Technology and the New Economy

edited by Chong-En Bai and Chi-Wa Yuen

Foreword by Robert E. Lucas Jr.

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Foreword

A public lecture series in which distinguished economic scholars discuss technology and the new economy seems a fine way to celebrate the ninetieth anniversary of the University of Hong Kong (HKU). The Hong Kong economy—that glorious symbol of the possibilities for economic growth that are available to any society, no matter how modest its resources—is just the right place to have such a series of lectures. I take the quality of the lectures collected in this volume as evidence of the rightness of the location, of the agenda, and of the people invited by HKU to speak and write on various aspects of this topic.

Even in this setting, though, it seems that economists are mistrustful of the novelty of the "new economy." Is it really new? Is new technology based on micro-circuitry fundamentally different economically from new technology based on small electric motors or hydrocarbon molecules? Does information technology really affect productivity? I find myself entirely out of sympathy with such guarded reactions. I remember looking across the airplane aisle last summer and thinking that I had never imagined I would live to see something as beautiful as the notebook computer on which another passenger was working, such an elegant and functional solution

to such a tightly constrained design problem. How can anyone doubt its novelty and importance?

My fellow passenger was working on color graphics, and I thought how common it has become to see graphics everywhere, and how much they have improved: axes labeled, units specified, sources cited, color imaginatively used. Michael Bloomberg made a fortune on this idea, and his firm produces only a few drops in the ocean of graphically presented information. Does this represent improvements in production possibilities? How can an economist ask such a question? People who can read, interpret, and construct graphs can *think* better than people who cannot. We know this is true for thinking about economics, and of course it is true for other subjects as well. We also know that people who think better are more productive, indeed, that better thinking is what productivity growth is. And graphics is just one side effect of the information technology (IT) revolution. Of course it can be hard to pick up such effects in aggregate time series, but we know from everyday experience that they are important, that they are changing our lives.

But what kind of economic analysis is needed to think about the new economy? The chapters in this volume take this question in a variety of interesting directions. My reactions, like those of these contributors, are idiosyncratic, based on my interests and my economic instincts.

The chapters by Bresnahan and Malerbo and by Jovanovic and Rousseau, and some of the discussion by Bai and Yuen in their postscript, raise some hard questions concerning industrial organization. We know from the Microsoft case that the new technology raises novel issues within the framework of American antitrust law and new possibilities for legal action.

But I cringed at the list of questions for oligopoly theory that Bai and Yuen provide: Do we have even a start when it comes to understanding any one of them? But we have lived without a workable oligopoly theory for a long time, and I take Jovanovic and Rousseau as proposing to seek regularity in competitively determined asset prices rather than in goods prices determined ... who knows how?

There is an undeniable cost of doing without a theory of oligopoly pricing. We have a body of regulatory practices and antitrust laws that are so arbitrary and so loosely connected to modern economic theory and evidence that economic analysis seems almost beside the point. Increasingly, no one even pretends to be able to measure the effect of legal actions and regulations on consumer welfare. What would be the consequence for economic growth and individual welfare if the antitrust laws were repealed? The whole issue of monopoly power, with the important exception of government or government-supported monopoly, seems to me little more than a ripple on the great tide of economic growth.

The possible implications of IT for international trade and growth, as touched on in the postscript, seem especially interesting to me. I agree with Bai and Yuen that it is far from clear what the implications of IT for world trade flows will be. But from the point of view of growth theory, it is the diffusion of *ideas* that is important, and goods flows are important mainly because we think they are related to the flow of ideas. For example, in the course of becoming manufacturers of cars that succeeded in world markets, the Japanese absorbed and became leading contributors to the frontier technology for producing cars. Could they not have done this by obtaining blueprints from Detroit and Turin and using the ideas so

acquired to produce cars for domestic sale only? Maybe, but the diffusion of ideas in this disembodied way always seems to come up short.

