to incorporate the perspective of the accounting community in addressing the measurement issues highlighted in this volume. One challenge is that even if a widespread consensus forms on the need to develop and improve measures of intangible capital, the measurement difficulties and the need for transparency in business accounting yield an inherent tension. Moreover, business accounting practices are currently undergoing scrutiny that stems from questionable accounting practices by some firms; often such practices are connected to the treatment of intangibles in business accounts. Although these developments raise a new set of challenges, we believe that it is essential to continue moving down the road toward a better understanding and fuller recognition of intangibles.

At the conference and in this volume, the issues highlighted in this introduction are addressed from a wide variety of perspectives and approaches. In the remainder of this introduction, each paper in the volume is summarized. The summaries are not exhaustive, as the papers speak for themselves, and some perspective is provided on how the papers fit together, given the objectives of the conference.

### **An Overview of the Papers**

The first paper in the volume, “Measuring Capital and Technology: An Expanded Framework,” provides guidance on what components of business spending should be included in measures of capital investment. Carol Corrado, Charles Hulten, and Daniel Sichel present an intertemporal

model that defines capital investment as follows: Any outlay that is intended to increase future rather than current consumption should be treated as investment. Thus, spending on a host of intangibles—computerized databases, R&D, new copyrights and licenses, brand equity, and improved organizational structures—should, in principle, be counted as investment in economic accounts. The authors use their framework to identify and measure the components of business capital spending on intangibles. They find that, by the late 1990s, business fixed investment in intangibles may have been as large as investment in traditional equipment and structures. They indicate further that a significant portion of this investment is excluded from the existing investment figures in U.S. national income and product accounts (NIPAs) and suggest that a move to recognize intangible capital might alter our understanding of the factors determining economic growth.

The next few papers explore conceptual and measurement issues for intangible capital. Jason G. Cummins in “A New Approach to the Valuation of Intangible Capital” raises both conceptual and measurement issues about the market valuation approach to measuring intangible capital that has appeared in the recent literature. In the market valuation approach, intangible capital is measured as the gap between the market value of a corporation’s securities and the replacement value of its physical assets. Cummins takes a different conceptual and empirical approach. He models intangibles within an adjustment-cost framework and then exploits data from analysts’ forecasts of earnings to test his approach and framework. Compared with the market valuation approach, Cummins’s approach finds a substantial, but much smaller, valuation of intangible capital.

In “The Valuation of Organizational Capital,” Baruch Lev and Suresh Radhakrishnan take a different approach in measuring what they call “organizational capital.” They define organizational capital as the knowledge and structure used to combine inputs, such as physical capital and labor, to produce goods and services. Some businesses have more of this organizational capital than others—that is, they are able to produce more or more-valuable goods and services with a given amount of physical and human capital. Using this conceptual framework, Lev and Radhakrishnan develop alternative measures of organizational capital. The primary approach is to measure organizational capital as a residual, much like total factor productivity. Lev and Radhakrishnan test the information content of these measures of organizational capital by considering how financial markets value them.

In “Intangible Risk,” Lars Peter Hansen, John C. Heaton, and Nan Li raise further questions about using financial market data to infer measures of intangible capital. They point out that drawing inferences about intangible capital from stock market returns must consider risk or offer some competing interpretation for the heterogeneity in stock market returns. Put

differently, asset valuations reflect beliefs about not only the future prospects for firms but also the riskiness of the implied cash flows. Taking risk into consideration, they present evidence that important differences exist between the risks associated with investments in traditional measured capital and those associated with intangible capital.

Other papers explore alternative direct measures of the factors that either compose or are closely connected to intangible capital. The first group focuses on human capital and human resource practices. The growing role of intangibles is conjectured to be linked to an increasing role of firm-specific human capital and associated human resource practices. That is, the tacit knowledge of employees is a key intangible asset, and successful businesses are those that manage the accumulation of such assets well through their human resource and organizational practices. For this important and difficult area of inquiry, the volume includes two papers.

