Telecommunications Policy 40 (2016) 383–397

Contents lists available at ScienceDirect

Telecommunications Policy

URL: www.elsevier.com/locate/telpol

The ICT revolution, world economic growth, and policy issues ☆

Dale W. Jorgenson [a], Khuong M. Vu [b]

[a] Department of Economics, Harvard University, USA
[b] Lee Kuan Yew School of Public Policy, National University of Singapore, Singapore

ARTICLE INFO

Available online 5 February 2016

Keywords:
ICT
Growth
Investment
World economy
Emerging economies
Policy
Projection

ABSTRACT

The ICT revolution fueled by the exponential progress of the semiconductor technology and the accelerated pace of globalization has become an important driver of economic growth across nations. In this rapidly changing landscape, the world economy is entering into a New Economic Order, in which developing Asia led by two fast-growing giant economies, China and India, will have much larger impacts on the world economy. This paper provides empirical evidence on these phenomena and highlights policy issues that deem important for a country to seize the ICT revolution for promoting economic growth.

1. Introduction

Information and Communications Technology (ICT) has brought about revolutionary changes in the way people work, communicate, learn, spend time, and interact. ICT has also profoundly transformed business and government practices. The impacts of the ICT revolution are now palpable in all countries, and are projected to be economically and socially revolutionary in the coming years as technology penetrates and fosters fundamental change in all sectors and dimensions of life.

At the heart of the ICT revolution is the rapid progress of semiconductors. The birth of modern ICT was marked by the invention of the transistor, a semiconductor device that acts as an electrical switch and encodes information in binary form. This takes the values zero and one, corresponding to the "off" and "on" positions of a switch. The first transistor, made of the semiconductor germanium, was constructed at Bell Labs in 1947 and won the Nobel Prize in Physics in 1956 for the inventors – John Bardeen, Walter Brattain, and William Shockley.[1]

The second major milestone in the progress of ICT was the invention of the integrated circuit by Jack Kilby of Texas Instruments in 1958 and Robert Noyce of Fairchild Semiconductor in 1959. An integrated circuit consists of multiple transistors that store and manipulate data in binary form. Integrated circuits were originally developed for data storage and retrieval and semiconductor storage devices became known as memory chips. Kilby was awarded the Nobel Prize in Physics in 2000 for the invention of the integrated circuit; regrettably, Noyce died in 1990.[2]

The progress of semiconductor technology has been the driving force of the ICT revolution. In 1965 Gordon Moore, Research Director at Fairchild Semiconductor and later a founder of Intel in 1968, made a prescient observation, later known

☆ Khuong Vu acknowledges the financial support of the NUS LKYSPP for this research and the research assistance provided by Kris Harley and Nguyen Chi Hieu.

[1] On Bardeen, Brattain, and Shockley. See: http://www.nobelprize.org/nobel_prizes/physics/laureates/1956/.

[2] On Kilby. See: http://www.nobelprize.org/nobel_prizes/physics/laureates/2000/.

