

1

The Challenge of Information Technology: Introduction

JAMUS JEROME LIM

The Information and Communications Technology (ICT)¹ revolution, which has swept the world since the 1990s, has been the source of much study and debate. Yet, like all general-purpose technologies,² the full impact of ICT has yet to be completely understood, although it is most likely to fall somewhere between the world-changing hype generated by optimists and the dismal negativism voiced by sceptics. The ASEAN (Association of Southeast Asian Nations) region, in particular, has moved boldly to embrace this new technology, and governments in Southeast Asia have been very pro-active in formulating technology policies.

How far, therefore, have these nations progressed, and what are the impacts and implications of ICT on their economies, societies, and politics? Indeed, what are the ramifications of these national policies on the region? The aim of this volume is twofold. First, it seeks to provide some broad-brush evaluations of the impact of ICT on the region, with

respect to several key issues. Second, as it delves into more detailed country-level studies of national ICT policies, it aims to examine the different approaches that countries have adopted in addressing ICT, and their attendant lessons. Through these two interrelated ways, it draws together commentary and analysis from experts in their respective fields to inform academics and policy-makers in the region regarding the ICT revolution.

The volume is organized into three main sections. The first section deals with the region as a whole, and explores issues of concern to all countries in the region, such as the digital divide, e-commerce, and the social and political impact of ICT. The second section preoccupies itself with case studies of a selection of ASEAN countries; specifically, it has limited itself to the study of Singapore, Malaysia, Thailand, and Vietnam. The third section treats the cases of Taiwan and Bangalore — other Asian countries that have been heavily involved in the development of ICT policies and are internationally recognized as drivers in the global ICT revolution.

1. Regional Issues in the ICT Revolution

The ICT revolution is, appropriately, a global event, and hence, involves many general issues that impact on all countries. The burgeoning literature on ICT can be broadly categorized into several key threads; these core ideas include:

- technological advancement and innovation;
- information and network economics;
- dynamics of domestic politics and international relations; and
- changes in cultural and social theory.

Research in the first category can be broadly classified into the literature on the impact of technology on economic growth, and the work on general-purpose technologies. The first can be further subdivided into models of neo-classical growth — where technical advancement is treated as a “black-box” and is exogenous in nature — and the later studies on the “new growth theory”, where such technological progress is endogenously driven, primarily through forces such as externalities and innovation.³ The second is centred on the various contributions that

distil the macroeconomic consequences that GPTs play in the economy, through mechanisms such as secondary innovations, diffusion, and human capital accumulation.⁴ More recently, research efforts have been focused on the contribution of technology to productivity growth, especially total factor productivity — and the corresponding material that has attempted to explain the “productivity paradox”⁵ of ICT.

The work on information and network economics, which tend to examine more micro-level issues in the ICT revolution, is premised on the potential of ICT to reduce asymmetric information through the promotion of information flows and the benefits that accrue from network externalities.⁶ Together, these building blocks form the foundation of research work in Internet economics and electronic commerce.⁷ Recent studies have emphasized the need to ensure adequate infrastructure for electronic commerce,⁸ influences of the production of weightless goods on industrial production and organization,⁹ and changes in consumer markets due to new mediums of exchange.¹⁰

In the third category, political science has examined two correlated areas — first, of the domestic consequences of the emergence of ICT, and second, the international relations aspects involving the global network economy. Studies in the former are on the whole preoccupied with the impact of ICT, especially the Internet, on democracy,¹¹ whereas the latter includes work on the importance of developing country involvement in international governance regimes for ICT — regimes like the Internet Corporation for Assigned Names and Numbers (ICANN) and the World Wide Web Consortium (W3C).¹²

The literature in the final category has looked at the impact of ICT on social development and the gradual diffusion of a singular world culture, or, more broadly, the increased speed by which globalization is expedited due to ICT. Clearly, the primary socio-economic consideration is that of the digital divide, which is yet another form of social stratification involving the disparity between individuals, groups, or countries with regard to their opportunities to access ICTs and the Internet. Other major themes are the debate over intellectual property rights, privacy concerns, and the empowerment of individuals through free speech and information access.¹³

The present volume narrows down this extremely diverse literature

into several key concerns that impact on most, if not all, the countries in the region. These key concerns include the contribution of ICT to development, the diffusion of ICT and the informatization of society, the importance of human capital and its influence on innovation, the economics associated with electronic commerce, and the impact of ICT on the social and political landscape.

The chapter by Kraemer and Dedrick takes up the pressing issue of the contribution of ICT to economic development. It surveys the literature on the contribution of information technology to economic growth, before estimating the contribution to gross domestic product (GDP) of ICT investment for a sample of thirteen Asian countries and an average of thirty-five non-Asian countries that include both developed and developing nations. It arrives at the somewhat dramatic conclusion that whereas there are positive returns to ICT investments in non-Asian countries, this is not so for Asian countries. Kraemer and Dedrick interpret their findings using a range of explanations, with the argument that ICT production — so often associated with Asia, especially East Asia — does not equate to use. The danger, therefore, is that “there is a digital divide between Asian and non-Asian countries, and that the digital divide is growing”.

