

Preface

The resurgence of the American economy since 1995 has outrun all but the most optimistic expectations. Economic forecasting models have been seriously off track and growth projections have been revised repeatedly to reflect a more sanguine outlook. It is not surprising that the unusual combination of more rapid growth and slower inflation touched off a strenuous debate about whether improvements in America's economic performance can be sustained.

A consensus has emerged that the development and deployment of information technology (IT) is the foundation of the American growth resurgence. A mantra of the "new economy"—faster, better, cheaper—captures the speed of technological change and product improvement in semiconductors and the precipitous and continuing fall in semiconductor prices. The price decline has been transmitted to the prices of a range of products that rely heavily on semiconductor technology, like computers and telecommunications equipment.

Swiftly falling IT prices provide powerful economic incentives for the diffusion of information technology. The rate of the IT price decline is a key component of the cost of capital, required for assessing the impacts of rapidly growing stocks of computers, communications equipment, and software. Constant quality price indexes, like those for computers in the U.S. National Income and Product Accounts (NIPA), are essential for identifying the change in price for a given level of performance.

A substantial acceleration in the pace of IT price decline occurred in 1995, triggered by a much sharper acceleration in the price decline of semiconductors—the key component of modern information technology. Although the decline in semiconductor prices has been projected to continue for at least another decade, the recent acceleration may be temporary. This can be traced to a shift in the product cycle from three

years to two years as a consequence of intensifying competition in markets for semiconductor products.

Chapter 2 begins with an analysis of U.S. economic growth throughout the postwar period and shows that investment has been the predominant source. Cheaper information technology in particular has given greater importance to more productive forms of capital. The rising contribution of investment since 1995 has been a key contributor to the U.S. growth resurgence and boosted growth by close to a percentage point. The contribution of investment in information technology accounts for more than half of this increase. Within information technology, computers have been the predominant impetus to faster growth, but communications equipment and software have made important contributions as well.

The accelerated IT price decline also signals faster total factor productivity growth in IT-producing industries. The IT-producing industries have accounted for a substantial share of the surge in economy-wide total factor productivity growth since 1995. It is important, however, to emphasize that faster total factor productivity growth is not limited to these industries.

In chapter 3 we show that the surge of IT investment in the United States after 1995 has counterparts in all other industrialized countries. It is essential to use comparable data and methodology in order to provide rigorous international comparisons. A crucial role is played by measurements of IT prices. The U.S. national accounts have incorporated measures of IT prices that hold performance constant since 1985. Paul Schreyer (2000) has extended these measures to other industrialized countries by constructing “internationally harmonized prices.”

We show that the acceleration in the IT price decline in 1995 triggered a burst of IT investment in all of the G7 nations—Canada, France, Germany, Italy, Japan, the United Kingdom, as well as the United States. These countries also experienced a rise in total factor productivity growth in the IT-producing industries. Differences in the relative importance of these industries, however, have generated wide disparities in the impact of information technology on economic growth. The role of the IT-producing industries is greatest in the United States, which leads the G7 in output per capita.

In chapters 4 through 8 we trace the American growth resurgence to the sources within individual industries. For this purpose we construct measures of output and total factor productivity for 44 industries. Output and total factor productivity for the four IT-producing

industries—semiconductors, computers, communications equipment, and software—can be separately identified at a level of detail not previously available. We then divide the remaining 40 industries between 17 IT-using industries, those particularly intensive in the utilization of IT equipment and software, and 23 Non-IT industries.

The gross domestic product (GDP) is the sum of value-added over these industries. Equivalently, GDP is the sum of expenditures on final demands—consumption, investment, and net exports. In chapters 2 and 3 we use the expenditure definition to provide a “top down” perspective on the American growth resurgence. The expenditure approach presents a concise overview of the economy without requiring detailed data for individual industries.

In chapter 8 we employ the value-added definition of GDP to give a “bottoms up” perspective on the American growth resurgence. The value-added approach characterizes the sources of growth for individual industries, while providing a great deal of supporting detail for growth of the economy. This approach traces the ramifications of rapid price declines for IT equipment and software for each of the 44 industries that make up the U.S. economy. The expenditure approach employed in chapter 2 and the value-added approach in chapter 8 provide similar views of the resurgence.

At the industry level the value of gross output is the sum of value-added, consisting of capital and labor, and the value of intermediate goods and services. Total factor productivity is defined as output per unit of input, where input includes capital, labor, and intermediate inputs. Chapter 7 analyzes the growth for individual industries using data for output and intermediate input taken from chapter 4, data for capital input from chapter 5, and data for labor input from chapter 6. This study is the first to measure total factor productivity growth, as well as growth of all three inputs, for the four IT-producing industries.

Intermediate inputs predominate in gross output for about 70 percent of the industries, so that gross output rather than value-added must be the primary focus in analyzing the sources of growth at the industry level. This definition has the crucial advantage that the role of intermediate goods and services, such as semiconductors used by the IT-producing industries, can be clearly identified. We provide a breakdown of intermediate inputs between IT and Non-IT products to provide additional insight into the importance of IT equipment and software.

While industry output is an aggregate of value-added and intermediate input, it is nonetheless remarkable that IT-producing sectors have

the most rapid growth of both intermediate inputs and value-added. The rapid growth of the four IT-producing industries has its sources in both inputs and total factor productivity, although the relative importance of these sources differs considerably. All the IT-producing industries have large contributions of intermediate goods and services, including inputs from other IT-producing sectors.

