TOWARDS AN INFORMATION SOCIETY:

DEVELOPMENTS IN APEC

APEC ECONOMIC COMMITTEE
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438 Alexandra Road
#14-00 Alexandra Point
Singapore 119958
Tel: (65) 2761880
Fax: (65) 2761775
E-mail: info@mail.apecsec.org.sg
Website: http://www.apecsec.org.sg

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FOREWORD

Since its formation at the 1994 APEC Ministerial meeting in Jakarta, the Economic Committee has pursued a work program aimed at fulfilling the three major objectives established for it: namely to serve as a forum for discussion of economic trends and issues in the region; to support the Ministerial and Leaders' meetings and other APEC fora; and to disseminate information on economic issues and linkages in the region. In line with these objectives, the Committee has maintained a very active research and publications program.

While the attention of the economic policy community in the region has been focussed since the onset of the economic and financial crisis on restoring economic growth and stability, analytic work on the foundations of longer-term growth and economic development continues. In this regard, no single development has as much potential impact on longer-term prosperity or implications for the structure of economies as the confluence of the revolutions in information technology and telecommunications out of which is emerging what has come to be termed the "information society".

In this study, *Towards an Information Society: Developments in APEC*, the Economic Committee has attempted to meet three objectives: to articulate the concept of an information society and to demonstrate its usefulness as a window through which to view and to assess the foundations that APEC member economies are establishing to support continued economic growth; to document the development of APEC member economies as information societies; and, in view of the many policy initiatives being developed by various APEC fora which contribute to the development of the information society, to look at how APEC member economies can work together to develop the infrastructure and supportive policy frameworks required to further foster the development of the information society in the region.

The work program of the Committee has consistently reflected the integrated nature of APEC's two broad agendas of trade and investment liberalization and facilitation (TILF) and economic and technical cooperation (ECOTECH). It is the hope of the Committee that this project, the companion study *Cost and Productivity Trends and Patterns of Specialization in APEC*, along with *The 1998 APEC Economic Outlook* which includes a structural chapter on the role of science and technology in supporting economic growth and development, will provide contextual background and analytical support for APEC's key ECOTECH theme in 1998, namely capacity building through human resource development and science and

technology, as well as for APEC's emerging high priority initiative on electronic commerce, its continued work on the Asia Pacific Information Infrastructure and the ongoing TILF agenda, including trade liberalization under the Information Technology and Telecoms Agreements.

As an institution that has evolved at the dawn of the information age, APEC in general, and the Economic Committee in particular, has pioneered a "virtual" form of operation, relying heavily on the contributions of member economies from capitals to lead individual projects and to develop the papers that serve as the basis of discussion. In this case, particular thanks are due to Ronald Hirshhorn of Canada and Gae-Iyong Choi and Nakgyoon Choi of Korea who prepared the initial drafts of this paper, led the discussion of the paper in Committee and Small Group sessions, and developed the final results based on the comments and inputs from member economies. Thanks are also due to Ms. Julie Gould, Director (Program) at the APEC Secretariat who has taken particular responsibility for seeing the study through to publication.

John M. Curtis

Chair
APEC Economic Committee
Ottawa, September 1998

SUMMARY AND CONCLUSIONS

The vision of an age in which information opens new possibilities for human development and for the collective solution of problems both within societies and globally has caught the imagination of policy-makers. For both organizations and economies, wealth is no longer measured primarily in terms of physical assets; decision-makers have come to understand that access to information is a crucial determinant of the productive potential of firms and of economic systems. As a result, the construction of information infrastructure and the establishment of interconnected information networks have become priorities in APEC and globally. It is within this broad context that this study assesses the movement of APEC member economies towards "information societies" and considers cooperative approaches towards the development of the region's information infrastructure.

What is an "Information Society"

The term "information society" is often used to convey the pervasive changes that are being wrought by rapid improvements in individuals' ability to manipulate, transmit and consume information through the revolutionary advances in computer and communications technology. As a result of these developments, some economies have already experienced major shifts in the nature of their economic activities and most observers believe that much more far-reaching changes are on the horizon.

But information technology and information itself are only means to an end. What is of ultimate importance is the ability of societies to use information to improve the well being of their citizens. From an economic perspective, societies face the challenge of positioning themselves so that they can take advantage of the potential of information to contribute to economic growth.

The Economic Role of Information

The economic role of information is the subject of an extensive economic literature. One role of information is to promote economic efficiency by helping consumers, producers and investors resolve problems of uncertainty. In particular, information helps to improve resource allocation, facilitates the organization and coordination of activities within organizations, reduces the costs of market coordination, and mitigates risks that market outcomes will be distorted because of imbalances in the information available to different participants.

Some of the most important economic benefits of information, however, arise from the accumulation of knowledge. In neoclassical growth models, it has been shown that sustained economic growth depends on technological change, which involves the reorganization of information into new forms and patterns (invention) and the subsequent incorporation of the new idea in a technology (innovation). New growth theorists have highlighted the unique

characteristics of information and shown how investments in R&D, education and other knowledge-enhancing activities can sustain economic growth. Other strands of economic research, including studies of the innovation process and historical inquiries into the determinants of long-run growth, have shed additional light on the role of information development as an engine of economic growth.

The Economic Role of Information Technology

As a result of the recent advances in information technology and telecommunications, economies now have a range of powerful new instruments to tap the potential of information as a factor of production and an agent of economic change. Possibilities for the development and use of information that could not be imagined by previous generations have been opened up, ranging from at-home banking, to electronic bar-coding, to sophisticated quality control monitoring systems, and so forth. Meanwhile, new modes of communication, such as electronic data interchange, e-mail and videoconferencing, have reduced the costs of transacting business both within and between firms. Many surmise that electronic commerce will emerge as a fundamentally transforming technology.

Potentially more important than the one-time gains from the information embodied in new products are the longer-term effects from the contribution of the new technology to the production and spread of ideas and the creation of more dynamic economies that are more attuned to new opportunities. For example, the new information technology can help producers to anticipate changes in demand and to visualize new design and engineering possibilities; it can help to realize the benefits of cross-fertilization by facilitating interaction among those working in other disciplines and different environments; it can facilitate the needed feedback and cooperation among researchers, developers and users of new technology; and it can facilitate training and learning. Some observers believe that information technology is also making it feasible to formalize and codify some knowledge that had previously been regarded as tacit. The implication is that all types of information are becoming more accessible.

The Emerging Information Society

While starting from different positions and moving at different rates, all societies are under pressure to mould their institutions and practices to the requirements for success in an information age.

Globalization, while creating new opportunities for information sharing, is also generating new pressures for economies to strengthen their economic and information links to the outside world. Indeed, economies must have well-developed information links with the outside world simply to avoid falling behind in their use of technology and in their international competitiveness. While recent theoretical and empirical studies show that knowledge spillovers have helped narrow the gap between high- and low-income economies, the evidence reinforces the importance of policies that focus on the mechanisms and capabilities that

economies require to benefit from international knowledge transfers.

The Development of APEC Member Economies as Information Societies

The development of APEC member economies as information societies is assessed using indicators relating to two issues: (1) the information access of economies; and (2), the extent to which economies possess those features that facilitate and support information use.

The Information Access of APEC Member Economies

Since information flows cannot be directly measured, it is necessary to resort to a range of proxy indicators:

- domestic information production, which is assessed in terms of inputs (e.g., R&D expenditures, numbers of research scientists and engineers, university research spending), outputs (patents, research publications), and measures of significance (patent and publication citations);
- access to information produced elsewhere, which is assessed by looking at the use made of available mechanisms for the international exchange of information, including trade and foreign direct investment, technology licensing, international alliances and joint ventures, student training abroad, the hiring of foreign consultants, and international conferences; and
- information technology use, which is examined using measures of computerisation, advanced manufacturing technology use, and communications access.

The review of relevant data supplemented by available information from other APEC reports indicates that APEC member economies are at different stages and following different paths in their development as information societies. In particular:

- The U.S. and Japan stand out because of their leadership role in the development of new information. While, in Japan, the emphasis is on information with potential commercial application, the U.S. has focused more broadly on expanding the base.
- Among APEC member economies that are heavily reliant on information produced elsewhere, Singapore and Hong Kong, China stand out because they have long taken particular advantage of the two traditional international mechanisms of information transfer, namely trade and foreign direct investment.
- Some APEC member economies – including Australia, Canada, Indonesia, Malaysia, the Philippines, Thailand and Chinese Taipei – have good information access because of strong economic links to the two main information-producing economies, the U.S. and Japan.
- Information access in some economies – notably Korea and Chinese Taipei – have been enhanced through the development of effective strategies for acquiring information and expertise to meet specific needs.

- Differences among APEC member economies in computerisation and communications facilities approximately correspond with differences in economic development; information access has been enhanced in wealthier economies through advanced information technology and impeded in poorer economies by inadequately developed communications infrastructure.

Factors Affecting the Development of Information Societies

Along with improving their access to information, economies that are to progress as information societies must give attention to those factors that affect their ability to take advantage of information. Among the most important of these "conditioning" factors are capital investment and human capital development. An economy with a well-educated and highly-trained workforce is better positioned to identify and to apply significant new innovations. With strong investment, an economy is able to realize more quickly and more fully the benefits from new information that is incorporated in physical capital. Two other conditioning factors are examined: economic infrastructure development and the political-economic environment. The influence of these factors has been more difficult to identify quantitatively, but studies suggest that deficiencies in these areas can significantly affect economies' ability to utilise technology.

Against this background, this study finds that conditioning factors have supported the progress of some APEC member economies as information societies and hampered the development of others. The results are clearest where the two main factors, human capital development and capital accumulation, have worked in the same direction. For example, over the period 1980 to 1993:

- good performance in physical investment and human capital development supported the impact of favourable information access in Korea and Chinese Taipei; and,
- weak performance in physical investment and human capital development impaired information access and use in Papua New Guinea, Mexico and the Philippines.

In some cases, poor or lacklustre performance with respect to one of the main conditioning factors has constrained the progress of APEC member economies. For example, over the period 1980-1993:

- slow investment growth moderated the impact of favourable information access in the U.S., Canada and Australia; and,
- poor human capital development reduced the benefits from reasonably good information access and strong investment growth in China, Thailand, Indonesia and Malaysia.

Expediting the Realization of the Asia Pacific Information Infrastructure

While the introduction of advanced information and communications systems cannot transform an economy into an information society, a well-developed information

infrastructure can significantly improve an economy's capacity to acquire and to utilise information. In this context, the paper explores how APEC member economies can work together to promote the development of a regional information infrastructure which includes advanced physical facilities along with the needed information applications and a supportive institutional framework.

First, it is important that APEC member economies appreciate that, despite their different priorities, they have a common interest in building the region's information infrastructure. A recent study by the Korea Institute for Industrial Economics, based on a regional input-output model, shows that a cooperative initiative to develop the Asia Pacific region's information infrastructure can substantially boost GDP in all APEC member economies. In addition, all APEC member economies have a stake in the longer-term benefits that will flow from the improved diffusion of information and the consequent improvement in the prospects for regional growth.

Along with recognising their mutual interest in improving economic links and expanding flows of goods and services, investment, and information, APEC member economies need to approach the development of a regional information infrastructure through a strategy that is sensitive to members' differing priorities and perspectives. APEC Ministers have indeed attempted to balance liberalization, which is needed to facilitate efficient markets in information products, with cooperative initiatives to address common problems and assist lower-income economies. Based on the principles set out in the 1995 Seoul Declaration on the Asia Pacific Information Infrastructure (APII), a number of projects have been launched to liberalise trade and investment in the telecommunications sector and to foster economic and technical cooperation. At the multilateral level, progress towards the goal of liberalization has been achieved with the WTO Information Technology Agreement and the recent WTO agreement on basic telecommunications services. The participation of APEC member economies contributed to the successful conclusion of the WTO/GBT negotiations on market opening of basic telecommunications services. Meanwhile, relevant cooperative actions have been initiated under the general rubrics of improving human resource training and harnessing technologies of the future, as well as specifically to promote electronic commerce. In this latter regard, a Task Force on Electronic Commerce is to consider principles for policy development and options for technical cooperation within APEC to address issues such as the appropriate regulatory environment, encryption and so forth.

While APEC Ministers have recognized the need to encompass all communities within the APII, ongoing efforts must be made to ensure that APEC action plans adequately address the concerns of low-income economies. Current initiatives, including pilot projects to promote the development of information technologies and the education and training programs of the Telecommunications Working Group, could be modified to be of greater interest to, and to attract the fuller participation of, lower-income economies. With a view to developing an appropriately balanced strategy for developing the APII, current programs of economic and technical cooperation should be reviewed to determine whether they need to be more sharply focused on the needs of developing APEC member economies.

Conclusion

The evidence shows that there is a significant relationship between an economy's information status and its economic performance. From a simple ranking of APEC member economies in terms of the major indicators of information status, it can be seen that there tends to be a positive relationship between an economy's progress as an information society and its per capita income. Accordingly, a coherent policy thrust to advance the development of the information society in the region can be expected to yield significant economic benefits.

APEC initiatives touch, to some degree, on all the major factors affecting an economy's information status. They impact on the capacity of economies to produce information, they affect the mechanisms by which economies access information produced elsewhere, and they influence the conditioning factors which determine how well individual APEC member economies are positioned to take advantage of new information. Viewed through the prism of the information society, it can be shown that many seemingly disparate and unconnected activities indeed have a common purpose. In turn, this insight can serve as the springboard for sharpening and focussing policy initiatives to improve policy coherence and to achieve meaningful breakthroughs.

- Facilitation of Information Production: APEC promotes information development through its broad range of projects to enhance technical cooperation and its programs to support human resource development in industrial science and technology. The Industrial Science and Technology (IST) Working Group promotes R&D more generally by facilitating joint research projects, promoting the exchange of researchers and helping member economies to develop a policy environment that is appropriately supportive of science and technology. The professional training that is needed to establish a research capability is a focus of consideration by most of the sector-specific working groups and by the IST and Human Resources Development Working Groups.
- Facilitation of Information Access: APEC also improves the information access of member economies by itself serving as an important vehicle for the exchange of scientific and technical information. APEC Fora allow experts to exchange information and to work towards cooperative solutions to common problems in sectors such as agriculture, transportation, energy, telecommunications, the fisheries, marine resources, the environment and so forth. By participating in APEC Working Groups and task forces and taking advantage of APEC conferences and exchange programs, member economies gain information on leading-edge technological developments in a number of sectors and relating to a range of common issues. As well, the distance learning initiative of the Telecommunications and Human Resources Development Working Groups promotes access to information by all members of society, including those in regions under-serviced by information infrastructure.
- Conditioning Factors: The broader policy coherence of APEC's agenda to promote trade and investment and economic and technical cooperation is best seen in terms of the

conditioning factors that support the development of the information society. APEC initiatives specifically target those factors that affect economies' capacity to utilise information – notably, capital investment, human capital development, economic infrastructure, and economic framework policies.

- Capital investment is likely to be positively affected by various APEC initiatives intended to bring about a more open and friendly business environment and to improve the functioning of capital markets in member economies.
- Important initiatives aimed at supporting human capital development in member economies include: promoting the use of new technologies in education and training and in lifelong learning; exploring internships, mentoring and other options to help youth to acquire skills and to make the transition to work; identifying exemplary educational policies and practices that can serve as benchmarks and models for other member economies; and focusing on how to meet selective training needs, such as those of small and medium-sized enterprise, and special requirements, such as those of impaired persons.
- Economic infrastructure, over and above information infrastructure itself, has also been recognized as important by APEC Economic Leaders who, at their Vancouver meeting, issued a framework calling for enhanced partnerships between the public and private sectors to develop and manage the infrastructure required in the APEC region.
- Finally, a broad range of initiatives under APEC's trade and investment facilitation agenda aim to improve economic framework policies, as do many of the initiatives under the program of economic and technical cooperation which seek to identify and widen the application of best practices in many areas.