This is clearly cause for concern. However, the upside of Asia’s strength in hardware production can be translated to general, economy-wide productivity gains if governments exploit their economies’ strength in ICT production and create favourable conditions to support ICT use — including, but not limited to, policies such as encouraging competition in ICT markets, realigning production towards the software and services industry, or what the authors call “production close to use”, and — perhaps most significantly — promoting ICT use over production.

This final theme is the central thesis of Wong and Singh’s contribution. The chapter draws a conceptual framework of the role of ICT in an economy and categorizes them into four main blocks: first, the ICT goods sectors; second, the information contents sectors; third, the communications network sectors; and fourth, the informatization sector.¹⁴ It then draws from data from the ASEAN-5 (Singapore, Indonesia, Malaysia, the Philippines, and Thailand) and selected Asian countries to argue that although the ASEAN-5 countries have “made

tremendous strides in leveraging the ICT revolution for economic development”, this has primarily been attained through the first block of ICT goods production and less so in the others. In particular, with the exception of Singapore, the degree of diffusion and adoption of ICT in these countries remains low *vis-à-vis* the United States and selected European countries.

With the emergence of increasing competition from low-cost labour from countries such as China, India, and Mexico, coupled with relatively low-priced skilled labour from countries such as Ireland and the Eastern European nations, ASEAN countries will need to embrace ICT and ensure that its adoption is widespread in their economies. Practical issues that need to be addressed include the need for a change in the traditional compartmentalization of policy-making institutions to ensure superior integration and co-ordination of policies affecting the four conceptual blocks, and the development of a national model for ensuring high levels of “e-readiness”. Such a model should possess common underlying elements present in the successful examples of Silicon Valley or Israel; including a system for national innovation that supports research and development (R&D) activity.

Such innovations that arise from ICT human capital are supported by four main factors: the degree of ICT utilization, the level of ICT education, the amount of participation in innovative activity, and the existence of an entrepreneurial spirit and atmosphere. Rasiyah argues that these are best captured by, respectively, the levels of PC and Internet penetration; the literacy level and the number of science graduates; the number of scientists, engineers, and technicians involved in R&D; and the number of entrepreneurs and start-ups in an economy.¹⁵ His conclusion is that ASEAN economies show large variations in all these indicators, but other than Singapore, the other members have fallen behind in their development of ICT human capital.

The solution to this conundrum, as suggested by Rasiyah, is to strengthen ICT infrastructure in order to promote economic growth. This statement, however, invites two critiques. First, the author has failed to fully consider alternative development objectives in making such a bold assertion about ICT investment. Many ASEAN countries, especially the transition economies of Cambodia, Myanmar, Laos, and Vietnam

(CMLV), are in a much earlier stage in their development, where ICT simply cannot feature amongst development priorities. Second, and more problematic, econometric issues render any statement declaring causality between infrastructure and growth as largely tenuous. Although this has been conceded in the chapter, the policy recommendation has been made nonetheless.

Still, this does not detract from the importance of ICT infrastructure in economic development. This must, however, be pursued under the rubric of a wider development policy — one that gives due diligence to the unique situation in each country. The danger of excess investment in ICT in the quest for seeking to embrace the knowledge-based economy is very real, and this is more so when spending on ICT is engaged in as a showcase or a political tool as opposed to an economic investment.

Political and social concerns such as these lead to the need for a systematic, careful study of how ICT might change the dynamics of politics and social interaction in the context of ASEAN. Although the volume concerns itself mainly with the economic questions that arise from ICT, political and social impacts are nonetheless of concern, and Soesastro's chapter appropriately sheds some insight on these other disciplinary viewpoints. Rather than attempt to hash together the wide-ranging literature in the area, he limits its focus to several key areas: the digital divide, the impact of free dissemination of information on the political control, and empowerment and democratization brought about by ICT.

This final point is particularly relevant in the context of ASEAN, where governments have traditionally held monopoly control over information and knowledge flows, and have emphasized Asian values and the attendant interventions in political, social, and cultural development. With the advent of the ICT revolution, and especially the Internet, such an approach towards state sovereignty may no longer be tenable, as ICT can concomitantly erode political authoritarianism whilst enhancing human security. This has been alluded to in the concluding note of Soesastro's chapter, but the topic deserves greater analysis and study; and as such, represents a possible direction for future research.

Another key area that has not been well covered by the chapter by Soesastro is that of e-government, although the respective country chapters

briefly touch upon this topic. E-government, which calls for a re-definition of the mode of delivery of government services as well as feedback mechanisms for parliament-citizen interaction, is not a preserve of developed economies alone. This issue therefore commands careful study in the context of ASEAN, and such an endeavour can also be the basis for future research.