Why should this be surprising? We learn how to play the piano by playing for our teacher and getting our teacher's criticism and by listening to him or her play the same pieces we have attempted. By such a trial-and-error process, in addition to our study of the score, the musical *blueprint*—we bring our playing closer to his or her standard. By *exporting* our music to a more sophisticated listener we improve our ability to produce it. I think the learning process described in this example is typical of the way trade fosters—is essential to—the diffusion of ideas, and why countries that have shifted their workforce to exports that compete with products from other, more sophisticated economies have been so much more successful than those that have closed themselves off.

Bai and Yuen cite the exciting example of Indian software exports. Another favorite of mine is the processing of New York traffic tickets in Ghana. They ask what "the implications of these developments for the overall pattern of international trade" might be. Surely one benefit of these new exports must be that they sidestep (for a while, at least!) some of the diabolical trade barriers that have long been in place in Ghana and India. But it must also be the case that such exports of services foster learning and the diffusion of technology, just as does the growth in exports of manufactured goods. Indian computer code must come up to American quality standards or its export will not be sustained. For economic growth, international flows of goods are important mainly as a means to the international flows of ideas, and it may be that new technology weakens the link between these flows: The ideas can travel, with or without the goods.

Michael Woodford considers how information technology may affect the workings of the monetary system. Certainly we can see it in details. I remember spending an entire afternoon in a bank in Bar Harbor, Maine, back in the 1960s: I had run out of cash while on vacation and needed more sent from my bank in Pittsburgh. Now I can get dollars anywhere in the world in seconds (in the unlikely event that I need cash at all)! How do such changes affect aggregate behavior? This is an even harder question than the one Solow asked, I think, but no less important.

These scattered reactions are hardly a substitute for the thoughtful essays contained in this volume. But I hope they will serve as an advertisement, or perhaps as an appetizer.

Robert E. Lucas Jr.
October 2, 2002

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Introduction

Chong-En Bai and Chi-Wa Yuen

One of the most important driving forces behind the rapid economic expansion in the United States and the world at large in the 1990s is the development of information technology (IT). The technology has made significant impact on many aspects of the economy, to the extent that "new economy" has emerged as a popular term both in the media and in academia. What is truly new about our economy today? What has contributed to the IT revolution? Has it been driven more by supply-side forces or demand-side forces? What kinds of government policies have contributed to it? What other institutions have contributed to it? Is it any different in its nature from other types of technological progress? What are the implications of such technological changes for output growth and macroeconomic fluctuations as well as for the design and implementation of growth and stabilization policies?

Believing that these are questions that would be interesting to people from different walks of life, we took advantage of a special occasion—namely, the ninetieth anniversary of our university—to invite some leading experts in various fields of economics to offer their perspectives on these issues. This book contains edited versions of lectures originally delivered by Boyan Jovanovic, Timothy Bresnahan, Danny Quah, Jeffrey

Sachs, and Michael Woodford at the University of Hong Kong in 2001–2002 in celebration of its ninetieth birthday. Together, these papers provide important clues to some of the most fundamental questions about the development of the information technology and its effects on the economy, ranging from such elements as competition policy (Bresnahan and Malerba), innovation-related institutions (Sachs and McArthur), and demand factors (Quah) to the long-run values of leading innovating firms (Jovanovic and Rousseau) and the effectiveness of monetary policy in stabilizing the economy (Woodford). Written in accessible language, the book is valuable to a wide audience, including academics, undergraduate and graduate students, and the general public with some basic knowledge in economics. In this introduction, we provide a summary of these essays. Some related issues are discussed in the postscript.