- Finally, the broad conclusion emerges that barriers to trade and investment are also barriers to the development of the information society. Accordingly, APEC helps to strengthen the two main international mechanisms of information transmission through its initiatives to promote free and open trade and investment in the region.

APEC member economies are at different stages and proceeding along different paths in their evolution as information economies. While the information access of all economies has improved as a result of the recent growth in international trade and investment, some economies have given greater attention than others over a longer period of time to developing links to other economies, especially the major knowledge-producing economies. APEC member economies also differ significantly in human capital development and other characteristics that influence their ability to take advantage of information access.

All APEC member economies stand to benefit from a cooperative approach to developing the region's information infrastructure. In this regard, current programs of economic and technical cooperation may have to be more sharply focused on the need of low-income economies. Developing member economies for their part must put a special emphasis on putting in place

the policy frameworks to promote the evolution of the information society.

APEC member economies also stand to benefit from initiatives to strengthen the main regional mechanisms of information and technology transfer, trade and foreign investment. Meanwhile, some individual APEC member economies have a special interest in human capital development programs and other APEC initiatives that address problem areas significantly hampering their development as information societies.

The concept of an information society provides us with a new way of looking at the contribution of a range of APEC programs and activities. Many of APEC's initiatives promote the development of information societies by enhancing the capacity of economies to produce information and to access information produced elsewhere, and by helping APEC members to acquire the characteristics that will enable them to more efficiently incorporate new information into production processes. In so doing, APEC's initiatives are working to enhance the ability of its member economies to take advantage of the opportunities provided by the advent of the information age and the emergence of the information society to improve the well-being of their citizens.

1. INTRODUCTION

The vision of an age in which information opens new possibilities for human development and for the collective solution of problems both within societies and globally has caught the imaginations of policy-makers. In many economies, the construction of an infrastructure that will be adequate to meet the information requirements of the 21st Century has become a priority. Internationally, initiatives relating to establishment of interconnected information networks have been taken in various contexts, including the OECD, the European Union, and the G7. Within APEC, the development of an Asia Pacific Information Infrastructure (APII) has been recognized as contributing to the broader objective identified at Bogor in 1994 of "accelerated, balanced and equitable economic growth".[1] At Vancouver in 1997, Leaders agreed that "the Asia-Pacific Information Infrastructure is an essential basis for ensuring the competitiveness of the region in the 21st Century"[2] and APEC Ministers called on APEC member economies to "implement actions necessary to make the Asia Pacific information society a reality".[3]

The planned arrangements for the networking of individuals and economies would not be possible without the extraordinary progress that has been made in the technologies for manipulating, storing and transmitting information. However, they also reflect other influences. With globalization, and especially the growth in foreign direct investment, there has developed a much greater need for the free and efficient flow of information. As well, there has been increasing recognition that information is an important economic resource in its own right. For both organizations and economies, wealth is no longer measured primarily in terms of physical assets; decision-makers have come to understand that access to information is a crucial determinant of the productive potential of firms and of economic systems.

It is within this broad context that this paper assesses the movement of APEC member economies towards "information societies". The focus is on the economic role of information and on the efforts of APEC member economies to take advantage of the opportunities from developing and using information. There are important differences in the role of information and information technology within the APEC region. Some APEC member economies have developed channels of access to knowledge and technology more carefully than others. Successful information societies also tend to have other characteristics that help them to realize the gains made possible by inflows of knowledge. The concept of an "information society" opens a window onto a range of factors that have an important influence on the long-term performance of economies.

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1 The reference is to the commitment made at the First APEC Ministerial Meeting on Telecommunications and Information Industry, in Seoul, Korea, May 29-30, 1995.

2 APEC Economic Leaders' Declaration, Connecting the APEC Community, Vancouver, Canada, November 25, 1997.

3 Ninth APEC Ministerial Meeting, Joint Statement, Vancouver, Canada, November 21-22, 1997.

The examination of the role of information in the APEC region begins in the next chapter with a general discussion of conceptual issues. While decision-makers in the public and private sectors have developed a new appreciation of the importance of information in recent years, information has a well-established and prominent role in the literature on economic growth. This chapter briefly reviews the literature's main findings and looks at the related pressures on economies to adapt to the requirements of an information age. In Chapter 3, there is an examination of various data that provide an indication of the information access of APEC member economies, and that highlight differences among these economies from an information perspective. As noted above, successful economies not only have favourable access to new knowledge and technology, but are also well endowed with those characteristics that support information use. The 4th chapter pursues the latter issue by focusing on some general characteristics of APEC member economies that affect their status as "information societies". Chapter 5 focuses on information infrastructure development in the Asia Pacific region. It considers cooperative strategies through which APEC member economies can work together to develop the basic infrastructure that is vital to the emergence of information societies.

2. INFORMATION SOCIETY: CONCEPTUAL ISSUES

The term "information society" has come into popular usage to convey the pervasive changes that are being wrought by rapid improvements in individuals' ability to manipulate, transmit and consume information through the revolutionary advances in computer and communications technology. As a result of these developments, some economies have already experienced major shifts in the nature of their economic activities. Most observers believe that much more far-reaching changes are on the horizon. In coming years, the so-called "information revolution" promises to touch, and significantly affect, many aspects of the lives of individuals in most parts of the world.

Information is, of course, only a means to an end. What is of ultimate importance is the ability of economies to take advantage of the opportunities provided by the new technology to improve the well being of their citizens. The growing role of information technology raises a wide range of issues – issues relating to politics, sociology and philosophy as well as to economics. An economic perspective, however, can provide some insights into the importance of information as a factor of production. It can also help us to understand the forces that are leading to the emergence of more information-oriented societies.

2.1 The Economic Role of Information

As participants in the economic system, individuals devote considerable time to acquiring, manipulating and communicating information. Information is a valuable commodity because it helps economic agents – i.e., consumers, producers and investors – to resolve problems of uncertainty and thereby better achieve their objectives.

Improved information can promote economic efficiency in a number of ways. More informed investment and production decisions improve the prospects that resources will be directed towards their most productive uses. Improved information access facilitates the organization and coordination of activities within organizations. It also reduces the costs of market coordination and the risks that market outcomes will be distorted because of imbalances in the information available to different participants.

Some observers trace the roots of the information society to the problems of economic coordination and control created by the industrial revolution. The rise in the complexity of industrial processes, the tendency towards specialization and the shift from local segmented markets to larger mass markets created what has been called a "crisis of control".[4] The resolution of the crisis required the development of new mechanisms of economic integration and control. This was facilitated by the development of a wide range of new communication technologies – photography and telegraphy (1830s), rotary power printing (1840s), the

4 This comes from James R. Beniger, The Control Revolution, (Cambridge, Mass.: Harvard University Press), 1986. As Beniger points out, a similar theme is implicit in the writings of Emile Durkheim, notably The Division of Labour in Society, G. Simpson translation, (New York: Free Press), 1933.

typewriter (1860s), transatlantic cable (1866), telephone (1876), motion pictures (1894), wireless telegraphy (1895), radio (1906), and television (1923).

As a framework for understanding the role of information, however, this is incomplete. Some of the most important economic benefits of information arise in fact from the accumulation of new ideas. Kenneth Boulding highlighted the crucial role of information in this context many years ago:

> "The plain fact is that knowledge or something equivalent to it in the form of equivalent structures is the only thing that can grow or evolve... As far as matter and energy are concerned, we are subject to inexorable laws of conservation. Here we are faced with simple exchange: what one system acquires, another system must give up. In the case of available energy, there is not even conservation: the second law of thermodynamics informs us there is constant degradation and decay.... It is only information and knowledge processes which in any sense get us out from under the iron laws of conservation and decay..." [5]

Technological change, which involves the reorganization of existing information into new forms and patterns (invention) and subsequently the incorporation of the new idea in a technology (innovation), has long been recognized to have a central economic role. The key role of technological change was given formal expression in the neoclassical growth models developed by Robert Solow and others in the mid-1950s.[6] More recently, new growth theorists, such as Paul Romer and Robert Lucas, have attempted to get inside the "black box" of technological change.[7] In this new literature, the models of long-run growth have been extended to incorporate a theory of knowledge accumulation. By taking account of the unique characteristics of information and, in particular, of its ability to be passed from user to user without losing its usefulness, the new growth theorists have shown why information is an especially valuable factor of production. Investments in education, invention, innovation, and other knowledge-enhancing activities are seen to be the key to extracting greater economic value out of the economy's limited resources.

Other strands of economic literature provide further evidence of the central importance of information-related activities. A large body of microeconomic research, for example, sheds light on the importance of innovation – and of government policies with respect to R&D and

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5 K E. Boulding, "The Economics of Knowledge and the Knowledge of Economics," American Economic Review, Vol. 56, No. 2, 1966.

6 Robert M. Solow, "A Contribution to the Theory of Economic Growth," Quarterly Journal of Economics, Vol. 70 1956. Also, T.W. Swan, "Economic Growth and Capital Accumulation," Economic Record, Vol. 32, 1956.

7 Two of the pioneering articles are: P. Romer, "Increasing Returns and Long Run Growth," Journal of Political Economy, Vol. 84, October 1986; and R. Lucas, "On the Mechanics of Economic Development," Journal of Monetary Economics, Vol. 22, July 1988.

intellectual property – on the performance of various firms and industries.[8] It has been found that an increase in business expenditure on R&D substantially increases total factor productivity in an economy.[9] A variety of empirical studies indicate that the social rate of return on research has been very high, in the order of 30 to 50 percent.[10] This is approximately double the long-term return to high-risk investment in physical capital. Economic historians have provided an additional perspective on the role of technology as an engine of growth.[11] A recent study, for example, which includes estimates back to 1820 for 21 economies, along with data back to 1950 for another 22 economies, concludes that "... the major engine of growth has been advancing knowledge and technical progress, which needs to be embodied in human and physical capital in order to have an impact".[12]

2.2 The Significance of Information Technology

The economic literature provides a helpful context within which to view recent advances in information technology (IT). The proliferation in new IT products is the result of the exponential increases in computing power that have occurred over the past two decades, great progress in digitalization, and innovations that have greatly expanded communications capacity and increased networking capabilities. It is now possible to transform virtually all forms of information – including text, calculations, sound, moving pictures, real-time simulations – into a digital stew of 1s and 0s that can be manipulated, processed, stored, and transmitted at high speed. The cost of information processing has declined precipitously, from one dollar per instruction per second in 1975 to one penny in 1995. At the same time, developments in telecommunications, including especially improvements in switching capability and the establishment of fibre optics cable systems, are making it possible to transmit vast amounts of information over long distances at very low cost.

The new technology is eliminating some of the distinctions between sectors. Computing, communications and information processing are merging into an integrated multimedia industry. Barriers of time and space are also being reduced. Communication networks are facilitating transactions among individuals in different organizations and on different

8 This literature is reviewed in Richard R, Nelson, "The Agenda for Growth Theory: A Different Point of View," mimeo., March 1995. Also, D. Mowery and N. Rosenberg, Technology and the Pursuit of Economic Growth, (New York: Cambridge Univ. Press), 1989. And P. Mohnen, The Relationship Between R&D and Productivity Growth in Canada and Other Major Industrialized Countries, (Ottawa: Supply and Services Canada), 1992.

9 This is based on a study of OECD economies. D.T. Coe and E. Helpman, "International R&D Spillovers," Centre for Economic Policy, Research Discussion Paper No. 840, London.

10 Zvi Griliches, "The Search for R&D Spillovers," Working Paper 3768, National Bureau of Economic Research, Cambridge, Mass., 1991.

11 For example, N. Rosenberg, Technology and American Economic Growth (New York: Harper and Row), 1972.

12 A. Maddison in W.J. Baumol, R.J. Nelson and E.N. Wolff (eds.), Convergence of Productivity: Cross-National Studies and Historical Evidence, (New York: Oxford Univ. Press), 1994.

continents. Although it is not a high band-with system and is thus only a precursor of a global information highway, the Internet has experienced phenomenal growth. The host computers that provide access to the net, which numbered only 100,000 in 1989, were estimated at over 16 million at the beginning of 1997.[13]

As a result of these developments, economies now have a range of powerful new instruments to tap the potential of information as a factor of production and an agent of economic change. The new technology, combined with the increasing globalization of modern economies, has opened possibilities for the development and use of information that could not be imagined by previous generations.

The most visible change has been the arrival of a wide range of new knowledge-based products and production processes. Information technology has made possible such products as at-home banking; new improved home and office security system; and "smart cars" which include electronic systems that monitor performance and diagnose mechanical problems. Many of the most important IT-based innovations, however, have been directed at making the production and delivery of goods and services more efficient. For example, using electronic bar-coding and related computerized systems, manufacturers are now able to track closely changes in consumer demand and to tailor their output and their input purchases accordingly. Sophisticated monitoring systems have allowed better quality control by manufacturers, and closer control of operations in service activities such as transport and delivery. New modes of communication, such as electronic data interchange, e-mail and videoconferencing, have reduced the costs of transacting business both within and between firms. Using e-mail, for example, an individual can send a 42-page document from New York to Tokyo in a fraction of the time and at one-third of one percent of the costs of faxing or overnight delivery.[14]

While economists have had difficulty in documenting the aggregate impacts of IT products,[15] some evidence of their positive contribution is beginning to appear.[16] Estimation problems may partly reflect the significant lags in the adoption and proper use of IT; most economies may still be at an early stage in terms of learning how to use IT and effectively integrating it into their production structures.

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13 From OECD, Information Technology Outlook 1997.

14 WorldCom 1996 Annual Report.

15 While, for example, in the U.S., the share of "information" equipment in total producer investment in durable equipment went from 17 percent in 1960 to 36 percent in 1992, much of this investment went into "unmeasurable" or poorly measured service activities. Its productivity effects are therefore "largely invisible". Zvi Griliches, American Economic Review, March 1994.

16 For example, Erik Brynjolfson and Lorin Hitt, "Is Information Systems Spending Productive? New Evidence and New Results," Sloan School, Massachusetts Institute of Technology, Working Paper No. 3571-93, June 1993; and D. Siegel and Z. Griliches, "purchased Services, outsourcing, Computers, and Productivity in Manufacturing," in Z. Griliches, (ed.), Measuring the Output of Service Sectors, NBER Studies In Income and Wealth, Vol. 56, (Chicago: Univ. of Chicago Press), 1992.

Potentially more important than the one-time gains from the information embodied in new products are the longer-term effects from the contribution of the new technology to the production and spread of ideas. Some observers expect that IT will contribute to economies being more dynamic and more attuned to new opportunities. There are a number of ways in which IT facilitates technical advance.[17] Information systems that allow a close tracking of customers' buying habits, for example, are being used by some companies to anticipate changes in demand and to help develop new products and services. Through computer-aided design systems and new virtual reality technologies, it has become easier to visualize new design and engineering possibilities and to assess their impacts. In the area of basic research, academics are finding that IT provides new opportunities for collaboration with colleagues working in other institutions and other economies. It is also making it easier for researchers to realize the benefits of cross-fertilization from interaction with those working in other disciplines and different environments. The new possibilities for cooperation and collaboration are of increased importance in view of recent evidence highlighting the interdependence among participants in the innovation process. IT facilitates the needed feedback and cooperation among researchers, developers and users of new technology.[18]

IT can also promote economic growth by contributing to the development and enrichment of economies' human capital. There is mounting evidence of the value of equipping students with IT technology that will provide access to the Internet and to high-quality educational software.[19] Interactive systems have been used to provide a high level of instruction to students in remote locations. They have also enabled firms to provide training to their employees that is more cost-effective than traditional classroom instruction.[20]

Some of the most important learning takes place on the job and involves the relatively slow acquisition of tacit knowledge. Some observers believe that IT is also having an impact in this area by making it feasible to formalize and codify some knowledge that had previously been regarded as tacit. The implication is that all types of information are becoming more accessible.