The recent bursting of the technology bubble in the United States, coupled with the dramatic failures of a slew of dot-coms and the continued non-profitability of others,¹⁶ have led to the reassessment of the entire ideology of e-business and e-commerce. Certain assumptions, often paraded as wisdom, have been debunked.¹⁷ In studying e-commerce in Southeast Asia, therefore, there is a need to draw from these collective lessons in understanding the developments, challenges, and issues.

Although the development of e-commerce in Asia remains in its nascent stages, estimates of business-to-consumers (B2C) e-commerce revenues in the Asia-Pacific place the figure at US\$14 billion by the end of 2001 (Michael, Sutherland, and Lang 2001), with estimates of business-to-business (B2B) revenues even higher at US\$996 billion by 2004 (GartnerGroup 2000). Clearly, these are numbers that cannot be ignored. Orbeta's chapter, hence, outlines global developments and initiatives that are likely to spill over into ASEAN, as well as early regional and national efforts. It also discusses benefits and costs presented by e-commerce. Such gains include those that accrue to producers, consumers, and society, stemming mainly from reduced business costs, a superior purchasing experience, and improved interactivity in the economy. The challenges arise from infrastructural considerations and the need to adapt current social, cultural, and legal systems. Indeed, as Orbeta has highlighted in his chapter, one such problem involves the taxation of e-commerce activity:

suppose a piece of music is composed by a German-citizen artist residing in the United States. The music is then produced and copyrighted in France. That particular music now sits on a server/seller in Japan. A copy ... is subsequently purchased by a Filipino in Manila using his credit card, which he has sent to the server. After the credit card is verified, the music is now downloaded into the Filipino's computer. The sale is then completed. Which jurisdiction has the right to collect sales taxes for this and other similar transactions?

In light of the relatively less mature legal and regulatory systems present in most Asia-Pacific nations, this aspect of e-commerce policy needs to be urgently addressed by governments. To a limited extent, the ASEAN countries have begun to formulate such laws, as evidenced by the country studies in this volume. Still, e-commerce-related policy issues are far from easy to assess, as Tangkitvanich contends.

His assessment is limited to five areas: telecommunications liberalization, taxation, trade negotiations under the General Agreement on Trade in Services (GATS), harmonization of e-commerce-related commercial laws, and intellectual property rights. Although the perspective of the chapter is written from that of Thailand, the conclusions drawn also apply more generally to most ASEAN nations that are in the midst of engaging e-commerce policy. The policy recommendations include the establishment of a competitive market for telecommunications, a need to broaden the tax base in order to compensate for the erosion of tax revenues due to e-commerce, a classification of e-commerce transactions as Mode 1¹⁸ services, a harmonization of commercial codes fashioned after the UNCITRAL E-Commerce Model Law (UNCITRAL 1998), and improved protection for intellectual property rights.

In the final analysis, such e-commerce policy recommendations can be classified along a dual continuum of consumer and producer welfare. Hence, in the assessment of global e-commerce proposals, there are clearly those that would have a negative impact on both consumer and producer welfare (such as the extension of patentable subject matters to include business methods), as well as those that increase both consumer and producer welfare (such as telecommunications liberalization). In the absence of political and economic influences, Asian nations should pursue e-commerce policies that fall in the first quadrant, that of increased producer and consumer welfare.

2. ASEAN Approaches to ICT Development

At the national level, the countries in ASEAN, together with others in Asia, have forged ahead in ICT policy. Naturally, the stage of development differs between countries. The volume selects a representative case of four nations, which broadly signify four different levels of ICT development. These range from very developed, world-class, ICT

standards (Singapore) to moderate levels of ICT development (Malaysia), to low levels (Thailand), and to virtually non-existent ICT development (Vietnam).¹⁹

Toh examines the case of Singapore in light of its recent policy to position itself as a regional IT hub. Besides outlining the four-phased development of Singapore's ICT infrastructure and policy which has led to achievements such as a Civil Service well-integrated with ICT (phase I: 1980–85), the establishment of electronic data interchange (EDI) networks for various trades (phase II: 1986–90), an advanced National Information Infrastructure (NII) (phase III: 1991–99), and the embracing of the Internet and e-commerce through various standards, laws, and regulatory regimes (phase IV: 2000 onwards).

The analysis further extends the case to the role of Singapore as a hub for ASEAN. This aim will be attained by leveraging the e-ASEAN Framework,²⁰ the ASEAN Free Trade Area (AFTA), and the ASEAN Investment Area (AIA) to foster ICT application in the region. As Singapore already possesses an existing, highly developed ICT infrastructure, it can “play a catalytic role in the development of other hubs in the region ... [and] cooperative competition will suggest that hubs resonating with one another will create far more network externalities than otherwise”. It is with this target in mind that regional issues — such as an ASEAN Information Infrastructure (AII), a regional e-commerce initiative, trade in weightless goods, and the digital divide — should be viewed.