Computers and Electronic Components have large growth rates of total factor productivity, while Computer Services, containing software, has a large contribution of labor input, but no total factor productivity growth. As a group, the four IT-producing industries contribute more to the growth of total factor productivity during the period 1977–2000 than all other industries combined. In fact, the contributions of the IT-using and Non-IT industries were slightly negative during this period, partly offsetting the positive contribution of the IT-producing industries.

Turning to the industry sources of the American growth resurgence, seventy percent of U.S. industries contribute to the acceleration in economic growth. The four IT-producing industries are responsible for only about three percent of the GDP, but a quarter of the resurgence. The 17 IT-using industries account for another quarter of the growth resurgence and about the same proportion of the GDP, while the non-IT industries with 70 percent of value-added are responsible for only half the resurgence. The contribution of the IT-producing industries is far out of proportion to their relatively small size.

We also show that the contribution of capital is the most important source of the growth resurgence, total factor productivity is next, and the contribution of labor is almost negligible. The acceleration in capital growth is primarily in IT equipment and software, reflecting the surge of IT investment after 1995, especially in the large IT-using sectors like Finance. Virtually all industries respond to the acceleration in the decline of prices of IT capital input after 1995 by substituting IT for Non-IT capital inputs and half of U.S. industries show a declining contribution of Non-IT capital input.

The IT-producing industries show accelerated growth in every dimension, but the aggregate impact is limited by their relatively small size. The IT-using sectors are especially prominent in exploiting opportunities for accelerated deployment of IT equipment and software, while the non-IT industries contribute impressively to faster total factor productivity growth. After 1995 the IT-producing industries show sharply accelerating growth in total factor productivity, while the

IT-using industries diverge from this trend by exhibiting a more rapid decline. Total factor productivity growth in the Non-IT industries jumps very substantially, accounting for most of the acceleration in economy-wide total factor productivity.

Two industries responsible for much of IT hardware—Computers and Office Equipment and Electronic Components—exhibit truly extraordinary rates of total factor productivity growth throughout the period 1977–2000, as well as a substantial acceleration after 1995. Total factor productivity growth, however, characterizes 28 of the 41 private industries. More than half the industries show periods of both positive and negative growth. This is inconsistent with the view that negative total factor productivity growth is only an indication of errors in the measurement of output. No doubt there are such errors, but negative total factor productivity growth has other explanations as well.

We find that an increased contribution of IT capital after 1995 characterizes 37 of our 41 private industries, so that the shift toward investment in IT equipment and software in response to more rapid IT price declines emerges very visibly at the industry level. Although the contribution of college-educated labor predominates over non-college labor for most of the period 1977–2000 and most industries, only about a third of the industries show acceleration in the growth of college-educated labor after 1995. The strong economy of the late 1990s drew many workers with relatively low skills and limited experience into employment.

Chapter 4 provides data on industry output and intermediate input, based on a time series of input-output tables developed by the Employment Projections Branch of the Bureau of Labor Statistics. This approach was introduced by Jorgenson, Frank Gollop, and Barbara Fraumeni (1987) and has become the international standard for productivity measurement, as presented by Schreyer (2001). We use inputs of intermediate inputs, as well as capital and labor services, in analyzing the sources of growth in industry outputs.

Chapter 5 provides data on investment and capital accumulation. We focus on investment in IT equipment and software, the most important mechanism for diffusion of advances in technology. The key to understanding the diffusion mechanism is the cost of capital, the factor used in converting asset prices to rental prices of capital. We present prices of capital input for all industries, classified by asset type and tax treatment. These estimates are based primarily on the BEA reproducible assets accounts and coincide with international standards, as presented by Derek Blades (2001).

The most distinctive features of IT assets are the rapid declines in prices of the assets, as well as relatively high rates of depreciation. These characteristics imply that rental prices of IT capital services are very large by comparison with the prices of IT capital assets. We find that capital from IT products has grown at stunning rates during most of the period 1977–2000 with a median growth rate of 19.11 percent. By contrast Non-IT capital has grown at a median rate of only 2.17 percent. The substantial acceleration in the growth of capital input after 1995 can be traced to the productivity surge and growing importance of information technology.

Chapter 6 presents measures of labor services by industry. We classify hours worked and labor compensation per hour by gender, class of employment, age, and education. The primary data sources are the Current Population Survey (CPS) and the decennial Census of Population; the data are benchmarked to the U.S. National Income and Product Accounts (NIPAs). Labor quality growth captures the shift in hours worked toward workers with higher rates of compensation, reflecting higher marginal products. Labor quality growth is dominated by the increased education and experience of workers.

Computer Services, containing software, has the most rapidly growing labor input. The very modest acceleration in the growth of labor after 1995 was concentrated in IT-using industries. Since the number of workers available for employment is determined largely by demographic trends, the acceleration in IT investment is reflected in rates of labor compensation and changes in the industry distribution of employment. The rapidly growing IT-using industries have absorbed large numbers of college-educated workers, while Non-IT industries have shed substantial numbers of non-college workers.

Chapter 9 concludes with a new agenda for economic research, Economics on Internet Time. The stagflation of the 1970s greatly undermined the Keynesian Revolution of the 1930s, leading to the New Classical Counter-Revolution that has transformed the economics of the business cycle. The unanticipated American growth resurgence of the 1990s has similar potential for revolutionizing the economics of growth. This book provides a unique perspective on this important and timely undertaking.

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