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## The impact of information technology on postwar US economic growth<sup>☆</sup>

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### ABSTRACT

We provide detailed information on the crucial role of information technology in the postwar growth of the U.S. economy, from the development of the telecommunications services and the telecommunications equipment industries through the successful commercialization of semiconductor technology and the ongoing shift to cloud-based IT services. Our industry-level data set reveals that productivity gains over the postwar period originated disproportionately in industries that produce IT, but the replication of established technologies through growth of capital and labor inputs explains by far the largest proportion of U.S. economic growth. We find that the substantial growth deceleration during the Great Recession was driven by modestly negative aggregate productivity growth, but that only a minor portion of the drop in the growth rate was due to the IT-producing industries.

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### 1. Introduction

The Information Technology producing (IT-producing) industries accounted for only 1.7 percent of value added in the US economy during the postwar period, 1947–2010. However, these industries contributed 7.6 percent of postwar economic growth and 32.8 percent of postwar productivity growth.

We build on the seminal work of [Jorgenson, Ho, and Kevin Stiroh \(2005\)](#), who have presented a less detailed industry-level data set for the U.S. economy for the period 1977–2000. By adding data for the period 1947–1977 we are able to capture the development of the telecommunications services and the telecommunications equipment industries before the successful commercialization of semiconductor technology. Jorgenson, Ho, and Stiroh show that these industries were transformed by this technology during the period 1977–2000. By adding data for the period after 2000 we are able to analyze the changing role of IT-producing industries in U.S. economic growth before, during, and after the Great Recession of 2007–2009. By providing highly relevant industry detail on the continuing role of IT-producing industries in U.S. economic growth after 2000, we add a new dimension to the debate over the future role of information technology.

Our new industry-level data set covers 86 industries in the U.S. and uses the North American Industry Classification System (NAICS). We provide new detail on the IT-producing industries, including software publishing and hardware manufacturing – computers and equipment, telecommunications equipment, and semiconductors. For the first time we are

<sup>☆</sup> The views expressed in this paper are solely those of the authors and not necessarily those of the US Bureau of Economic Analysis or the US Department of Commerce.

able to identify the separate role of IT services – information and data processing and computer systems design. We give estimates of output for each industry, as well as inputs of capital (K), labor (L), energy (E), materials (M), and services (S). Productivity growth is the key economic indicator of innovation, where we measure productivity as the ratio of output to input.

The successful introduction of new or higher quality products, especially information technology hardware and software, can generate growth of output that exceeds the growth of capital and labor inputs. This results in growth in productivity or output per unit of input. Similarly, new or altered processes, organization structures, systems, and business models, especially those that rely on information technology services, also generate growth in productivity. We show that innovation accounts for only twenty percent of U.S. economic growth during the postwar period. This is the most important empirical finding from the extensive research on productivity measurement surveyed by Jorgenson (2009). However, the long-run growth of the U.S. economy depends critically on the performance of a relatively small number of sectors where innovation takes place, especially the IT-producing industries.

Our paper begins with a brief review of the recent literature on the role of information technology in the slowdown of U.S. economic growth since the Great Recession of 2007–2009. Unfortunately, much of this literature is based on aggregate data and none of it uses a comprehensive industry-level data set for the U.S. economy. In this paper, we analyze the sources of productivity growth within the IT-producing sector. We show that this detail is important for understanding the evolution of the industries that use information technology, which comprise about half of the U.S. economy. We then consider the measurement of productivity at the industry level and its critical importance in understanding economic growth for the U.S. economy as a whole. We next discuss the sources and methods used for our estimates of industry-level data on productivity data for the United States.

We present new estimates of U.S. productivity growth for the period 1947–2010. For the period before 1973, the role of information technology was largely limited to telecommunications services and telecommunications equipment. The relative importance of information technology increased after 1973 and accelerated considerably during the Investment Boom of 1995–2000. U.S. economic growth has slowed substantially after the Dot-Com Crash of 2000, but information technology has remained a predominant source of U.S. productivity growth. In summarizing these recent developments we provide additional detail on the sub-periods 1995–2000, 2000–2005, and 2005–2010. We conclude with a brief discussion of the continuing importance of information technology in the formulation of economic policies to close the gap between the actual and potential growth of the U.S. economy in the aftermath of the Great Recession.

## 2. The role of IT-producing industries

The slowdown of US economic growth since the Great Recession of 2007–2009 has generated a vigorous debate on the role of the IT-producing industries in future US economic growth. David Byrne, Stephen Oliner and Daniel Sichel (2013) survey recent contributions to this debate. Tyler Cowen (2011) presents a pessimistic outlook in his book, *The Great Stagnation: How America Ate All the Low-Hanging Fruit, Got Sick, and Will (Eventually) Feel Better*: His views are supported by Robert Gordon (2012, 2014), who analyzes six headwinds facing the US economy, including the purported end of productivity growth in the IT-producing industries. Cowen (2013) has expressed a more sanguine view in his book, *Average is Over: Powering America Beyond the Age of the Great Stagnation*.

Gordon's pessimism about the future of the IT-producing industries has been strongly countered by Erik Brynjolfsson and Andrew McAfee (2014) in the *Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*.<sup>1</sup> Martin Baily, James Manyika and Shalaba Gupta (2013) have summarized studies of technological prospects for American industries, including the IT-producers, conducted by the McKinsey Global Institute and summarized by Manyika et al. (2011). These studies also provide a more optimistic view of the role of the IT-producing industries in future economic growth.

John Fernald (2012) showed that productivity growth slowed before the Great Recession. He concluded that only about half the shortfall in growth, relative to pre-recession trends, is due to slower growth in potential output. Byrne, Oliner and Sichel present detailed evidence on the recent behavior of IT prices, an important driver of the economics of Information Technology. Their evidence of a continuing decline in IT prices supports the optimistic views of the future role of IT in economic growth of Brynjolfsson and McAfee and the Baily, Manyika, and Gupta.

Chad Syverson (2013) points out that a detailed view of developments in semiconductor technology, a key input in IT-related products and services, supports the view the size of transistors has continued to shrink. However, performance of semiconductor devices has improved much less rapidly, which is consistent with the findings of Byrne, Oliner, and Sichel. This view is supported by research on semiconductor prices by Unni Pillai (2011) and studies of semiconductor performance by the computer scientists John Hennessey and David Patterson (2012).<sup>2</sup>

<sup>1</sup> See also: Brynjolfsson and McAfee (2014). Brynjolfsson and Gordon have debated the future of information technology on TED. See: <http://blog.ted.com/2013/02/26/debate-erik-brynjolfsson-and-robert-j-gordon-at-ted2013/>.

<sup>2</sup> See Hennessey and Patterson (2012, Fig. 1.16, p. 46). An excellent journalistic account of the turning point in the development of Intel microprocessors is presented by John Markoff in the New York Times for May 17, 2004 (Markoff, 2004). See: <http://www.nytimes.com/2004/05/17/business/technology-intel-s-big-shift-after-hitting-technical-wall.html>.

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