Although Malaysia lags behind in terms of its level of ICT development, the country has made decisive steps in order to accelerate the pace of information and knowledge production, distribution, and dissemination in the economy. The flagship project to realize this objective is the creation of the Multimedia Super Corridor (MSC) — a 15-by-50-kilometre strip that is to be an experimental test-bed for multimedia and content industries. Phase I of the MSC is expected to be completed between 1996 and 2003, and benchmarks include a world-leading framework of cyber laws, fifty world-class companies, and seven “flagship applications”.²¹ Phase II (2004–10) would include a “web” of corridors, coupled with 250 world-class companies, and four to five “intelligent cities”, whereas phase III (2011–20) would extend the project

to all of Malaysia, include twelve intelligent cities, and house 500 world-class companies.

The MSC is managed by the Multimedia Development Corporation (MDC), which has come under criticism for being a political vehicle for Prime Minister Mahathir Mohamad or, worse, a misguided project that is at conflict with the country's other economic priorities.²² Although Tyndall does not undertake a full-blown impact assessment at this premature stage, he draws from corporate, info-structure, and macro indicators to gauge the progress and development of the MSC. His conclusion is that whilst "hard" infrastructure such as the establishment of a Multimedia University has been relatively more successful, "soft" factors that include ICT and R&D talent development and venture capital are still either lacking or underdeveloped. In fact, Tyndall goes so far as to assert that "the lack of knowledge workers ... is a major concern, especially in the short- to medium-term". Similarly, "sources and avenues for [venture capital] are visibly lacking in Malaysia". These findings have been echoed by an independent report of the status of the MSC (Chen 2001).²³ Evidently, the need for a more rigorous assessment at a later stage would be the starting point for future research in the area.

ICT in Thailand faces greater challenges. As Montreivat argues in her chapter, the market for ICT infrastructure remains largely closed to competitive forces, with the Communications Authority of Thailand holding key stakes in all Internet service providers (ISPs), telecommunications provision still a government monopoly under the Telephone Organization of Thailand, and mobile phone providers similarly being subject to the need to obtain concession rights from these government bodies. E-commerce activity is light, reaching only an estimated US\$15 billion by 2004 (*Nation*, 2001).

Thailand has therefore worked on creating an "e-Thailand", with the National Electronics and Computer Technology Centre (NECTEC) as its lead agency. The guidelines include a stress on e-society, e-government, e-business, e-commerce facilities, and an information infrastructure. The main initiatives that have been undertaken thus far are SchoolNet Thailand, the Government Information Network (GINet), a Software Park, various e-commerce projects, and social projects utilizing

ICT. In addition, NECTEC has also drafted six ICT-related laws, including an Electronics Transactions Act, a Data Protection Act, and a Computer Crime Act — all to be completed by 2001.

Admittedly, Thailand is at an initial stage in terms of its ICT development, and as such, it is difficult to fully evaluate the returns expected to ICT investment. The challenge here is to learn from the experiences of more advanced ICT nations and, without the burden of existing legacy systems, to leapfrog the other nations by the implementation of advanced technologies and infrastructure. As Montreevat contends:

[previous] empirical study ... finds evidence that investment in digital infrastructure is responsible for a substantial fraction of the recent growth in consumer welfare and business revenue ... Thailand could well learn from that lesson.

Doanh picks up on this theme in his contribution on the case of ICT development in Vietnam. Although there is a significant digital divide between the CLMV countries and the rest of ASEAN, if properly addressed, the possibility of leapfrogging should not be dismissed. In this respect, the constituents of the divide — namely, differences in economic structure, GDP per capita, human resource development, the number of ICT professionals, accessibility to ICT, organizational structure for R&D, institutional framework, ICT infrastructure, and socio-economic status — require attention.

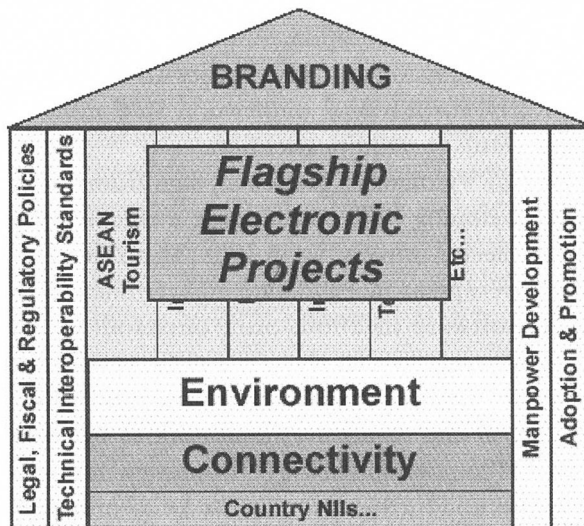
For the case of Vietnam in particular, significant steps have been made towards developing ICT. Policies have included a programme of ICT training in selected universities in 1994, an accelerated application of ICT in the government in 1996, and a government action plan for developing the software in 2000. Still, outstanding issues remain numerous. Doanh suggests that there is a need to reform educational policy to improve training in creativity and innovative capability, restructure the legal and regulatory framework to better engage ICT, increase the level of competition in the ICT industry, improve the existing ICT infrastructure, and further assimilate and disseminate ICT into the economy. Specifically, a masterplan for ICT development in Vietnam is urgently needed. One can easily imagine that these policy prescriptions