Boyan Jovanovic and Peter L. Rousseau (chapter 1) examine the relation between innovation and the stock market value of the innovating firm. They identify three waves of technological innovation that occurred at the beginning, the middle, and the end of the twentieth century, namely, electricity and internal combustion, chemicals and pharmaceuticals, and the computer and the Internet. They find that each wave of innovation is followed by a vintage of stock market listings and that firms in each of the vintages have produced a higher-than-average rate of return to investment. The stock market values of these vintage firms have been highly stable over time, thus suggesting that their high valuation is not due to bubbles and not based on specific technologies that would tend to become obsolete over time. Rather, they are based on a superior organizational capital of the firms, which may include the quality of management and the corporate culture that encourage innovation and entrepreneurship.

The current third wave of innovation in IT is found to be more similar to the first wave than to the second. The age of the entrant in the stock market is lower in the first and third waves than in the second wave, implying that innovation is carried out by young firms in the first and third waves but by older firms in the second. One possibility is that innovation in the first and third waves requires lower fixed costs than in the second wave. This appears to be confirmed by the count of patents over the years, which exhibits a U shape. The low cost of innovation seems to be more salient with IT than with electrification: IT represents an "invention in the method of inventing" and is also associated with strong spillover effects. This value of IT is evidenced by the surge in patenting in the last six years. Very likely, the wave of IT innovation is far from over. The recent setbacks in the IT sector can be understood in light of the fact that it is not necessarily the first users of a technology that reap the greatest benefits, as was the case in the electrification wave.

Timothy F. Bresnahan and Franco Malerba (chapter 2) consider conditions for sustained innovation in terms of the institutional environment, particularly government policy. Based on a detailed investigation of the five eras of the computer industry (namely, the mainframe, minicomputer, PC, supermini and client-server computing, and the Internet), their analysis centers on two questions. In the short term, what explains the concentrated location of rent-generating supply within each segment of the computer industry in a single country? In the long term, what explains the persistent U.S. success in all the segments?

In the short run, concentration in each segment has a lot to do with scale economies. This seems to suggest the validity of the "new trade theory": The first-mover advantage is

substantial, and government intervention is desirable in ensuring the emergence of the first mover from within the country. However, the long-term history suggests otherwise. New trade theory cannot explain why the United States has maintained persistent dominance in all the segments in spite of dramatic discontinuity between various eras of the computer industry.

The transition from one era to the next in the computer industry has experienced dramatic changes in the technology, the market structure, and the dominant players (including the customers). Therefore, for individual firms and for a country, success in one segment of the industry does not imply success in other segments. Since the origins of various segments were characterized by high degrees of uncertainty, it would be impossible for the government to pick the winner. Instead, the market is the best selection mechanism, where the winner can be picked after numerous approaches to experimentation and exploration have been taken by various parties. The United States provides an excellent environment for such experimentation and selection. First, the U.S. government allows market selection to work without intervention, which levels the playing field for participants in the selection process. Second, market selection is strengthened by competition policies that enhance the influence of demanders on the selection mechanism. The low barrier to exit also reinforces the mechanism. Finally, institutions exist that increase the variety of experiments from which the market selects. Universities are fertile breeding grounds for new ideas and entrepreneurship. It is easier for new businesses to get started, get funding, and grow in the United States than in other parts of the world. All these factors have not only facilitated the efficient emergence of concentration within each segment, but also helped the United States maintain its dominance through various eras of the computer industry.

Ever since Solow (1956), we have understood that technical progress (rather than physical capital accumulation) is the ultimate engine of economic growth, and technology dissemination is an important channel of equalizing income differences across countries in the world. On this basis, Danny Quah (chapter 3) argues that there is nothing new in the new economy if the proliferation of information and communications technology (ICT) is interpreted as merely "the most recent manifestation of an ongoing sequence of technical progress." Besides, such supply-side interpretation fails to resolve three paradoxes in the new economy, namely, the Solow productivity paradox (that IT investment has not been accompanied by significant improvement in measured labor productivity), the falling deployment of human capital in science and technology in the face of output growth, and the trade deficits in ICT products experienced by technology leaders such as the United States.