http://dx.doi.org/10.1016/j.telpol.2016.01.002
0308-5961/

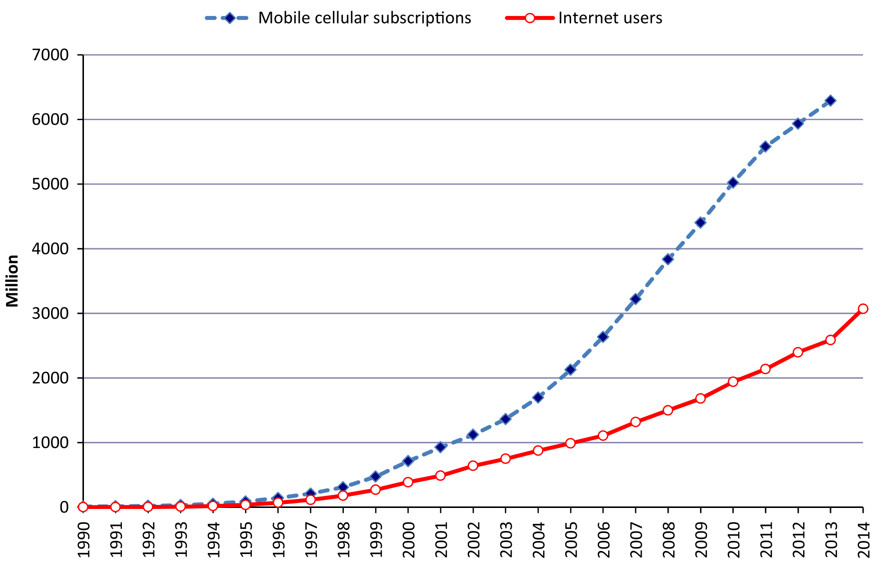

Fig. 1. World internet users and mobile phone subscribers, 1990–2014.
Data source: World Bank Development Indicators; see: http://wdi.worldbank.org/tables.

as Moore's Law: The number of transistors on a new chip would double within 18–24 months, which implied an exponential growth rate of 35–45 percent per year.[3]

In 1971 Intel created the Intel® 4004, the world's first central processing unit (CPU), which revolutionized the way computers are designed and applied. The CPU takes instructions from a stored program in read-only memory and works as the brain of a computer. The processing capability of a computer can be roughly assessed on the basis of the number of transistors on its CPU chip, which has followed Moore's Law since it was introduced.

For example, the number of transistors on Intel's CPU chip increased from 2250 in 1971 (the Intel® 4004 model) to 125 million in 2004 (Pentium 4 Prescott), 291 million in 2006 (the Core 2 Duo Conroe model), and 5560 million in 2014 (the 18-core Xeon Haswell-E5 model).[4] This implies an annual growth rate of 41 percent over 1971–2014. Moore has forecast that the Moore Law will continue to hold for the next 10 years.[5]

Just as the innovation in semiconductors and personal computers has established the foundation for the progress of ICT, the emergence of the internet and mobile technology in the 1990s, together with the accelerated pace of globalization, has fueled the dramatic spread of applications of ICT across sectors and nations. In Fig. 1 we show that the world's internet users soared from three million in 1990 to more than three billion in 2014. The number of mobile phone subscribers increased from 11 million to more than six billion over the same period.

The spread of ICT in developing countries has been even more remarkable. The penetration of internet and mobile phone went from nil in the early 1990s to impressively high rates even in the poorest and most isolated nations.[6] The spread of ICT into all corners of the world has had a profound effect on economic development, particularly in areas where communication, access to information, learning, research, and innovation play a key role in driving success. The investment in ICT, therefore, has had measureable effects on economic growth for all nations.

In Section 2 we present empirical evidence on the contribution of ICT to economic growth in the past two decades, from 1990 to 2012. In Section 3 we analyze the future impact of ICT on world economic growth by presenting intermediate-term projections for the world economy, regions of the world, and major developed and emerging economies. In Section 4 we consider the implications of ICT for economic policy.

[3] Intel (2015): http://www.intel.com/content/www/us/en/silicon-innovations/moores-law-technology.html?wapkw=moore%ca%b9s+law.

[4] Intel had to change its strategy of increasing the number of transistors on a single processor to raise the computing power of CPU in 2004 when it hit "a thermal wall" caused by energy consumption inefficiency. The company then followed the multiple core strategy, which stamps multiple processors on a single CPU chip to increase its number of transistors. This development of Intel microprocessors is discussed by Markoff (2004). See: http://www.nytimes.com/2004/05/17/business/technology-intel-s-big-shift-after-hitting-technical-wall.html.

[5] Moore (2015): http://venturebeat.com/2015/05/11/intels-gordon-moore-speculates-on-the-future-and-the-end-of-moores-law/.

[6] For example, in 2013 the penetration rate of mobile phones (per 100 inhabitants) was 9.7 in North Korea, 12.8 in Myanmar, 25.3 in South Sudan, and 27.3 in Ethiopia, which were comparable with the rates observed for the industrialized countries in early 1990s.