are just as applicable in any of the other CMLV countries.

At this juncture it is perhaps appropriate to engage in a brief digression on the e-ASEAN project, as its ultimate aim of establishing an AII is relevant for all ASEAN nations, and for the future regional development of ICT in general. The e-ASEAN Task Force was founded in November 1999 to develop a broad and comprehensive action plan for an ASEAN e-space and to develop competencies within ASEAN to compete in the global information economy. It was asked to examine the economic, legal, logistical, physical, and social infrastructure needed to ensure ASEAN's competitiveness into the twenty-first century.

The Task Force noted severe obstacles to effective e-commerce in ASEAN. In order to achieve a seamless environment for e-commerce, policies would have to focus on not just the physical infrastructure, but also the legal framework and human resources in each country. The points in the agreement include the creation of a legal and regulatory

Figure 1.1
Conceptual Pillars of E-ASEAN



Source: Working Group on ASEAN Information Infrastructure (1999).

environment favourable to the uptake of ICT by the private sector. A time schedule was drawn up for achieving region-wide targets; these include establishing a standard for certifying digital signatures by 2001, creating a secure payments system by 2002, writing an e-commerce code by 2003, introducing cyber laws by 2004, and the formation of a region-wide broadband telecommunications backbone — the AII — by 2005.²⁴ (Working Group on AII 1999). The conceptual pillars of e-ASEAN are summarized in Figure 1.1.

3. Regional Approaches to ICT Development

The other two countries examined in this volume have extremely different backgrounds. Taiwan has a strong ICT goods industry that comprises small and medium enterprises. Its government has been relatively involved in the development of ICT, and, more recently, the economy has complemented its capability in hardware innovation²⁵ with upstream value-added activities, such as the production of weightless knowledge goods and services. India — and for the purposes of this volume, Bangalore — is an innovational hotbed for software development that has little or no hardware production capacity to speak of. The disparities in the approaches and comparative advantages of these cases make their inquiries especially interesting.

The study of Bangalore is often of deep interest to researchers due to its ability to have emerged as a internationally competitive, high-technology cluster in the midst of a country that is not generally regarded as being very advanced in its ICT development. Venkatesan and Malvea pose the question, “Why Bangalore?” before proceeding to draw from various schools of thought to explain the emergence of the software cluster in Bangalore. Essentially, these explanations are: first, extensions of neo-classical trade theories based on factor intensities; second, an extension of the Porter (1990) competitiveness diamond model to the software industry; third, international comparisons with other successful clusters; and fourth, an urban economics-based approach that is premised on microeconomic, macroeconomic, and multi-disciplinary theories. These factors add to Bangalore’s international competitiveness as a software hub although, as they state, “no single theory explains the

phenomenon, [but] various approaches yield insights that are crucial towards increasing our understanding of the process”.²⁶

The role of government in Bangalore has primarily been in the provision of a superior infrastructure. The state government in Karnataka has provided industrial parks for ICT goods, export-oriented industries, and software technology, physical infrastructure such as transport and a fibre-optic ICT network, and non-physical infrastructure including intellectual property laws and an environment that encourages innovation, *inter alia*. These, together with the continued availability of human resource and human capital training, should sustain Bangalore’s competitiveness into the future.

Chen and Liu broaden their study to include not only ICT, but that of the knowledge-based economy in general, arguing that “information technology and networks, which are central to knowledge creation, distribution and utilization, will become necessary conditions for industrial development in the knowledge-based economic era”. This overlap between the contribution of ICT to the knowledge economy and vice versa is evident throughout the chapter. For example, in Taiwan’s information industry, its involvement in the global production networks for ICT manufactures are now complemented by global logistics, where logistical operations are also outsourced. Similarly, OEM, once the mainstay of Taiwanese ICT operations, is increasingly being supplemented with both upstream and downstream knowledge activities, such as R&D and distribution. Another theme that emerges from the study of the case of Taiwan is its strong network linkages with the United States.