2.3 The Emerging Information Society

Competitive pressures and a growing appreciation of the role of information in helping

17 The focus is here is on the users of IT. Those societies that are producers of IT will also benefit from the spillover-effects from R&D in telecommunications and other IT products. Bernstein (1995, *op. cit.*) has shown the importance of such spillovers.

18 D. Mowery and N. Rosenberg, Technology and the Pursuit of Economic Growth, (New York: Cambridge University Press), 1989.

19 Recent Canadian developments are discussed in, Connection, Community, Content: The Challenge of the Information Highway, Final Report of the Information highway advisory Council, (Ottawa: Minister of Supply and Services), 1995.

20 Examples are provided in Robert B. Cohen, The Impact of Broadband Communications on the U.S. Economy and Competitiveness, (Washington: Economic Strategy Institute) 1992.

organizations to compete and economies to achieve sustainable growth are impacting on all societies. While starting from different positions and moving at different rates, all societies are under pressure to mould their institutions and practices to the requirements for success in an information age. The emerging "information society" will be well positioned to take advantage of the power of ideas through its high quality digital technology and its well developed economic and information links to the rest of the world.

As a result of its "shareability", information always has been, to a considerable extent, a global resource. This is becoming much more so with the dismantling of barriers to trade and investment and the growth of international production. In many important industries, markets are now dominated by multinational enterprises (MNEs) with operations dispersed around the globe. The internal transactions of MNEs account for a significant and growing share of international trade. At the same time, MNEs have become increasingly important mechanisms for the international transfer of technology and technical know-how.

While globalization is creating new opportunities for information sharing, it is also generating new pressures for economies to strengthen their economic and information links to the outside world. As international competition intensifies, and information becomes a more important factor of production, it becomes more costly for economies to limit their participation in global information networks. One of the consequences of the more competitive environment for new ideas is that knowledge is becoming obsolete more quickly; economies must have well-developed information links with the outside world simply to avoid falling behind in their use of technology and in their international competitiveness.

Recent theoretical and empirical studies point to the special importance of such information links to less-developed economies. While some of the initial "endogenous growth" theories suggested that knowledge spillovers may primarily benefit richer economies by freeing them from the operation of the law of diminishing marginal productivity of capital,[21] more recent evidence stresses the importance of international knowledge transfers.[22] Rather than helping richer economies to maintain their lead, knowledge spillovers have helped narrow the gap between high- and low-income economies. The evidence, however, also reinforces the importance of policies that focus on the mechanisms and capabilities that economies require to benefit from international knowledge transfers.

2.4 Conclusion

Information is a valuable resource. It plays an essential role in the coordination of economic activities. Beyond that, information is a central factor in the ability of economies to achieve

21 This is based on Romer, 1986, *op. cit.*

22 There is a good discussion of this literature in Jeffrey D. Sachs and Andrew Warner, "Economic Reform and the Process of Global Integration," Brookings Papers on Economic Activity, 1995:1.

the sustained economic growth that allows for continuing improvements in living standards. Growth depends on an economy's ability to find ever more valuable ways to make use of its tangible resources, and that, in turn, depends on the application of new information.

Increasingly powerful computer and telecommunications technologies are allowing economies to benefit from improved access to information. Societies are still in the process of implementing the major organizational and other changes needed to take advantage of the new technology. Those firms that have been leading the way in the use of IT, however, have enjoyed efficiency gains in a number of different areas of activity. Besides reducing transactions costs, IT significantly facilitates both the production of new information and its diffusion. As a consequence, digital networks provide the promise of significant improvements in long-term productivity growth.

The intensification in global competition and the increased scope for adaptation and change are impacting on all economies. To avoid falling behind, economies must adapt their institutions and practices to the requirements of an increasingly information-oriented age. Some economies are in a better position than others to take advantage of the new opportunities. Those economies with a strong industrial base in IT products and services[23] have benefitted especially from recent developments. But all economies are feeling the pressure to evolve into "information societies" that are characterized by sophisticated digital technology and well developed economic and information links to the rest of the world.

23 This includes a number of APEC member economies as we discuss in Chapter 5.

3. EVOLUTION OF INFORMATION SOCIETIES IN THE APEC REGION

To benefit from the productive potential of information, an economy must have ready access to new information along with efficient mechanisms for transferring information to those who can benefit from it. In this chapter, we examine various data that shed light on the production and use of information in APEC member economies. The chapter is divided into three sections. In the first section, indicators of information production in APEC member economies are examined. While some economies invest heavily in the discovery of new knowledge, others focus mainly on gaining access to information developed elsewhere and promoting its dissemination. The second part of the chapter looks at indicators of information access and use. Because of their important role in facilitating the production and dissemination of information, modern information technologies warrant special examination. The use of information technologies in APEC member economies is examined in the third part of the chapter.

3.1 The Production of Information

For the purposes of this paper, interest centres on the economic role of information, as distinct from its cultural or entertainment role. Nonetheless, this still encompasses a wide range of information-related activities.[24] New information results from the R&D investments of firms, the basic research undertaken at universities and research institutes, and the experience and insights gained by workers on the job. While the direct contribution of new knowledge to the growth in an economy's stock of wealth is difficult to measure, new information supports inventive activities that create value in various ways and that may ultimately lead to new products, more efficient production processes, improved organizational arrangements, or new methods of marketing or financing.

The science and technology policies that support R&D in APEC member economies have been the focus of discussions of the APEC Industrial Science and Technology Working Group. The Working Group's recently published *Guidebook to Industrial Science and Technology Policies in Selected APEC member economies, 1996* provides an overview of R&D policies and programs in 13 of the APEC member economies. The National Innovation Systems of APEC member economies was also a focus of APEC Ministers responsible for Science and Technology at their meeting in Mexico on Regional Science and Technology Cooperation, October 18-23, 1998, and of the structural issues chapter in the Economic Committee's *1998 APEC Economic Outlook*.[25]

International comparisons are most commonly made on the basis of R&D investment,

24 The distinction between information as a factor of production and as a consumption good is not always clear. With the convergence of computing, communications and content provision, the boundaries have become further blurred.

25 Economic Committee, *Economic Outlook Part II: Technical Cooperation and the Sustainable Development of APEC member economies*.

although this accounts for only a portion of an economy's commitment to the development of new information. Table 1 shows that the U.S. and Japan, the two largest APEC member economies, and in recent years Korea as well, devote the largest portion of economic activity to R&D. While the U.S. has traditionally had a high commitment to R&D, Japan's R&D expenditure ratio has grown substantially over the past two decades. The entry of Korea into the ranks of the most R&D-intensive economies is still more recent. As can be seen from Table 1, Korea, along with Chinese Taipei and, to a lesser extent, Singapore have dramatically increased their commitment to R&D since the early 1980s. Australia and Canada invest more in R&D than most APEC member economies, although their expenditure ratios are well below those of the U.S. and Japan and, now, also less than those of Korea and Chinese Taipei.

On a per capita basis and adjusted to reflect differences in purchasing power, Japan's relative investment in R&D approaches that of the U.S. (See Table 2). Moreover, Japan's employment of R&D scientists and engineers on a per capita basis exceeds by a substantial margin that of all other APEC member economies (See Table 3). Canada and Australia also show a somewhat stronger commitment to R&D using per capita indicators.

In absolute terms, however, the U.S. ranks well ahead of all other economies in R&D investment. This is highlighted in Table 4 where gross R&D expenditures among the group of APEC member economies that also belong to the OECD are compared in terms of purchasing power parity. Over much of the postwar period, U.S. R&D investment exceeded that of all other OECD economies combined.

R&D measures are an imperfect proxy for what is mainly of interest, which is the new information produced by research. While the measurement of research outputs is problematic, patent data offer some insights. Tables 5 and 6 show the clear leadership of the U.S. and Japan in the development of useful innovations. The number of patents granted in Japan has grown substantially since 1981, and Japanese residents continue to account for the predominant share of these grants (See Table 5). While U.S. residents do not dominate their own system to the same extent, they are responsible for a major share of the patents granted in other APEC member economies (See Table 6) and globally. Other APEC member economies lag far behind the U.S. and Japan, but the substantial growth in innovative activity in China and Korea, as measured by the growth in patent grants to residents (See Table 5), deserves note. The substantial decline in Canadian patent grants was not accompanied by a decline in filings and is partly attributable to resource constraints within the Canadian patent office.[26]

Patent counts can be misleading because all patents are not of equal significance. However, attempts to address this problem by assessing patents on the basis of how often they are cited in subsequent patent applications does not significantly change the overall picture. In the U.S. system, citations of both Japanese and U.S. patents exceed these economies' share of total U.S.

26 Another factor was the introduction of legislation in 1989, which changed the basis for patent grants from "first to invent" to "first to file". Patent applications rose sharply prior to the introduction of this legislation, and declined subsequently.

patents, indicating that innovations developed by U.S. and Japanese residents are of greater than average importance.[27] The citation frequency of Japanese patents has risen over the past decade, suggesting that the importance of Japanese innovations has increased over time.

Due to the nature of information, and particularly the difficulty that producers of information have in exercising control over their product and excluding others from using it, markets do not lead to socially optimal investment in R&D. To strengthen incentives for R&D, governments provide intellectual property protection and offer various subsidies and other fiscal incentives. Intellectual property laws strike a balance between society's interest in encouraging innovation and in providing access to all who can benefit from existing innovations. The development of appropriate intellectual property laws involves a number of complex issues. Patent protection, for example, can induce the development and disclosure of technological innovations, but if the patent-holder refuses to license the technology, the development of follow-on products and processes can be impeded.[28] The impact of various tax incentives and subsidies to support innovation has also been the subject of considerable debate.[29] There are difficulties in evaluating financial incentives for R&D, but one study has judged fiscal incentives in Canada and Australia to be generous compared to those available in other major industrial economies.[30]

In the U.S., significant incentives for private investment, including both financial incentives and stringently enforced intellectual property laws, have been supplemented by substantial government financing of R&D. Government spending, a high proportion of which has been directed to the defense sector, has been declining in importance, however, and R&D in the U.S. is currently not as dependent on government support as in some other APEC member economies (i.e., Mexico, New Zealand, Thailand, the Philippines), where governments finance the majority of R&D (See Table 7).

The leadership role of the U.S. as a knowledge-producing economy is also based on the strong research capacity of its universities.[31] Supported by federal grants, contracts, and programs to expand the pool of scientific personnel, the quantity of research performed at U.S. universities increased almost six-fold between 1960 and 1990. In 1993, the U.S. accounted for 35 percent of the world's output of scientific papers, far above that of any other economy (See Table 8). Over half of the scientific citations recorded in the Science Citation Index Database in that

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27 CHI Research Inc. International Technology Database. Cited in National Institute of Science and Technology, Science and Technology Indicators: 1994, NISTEP Report No. 37, Japan 1995.

28 This issue is discussed in S. Scotchmer, "Standing on the Shoulders of Giants: Cumulative Research and Patent Law," Journal of Economic Perspectives, 5, 1991.

29 For example, OECD, Impacts of National Technology Programs, (Paris: OECD), 1995.

30 P. Hanel and K. Palda, "Appropriability and Public Support of R&D in Canada," paper contributed to INSEE seminar on "L'Appropriation technique," Paris, 1992.

31 The importance of university research is highlighted in, S. Ostry and R. Nelson, Technonationalism ad Technoglobalism: Conflict and Cooperation, (Washington: Brookings Instit.), 1995.

year came from papers of U.S. origin. While China and the Newly Industrialized Economies of Asia[32] have greatly increased their production of scientific papers, these economies still account for a very small share of world output.

In Japan, government finances a much smaller proportion of R&D than in the U.S. and most other economies (See Table 7). At the same time, Japanese universities have not supported the innovation system in the same way as have universities in the U.S. The growth in R&D in Japan rather reflects the increasing efforts of Japanese manufacturing firms over the past two decades to develop their own leading-edge technologies. Japan's success in innovation is also the result of a corporate culture that creates strong incentives for the creation of patentable products and processes. The result has been to tilt Japanese information development towards technology, rather than basic scientific information. Thus, while Japan's share of the world output of scientific papers has been increasing, its 8 percent share in 1993 was still well below that of the U.S. (See Table 8). In terms of scientific paper citations, Japan ranks below the U.S., as well as some other major industrial economies – a result that may, however, be partly explained by language differences.

Information technology products (i.e., office machinery and data processing equipment, telecommunications equipment and electronic components) have become an increasingly important focus of industrial R&D. In 1993, they accounted for almost 20 percent of the total patents granted in the U.S.[33] It is not coincidental that the U.S. and Japan, which together supply over 40 percent of world exports of information technology products, are the most research-intensive economies in the world. In this context, it is also understandable that R&D has become more important in the Newly Industrialized Economies of Asia where exports of information technology products have grown at an annual average rate of 23 percent between 1986 and 1993.[34]

In Korea, the shift towards substantial private sector investment in R&D is very recent. Prior to the 1980s, the government was still responsible for the major share of R&D (See Table 7). The growth in industry spending reflects the efforts of newly developed firms in R&D-intensive industries, such as semiconductors, computers, telecommunications and fine chemicals to strengthen their competitive position.[35] Industrial R&D has been encouraged by significant subsidies and tax incentives, and by the establishment of science and research centres to support the development activities of the private sector.[36] In 1992, the government

32 Hong Kong, China; Korea; Singapore; and Chinese Taipei.

33 OECD, Information Technology Outlook, 1995, (Paris: OECD), 1996.

34 United Nations, World Economic and Social Survey, 1995, (New York: United Nations), 1995.

35 David C. O'Connor, "Technology and Industrial development in the Asian Newly industrialized economies: Past Performance and Future Prospects," in D.F. Simon (ed.), The Emerging Technological Trajectory of the Pacific Rim, (Armonk, New York: M.E. Sharpe, Inc.) 1995.

36 One hundred science and engineering research centres are planned by the year 2000. As large firms improve their research capacity, these research institutes are focusing less on industry-related R&D and more on generic and advanced research. Richard G. Lipsey and Russel M. Wills, "Science and Technology Policies in Asia Pacific

launched a program aimed at mustering the R&D resources of industry, academia and non-profit research institutes in a concerted effort to promote technology development in 11 targeted areas. The HAN (Highly Advanced Nation) project is expected to result in US$4.6 billion in investment over 10 years, 56 percent of which would be provided by the public sector.

In Chinese Taipei, the other APEC member economy that has experienced a particularly strong growth in R&D investment over the past decade, government has played a critical role in driving the innovative process (See Table 7). The small and medium-sized enterprises in Chinese Taipei have required public support to cover the steep costs associated with high-technology research.[37] The government has established a number of research institutes to promote technological upgrading, and created the Industrial Technology Research Institute (ITRI) to foster the development of critical generic technologies. ITRI was instrumental in the creation of a very large integrated circuit company[38] and its laboratories have played a major role in the development of key technologies for the electronics and other industries.

3.2 The Acquisition of Information

The stock of information available to most economies is less dependent on their own productive efforts than on their access to information developed elsewhere. This is partly a result of the special characteristics of information; because information does not lose its usefulness when it is shared and is therefore subject to vast economies of scale, much information is widely and freely disseminated. In addition, in recent decades, the mechanisms for exchanging information internationally have grown significantly in number and importance. The increasing globalization of economic activity has been accompanied by a growth in the importance of trade and direct investment, the two traditional avenues by which technology has diffused internationally. At the same time, we are witnessing a proliferation of alternative formal and informal exchange mechanisms, including international alliances and joint ventures, international academic conferences, government-to-government science and technology agreements, international consulting contracts, and academic exchange programs.

APEC member economies have all benefitted from these information and technology transfer mechanisms, although to differing degrees. Some economies have participated more fully than others in the internationalisation of economic activity, and have acquired more of the human and economic capital that is needed to take advantage of international information flows (an issue that we explore more fully in the next chapter).