In addition to changes in the supply-side (or cost) characteristics of the economy, the ICT revolution has also brought about changes in the nature of goods and services consumed that make them more and more like knowledge, namely, being nonrival (or infinitely expansible) and aspatial. Quah proposes that this change in the "knowledge content" of goods and services especially on the demand/consumption side—the technology/final consumer linkage—is what really constitutes the "newness" in the new economy. To illustrate the importance of demand considerations as determinants of the sustainability of economic growth, he cites the example of ancient China to highlight the possibility of growth being bogged down by inadequate demand. This possibility could be much higher in the new economy because the consumer has to incur some learning cost before he or she can truly enjoy the

consumption of these new knowledge products. Contrary to Say's Law, therefore, supply may not be able to create its own demand. This demand-side hypothesis can potentially help resolve the three productivity puzzles.

Like Quah, Jeffrey D. Sachs and John W. McArthur (chapter 4) cite Solow's contribution to introduce the "old" economy view of the unimportant role of savings or capital accumulation and the indispensable role of (endogenous) technological production/innovation and diffusion as engines of sustained, long-run growth. They also explain why technology adopters can never "catch up" with technology innovators.

Based on evidence from patenting data, they classify countries into three tiers of technological capacity: the high innovators (the U.S., Japan, Germany, Korea, Taiwan, Israel, etc.), the technology users (most other countries, China included), and the technologically excluded. Most countries in Asia are found to belong to the second category, although some of them are undergoing a transition from being a technology borrower to becoming a technology innovator.

Sachs and McArthur then discuss how the success of innovation hinges crucially on the government's choice of strategies/processes and the underlying economic systems. Eight basic characteristics of the innovation process, both market and nonmarket based, are identified—ranging from its general scale economies and creative-cum-destructive nature to site, organization, and financing specificity. The experience of the United States, the most innovative country in the world, is then used to explain how nine characteristics of its innovation system—again both market and nonmarket based, ranging from its heavy investment in basic science to its effective higher education and patent systems—have helped the United States achieve such high and sustained rates of innovation.

Finally, they use these characteristics to shed light on the challenges facing Asia, concluding that Asia's growth prospects depend on the emergence of technological innovation (rather than pure adoption/imitation) induced endogenously by a well-structured institutional and policy framework.

Michael Woodford (chapter 5) addresses the concern that, with improvement in information technology and hence efficiency of financial markets, central banks may be less able to stabilize the macroeconomy through monetary policy—because (a) the ability of central banks to "surprise" the markets will be reduced as economic agents become better informed about monetary policy decisions and actions, and (b) private-sector demand for base money will shrink as a result of such financial innovations as e-money and more efficient clearing systems.

Woodford explains why the result that "under rational expectations, only unanticipated policy matters" does not imply that the effectiveness of monetary policy hinges on the ability of central banks to fool the markets about what they do. Instead, by allowing the central banks to signal more precisely their future policy plans and by tightening the link between the interest rates they directly control and other market rates, monetary policy can be even more effective—in affecting in a desired way the evolution of market expectations about interest rates and inflation and in strengthening the intended effects of such policies—in the information economy.

Woodford also dismisses the relevance of the size and the stability of the demand for base money to the implementation of monetary policy. By reducing an important source of disturbance, the erosion of currency would actually help simplify the central bank's problem. Instead of targeting the monetary base, what really matters for the effectiveness of monetary

policy is central bank control of overnight interest rates, which will not be affected much by the erosion of base money. He acknowledges, though, that improvements in information technology, hence efficiency of the financial system, may have important consequences for some specific operating and decision procedures that the central banks have to follow in relation to the choice and implementation of their policy targets.

These essays address a selection of important topics about technology and the new economy. A brief discussion of some other topics relevant to the IT revolution that are nonetheless left out in these essays is relegated to the postscript.

Reference

Solow, Robert. 1956. "A contribution to the theory of economic growth." *Quarterly Journal of Economics* 70 (February): 65–94.