A detailed sector-level study of the integrated circuit (IC) industry in Taiwan highlights this trend. The authors find that there is an “interesting pattern emerging in the international division of labour between the United States and Taiwan”. This is evidenced by comparing statistics for R&D intensity and capital expenditure for the four largest IC industry players,²⁷ together with data for the geographical breakdown of Taiwan’s IC foundry service clients, and the literature on the intensive interface between ICT specialists in both countries. However, Taiwan’s software and applications industry is still underdeveloped — a phenomenon that Chen and Liu hypothesize could be the cause of the

inferior productivity of the service sector *vis-à-vis* the non-service sector in terms of productivity. Although the regression run in the study suffers from minor data problems and an odd specification for the production function,²⁸ the crux of Chen and Liu's argument — that Taiwan needs to look beyond industrialization and into increasing the level of value-added activity in order to reap productivity gains — remains valid.

4. Conclusion

This brings the volume a full circle, back to the argument first set forth by Kraemer and Dedrick, and echoed by the other authors — that a organized, well-developed ICT policy can be a source of productivity and hence economic growth. This central thesis has been reiterated not only in the general chapters that form the first part of this volume, but also in the specific country studies, where it is evident that due to the public good nature of innovation in general and ICT in particular, there is some merit in policy that promotes its production, application, and diffusion in the economy.

The focus of the volume on the countries of Asia has been deliberate, and for good reason. The economies of the Asia-Pacific have generally been regarded to be at the forefront of the ICT revolution, but as the chapters make amply clear, production of ICT goods cannot be equated to its diffusion, and the sustainability of economic growth further requires a shift from ICT goods to service and content provision. The countries in the region have adopted different strategies, and enquiries into these differing experiences can be a valuable resource for others seeking to embrace the ICT revolution.

Evidently, the study of the challenges as well as opportunities posed by the new ICT remains unfinished. In a sense, it can never be, since general-purpose technologies by definition will impact on all sectors of economy and society, making any comprehensive analysis of its influence superfluous. That is not, however, something to rue; indeed, it is precisely when ICT has become an integral and essential part of life that it has fulfilled its true potential not just in economic terms, but also in a political, social, and cultural context.

NOTES

1. Or, alternatively (and more narrowly), Information Technology (IT). In the late 1990s, traditional tools of IT (such as computers) began to rapidly converge with communication technologies, leading to the introduction of the new terminology and yielding products that combined the two (such as mobile telephones with basic computing functions or personal digital assistants with communication capabilities). Throughout this volume, the terms ICT and IT shall be used interchangeably.
2. General-purpose technologies (GPT) are dramatic technological innovations that have a widespread impact on a large range of economic activity as well as generate innovational complementarities. Examples of GPTs include the dynamo and the steam engine.
3. The standard reference for neo-classical growth theory is Solow (1956), whereas the contributions of Aghion and Howitt (1992), Grossman and Helpman (1991), and Romer (1986, 1990) exemplify the latter. Beyond these essentially supply-side explanations, Quah (2001*a*) convincingly argues for a demand-side approach to the role of technology in development.
4. The sociological literature on the diffusion of innovations (Rogers 1995; Utterback 1996) can be regarded as the theoretical antecedent to the formal modelling by economists, of which the volume edited by Helpman (1998) is the seminal work in the field.
5. The productivity paradox was first coined by Solow, who stated in a 1987 *New York Times* book review that “we see the computer age everywhere but in the productivity statistics”. The paradox was not limited to the United States, with similar situations being found in both industrialized as well as the developing nations. The chapter by Kraemer and Dedrick in this volume briefly surveys the literature on the productivity paradox. Triplett (1998) summarizes the various explanations that have been proposed to resolve the phenomenon.
6. Network externalities are based on the concept that high-technology products increase in value as their adoption becomes more widespread.
7. In these areas, academic publications have mixed freely with pop-culture books. The more authoritative academic sources include the collection edited by McKnight and Bailey (1996) on Internet economics and the survey on network economics by Economides (1996). The books by Choi, Whinston, and Stahl (1997) and Shapiro and Varian (1998) are standard references for the economics of e-commerce and the network economy.
8. This includes both the physical, such as national telecommunications networks, as well as the non-physical, such as a legal and regulatory framework that supports electronic transactions.
9. As in the recent furore involving Microsoft over the likelihood of path dependence

leading to monopoly emergence. The volume by Evans, Fisher, Rubinfeld, and Schmalensee (2000) summarizes the two opposing views in the Microsoft case.