The data depicting APEC member economies' openness to trade and investment provide a useful entry point into this issue. Trade provides access to products incorporating new

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Countries - Challenges and Opportunities for Canada."

37 *ibid*.

38 The Taiwan Semiconductor Manufacturing Corporation.

technology and, more generally and often more importantly, establishes informal channels through which information and technical expertise can travel. Direct investment is a source not only of capital, but also of technology and know-how. Transnational corporations account for an estimated 75 to 80 percent of all global, civilian R&D,[39] and foreign affiliates have privileged access to the resulting technological innovations.[40] Moreover, with direct investment, host economies often gain access to the specific skills and on-the-job know-how that is needed to effectively utilise new technology but that is difficult to acquire separately.

The growing importance of trade and foreign investment to the region's economies has been examined in previous Economic Committee reports.[41] Table 9 shows the importance of exports and imports to various economies, and the significant increase in the role of trade that has occurred in some economies. Since 1970, exports and imports have increased substantially relative to GDP in China, Chile, Korea, Malaysia, Thailand and the Philippines. Table 10 shows the growing importance of inward direct investment to APEC member economies.

The import of capital goods has been an especially important form of technology acquisition for many developing APEC member economies. From Table 11, it can be seen that Singapore and Thailand are heavily reliant on imported capital and high-technology goods, but that such imports also constitute a significant share of GDP in the Newly Industrialized Economies of Asia and in lower-income APEC member economies. In China and Mexico, the importance of capital goods imports has increased considerably since 1990. Some economies, most notably Korea and Chinese Taipei, have become adept at "unpackaging" imported technology and adapting it to their needs.

As mechanisms of information acquisition, both trade and investment are less important to the two largest APEC member economies, the U.S. and Japan, than to smaller economies with less capacity to satisfy their own information needs. One aspect of this point is illustrated in a recent OECD study that assesses the contribution of technology imports in the form of machinery, equipment and components. This "goods-embodied diffusion" was found to make an important contribution to industrial technology in smaller OECD economies, including Canada and Australia, but to be much less important to larger, more self-reliant economies, most notably the U.S. and Japan.[42] Notwithstanding their self-reliance relative to other APEC member economies, the U.S. and Japan are part of a world in which ideas flow relatively

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39 UNCTAD, World Investment Report, 1995, (New York: United Nations), 1995, p. 149.

40 This is supported by UNCTAD data showing that between 80 and 90 percent of international payments received by Germany, United Kingdom and the United States in the early 1990s were made on an intra-firm basis. UNCTAD, *ibid*.

41 Of particular relevance is Foreign Direct Investment and APEC Economic Integration, APEC Economic Committee, June 1995, which documents the strengthening trade and investment linkages within the region, and examines the interrelationship between trade and investment. Meanwhile, the policies underlying the trend towards liberalization of foreign investment regimes are examined in The Impact of Investment Liberalization in APEC, APEC Economic Committee, November 1997.

42 OECD, Industrial and Technology Scoreboard of Indicators (Paris: OECD), 1995.

freely and the growth of knowledge often results from incremental contributions by researchers in a number of economies. Japan, which was heavily dependent on imported technology in the decades after World War II, has only very recently achieved a positive balance in its technology balance of payments (See Table 12). As well, the costs and risks involved in the development of leading-edge technologies are leading to increasing cooperation and interdependence among major high-tech participants in the U.S., Japan and the Newly Industrialized Economies.

At the other extreme from the U.S. and Japan are those APEC member economies that depend heavily on the traditional mechanisms of technology transfer. Hong Kong, China along with Singapore, the two most open economies in the world, have had access to information and technology flows through their roles as entrepot trade centres. The importance of imports and exports to these two economies is apparent from Tables 9 and 11. Further, both economies have invested in educating their workforces and establishing the infrastructure needed to benefit from information spillovers. In Hong Kong, China, local training built on the base of knowledge and skills brought by Chinese engineers and technicians, and by British business and finance houses. While Hong Kong, China has largely relied on market forces to determine the direction of development, it has used its Productivity Centre and other instruments to accelerate the diffusion of technology.

Information and technology access in Singapore has been influenced by that economy's strong efforts to establish itself as a base for foreign multinationals, and by its "market-leading" policies aimed at promoting investment in "strategic" industries. As a result of its success in attracting high-value-added technology and knowledge-based industries, Singapore benefits from well-developed conduits for the inflow of both highly trained workers and advanced technologies. Various policy initiatives have been introduced to strengthen the economy's competitiveness in selected key technologies,[43] with the National Science and Technology Board playing a lead role in promoting domestic research and encouraging the acquisition and transfer of promising technologies.

An additional perspective on the information and technology access of APEC member economies is provided by examining their links to the two major information-producing economies, as they relate to the traditional mechanisms of information and technology access (Tables 13 and 14). Those economies that have strong trade and investment links with the U.S. or Japan would be expected to be in a better position to access new information. This is supported by studies that have found that economies that perform substantial R&D provide important spillover benefits for their trading partners. One study of OECD economies found that, for smaller economies, total productivity growth was, in fact, more responsive to changes

43 Through a consultative process, the National Science and Technology Board has identified nine key technology areas that can serve as a focus for Singapore's science and technology efforts: information technology, microelectronics, electronics systems, advanced manufacturing technology, materials technology, energy, water and environment, biotechnology, food and agriculture, and medical sciences. This is discussed in Lipsey and Wills, *op. cit.*

in the R&D of its main trading partners than to changes in its domestic R&D.[44] Table 14 sheds some light on another vehicle by which information spreads outwards from the major information-producing economies, namely foreign-student training. Students in many APEC member economies rely significantly on the high-quality training available from U.S. universities.[45]

Canada and Mexico are clearly well positioned to benefit from information spillovers due to their proximity to the U.S. economy. While liberalization in Mexico is fairly recent, the economy has become host to a significant contingent of U.S. multinationals which account for a significant share of activity in the advanced sectors of the Mexican economy. Canada has well-developed links with the U.S. that include not only strong trade and investment ties and significant student enrolment at U.S. universities (Tables 14 and 15), but also a host of formal and informal arrangements that encourage information-sharing and promote cooperation among those working in academia, industry and government. These factors, and especially Canada's position as a major host to U.S. multinationals, help to explain, to some extent, Canada's low level of technological activity, as measured by industry R&D and domestic patent filings, relative to other industrialised economies.[46] Various pieces of evidence confirm the importance of Canada's privileged access to U.S. information sources. These include findings with respect to: the importance of imported technology embodied in machinery and equipment to Canadian firms;[47] the contribution of U.S. direct investment to Canadian growth;[48] and the importance of the spillover benefits for Canada from R&D performed in the U.S.[49]

The ripple effects of U.S. investment in information development extend well beyond neighbouring economies. Other significant beneficiaries include Australia and New Zealand, which purchase a significant share of their imports from the U.S. and are important hosts to

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44 David T. Coe and Elhanen Helpman, "International R&D Spillovers," NBER Working Paper No. 4444, August 1993.

45 Total foreign-student enrolment in third-level studies in Japan was less than 10 percent of the total for the U.S. Among APEC member economies, China was the major source of foreign students. China accounted for 25,697 post-secondary foreign students in 1991, which was somewhat over half of all third-level foreign students enroled in Japan in that year.

46 This issue is discussed in a recent OECD report on Canada. OECD, Economic Surveys: Canada, 1995, (Paris: OECD), 1995.

47 OECD, Industry and Technology Scoreboard of Indicators, op.cit.

48 Research documenting the benefits Canada has derived as a host to foreign investment from the U.S. and elsewhere is reviewed in Ronald Hirshhorn, "Industry Canada's Foreign Investment Research: Messages and Policy Implications," Industry Canada Discussion Paper No. 5, October 1997.

49 P. Mohnen, The Relationship Between R&D and Productivity Growth in Canada and Other Major Industrialised Countries (Ottawa: Supply and Services Canada), 1992. Also, Jeffrey I. Bernstein, "International R&D Spillovers Between Industries in Canada and the United States," Industry Canada Working Paper No. 3, 1994; and J. Bernstein, "R&D and Productivity Growth in Canadian Communication Equipment and Manufacturing," Industry Canada, Working Paper No. 10, 1996.

the affiliates of U.S. multinationals.[50]

Investment in information development by Japan provides important benefits for the APEC member economies of East Asia, while also creating ripple effects that impact on economies outside the region. Japan's well-recognized contribution to the development of the Newly Industrialized Economies of Asia (NIEs) and the ASEAN economies owes much to its role as a leading source of new technology and technical expertise.[51] The NIEs, however, have also benefitted from important links with the U.S. For Korea and Chinese Taipei, the share of imports from the U.S. is not much below the share from Japan (See Table 13); and Chinese Taipei is host to almost the same amount of U.S., as Japanese, foreign direct investment (See Table 14).

As well, information acquisition has been influenced by the policies pursued by the East Asian economies themselves; domestic initiatives have helped some East Asian economies to become especially successful in acquiring and utilising advanced technology. Korea and Chinese Taipei have based their technology and information acquisition policies on carefully planned strategies aimed at promoting strategic industries and sectors. In both economies, industrial development has occurred with a relatively low level of foreign direct investment, although foreign direct investment has become more important in recent years (See Table 10). In Korea, a greater emphasis has been given instead to importing capital (See Table 11) and, where necessary, licensing technology and hiring needed foreign technical assistance.[52] A number of policies have helped build a strong indigenous capacity to assimilate and adapt foreign technology. These have included a heavy commitment to education and training, support for the emergence of giant enterprises, or *chaebol*, and the encouragement of private sector R&D. Korea has also supported programs of overseas training;[53] about half of its doctoral degrees are from U.S. universities.[54] In addition, in recent years, Korean firms have taken advantage of new opportunities to engage in cooperative efforts with Japanese producers.[55]

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50 The significant impact of U.S. R&D investment on total factor productivity in Australia and New Zealand are indicated in Coe and Helpman, *op. cit.*

51 The role of Japan as a driving economic force in the region is a theme of the so-called "flying geese model" of East Asian development. See S. Yamashita, "Japan's Role as a Regional Technological Integrator and the Black Box Phenomenon in the Process of Technological Transfer," in D.F. Simon (ed.), The Emerging Technological Trajectory of the Pacific Rim, *op. cit.*

52 David O'Connor, *op. cit*.

53 An example, provided by Lipsey and Mills (*op. cit.*), is the program for overseas graduate training operating through the Korean Science and Engineering Foundation. The intention was to send over 10,000 science and engineering PhDs for overseas post-graduate training by the year 2000. Given the rise in cost of overseas training as a result of the decline in the Korean won during the recent crisis, this ambition may not be realized within the desired timeframe.

54 U.S. National Science Board, Science and Engineering Indicators, 1993.

55 For example, in 1989 Hitachi entered into a joint venture with the Korean producer Goldstar for the production of 1MB DRAM chips. Hitachi has also provided Goldstar with assistance for the production of 4MB and 16 MB

In Chinese Taipei, a well-developed base of human capital has helped firms to acquire and adapt the technology needed to achieve competitiveness in skill-intensive activities. The economy's small and medium-sized enterprises have been assisted by the important technology support services provided by the government. Technology and other information have also been acquired through joint ventures and less formal interchanges with Japanese and U.S. firms.[56] A number of the economy's leading firms are headed by engineers and scientists who were trained in the U.S. (See Table 15), or have returned from the U.S. as part of the "reverse brain drain".[57] The economy's successful semiconductor industry benefitted from the input of foreign advisors who sat on the Science and Technology Advisory Group.[58] In addition, outward investment by Chinese Taipei, especially in companies located in the U.S. Silicon Valley, is reportedly an important vehicle for technology intelligence.[59]

While technology acquisition in Korea and Chinese Taipei supplements a significant domestic research capacity, the ASEAN economies are still highly dependent on imported or transferred technologies. A study of Thai companies, for example, found that even those enterprises that utilised state-of-the-art operating systems essentially relied on existing technology that could, where necessary, be easily adapted to the local environment.[60] Foreign direct investment has been an important channel for the inflow of technology and technical know-how to Malaysia, and, to a lesser extent, Thailand. Multinationals that have shifted the more labour-intensive portions of their production of integrated circuits and computers and peripherals to ASEAN economies have brought modern process and management technologies that have set a standard for input suppliers and other domestic producers.[61] There is recognition, however, that the ASEAN economies need to develop their base of human resources and to build their indigenous capabilities in science and technology so that they can become more proficient at

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DRAM chips. From, Denis Fred Simon, "Globalization, Regionalization and the Pacific Rim," in D.F. Simon (ed.), The Emerging Technology Trajectory of the Pacific Rim, *op. cit.*

56 Chinese Taipei firms have, for example, entered into major agreements for the manufacture of sophisticated computer memory chips with U.S. (Acer and Texas Instruments) and Japanese (Vitelic and Hualon) corporations.

57 Before 1980, less than 1,000 overseas graduates returned each year. Since 1992, the number of students returning to seek employment in Chinese Taipei has exceeded 5,000 per year. The government offers a financial incentive to encourage students educated overseas to return home.

58 This is discussed in C.S. Meaney, "State Policy and the Development of Taiwan's Semiconductor Industry," in J.D. Aberbach, D. Dollar and K.L. Sokoloff (eds.), The Role of the State in Taiwan's Development, (New York: M.E. Sharpe), 1994.

59 Denis Fred Simon, "Globalization, Regionalization and the Pacific Rim," *op. cit.*

60 C. Sripapian et. al., Enhancing Private Sector Research and Development in Thailand, ((Bangkok: Thailand Development Research Institute), 1990.

61 The positive influence of multinational affiliates on domestic suppliers of inputs has been identified as one of the factors underlying the increases in total factor productivity that followed Malaysia's liberalization of inward foreign direct investment in the mid-1980s. Okamoto, 1994.

identifying promising technologies and adapting them to domestic requirements.[62]

3.3 Use of Information Technology

Information technology has been defined in various ways. For the purposes of this discussion, a broad definition, which incorporates all computer and communications products and services that may contribute to the performance of APEC member economies, is appropriate. The relevant categories include computer-related equipment and services; advanced manufacturing technologies; and communications equipment and services.[63]

Computer-Related Equipment and Services

Computer-related equipment and services constitute "information technology" under the OECD's use of this term. The world markets for computer hardware, computer software, data communications equipment, and computer support and professional services were estimated to have a value of US$527.9 billion in 1995. The U.S. alone accounts for some 45 percent of world sales (based on 1994 data), with Japan accounting for about 17 percent.[64] Table 16 indicates the dominant role of the U.S., and also the very rapid growth that is underway in some Asian markets. While the worldwide IT market expanded at a rapid 10 percent annual rate over 1987-94, the market in a number of East Asian economies grew at close to double, and in some cases more than double, this rate, although these markets still represent a very minor portion of world sales.[65]

The high degree of computerisation in the U.S. can be seen from the data in Table 17. Measured on a per capita basis, computer penetration is second highest in Australia, followed by New Zealand and Canada. Personal computer (PC) use in Japan is low by comparison to other industrial economies, although this is partly offset by a relatively heavy use of mainframe computers.[66] In 1995, however, PC sales in Japan experienced unprecedented growth, due in part to the removal of some significant structural impediments.[67] Singapore,

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62 Collaborative efforts by the ASEAN economies to address human resource problems and related science and technology issues are described in, Anuwar Ali, "Science and Technology Collaboration at the Regional Level: Lessons from ASEAN," in The Emerging Technological Trajectory of the Pacific Rim, *op. cit.*

63 This excludes audiovisual, including broadcasting, services. These are of less interest to the extent they have an entertainment role.

64 OECD, Information Technology Outlook, 1997, *op. cit.*

65 *ibid*.

66 In 1993, Japan had an installed base of about 3.5 mainframe units per 100,000 inhabitants as compared to about 3.9 for the U.S. OECD, Information Technology Outlook, 1995, p. 22.