In the first paper, “The Relation among Human Capital, Productivity, and Market Value: Building up from Micro Evidence,” John M. Abowd, John Haltiwanger, Ron Jarmin, Julia Lane, Paul Lengermann, Kristin McCue, Kevin McKinney, and Kristin Sandusky explore new micro-based measures of human capital and the connections among human capital, productivity, and market value. Well established in the literature is that traditional human capital measures (for example, education) are important factors in production and that traditional measures capture only a small fraction of what we think of as human capital. Using newly developed, longitudinal, employer-employee matched data, the authors construct new, comprehensive measures of human capital and look at the connection between the new human capital measures and firm performance. Interestingly, but perhaps not surprisingly, the new measures help account for the observed variation in labor productivity across businesses. Even more interesting is that the new human capital measures also help account for the variation in market valuation across businesses after controlling for observed physical assets. The latter finding suggests that human capital is closely connected to intangible capital.

In their paper “Measuring Organizational Capital in the New Economy,” Sandra E. Black and Lisa M. Lynch explore these closely related issues but use a different approach. Rather than focusing on the differences in human capital across businesses, Black and Lynch focus on the observed differences in human resource practices (including training) across businesses. Of course, the latter may have an effect on and interact with the differences in human capital across businesses, but the focus here is on the differences in the management of human capital across businesses. These authors review the burgeoning recent literature in this area and argue that human resource practices appear to be quite important in accounting for observed differences in firm performance. Moreover, the authors discuss recent related findings that the returns from the adoption of advanced

technologies are improved by the adoption of state-of-the-art human resource practices.

Industrial R&D has long been seen as one of the key factors underlying the differences in the products and processes across businesses. In other words, R&D has long been viewed as one of the critical factors determining the growth in total factor productivity. However, measuring R&D capital and its effects on firm performance is inherently difficult. One of the major challenges is having the appropriate data to capture the full effects of R&D on firm performance. In his paper “Pharmaceutical Knowledge-Capital Accumulation and Longevity,” Frank R. Lichtenberg takes a fresh look at these difficult issues in the pharmaceutical industry. Using rich micro-level data on the development of new drugs and data on the effects of such new drugs on human longevity, Lichtenberg generates novel results on the returns from R&D. In so doing, he raises several questions about the existing methods that are used to measure R&D capital and its effects on business performance.

Barbara M. Fraumeni and Sumiye Okubo in their paper “R&D in the National Income and Product Accounts: A First Look at Its Effect on GDP” look at related issues, but from the top down instead of the bottom up. Fraumeni and Okubo discuss the data collected on R&D expenditures in the U.S. economy. They discuss how an R&D capital stock could be constructed for the U.S. NIPAs, and then they examine the relationship between their measures and existing GDP. This paper is important in its own right, but it is also important because it fulfills one objective of the conference—which was to spur consideration of how measuring intangible capital may change the existing statistics. Fraumeni and Okubo offer direct guidance on this subject.

The next set of papers explores measurement issues for what might be called “high-tech” capital. High-tech capital is inherently difficult to measure because accurate measurements of quality change and of depreciation are particularly difficult. Tremendous progress has been made in the measurement of certain high-tech products such as computers and semiconductors. The focus of this set of papers is on the areas of high-tech capital in which progress has been slower—in particular, communications equipment and software.

In “Communications Equipment: What Has Happened to Prices?” Mark Doms uses unique, newly developed data to study price and quality change for communications equipment. He found a high pace of quality change in communications equipment, particularly for the components used to create and provide business computer networks, such as high-end routers, switching equipment, and fiber optic equipment. The estimated pace of quality change is not as dramatic as that for computers and semiconductors but is still quite rapid and faster than official statistics suggest. Doms also points the way for improving the measurement of real output,

prices, and productivity growth in this important industry by offering new ways of classifying its highly diverse components.

One relatively recent change is that software is now treated as an investment good in the NIPAs. This change is important conceptually and has had significant implications for the national accounts. Treated as an investment good, software now contributes to the aggregate capital stock, and the difficult issues of measuring quality change and depreciation for capital goods must now be addressed for software. In “Information-Processing Equipment and Software in the National Accounts,” Bruce T. Grimm, Brent R. Moulton, and David B. Wasshausen carefully document the measurement of high-tech assets in the national accounts, including the current treatment of software. The paper goes beyond summarizing the new treatment of software, however. The authors discuss the limitations and difficulties associated with the new methodology, outline areas in which the BEA hopes to make future progress, and discuss recent changes in the methods the BEA uses to measure information-processing equipment.