10. Including, but not limited to, online auctions (and its variants) and electronic exchanges.
11. Significant studies in this vein have included Davis (1999), Hill and Hughes (1998), and Tsagarouisanou, Tambini, and Bryan (1998). The online forum Democracy Online — Asia (<http://groups.yahoo.com/group/do-asia/>) is another excellent resource for exploratory studies into the effect of the Internet on trends in governance, civil society, and the media.
12. See *NAIS Final Report* (2001) and Yergeau and Dürst (1999) for academic studies on international relations regarding ICANN and W3C, respectively.
13. The treatises by Castells (1996, 1997, 1998) are possibly the authority in the field. On the topic of the digital divide, see also NTIA (2000).
14. Examples of each are computers, music, network cables, and Internet service providers. Wong and Singh elaborate on these in their chapter.
15. Due to data problems, however, Rasiah did not capture this final aspect in his chapter.
16. Celebrated dot-coms that have folded include eToys, Pets.com, and Webvan. Amazon.com continues to struggle to attain profitability, and even in the financial sector — where the lower transactions costs associated with Internet trading were expected to make a big splash — E*Trade and its contemporaries have only enjoyed limited success (Currie 2000). The general disillusionment is summed up in Streitfeld (2001). Webmergers (<http://www.webmergers.com>) tracks merger and acquisition activity of e-commerce firms.
17. These fallacies include the belief that first-comer advantage would ensure market share, the elimination of the role of the middleman, and the need to completely re-engineer firms to position them for the Internet age.
18. The concern here is the appropriate classification nomenclature for online service provision under the GATS. Tangkitnovich argues that developing countries such as Asian nations benefit most with progressive liberalization, and hence proposes that online services be classified as Mode 1, or cross-border supply, type services.
19. The Information Society Index (ISI) ranks fifty-five countries according to their position in taking advantage of the information revolution. Singapore is ranked 9th (under a category known as “skaters”), Malaysia 32nd (“sprinters”), Thailand 47th (“strollers”), and Vietnam and the other CMLV countries do not feature in the list (IDC and World Times 2001). The chapter by Wong and Singh lists the rankings and scores of selected Asian nations.
20. The e-ASEAN Framework is a comprehensive action plan to create an ASEAN e-space that would develop competencies and enable the region to compete in the

global information economy. e-ASEAN is elaborated upon in detail in Toh's chapter, and briefly at the end of this section.

21. Flagship applications are areas of multimedia application that have been earmarked for priority development. For phase I of the MSC, these are electronic government, multi-purpose cards, smart schools, telemedicine, R&D clusters, world-wide manufacturing webs, and borderless marketing.
22. In particular, the imposition of capital controls and the fixed peg of the Malaysian ringgit to the U.S. dollar have severely affected foreign investment flows into the country, and this has been exacerbated by the regional financial crisis that has led to an economic downturn in Malaysia.
23. The confidential study was performed by the international consultancy firm McKinsey & Co. Other suggestions made in the McKinsey report include the need to be directly aware of high-value contracts to high-priority global technology companies, to provide special incentives to big local companies to entice them to work with technology companies within the corridor, and to build a stronger talent pool by bringing in top universities.
24. The AII is to build on the information infrastructure plans of member countries, such as Indonesia's Nusantara 21, Malaysia's Multimedia Super Corridor, and Singapore's NII, in order to increase efficiency in information and technology transfer across ASEAN nations.
25. The national innovation system in Taiwan, and that of most of the Asian Tiger economies, has followed a "reverse value chain" strategy that moves from original equipment manufacturing (OEM), to original design manufacturing (ODM), followed by original idea manufacturing (OIM), and then own brand manufacturing (OBM). This development strategy is characteristic of latecomer economies seeking technological catch-up. This is elaborated in Wong (1999).
26. A somewhat glaring omission would be recent research on the New Economic Geography, which is well-summarized in the book by Fujita, Krugman, and Venables (1999). Quah (2000, 2001*b*, 2001*c*) has actively applied the tools of the literature to explain ICT cluster emergence.
27. Namely, the United States, Japan, South Korea, and Taiwan.
28. Specifically, the data used in Chen and Liu's chapter dates up to only 1996, and the production function used is fairly uncommon although, admittedly, drawn from another source.

REFERENCES

- Aghion, P. and P. Howitt. "A Model of Growth Through Creative Destruction". *Econometrica* 60 (1992): 323–51.