67 The surge in Japanese PC sales was partly a cyclical rebound, following a long period of low or negative growth. It is also attributed, however, to market changes that began in 1993 when Microsoft began producing a Japanese-language version of its Windows operating system for NEC and IBM computers. Until then, the Japanese market was dominated by NEC with an architecture that was incompatible with IBM/DOS standards. See OECD Information Technology Outlook 1997, p. 18.

by contrast, has a relatively high degree of PC penetration – above that of Japan and the other Newly Industrialized Economies, and only somewhat lower than Canada's.

In the U.S., computers have become an important tool both at home and in the workplace. It was estimated that almost 46 percent of employed adults used computers at work in 1993, and that more than a quarter of adults had access to a computer at home.[68] Almost 61 percent of schoolchildren reported using a computer at school. Among industries, computer use is greatest in finance, insurance and real estate, followed by public administration, and then by professional and related services.

Advanced Manufacturing Technologies

There are significant differences among APEC member economies in the use of computer-controlled product and process technologies. These differences partly reflect the ability of some economies to more rapidly assimilate sophisticated microelectronic technologies. They are also a result of differences in industrial structure; advanced manufacturing technologies (AMT) are more common in large plants than small ones, and they are most widely used in certain industries, including automobiles, engineering, aerospace and electronics.

Table 18 provides the results of one survey of industrial automation expenditures. AMT use in the U.S. is concentrated in the area of computer-aided design and computer-aided engineering, which require less investment than advanced fabrication and assembly and other production technologies. Surveys indicate that the U.S. lags significantly behind Japan in the application of AMT systems to production.[69] They further suggest that Canada trails the U.S., and that Australia is some distance behind Canada, in the application of microelectronic systems.[70] A recent survey confirms that, among Canadian manufacturing firms, advanced design and engineering technologies have a relatively high incidence of use and that advanced fabrication and assembly technologies have only a moderate incidence of adoption.[71]

The importance of automated systems in Japan is illustrated by the data on use of numerically controlled technology[72] (See Table 19) and robots (See Table 20). Japan accounts for a large share of the total market for numerically controlled machines, and it is by far the heaviest user

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68 *ibid*. p. 55.

69 These results are reported in OECD, The OECD Jobs Study: Evidence and Explanations- Part 1, (Paris: OECD), 1994.

70 *ibid*.

71 While advanced design and engineering technologies have been adopted in plants that account for 63 percent of shipments, the incidence of use for fabrication and assembly technologies is 46 percent. J. Baldwin, D. Sabourin, and M. Rafiquzzaman. Benefits and Problems Associated with Technology Adoption in Canadian Manufacturing, Statistics Canada Cat. No. 88-514E, 1996.

72 Numerically controlled machines use a computer and a program that regulates the motion and speed of the machine and such functions as changing of tools and workpieces.

of industrial robots. A major share (over 40 percent) of Japanese robots are involved in assembly operations, primarily for the economy's large consumer electronics industry. Korea, Chinese Taipei and Singapore are also significant users of numerically controlled machines and robots. In Korea, the use of robots has been stimulated by the expansion of the electronics and the automobile (where welding robots are used) industries. The other APEC member economy (besides those included in the Tables) that is an important user of automated production technology is Mexico. The use of advanced production technologies has increased substantially in Mexico as U.S. multinationals in the automotive and other industries have endeavoured to ensure that their Mexican affiliates are equipped to meet international cost and quality standards.[73]

Communications Systems

The communications systems of APEC member economies are undergoing change as policies and infrastructures are adapted to the needs of the information age. These developments will be discussed in Chapter 5. In the context of the current discussion, it is important to gain a sense of the extent to which communications networks facilitate information flows in APEC member economies. Accordingly, Tables 21, 22 and 23 attempt to show how well APEC member economies are served by the six main pathways through which information travels in a modern economy:[74] the public telephone network, cellular and other mobile communications networks, terrestrial broadcast television, cable television networks, direct-to-home satellite services, and the Internet.

Table 21 shows that telephone access, measured by mainlines per 100 inhabitants and cellular subscribers per 100 inhabitants, is greatest in the U.S., Japan, Canada, Australia, New Zealand, Singapore and Hong Kong, China. While the telephone is a mature service and mainline growth rates have been modest in many APEC member economies (the exceptions being China, Thailand, Indonesia, Korea, Chile and Malaysia), cellular service has grown very rapidly in virtually all APEC member economies. Even economies with a significant base of subscribers (such as the U.S.; Singapore; Hong Kong, China; and Australia), have seen a strong growth in cellular service in recent years (See Table 21). Member economies have also committed increasing resources in recent years to converting their networks from an analog to a digital format. Digitalization, which allows content in various forms to be communicated at high speed and manipulated by computers, is a key to achieving the convergence of computing, telecommunications and television. Singapore, along with Chile and Hong Kong, China are leading the way, each having digitalised 100 percent of its local telephone networks (See Table 21).

Over-the-air television, which is the world's most important information pathway based on

73 Susumu Watanabe, "Microelectronics and Third World Industries: An Overview," in UNCTAD, Advanced Technology Assessment System, Issue 10, Autumn 1995.

74 This is based on the International Telecommunications Union, World Telecommunications Development Report, 1995, 1995, p. 21.

access points, is another relatively mature service (See Table 22). Growth has slowed in the 1990s, but some APEC member economies (i.e., China, Indonesia and Thailand) are still experiencing very rapid annual rates of increase in use. Cable television is important in Canada, and to a lesser extent the U.S. and Chinese Taipei (See Table 22). DTH satellite covers a small percent of households, but it is a young and rapidly growing technology.

The Internet has experienced the most impressive growth of any network over the 1990s. Over the past decade, the rate of growth worldwide has exceeded 100 percent per year. Up to now, Internet use has largely been concentrated in North America and, to a lesser extent, Western Europe. Among APEC member economies, Internet penetration, measured by the number of hosts per 100 inhabitants, is highest in the U.S., followed by Australia, New Zealand, and Canada. As can be seen from Table 23, Internet penetration in these economies is well above that in other APEC member economies.

3.4 Conclusion

In their evolution as information economies, APEC member economies are following different paths. The two largest economies, the U.S. and Japan, have assumed a leadership role in the development of new information. While in Japan the emphasis is on information that has an industrial application, the U.S. has focused more broadly on expanding the base of scientific and technological knowledge. Other APEC member economies rely much more heavily on information "imports", although, in some economies, including Canada, Australia, Korea and Chinese Taipei, information acquisition is supplemented by significant domestic R&D. The expansion of research capacity in Korea and Chinese Taipei over the past decade is especially notable.

As information importers, APEC member economies have benefitted generally from the growth of trade and direct investment, which have traditionally been the two main vehicles for information diffusion. Some economies, however, have been especially well positioned to benefit from information inflows. This includes those economies that have long been highly open to trade and investment (notably, Singapore and Hong Kong, China); those economies that have especially strong links to one or both of the major information-producing APEC member economies (Canada and, to a lesser extent, the economies of Southeast Asia); and those economies that have carefully designed their policies to encourage the acquisition and use of information in selected technological areas (notably, Korea and Chinese Taipei). As distinct from these economies, there are those APEC members that are at an earlier stage in developing the foundation, and especially the base of human capital skills, that is needed to fully benefit from information inflows – an issue that is further examined in the next chapter.

Information technology has supported the information-related activities of APEC member economies in different ways. While the U.S. has led the way in the use of personal computers and the Internet, Japan has been the leading user of microelectronic production technologies, such as numerically controlled machines and industrial robots. Korea, Chinese Taipei, Singapore and Mexico have also made significant progress in adopting advanced

manufacturing technologies. The more developed APEC member economies, which are well served by the traditional telephone and over-the-air television networks, are now experiencing a strong growth in cellular telephone and satellite television service. Major efforts are also being devoted to transforming networks from analog to digital. Among more developed economies, Singapore stands out because of its relatively high ranking across several indicators – computer use, the adoption of advanced manufacturing technology, telephone penetration, cellular use, and digitalization.

4. FACTORS INFLUENCING THE DEVELOPMENT OF INFORMATION SOCIETIES

To understand the role of information it is necessary to look not only at indicators of an economy's information access; it is also important to consider those aspects of an economy's social and economic infrastructure that influence its ability to take advantage of information. Evidence supporting the so-called convergence hypothesis suggests that the rapid growth of productivity and output per capita in lower-income economies is not an automatic process, but depends on the presence of certain "conditioning" factors.[75] Cross-country studies of economic growth similarly indicate that the ability of an economy to adapt new technologies depends on a variety of factors in addition to its openness to trade and investment.

In this chapter, we examine four factors that may significantly influence the role and importance of information within APEC member economies. The first two factors, capital investment and human capital development, have been identified as important variables in a number of growth studies.[76] The last two factors, economic infrastructure and the political-economic environment, have a less robust correlation with growth,[77] but deficiencies in these areas can become significant limiting factors that prevent economies from realising the benefits of information access.

4.1 Capital Investment

It is often through capital investment that the information incorporated in new technology gets applied to the production process. Table 24 shows that a number of APEC member economies benefit from very high rates of capital investment. Gross domestic investment comprises an especially high percentage of GDP in China, Indonesia, Thailand, Korea, Malaysia and Japan – all of which have experienced a major increase in the importance of investment since 1970. Investment may not provide the desired channel for import of foreign ideas and technology if investment incentives have become distorted. With the recent difficulties in East Asia, it has come to be understood that not all of the substantial investment in recent years in this region has translated into productive capital spending; a not insignificant portion of investment has gone into real estate and other construction projects that were attractive in part because of inappropriately low borrowing costs and overvalued currencies.

Still, over the longer term, there is considerable evidence pointing to the important role of investment in the growth of the East Asian economies. In Japan and Korea, capital investment

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75 For example, D. Dollar and E.N. Wolff, Competitiveness, Convergence and International Specialization, (Cambridge: MIT Press), 1993. Also, W.J. Baumol, R.R. Nelson and E.N. Wolff, Convergence of Productivity: Cross-National Studies and Historical Evidence, (New York: Oxford Univ. Press), 1994.

76 This is based on Ross Levine and David Renelt," A Sensitivity Analysis of Cross-Country Growth Regressions," The American Economic Review, Vol. 82, September 1992.

77 *ibid*.

rates started to increase significantly in the 1950s. Between 1960 and 1980, it has been estimated that, in terms of purchasing power parity, the ratio of gross fixed investment to GDP doubled in Chinese Taipei, tripled in Korea and quadrupled in Singapore.[78] Higher investment rates have been cited as one of the factors underlying the more rapid growth of Asian, as compared to Latin America economies.[79] Among APEC member economies, rates of capital investment are higher in the Newly Industrialized Economies as well as in Malaysia and Thailand than in Chile and Mexico, although the latter economies enjoy relatively high investment rates by Latin American standards. In Chile, the ratio of capital formation to GDP has increased substantially since the mid-1980s, and private investment has become one of the most dynamic components of the economy.

Table 24 also shows that Malaysia, the Philippines and Thailand have depended significantly on foreign savings to help finance their high rates of investment. Most APEC member economies, however, generated sufficient domestic savings in 1995 to cover their capital investment. In some cases (notably Korea and Singapore), this represented a change from earlier years when there was a high reliance on foreign savings.

Savings and investment rates in the U.S. have been low in comparison to other APEC member economies. This suggests that, although the U.S. is a leading producer of new information, it has not benefitted to the same extent as other economies from the growth-stimulating effects of new information embodied in capital equipment.

4.2 Human Capital

The quality of human capital is widely recognized as a critical determinant of an economy's ability to benefit from information.[80] While human capital is generally evaluated on the basis of a population's school achievement, important learning also occurs on the job. As well, a large component of health spending constitutes human capital investment.

Table 25 provides some information on this latter aspect. The indicators point to some differences among APEC member economies in the development of their health-related infrastructure. Some or all of health services, safe water and sanitation are not available to significant portions of the population in China, Indonesia, the Philippines, Thailand, Malaysia, and Mexico. These indicators do not relate directly to information use, but economies that lag in satisfying these basic health requirements might be expected to have greater difficulty in building the base of skilled and productive workers that is needed to participate fully in a

78 A Young, "lessons from the East Asian NICs: A Contrarian View," European Economic Review, Vol. 38, April 1994.

79 Ajit Singh, "Growing Independently of the World Economy: Asian Economic Development Since 1980," UNCTAD Review, 1994.

80 For example, Dollar and Wolff, *op. cit.*, and Levine and Renalt, *op. cit*.

global information age.[81]

Education promotes information use in two ways: it allows individuals to access a wider range of information sources, and it improves their ability to decipher new information acquired both from external sources and their own experience.[82] APEC member economies face different challenges in terms of improving educational achievement. While lower income economies must ensure that basic education is made more widely available, industrialized economies must contend with the growing demand for workers with higher skills and increased education. The shift towards higher skill requirements in industrialized societies has been attributed to the growing use of new and rapidly changing information technologies in manufacturing and service activities. Evidence from OECD economies suggests that "upskilling" in industrialized economies is occurring in most industries.[83]

Table 26 displays a number of indicators of the educational attainment of APEC member economies. Adult illiteracy indicates the extent to which minimal education standards have not been met. The adult illiteracy rate is below 10 percent in all but six APEC member economies: Brunei Darussalam, Malaysia, Indonesia, Papua New Guinea, Mexico and China. In China, the rate is almost 20 percent, and in Papua New Guinea it approaches 30 percent.

Schooling can be more generally compared on the basis of enrolment rates, particularly at the secondary and post-secondary levels.[84] On this basis one can distinguish (using the most recent available data) between those APEC member economies in which secondary enrolment is under 60 percent (China, Indonesia, Papua New Guinea, Thailand, Malaysia, and Mexico); those with higher rates of tertiary enrolment and secondary enrolment rates of between 60 and 80 percent (Brunei Darussalam; Chile; Hong Kong, China; the Philippines; and Singapore); and those economies with secondary enrolment rates above 60 percent and tertiary enrolment rates of over 30 percent (Canada, Japan, the U.S., Australia, New Zealand, Korea and Chinese Taipei).

A number of economies with relatively low enrolment rates have succeeded in substantially increasing secondary school attendance over the past few decades. Secondary enrolment rates have more than doubled since 1970 in Mexico, Indonesia and China, and almost doubled in Thailand. Korea and Chinese Taipei have sharply increased school attendance at all levels.

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81 For example, the United Nations, in its Human Development Report, treats health as one of factors that enters into the determination of human capabilities. These capabilities, in turn, determine people's ability to engage in productive, as well as social, political and other activities.

82 The nature of these gains from schooling are discussed in Mark R. Rosenzweig, "Why Are There Returns to Schooling?" American Economic Review, May 1995.

83 OECD, The OECD Jobs Strategy: Technology, Productivity and Job Creation, Vol. 2, Analytical Report (Paris: OECD), 1996.

84 Secondary and tertiary enrolment rates are preferable to primary school enrolment rates and literacy rates because many APEC member economies have reached the upper bound for these latter two measures.

Table 26 also highlights the very strong growth that has occurred since 1980 in Canada's post-secondary education system.

Tertiary enrolment in Japan is low by comparison to other high-income APEC member economies. Relative to GDP, overall education spending is lower in Japan than in many other APEC member economies.[85] Japan benefits, however, from a well-developed system of corporate training for upgrading production and management skills. Japanese corporations also provide much of the advanced training for scientists and engineers.

The U.S. ranks near the top on all indicators in Tables 25 and 26. Still, there is recognition that further efforts are needed to ensure the high levels of proficiency on the fundamentals needed for economic success in the information age.[86] This was highlighted by a 1994 international survey that compared adults in various industrial economies in terms of their abilities to read and comprehend prose, documents, and quantitative information.[87] Compared to other economies in the survey, the U.S. had a high concentration of adults who scored at the lowest level across the three literacy measures.