The remaining papers cover areas that bridge more than one of the aforementioned topics. “Growth of U.S. Industries and Investments in Information Technology and Higher Education” by Dale W. Jorgenson, Mun S. Ho, and Kevin J. Stiroh explores the connections among productivity growth, human capital investment, and information-technology investment at the industry level. Much has been made of the contribution of information technology to the rapid and accelerated pace of productivity growth in the late 1990s. This paper uses industry-level data to explore the contribution of information technology at a more disaggregated level. Also, much has been made in the literature about skill-biased nature of the information-technology revolution. The rise in the demand for skilled workers in the past few decades and the associated changes in wage inequality have been the subjects of much research and debate. Using the growth accounting methodology that Jorgenson helped pioneer, the authors explore how all of these factors interact at the industry level. Their findings confirm the important contributions of both information technology and investment in human capital (via higher education) to productivity growth. Moreover, the paper raises several issues about measurement. In particular, the lack of comprehensive and integrated industry accounts makes the empirical exercises in this paper challenging, and the authors provide a useful perspective on the ways the official statistics could be improved along these lines.

Finally, W. Erwin Diewert in “Issues in the Measurement of Capital Services, Depreciation, Asset Price Changes, and Interest Rates” provides a unified framework for the measurement of capital that addresses many of the issues and topics covered in the volume. Diewert reviews the standard methods for measuring capital, examines a range of alternatives for the



treatment of depreciation, and explores the role of quality change and how intangible assets stocks could be measured. He uses this unified framework to discuss the pros and cons of the alternatives statistical agencies might face from both a conceptual and a practical point of view. In the context of the other papers in the volume, Diewert provides direct guidance on the various reasons for the difficulty in measuring intangible assets and high tech capital.

## **Conclusion**

As in past NBER and CRIW conferences, this one stimulated a rich discussion by experts in the areas covered by the volume. For many of the published papers, the discussants' comments are also included. These comments provide useful perspectives on the papers themselves and on the relevant broader issues. In addition, the conference included two panel discussions that provided important perspectives on the issues of the conference. The first panel assessed private-sector approaches to accounting for intangible assets and included Martin Baily, Ed Bersoff, Janamitra Devan, and Baruch Lev. The second roundtable discussed "next steps" for the measurement community and included Brian Kahin, Frederick Knickerborcker, Randall Kroszner, Steven Landefeld, Marilyn Manser, and Larry Slifman.

The volume includes written remarks by noted contributors to the related literature who also participated actively in the conference. After welcoming remarks by Martin Feldstein and introductory remarks by Alan Greenspan, Robert Hall discussed his provocative work on the use of the stock market valuations to measure intangible capital. His remarks, published in this volume, offer an interesting perspective, especially in light of the sharp declines in stock prices in recent years. Besides presenting his paper on organizational capital, Baruch Lev participated actively in the panels and discussion, relating the perspectives of the accounting profession on the measurement of intangible capital. As discussed earlier, incorporating the perspective of the accounting profession is important, and his remarks are published in the volume. Finally, the volume includes written remarks by Erik Brynjolfsson and Loren Hitt. They have been active contributors to the literature on the measurement and contribution of intangibles to productivity, firm performance, and growth. One of the special features of this work is the initiation, supervision, and analysis of private surveys on these topics, yielding a unique perspective on these issues.

Not surprisingly, no overall consensus emerged from the conference. Because capital measurement issues are difficult and the debate is ongoing, this lack of consensus is consistent with the conference tradition. The statistical, research, and policy communities will be grappling with the difficult issues in measuring capital for some time to come—and the problems

associated with defining and measuring intangible capital and measuring high-tech capital will be at or near the top of the list. We believe that the papers in this volume will help define the issues, stimulate debate on these topics, and generate advances in both theory and practice.

Indeed, an area of agreement at the conference was that the statistical agencies could use satellite accounts as a repository for the new measures being developed for some components of intangibles (for example, R&D capital and human capital). We hope that the statistical and research communities will use the rich insights presented here in this way and in other ways for years to come.

The conference organizers and attendees thank those who made this conference a success and the NBER and CRIW volume possible: the National Science Foundation and the NBER and CRIW for financial support; the Federal Reserve Board for hosting the conference; and the NBER, especially Helena Fitz-Patrick, for assistance in compiling this volume.

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