- Castells, M. "The Rise of the Network Society". In *The Information Age: Economy, Society, and Culture*. Vol. I. Oxford: Blackwell, 1996.
- . "The Power of Identity". In *The Information Age: Economy, Society, and Culture*. Vol. II. Oxford: Blackwell, 1997.
- . "End of Millennium". In *The Information Age: Economy, Society, and Culture*. Vol. III. Oxford: Blackwell, 1998.
- Chen M.Y. "Glitches Zap Malaysian Tech Corridor". *Asian Wall Street Journal*, 26 March 2001.
- Choi S.Y., A.B. Whinston, and D. Stahl. *The Economics of Electronic Commerce*. Indianapolis, IN: Macmillan Technical, 1997.
- Currie, A. "The X-Men of e-Finance". *Euromoney*, September 2000, pp. 62–67.
- Davis, R. *The Web of Politics*. New York, NY: Oxford University Press, 1999.
- Economides, N. "The Economics of Networks". *International Journal of Industrial Organization* 14, no. 6 (1996): 673–700.
- Evans, D.S., F.M. Fisher, D.L. Rubinfeld, and R.L. Schmalensee. *Did Microsoft Harm Consumers? Two Opposing Views*. Washington, DC: AEI-Brookings Joint Centre for Regulatory Studies, 2000.
- Fujita, M., P. Krugman, and A.J. Venables. *The Spatial Economy: Cities, Regions and International Trade*. Cambridge, MA: MIT Press, 1999.
- GartnerGroup. "GartnerGroup Forecasts Asia/Pacific Business-to-Business E-Commerce to Reach \$1 Trillion in 2004". GartnerGroup Press Release, 17 February 2000.
- Grossman, G.M. and E. Helpman. *Innovation and Growth in the Global Economy*. Cambridge, MA: MIT Press, 1991.
- Helpman, E. *General Purpose Technologies and Economic Growth*. Cambridge, MA: MIT Press, 1998.
- Hill, K.A. and J.E. Hughes. *Cyberpolitics: Citizen Activism in the Age of the Internet*. Lanham, MD: Rowman and Littlefield, 1998.
- International Data Corporation (IDC) and World Times. *2001 IDC/World Times Information Society Index* (http://www.worldpaper.com/2001/jan01/ISI/2001_Information_Society_Ranking.html).
- McKnight, L.W. and J.P. Bailey, eds. "Special Issue on Internet Economics". *Journal of Electronic Publishing* 2, no. 1 (1996).
- Michael, D.C., G. Sutherland, and N.S. Lang. *Digital Dragons — How Asia Pacific's Large Companies Can Generate Real Revenue from Consumer E-Business*. Kuala Lumpur: Boston Consulting Group, 2001.
- National Telecommunications and Information Administration (NTIA). *Falling Through the Net: Towards Digital Inclusion*. Washington, DC: U.S. Department of Commerce, 2000.

- NAIS Final Report*. NGO and Academic ICANN Study. Stockholm: NAIS, 2001.
- Porter, M. *The Competitive Advantage of Nations*. New York, NY: Free Press, 1990.
- Quah, D. "Internet Cluster Emergence". *European Economic Review* 44, no. 4–6 (2000): 1032–44.
- . "The Weightless Economy in Economic Development". In *Information Technology, Productivity, and Economic Growth: International Evidence and Implications for Economic Development*, edited by M. Pohjola. Cambridge: Oxford University Press, 2001a.
- . "ICT Clusters in Development: Theory and Evidence". *European Investment Bank Papers* 6, no. 1 (2001b): 85–100.
- . "Demand-Driven Knowledge Clusters in a Weightless Economy". Proceedings of the Knowledge as an Economic Good Conference, Palermo, Sicily, April 2001c.
- Rogers, E.M. *Diffusion of Innovations*. 4th edition. New York, NY: Free Press, 1995.
- Romer, P.M. "Increasing Returns and Long-Run Growth". *Journal of Political Economy* 94 (1986): 163–202.
- . "Endogenous Technical Change". *Journal of Political Economy* 98 (1990): S71–102.
- Shapiro, C. and H.R. Varian. *Information Rules: A Strategic Guide to the Network Economy*. Boston, MA: Harvard Business School Press, 1998.
- Solow, R. "A Contribution to the Theory of Economic Growth". *Quarterly Journal of Economics* 70 (1956): 65–94.
- . "We'd Better Watch Out". *New York Times Book Review*, 12 July 1987, p. 36.
- Streitfeld, D. "Amazon.com: Was It Only a Mirage". *International Herald Tribune*, 23 July 2001.
- "Thai B2B to Reach \$15bn by 2004 — Gartner". *Nation*, 27 December 2000.
- Triplett, J.E. "The Solow Productivity Paradox: What Do Computers Do to Productivity?" Mimeographed. Washington, DC: Brookings Institution, 1998.
- Tsagarouisanou, R., D. Tambini, and C. Bryan. *Cyberdemocracy*. London: Routledge, 1998.
- United Nations Commission on International Trade Law. *UNCITRAL E-Commerce Model Law*. New York, NY: UNCITRAL, 1998.
- Utterback, J.M. *Mastering the Dynamics of Innovation*. Boston, MA: Harvard Business School Press, 1996.
- Wong P.K. "National Innovation Systems for Rapid Technological Catch-up: An Analytical Framework and a Comparative Analysis of Korea, Taiwan and Singa-

pore”. Proceedings of the DRUID Summer Conference on National Innovation Systems, Industrial Dynamics and Innovation Policy, 9–12 June 1999.

Working Group on ASEAN Information Infrastructure. *Report on the Feasibility Study of the AII*. Makati City, Philippines: e-ASEAN Task Force Secretariat, 1999.

Yergeau, F. and M. Dürst. “Weaving the Multilingual Web”. Proceedings of the 15th International Unicode Conference, 31 August 1999.