The data in Table 26 suggest that some APEC member economies may be at a disadvantage in acquiring and utilising information because of lower levels of educational attainment and, in some cases, relatively low rates of basic adult literacy. The ASEAN economies still have some distance to go to achieve a degree of educational provision equivalent to the highest-income APEC member economies. Singapore and Hong Kong, China also require an increased commitment of resources to bring their schooling systems up to the level of the APEC members with the highest level of educational attainment.

Korea and Chinese Taipei have had greater success in expanding the reach of their schooling systems. Over the past two decades, the post-secondary enrolment rate has increased from 10 percent in Korea and 17 percent in Chinese Taipei to over 45 percent in both economies. Even in 1960, however, when Korea and Chinese Taipei were relatively poor economies, their workers were considerably better educated than would be expected on the basis of average income levels. This can be seen from Table 27, where actual educational levels are compared with predicted levels derived from cross-section regressions of educational indicators on per capita income and its square.[88] Government efforts to build on this base in subsequent years were facilitated by demographic developments that led to a slowing in the growth of the number of school age children.

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85 Total expenditure on education in Japan was 5.0 percent of GDP in 1991, as compared to Canada (7.4), the U.S (7.0) , Australia (5.5), and New Zealand (5.8). UNCTAD, World Development Report, 1995.

86 U.S. Department of Education, The Condition of Education, 1996, NCES 96-304.

87 OECD and Statistics Canada, Literacy, Economy and Society: Results of the International Adult Literacy Survey, (Paris: OECD), 1995.

88 This is from Dani Rodrik, “Getting Interventions Right How South Korea and Taiwan Grew Rich", Economic Policy, April 1995.

As compared to Japan and the U.S., university students in Korea and Chinese Taipei concentrate much more heavily on the natural sciences and engineering (as distinct from the social sciences). While the strong growth in the supply of well-educated science and engineering workers has brought some adjustment problems,[89] these economies have been especially well positioned to acquire and build upon the information flows resulting from the developments discussed in Chapter 3.

4.3 Infrastructure

An economy's ability to acquire and disseminate information will be clearly and directly affected by the quality of its communications infrastructure, an issue to be addressed in chapter 5. It can also be significantly affected by the state of infrastructure development in other areas. An absence of adequate power, water and transport facilities can block the diffusion of information by preventing firms from introducing new technologies and more efficient production processes. Experience indicates that in those economies and regions where infrastructure is deficient, the operation of mechanisms for information and technology transfer can be significantly impaired and economic growth can suffer.[90]

Table 28 provides an overview of infrastructure development in a number of major areas (excluding telecommunications, which is described in Table 21). The table indicates that, with some exceptions, the availability of infrastructure services corresponds to the distinctions the World Bank has drawn between high-income, upper-middle-income, and other (mainly middle-income) economies. The supply of infrastructure services is generally greatest in the first group (which includes the U.S.; Japan; Canada; Australia; New Zealand; Hong Kong, China; and Singapore), and most limited in the latter group of economies (which includes China, Indonesia, the Philippines, Papua New Guinea, and Thailand).

Table 28 does not provide a complete picture of imbalances between the supply and demand for infrastructure services, nor does it tell us if imbalances are likely to arise because of a failure of infrastructure investment to keep pace with population and economic growth. The latter issue can be difficult to assess empirically, particularly where growth rates are changing. Moreover, historical trends may provide a misleading indication of future infrastructure requirements. A recent U.N. Commission report, however, points to some important infrastructure deficiencies within Asian economies.[91] In a number of areas, there is estimated to be a need for major additional funding beyond what has already been committed for the

89 For example, the significant rise in unemployment among Korean college graduates in the mid-1980s has been attributed in part to the expansion of the college enrolment quota in 1981. See OECD, Issues in Education in Asia and the Pacific: An International Perspective, Proceedings of a Conference in Hiroshima, 1994.

90 This is discussed in Asian Development Bank, "Building for Development: Infrastructure in the Asia-Pacific," Annual Report, 1993.

91 U.N. Economic and Social Commission for Asia and the Pacific, Infrastructure Development as Key to Economic Growth and Regional Economic Cooperation, (New York: U.N.), 1994.

expansion of existing facilities:

- The power sector is expected to have the greatest funding requirements within Asia in coming years. Very large investments are needed to cover electric power requirements in China. Major investment in power facilities is also required in Korea, and in the ASEAN economies which have experienced significant power shortages in recent years.[92]

- Water supply and waste treatment are projected to have the next largest requirements in terms of additional financial resources. Facilities are needed to meet growing urban and agricultural demands and to improve access to safe water and sanitation (See Table 25), especially in rural areas.

- With respect to rail infrastructure, the shortage of route capacity has created severe problems in China in recent years and a number of projects are underway to expand capacity. Further major investments are needed between now and 2000 to cope with the economy's growing requirements for medium- and long-distance freight transportation.

- Road infrastructure has been expanding at a significant rate in Indonesia, Malaysia, and Thailand. In coming years, significant investments will be required to maintain high standards of road development in these economies, and to improve standards in the Philippines and elsewhere where road expansion has lagged population growth.

- In urban public transport, significant funding is needed to satisfy planned investment in subway systems in Korea.

- Airport facilities are being expanded to address capacity problems in a number of economies, with major new facilities coming on stream in 1998 in Malaysia (Kuala Lumpur) and Hong Kong, China.[93]

Infrastructure inadequacies have not prevented many Asian members of APEC from achieving strong rates of economic growth, due in large part to offsetting factors, including especially high rates of private investment and a strong base of human capital. Nonetheless, infrastructure deficiencies can create bottlenecks that distort the development process. Serious shortages, such as those relating to power and rail capacity in China, can potentially slow an economy's rate of development.[94]

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92 The sharp decline of economic activity in a number of these economies during the recent crisis has had the effect of postponing some requirements for additional capacity in the power sector.

93 Further insight into the problems in the region's transportation infrastructure is provided by the Congestion Points Study produced by APEC's Transportation Working Group. In one phase of the study, for example, congestion problems were identified at a number of international airports, including in Bangkok, Seoul and Taipei. Along with inadequacies in infrastructure facilities, the study found problems arising from inadequate technology and inappropriate operations, and from regulatory and institutional constraints in air transportation.

94. The impact of infrastructure on economic growth, however, has been difficult to quantify.

The economic and financial crisis in East Asia has changed the environment for infrastructure development considerably, with a withdrawal of private sector financing and a reassessment by governments of priorities. The pressures to improve the efficiency of infrastructure provision through various strategies such as commercial development and management, competition, and increased stakeholder participation.[95] It is appropriate, therefore, that at their meeting in Vancouver in November 1997, APEC Economic Leaders agreed to a "framework" encouraging stronger partnerships between the public and private sectors in developing needed infrastructure facilities.[96]

4.4 Political-Economic Environment

Political and economic instability will impede information-related activities, just as they will undermine the operation of other important engines of economic growth. An economy's information access will be impeded partly because the resulting uncertainty will discourage investment, including the foreign direct investment that is an important vehicle of information and technology transfer. In addition, and more generally, one might expect that an uncertain environment would be less conducive to the entrepreneurial initiative that often drives the search for new ideas.

The recent period of financial turbulence has underlined the importance of a stable economic environment and of governments "getting the basics right" through appropriate monetary, fiscal and exchange rate policies, and a supervisory regime that enforces prudent behaviour by financial institutions.

One perspective on this issue is provided by the credit ratings that have been developed to reflect investment risks based on the political-economic environment in various economies. Table 29 shows the risk indicators developed by Dun & Bradstreet, while Table 30 provides the credit ratings issued by the journal Institutional Investor on the basis of their annual survey of 75 to 100 leading international banks. There are some differences between the two systems, but both attach a higher risk to investment in a number of lower-income APEC member economies: Papua New Guinea, the Philippines, Thailand, Mexico, Indonesia and China. The higher perceived risks add to the difficulties that these economies face in promoting the development and diffusion of information. Japan and the U.S., not unexpectedly, have the highest credit ranking among APEC member economies.

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95 The use of performance incentives is discussed in, World Bank, World Development Report 1994: Infrastructure for Development, (New York: Oxford University Press), 1995. In APEC, improving the efficiency of infrastructure design, development and management is a major objective of the on-going work of the Economic Committee's Infrastructure Workshop and of the Energy Working Group in respect of power infrastructure in particular.

96 This refers to The Vancouver Framework for Enhanced Public-Private Partnerships for Infrastructure Development in APEC that was endorsed by APEC Economic Leaders at their meeting in Vancouver, November 1997.

Under Dun & Bradstreet's latest set of indicators, Thailand has dropped a notch, but most economies have maintained their previous credit ratings. All but one APEC member economy (Papua New Guinea) achieved DB3, representing "creditworthiness", or higher in 1997. It is interesting that, notwithstanding recent financial difficulties, Singapore, Chinese Taipei, and to a slightly lesser extent, Korea and Hong Kong, China, continue to rank relatively high in international comparisons of country risk. This does not reduce the importance of measures to address the fundamental problems at the root of these economies' recent financial difficulties. However, as Dun & Bradstreet points out, recent financial difficulties are appropriately viewed against "the remarkable historical commitment [Asian leaders have shown] to macroeconomic stability and stable growth."

4.5 Conclusion

APEC member economies differ significantly in certain factors that affect information use. Economies with high rates of capital investment and a base of healthy, well-educated workers are best positioned to realize the benefits from those information-related activities and mechanisms described in Chapter 3. Although recent problems point to inefficiencies in investment decision-making in some East Asian economies over the past few decades, Japan, the Newly Industrialized Economies and ASEAN economies have all benefited substantially from high rates of capital formation. Japan, Korea and Chinese Taipei also enjoy the advantage of being among those APEC member economies with the highest level of educational attainment. Schooling rates are somewhat lower in Hong Kong, China as well as in ASEAN-members Singapore and the Philippines; and lower still in the other ASEAN economies. Among developing APEC member economies on the other side of the Pacific, Chile has established a more comprehensive schooling system than Mexico, although it trails those economies with the most advanced schooling systems.

While inadequate telecommunications capacity can impair the flow of information, deficiencies in other forms of infrastructure can slow the diffusion of information by preventing firms from adopting new technologies. Certain problem areas within the APEC region warrant attention in this respect. These include the shortages of electric power and rail capacity in China, the inadequacy of road networks in the Philippines, and the lack of safe water for significant portions of the population in many middle and lower-income APEC member economies.

An environment characterized by political or economic instability is likely to discourage activities that are important for the diffusion and use of information. Although APEC member economies rank relatively high in international credit rating comparisons, some less developed APEC member economies – Papua New Guinea, Mexico, Indonesia and China – have been somewhat disadvantaged by their perceived riskiness relative to higher-income economies. Moreover, recent financial difficulties in East Asia underline the vulnerability of economies to a loss in investor confidence. Information-related activities, and economic growth in general, will be impaired where economies do not give attention to the conditions needed to achieve

economic stability.

Government policies have an important influence on the factors discussed in this section. Those economies that have succeeded in establishing an infrastructure that is conducive to information use have benefitted from well-designed policies in a number of areas. Private investment has been encouraged by policies that achieve macroeconomic stability and support long-term business planning. There has been recognition of the importance of public investment in human capital. Along with ensuring adequate access to health services and such basics as safe water and sanitation, the relevant governments have invested heavily in providing their citizens with the skills that they require to become productive members of the workforce. Policies have also given recognition to the importance of adequate physical infrastructure. Governments have developed needed facilities in some cases, while in other cases, results have been achieved by policies creating the appropriate incentives and conditions for private sector development.

5. COOPERATIVE STRATEGIES TO EXPEDITE THE REALIZATION OF THE ASIA PACIFIC INFORMATION INFRASTRUCTURE

The focus of this chapter is on the challenge that APEC member economies face in establishing cooperative arrangements to promote the development of information infrastructure in the Asia Pacific region. In keeping with recent approaches, information infrastructure is defined broadly to include not only communications hardware, but also the applications used to manipulate and transmit information and the institutional framework that supports the development and use of information hardware and applications. A well-developed infrastructure, with the required physical, and information service and policy components, is a prerequisite for, and precursor to, the emergence of an information society. While most APEC member economies have recognized this, they are approaching the challenge in different ways. The U.S. and Japan, for example, have developed their own plans for the creation of national and international information infrastructures. Other developed economies in the region are taking steps to establish their own national information infrastructures. Meanwhile, the first priority of lower-income APEC member economies is to construct core telecommunications networks providing adequate basic service. There is a need for a cooperative approach within APEC that is consistent with the divergent interests and priorities of members. In this context, this chapter considers how to shape a cooperative strategy to advance the development of an information infrastructure that can contribute to the achievement of the broader economic and social aspirations of APEC member economies.

Although information infrastructure has been singled out for attention, there is scope for cooperation in many of the other areas identified in previous chapters that influence an economy's ability to access and use information. APEC's general initiatives aimed at liberalizing and facilitating trade and investment among member economies will help promote the development of information societies. The range of cooperative programs within APEC to address structural issues relating, for example, to human capital, financial markets, economic infrastructure and science and technology,[97] will also enhance the ability of APEC member economies to take advantage of the opportunities from developing and using information. Information infrastructure is not the only component of an information society and should not be the exclusive focus for cooperative efforts to contribute to the broader evolution of societies, as discussed in previous chapters. However, because of the critical role of information industries and telecommunications in particular, and the divergent policy approaches of APEC member economies towards these sectors, cooperative strategies that will enable all members to benefit from well-developed information infrastructures warrant particular attention.

5.1 Infrastructure Differences within the Asia Pacific Region

97 These are discussed in APEC Economic Committee, The State of Economic and Technical Cooperation In APEC (Singapore: APEC Secretariat), 1996.

An effort to forge cooperation must begin with recognition of the significant differences in information technology among APEC members. While they may agree on the importance of information infrastructure to their social and economic development, APEC member economies are at different stages in building their networks and applying advanced hardware and software for telecommunications, broadcasting and computer communications.

Differences in information technology, which were discussed in Chapter 3, are further highlighted in Figure 1 where APEC member economies are grouped by their income levels and stage of development. There are clearly substantial disparities among higher- and lower-income APEC member economies in terms of access to electronic networks. Differences between telecommunications "haves" and "have-nots" are also reflected in data on telecommunications revenue per inhabitant (Figure 2).

Differences in the size and relative importance of the telecommunications services sector within APEC member economies are shown in Table 31. Although telecommunications revenue tends to represent a smaller proportion of GDP in lower-income than higher-income APEC member economies, the relative importance of an economy's telecommunications sector is not strictly a function of its average income level. Telecommunications is most important (measured by revenue as a proportion of GDP) in a number of smaller, high-income economies that have depended on telecommunication networks to maintain strong links with the rest of the world (i.e., New Zealand; Australia; Hong Kong, China; and Singapore).

There are, as well, significant differences in telecommunications policy among APEC member economies. While the trend towards increasing liberalization of telecommunications services is well underway in the region, many important markets continue to be characterized by a monopolistic or duopolistic structure. The public sector still has a major stake in the provision of telecommunications services in Australia, China, Indonesia, Malaysia, Korea and Thailand.

Given these differences, APEC member economies can be expected to follow different paths in their evolution towards information societies. Investment in information infrastructure is likely to proceed at a different pace in developed and developing economies where the demands for information content are quite distinct. Even economies at a similar stage of development are likely to require different strategies to develop information infrastructures that satisfy their social and economic objectives.

Some of these differences in approach are documented in a recent report issued by the APEC Telecommunications Working Group.[98] In a number of economies, plans to upgrade telecommunications facilities to meet the growing demand for high-speed, interconnected broadband networks are well advanced. In the U.S., for example, various private carriers are installing the infrastructure to provide advanced video and data services under the policy framework governing the National Informational Infrastructure (NII). Japan is encouraging private firms to gradually expand broadband services so that all cities with a population of 100,000 or more, along with designated "priority cities", would be covered by 2005, and all parts of the nation would have broadband access by 2010. In addition, many economies are experimenting with the use of advanced information systems to promote R&D, and to facilitate the provision of education and health services. Chile, for example, is actively and systematically introducing pedagogic approaches based on advanced information technologies into its educational system. By the year 2000, it is expected that 50 percent of that economy's primary schools and 100 percent of its secondary schools will be incorporated within Chile's "Links Project" (Proyecto Enlaces).

Meanwhile, some economies, including China, Indonesia, the Philippines, Thailand, and Papua New Guinea are primarily directing their efforts to satisfying the need for more adequate basic service. Some APEC member economies, notably the Philippines and Thailand, have had difficulty simply keeping pace with population growth, and are facing a rapidly growing unmet demand for telecommunications services.[99]

While a cooperative approach must be sensitive to the different imperatives driving infrastructure development in various APEC member economies, these differences should not impede cooperation. Some economies in the region, however, have seen their specific circumstances as a justification for policies that are at odds with the general trend towards liberalization in trade and investment. Developing economies, in particular, have been reluctant to remove trade and foreign investment restrictions in their information and telecommunications industries. Studies indicating that the social rate of return from R&D in high technology sectors is well above the private return[100] have contributed to the view that information technology and telecommunications are strategic sectors that merit special treatment. In addition, studies of "learning by doing" have been used to justify the protection of indigenous high-technology firms that are seen to have an important role in nurturing local technological capabilities.[101]

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98 APEC Telecommunications Working Group, Final Report on Telecommunications Information Infrastructure Questionnaire, March 1996.

99 This is discussed in U.N. Economic and Social Commission for Asia and the Pacific, *op. cit.*

100 The analysis of U.S. patent data suggests that R&D may spillover across firms and technologically related industries. See Adam Jaffe, "Technological Opportunity and Spillovers of R&D: Evidence from Firm's Patents, Profits, and Market value," The American Economic Review, No. 5, 1986. Also, see J. Bernstein, *op. cit.* 1995.

101 The empirical evidence on "learning by doing" is surveyed by Marvin Lieberman, " The Learning Curve and Pricing in the Chemical Processing Industries,' Rand Journal of Economics, No. 2, 1984.

Economies have enlisted these and other arguments[102] to support protectionist measures without properly evaluating the gains from trade and foreign direct investment. These concerns do not apply solely to developing countries; some major industrialized economies have viewed the high-technology sector as an important source of productivity growth and international competitiveness and introduced various measures favouring domestic information technology firms.[103] Such policies are often based on a short-term analysis of an economy's national interest and often fail to take account of the consequences of reciprocal actions by other economies. While APEC member economies have different objectives and priorities, it is important that they come to an understanding of their common interest in cooperative arrangements that can facilitate the realization of information societies within the Asia Pacific region.

5.2 Common Interests within APEC

The shared interests of APEC member economies in the development of information infrastructure can be viewed from different vantage points. At a broad level, the development of information infrastructure can be viewed as part of the efforts of APEC member economies to establish a foundation that will allow them to realize the opportunities for growth in an increasingly information-oriented age. By improving their status as information economies, lower-income APEC member economies should be better positioned to benefit from the knowledge and technology developments in higher-income economies and to achieve higher standards of living. More narrowly, the development of information infrastructure in one APEC member economy will directly affect other regional economies simply because of the significance of intra-regional commerce in telecommunications equipment and services. The following discussion briefly elaborates on these two related aspects of common interest.

Information Society and Economy

From a broad vantage point, the importance of information infrastructure for individual economies and for APEC as a whole arises from the existence of a significant relationship between an economy's information status and its economic performance. By enhancing the information status of individual, and especially of lower-income APEC member economies, infrastructure development is likely to enhance these economies' growth prospects and, in the process, to generate benefits in terms of improved trade and investment opportunities for other APEC members.

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102 There has been concern, for example, that foreign direct investment may harm a local economy if the foreign acquisition eliminates a local competitor and thereby prevents timely access to a new technology. See J. Dunning, The Globalization of Firms and the Competitiveness of Countries: Some Implications for the Theory of International Production, (Lund, Sweden: Institute of Economic Research) 1990.

103 See, for example, L. Tyson, Who's Bashing Whom?: Trade Conflict in High-Technology Industries, (Washington: Institute for International Economics), 1992. Also, S. Ostry and R.R. Nelson, Techno-Nationalism and Techno-Globalism: Conflict and Cooperation, (Washington: Brookings Institution) 1995.

To appreciate these relationships, it is not necessary to sort through various efforts to explain the growth of APEC member economies. The rapid growth of the Newly Industrialized Economies, which notwithstanding recent developments arguably remains the most remarkable development among APEC member economies in recent decades, has been the subject of a significant literature and there is no consensus view on the lessons to be learned from this experience. For the purposes of this discussion, however, it is sufficient that information access is considered a critical factor in virtually all growth studies. While various analyses attach different weights to the indicators discussed in previous chapters, the importance of international knowledge transfers to the growth of high-performing APEC member economies is not called into question.

The widely quoted World Bank study of Asian economies, for example, attributes the growth of the high-performing economies (HPAEs) to high rates of investment (exceeding 20 percent of GDP on average between 1960 and 1990), high and rising endowments of human capital, and high levels of productivity growth. The latter was partly due to the ability of the HPAEs to catch up technologically to the industrial economies, which in turn was partly a result of their openness to foreign technology. As the World Bank noted, the HPAEs actively sought foreign technology through a variety of mechanisms, including by welcoming technology transfers in the form of licenses, capital goods imports, and foreign training, and by openness to foreign direct investment (which sped the acquisition of technology in Hong Kong, China, as well as in Malaysia, Singapore, and, more recently, Indonesia and Thailand). A number of East Asian economies (Japan, Korea and, to a lesser extent, Chinese Taipei) which restricted foreign direct investment offset this disadvantage by aggressively acquiring foreign knowledge through other means (licenses, etc.).[104]

While there is considerable agreement with the views expressed in this study, some of the World Bank's conclusions have been challenged. One point of contention has been on the importance of productivity growth. Based on different empirical evidence, it has been argued that capital accumulation can explain much of the growth of the Newly Industrialized Economies and that, contrary to the findings of the Bank, total factor productivity growth in these economies has not been exceptional.[105]

This dispute, however, relates essentially to the importance of alternative mechanisms of information transfer. By assigning a greater explanatory role to capital accumulation, economists are not suggesting that there is little borrowing of foreign technology. Rather, the argument is that most technical change is embodied in new capital goods. It is, therefore, the high rates of investment that lead to faster technical progress, greater learning on the job, and related developments which in turn promote competitiveness and faster economic growth. The

104 *ibid*., p. 21.

105 A Young, "Lessons from the East Asian NICs: A Contrarian View," European Economic Review, Vol. 38, April 1994. L.J. Lau and J. Kim, "The Sources of Growth of the East Asian newly Industrialised countries," Journal of the Japanese and International Economies, 1994.

implication of this argument is that economies that rank poorly on the indicators discussed in previous chapters would still perform poorly. However, it is not sufficient to have a high status as an information society, based on the indicators discussed in Chapter 3; economies must also have high rates of capital accumulation to achieve strong economic growth.

In Table 32, a number of the more important information indicators are set alongside an indicator of real per capita income growth in APEC member economies over 1980 to 1993. The data end prior to the recent period of financial turbulence, and they only relate to the recent period as distinct from the 30-year period covered in the World Bank study. Moreover, the indicators in Table 32 are limited in their ability to convey the role of information in APEC member economies. The indicator of openness, for example, is based on a comprehensive review, but one that focuses primarily on trade policies and does not attempt to take account of the special importance of trade with major information-producing economies. Nonetheless, these data lend general support to the expected relation between information status and economic growth. Among developing and the Newly Industrialized Economies,[106] the highest rates of per capita growth have tended to be achieved by those that are more open, have better-educated workers and enjoy relatively high rates of investment. Korea and Chinese Taipei, which have experienced among the highest rates of per capita growth over 1980 to 1994, stand out as especially successful information economies.

China's high rate of per capita growth appears to be, in this context, somewhat of an anomaly. Although China has benefitted from very high rates of capital formation, it ranks low on the other indicators in Table 32. Given the importance of international knowledge transfers, China's economic success is especially puzzling in the face of its restrictive trade policies. It has been argued, however, that China's experience is indeed consistent with the importance of open policies.[107] Major market reforms introduced in China at the end of the 1970s freed the peasant economy from state controls and liberalised trade for non-state firms, especially those operating in the Special Economic Zones. These reforms were "sufficient to unleash economic development and a labour-intensive export boom".[108] In the early 1990s, the strong growth in inward foreign direct investment made possible by the liberalization of China's investment policies, provided new opportunities for the economy to benefit from the import of foreign technology and foreign know-how. In short, efforts to classify China according to standard criteria do not capture the impact of market reforms in opening China to the influence of international knowledge transfers.

Attempts to test convergence support the connection between information access and

106 Since real growth depends partly on an economy's initial level of per capita income, the high per capita income of industrialized economies such as the U.S. and Canada may account for their relatively low growth rates, rather than their rankings in terms of particular information indicators. There is merit, therefore, in excluding the major industrialized economies (i.e., the U.S., Japan, Canada, Australia and New Zealand) in interpreting Table 34.

107 Jeffrey D. Sachs and Andrew Warner, 1995, *op. cit.*

108 *ibid*., p.46.

economic growth. Recent studies have found evidence of conditional convergence among Asian economies, once they are split into groups taking into account their differing degrees of openness.[109] Over the 1980s, the most rapid growth in per capita income occurred in those economies that were most open and, among this group, in those with the lowest 1980 GDP per capita relative to the U.S.. In particular, Korea and Chinese Taipei were found to be the leading performers among the most open economies.[110]

In general then, available evidence confirms the importance of information-related variables to economic growth in the Asia Pacific region. The research supports the expectation that investments and policies to build an economy's information infrastructure and to enhance its ability to access foreign technology will improve growth prospects, to the benefit not only of the investing economy but also of its trade and investment partners.

Telecommunications Linkages within APEC

As major international producers of telecommunications goods and services, APEC member economies have a significant direct interest in the further development of the region's information infrastructure and the trade and investment opportunities for communications goods and service suppliers that this will create.

109 John F. Helliwell, "Asian Economic Growth," in W. Dobson and F. Flatters (eds.), Pacific Trade and Investment: Options for the 90s, (Kingston: John Deutsch Institute), 1995. Also J. Helliwell, "Economic Growth and Social Capital in Asia," NBER Working Paper No. 5470, Feb. 1996.

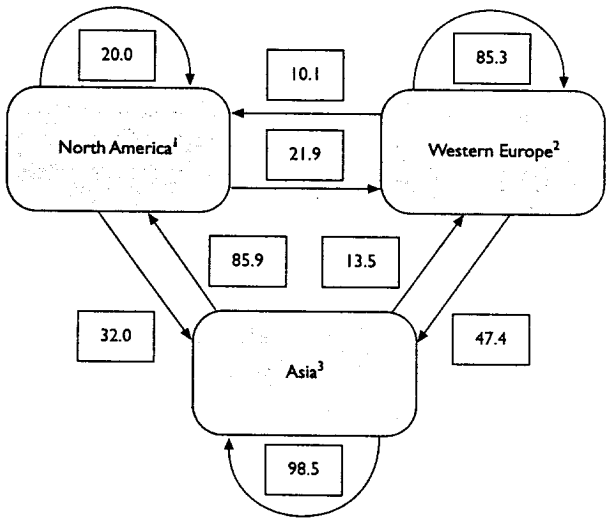
110 *ibid*. A number of recent Economic Committee reports provide additional support for measures to promote an economy's information development. One recent study, The Impact of Trade Liberalization in APEC, highlights the benefits of measures to facilitate trade and investment, two important determinants of a society's information status. Using a computable general equilibrium model, the study finds that the trade and investment liberalization and facilitation measures set out in the Manila Action Plan for APEC (MAPA) will significantly raise the real GDP of APEC member economies. Further evidence of the positive influence of trade on the growth of APEC member economies is provided in Cost and Productivity Trends and Patterns of Specialization in APEC, APEC Economic Committee, November 1998.

From Table 33, it can be seen that APEC member economies account for a major share of the world's production of information and communications technology (ICT) goods. In 1994, the U.S. and Japan alone produced almost 60 percent of world ICT goods. The Newly Industrialized Economies and the ASEAN economies have greatly increased ICT production over the past decade; in 1994, these APEC members accounted for about 19 percent of total world output. Figure 3 shows regional trade flows for the important office machine and telecommunications equipment segment of the ICT sector. These data highlight the substantial trade in telecommunications products that takes place within and between the North American and Asian parts of the APEC region.

Fig 3.

Major regional flows in world exports of office machines and telecommunication equipment, 1994

Billion US$



1. North America: Canada, United States.
2. Western Europe: EU + EFTA.
3. Asia: Japan + DAEs.

Source: OECD Secretariat calculations from WTO (1995).

Trade in telecommunications services takes the form of cross-border transactions as well as of payments associated with international investments, the licensing of technology, and the provision of international consulting services. Cross-border transactions, and more specifically international telephone calls, are the most important component of service trade. As shown in Table 34, outgoing telephone traffic has been growing rapidly in many APEC member economies. The amount of outgoing traffic in a number of Asia Pacific economies, as measured by minutes per inhabitant, is well above the international average.

Infrastructure investment will create new opportunities for producers of telecommunications equipment and providers of related services within the APEC region. Accompanying policy reforms, extending the process of liberalization that is already well underway in some APEC member economies, will increase foreign investment opportunities. In addition, trade in telecommunications services can be expected to increase as policies permitting increased competition give rise to lower telecommunications rates.[111]

An indication of the potential impact of cooperative initiatives to develop telecommunications facilities and systems in the Asia Pacific is provided in a recent analysis by the Korea Institute for Industrial Economics and Trade. This study evaluates the specific economic effects of APEC cooperation in the telecommunications industry on each sector of APEC member economies, including the repercussion effects, based on industrial input-output tables.

For a given economy *k,* the forward-linkage effect denotes the amount of final demand for industry *i*'s output induced by one unit of additional demand created in all other industries. Repercussion effects are captured by the index of sensitivity degree, which is obtained by dividing industry *i*'s induced output by the average induced output in all industries. On the other hand, the backward-linkage effect denotes the effect of one additional unit of output in industry *i* on the output of all other industries. Repercussion effects are captured by the index of dispersion power, which is obtained by dividing industry *i*'s effect by the average effect of all other industries.

Using the database developed by the Institute of Developing Economies for 1993, the index of sensitivity degree of telecommunications turns out to be greater for developed economies including the U.S., Japan, Canada, and Australia than for developing Asian economies. The results for developed economies range from 1.64 to 1.88, while those for Asian developing economies range from 1.00 to 1.52.

It is interesting that the index of dispersion power for telecommunications and other service industries is similar throughout the region. The results for the U.S., Japan, Canada and Australia range from 0.75 to 0.82, while those for other economies from 0.69 to 0.87.
Using the same database, the study traces the impact of an increase in telecommunications

111 The influence of competition on telecommunication rates is discussed in OECD, Communications Outlook, 1995. The impact of long distance competition on long distance prices in Australia, Japan and New Zealand is discussed in International Telecommunications Union, Asia-Pacific Telecommunications Indicators, 1997, Box 2.1, p. 22.

spending on different sectors throughout the APEC region. Against a base case projection of GDP in APEC member economies to the year 2010 (from Wharton Econometric Forecasting Associates), the impact of faster growth in the telecommunications and service (TS) sector resulting from increased infrastructure investment by member economies is then estimated. Various scenarios are tested, but the general conclusion is that cooperative initiatives that lead to increased telecommunications spending can significantly boost GDP in all member economies. If, for example, the TS sector grows at 5 percent on average rather than simply keeping pace with base case GDP growth (i.e., 3 percent per annum for developed and 7 percent for developing economies), it is estimated that the real GDP of all APEC member economies will be about US$ 2 trillion, or almost 10 percent, higher in 2010.

The study concludes that all APEC member economies will benefit from a cooperative approach to building the region's telecommunications and information sector. For instance, the dynamic effects from joint research and development as well as international standardisation and investment will magnify the beneficial effects of APEC cooperation in the telecommunications sector.

5.3 Proposed Initiatives for the Cooperative Development of Information Infrastructure

Some insights into how cooperative initiatives can be used to harness the common interests of APEC members in developing information infrastructure can be obtained by reviewing some proposed projects for international cooperation in this area.

The first major proposed initiative was the U.S. recommendation for the development of a Global Information Infrastructure (GII).[112] The proponents of the GII emphasised the need to: encourage private investment; promote competition; apply less stringent regulation; open access to telecommunications networks/services; and provide universal services. The proposal also gave attention to the effective protection of intellectual property rights. A major objective was to create a favourable environment for trade and investment in the information and telecommunications sector. In discussing the provision of universal service, the authors of the GII report pointed to the need to select a process of provision that takes account of the benefits from competition and private investment.

The proposal for an Asia Pacific Information Infrastructure (AII) put forward by Japan gave explicit recognition to the difficulties faced by developing economies. By harmonising their legal frameworks and supporting the development of new technology and new applications, it was suggested that industrialized economies can help to create the demand for information infrastructure in their own economies. At the same time, developed economies were seen to have a role in supporting infrastructure development in lower-income economies. This notion of North-South cooperation, however, was not given concrete expression through the formulation of implementation plans and the specification of financing arrangements.

112 IITF, Global Information Infrastructure: Agenda for Action, 1995.

The G-7 Ministers elaborated on their vision of the Global Information Society (GIS) at a conference in February 1995. There was recognition of the need for international cooperation in creating an environment that promotes competition and encourages private investment. The G-7 Ministers emphasised the importance of effective intellectual property policies and the development of global markets for networks, services and applications. The proposed framework paid particular attention to the needs of less-developed economies but, as in the AII proposal, these intentions were not backed by concrete action plans.

The concept of the Asia Pacific Information Infrastructure (APII) that has emerged within APEC sets out a cooperative framework through which APEC member economies can work together towards the development of a seamless region-wide infrastructure that removes barriers of time and space among member economies. The APII initiative has three major objectives: building an information superhighway within the Asia Pacific region; narrowing the information and infrastructure gaps among member economies; and facilitating the realization of an Asia Pacific Information Society. Moreover, the APII is seeking balanced development among member economies by reflecting the interests of less-developed economies in expanding their capacity to utilise information.

By promoting liberalization of intra-regional trade and investment, the APII will contribute to the formulation of an APEC-wide economic community. The APII differs from other initiatives in that its core principles recognise both members' needs to construct their domestic telecommunications and information infrastructure "based on their own reality" and the importance of narrowing the infrastructure gap between advanced and developing economies.

There are two themes that, to some degree, underlie all these proposed initiatives: the importance of liberalization along with regulatory reforms to promote market competition; and the need for increased international cooperation. A balanced approach is required that effectively addresses each of these themes.

A less-restrictive and more market-oriented environment is required to encourage private investment in the development of information infrastructure. The theme of cooperation encompasses the need for supportive measures to reduce the infrastructure gap between high-income and developing economies. Such measures are desirable in their own right, but also because they can help win the support of middle- and lower-income economies for broad initiatives that incorporate market liberalization and the development of global markets for information technology goods and services. Efforts need to be devoted to designing a strategy that balances liberalization to achieve efficient international markets for information technology products with cooperative measures that respond to the particular concerns of lower-income economies.

Herein lies the major challenge for APEC member economies. While the importance of bringing developing economies within the APII has been recognized, there is a need to put in place measures that give expression to the goal of regional cooperation and provide lower-income economies with assurance that they will share in the benefits from the

development of regional information infrastructure. A good start has been made. In the next two sections, these points are elaborated. Section 5.4 looks at APEC initiatives to promote market liberalization in telecommunications goods and service markets, while Section 5.5 reviews APEC's APII-related initiatives under the rubric of economic and technical cooperation.

5.4 Liberalization and the Transition to a more Market-Oriented Environment

APEC member economies have supported trade and investment liberalization and facilitation in the information sector both at the multilateral and regional levels. At the multilateral level, APEC member economies contributed significantly to the World Trade Organization (WTO) Information Technology Agreement (ITA) and the more recent WTO agreement on basic telecommunications services. Moreover, APEC member economies, most of whom are members of the WTO, have agreed to work to increase competition and to reduce foreign investment restrictions consistent with or surpassing commitments in the WTO agreement on telecommunications services.

APEC member economies contributed significantly to the success of the WTO/GBT negotiations. After the second APEC Senior Officials Meeting (SOM) for the Ministerial Meeting on the Telecommunications and Information Industry in May 1996, where the ITA was raised as an issue to be addressed by APEC, member economies (except Chile and China) put forward their official position approving the ITA at the 4th SOM (October, 1996) and at the 4th APEC Economic Leaders' Meeting (November, 1996). This laid the groundwork for the decision to liberalise the information technology sector at the WTO Ministerial Meeting in Singapore in December 1996. The ITA was concluded at the end of March 1997 with 43 economies, accounting for more than 90 percent of the world IT products market, as signatories. The ITA aims to gradually reduce, and by the year 2000 eliminate, tariffs on 202 items (including computer hardware, software, semiconductors, telecommunications equipment and a number of parts). The February 1997 WTO Agreement on basic telecommunications services was signed by 69 countries representing 95 percent of world revenues.

APEC member economies are now participating in multilateral efforts to develop an international telecommunications sector by raising allowed ceilings on foreign investment in their telecommunications sectors and pursuing other initiatives in accord with the letter and spirit of the ITA agreements. Following the direction received from APEC Leaders at their meeting in Vancouver, the APEC Telecommunication Working Group (TEL) created a WTO Implementation Task Group to help APEC WTO members to implement the Agreements and learn from each other's experience. Table 35 summarises the commitments of APEC member economies under the WTO/GBT agreements.

Zero tariffs in IT trade will increase the volume of world trade and promote the growth of the IT industry. Along with the conclusion of NGBT/WTO, there has been a strong movement around the world to liberalise the telecommunications sector. APEC is assuming a leadership role in efforts to conclude an ITA II which would cover video and audio equipment, items that were excluded in the previous ITA Agreement but were included in the list presented by the United States, Japan and the EU.

In addition to assisting in the conclusion and implementation of these important multilateral agreements, APEC member economies have pursued initiatives to further open up telecommunications markets within the Asia Pacific region. Ministers have instructed the TEL to make the telecommunications and information sector a "model" sector in achieving the goals of free trade and open investment established at Bogor. The document titled "To Make the Asia Pacific Information Society a Reality by the Year 2001"[113], adopted at the 5th APEC Economic Leaders' Meeting, urges member economies to develop individual and collective action plans to accelerate liberalization of the information and communications sector.

The TEL is also spearheading collective actions in a number of areas. Its Liberalization Steering Group (LSG), for example, is promoting implementation of APEC guidelines for trade in International Value added Network Services (IVANS). IVANS has been identified as a priority sector for early voluntary liberalization. The TEL is also encouraging member economies to accept the framework that it has finalised on Mutual Recognition Arrangements (MRA) for telecommunications equipment. By providing for mutual recognition of the test results and certification provided by accredited bodies within the signatory economies, the MRA will significantly facilitate trade in telecommunications equipment.

5.5 Economic and Technical Cooperation

APEC Leaders have recognized that Economic and Technical Cooperation (ECOTECH) must accompany trade and investment liberalization to achieve the vision of a Pacific community with improved economic and social well-being. The organising themes that have been developed by APEC Leaders to guide cooperative activities provide a framework for the formulation of action plans "to make the Asia Pacific Information Society a reality by the year 2001."[114] Concrete deliverables, that are achievable by the end of the year 2000, have been identified in all six of these ECOTECH priority areas.[115] While some of the agreed initiatives are aimed at generally enhancing member economies' ability to benefit from the enabling effects of telecommunications and information infrastructure, other initiatives focus on impediments in specific areas. As an example of the latter, in the subsection below, we look at the cooperative actions to be taken to promote electronic commerce.

In the area of human capital development, programs are being developed to help prepare

113 "Strengthening Economic Infrastructure in the APEC Region", Background Paper, Ninth APEC Ministerial Meeting, Vancouver. November 21 ~ 22. 1997

114. The framework on economic cooperation and development was adopted in Manila in 1996. At the 5th APEC Economic Leaders/ Meeting in Vancouver in November 1997, specific cooperative measures for the development of infrastructure and achievement of the other five priority objectives were agreed upon.

115 These six themes are: human capital development; the achievement of stable, safe and efficient capital markets; strengthening economic infrastructure; harnessing technologies of the future; safeguarding the quality of life through environmentally sound growth; and, developing and strengthening the dynamism of small and medium-sized enterprises.

regulatory bodies for the issues that emerge in information societies. Efforts to help APEC member economies harness technologies of the future include: ensuring that all member economies have at least one point of connection with advanced broadband network and testbeds being used to develop APII technologies; ensuring that all universities in member economies are interconnected (initially through the Internet and later through the APII) and the Distance Learning Network for APEC can be realised; encouraging the interconnection of public institutions, including hospitals, museums and libraries; and encouraging the participation of member economies in International Joint Research Projects to develop advanced telecommunications technologies. The TEL's Development Cooperation Steering Group (DCSG) and the Human Resources Development Steering Group (HRDSG) are coordinating many of the pilot projects being undertaken to build the APII.

Economic and technical cooperation in the areas of information and telecommunications is founded on the five objectives and ten principles of the APII contained in the Seoul Declaration, and subsequently translated into action plans at the 2nd and 3rd Ministerial Meetings. The APII initiative seeks to reflect the interests of less-developed economies in the increased utilisation of information; in particular, one of its objectives is to narrow the information and infrastructure gaps among member economies. Hence, in attempting to "harness technologies of the future," economically advanced member economies are encouraged to engage in technical cooperation and joint R&D with developing member economies. As part of their efforts to promote "environmentally sound growth," APEC members are encouraged to expand the availability and affordability of basic telecommunications services throughout the region. Special emphasis is to be given to raising the teledensity of APEC member economies whose access lines per 100 inhabitants were below the region's 1995 median – although it is understood that major progress in this area will require the cooperation of the private sector, multilateral financial institutions and governments.

As shown in Table 36, substantial differences exist among member economies in terms of the emphasis that they place on TILF and ECOTECH respectively. For example, some economies focus on TILF, especially policy and regulations, while other economies funnel their resources to ECOTECH-related projects involving the telecommunications network, technology or applications. Such differences reflect the diverse needs of member economies, while also revealing some of the tensions that exist between economies that favour liberalization and economies that place major importance on economic and technical cooperation.

Cooperation to Promote Electronic Commerce

In various APEC fora, it has been recognized that electronic commerce ("e-commerce") is potentially one of the most important technological developments of the decade. In many APEC member economies, however, there are not enough electronic sites where business can be done. Trust and confidence in e-commerce is hampered by regulations requiring paper forms, signatures and the like. Some APEC member economies impose restrictions on electronic trade or on the use of high-level encryption technology.

A SOM Task Force on Electronic Commerce has been established within APEC to address

these and other problems. In the first stage of its work, the Task Force will focus on studies and information exchange[116]. In the second stage, it will consider principles for policy development and the options for technical cooperation within APEC.

In "To Make the Asia Pacific Information Society a Reality by the Year 2001", three initiatives to promote e-commerce were identified: incorporating the OECD guidelines on privacy, security and cryptography as the APEC model framework; implementing UN/EDIFACT as the standard EDI/Electronic Commerce Data Protocol for customs documents; and encouraging ratification and implementation by APEC WIPO members of the WIPO Copyright Treaty and the WIPO Performances and Phonograms Treaty. By achieving progress on these issues, APEC member economies would go some distance in creating an environment that is conducive to the development of e-commerce APEC-wide.

In addition, a number of more specific e-commerce projects are currently underway within APEC. The Transportation Working Group has initiated a pilot EDI program to facilitate e-commerce and to eliminate the requirement for paper documents. The TEL has launched a number of projects, including one to establish a Certifying Authority and procedure for the use of digital signatures. The INGECEP/CyberNet project experiments with electronic commerce applications over both the narrowband (Internet) and broadband (ATM) networks connecting APEC and G7 member economies. The TEL is also conducting seminars and undertaking surveys on e-commerce. The Human Resources Development Working Group (HRD WG), meanwhile, is developing training modules and courses to help prepare government officials for the public policy issues arising from e-commerce.

The growth of e-commerce in the region will depend not only on these initiatives, but also on APEC's success in reducing the information infrastructure gap among member economies. Therefore, there is strong link between cooperation on e-commerce and other APII-related ECOTECH programs.

5.6 Conclusion

APEC member economies are at different stages in building their telecommunications and information systems and in utilising advanced information technologies. These differences need to be understood and accommodated, but they should not be allowed to undermine the efforts of APEC members to work together to promote the development of information infrastructure in the Asia Pacific region.

It is important, first, for APEC members to appreciate their common interest in facilitating infrastructure development in the region. Many economies have a direct interest in the trade and investment activity associated with infrastructure development. All APEC member economies have a stake in the longer-term benefits that will flow from the improved diffusion of information and the consequent improvement in the prospects for regional economic growth.

116. APEC Task Force On Electronic Commerce: Summary report, 18 February 1998, Penang

TABLE 1

R&D EXPENDITURES AS A PERCENTAGE OF GNP FOR APEC MEMBER ECONOMIES, VARIOUS YEARS

	Year	%		Year	%
Australia	1994	1.6 [1]	Malaysia	1992	0.4
	1981	1.0			-
	1968/69	1.4			-
Brunei	1984	0.1	Mexico	1995	0.3 [1]
		-		1984	0.6
		-		1970	0.1
Canada	1997	1.6 [1]	New Zealand	1995	1 [1]
	1981	1.3		1979	0.9
	1971	1.2		1971	0.5
Chile	1992	0.7	Papua New Guinea		-
	1980	0.5			-
China	1995	0.5	Philippines	1992	0.2
		-		1982	0.2
Hong Kong, China	1995	0.3	Singapore	1995	1.1
		-		1981	0.3
Indonesia	1995	0.1	Chinese Taipei	1995	1.8 [1]
	1983	0.4 [1]		1982	0.9 [1]
	1976	0.2			-
Japan	1995	3.0 [1]	Thailand	1995	0.1
	1981	2.4		1987	0.2
	1971	1.9		1969	0.3
Korea	1995	2.7 [1]	United States	1996	2.5 [1]
	1981	0.7		1981	2.5
	1971	0.3		1971	2.6

Notes:
1. Data for OECD members and Chinese Taipei express R & D as a % of GDP, rather than GNP.
Source:
For OECD member economies, data are drawn from the OECD, Main Science and Technology Indicators, 1997. For Chinese Taipei, data are drawn from its Statistical Data Book, 1997. For all other economies, data are drawn from UNESCO Statistical Yearbook, 1997, 1994, 1970

TABLE 2

PER CAPITA GROSS EXPENDITURES ON R & D ON A PURCHASING POWER PARITY (PPP) BASIS, SELECTED APEC MEMBER ECONOMIES, 1995 OR LATEST

	Current PPP $[1]
Australia [2]	310.3
Canada [3]	359.2
Japan	649.2
Korea	335.6
Mexico	22.8
New Zealand	164.5
United States [3]	695.4

Notes:
1. Current domestic expenditure converted to US$ from local currencies at purchasing power parity exchange rates.
2. 1994
3. 1996

Source:
OECD, Main Science and Technology Indicators, 1997

TABLE 3

NUMBER OF SCIENTISTS AND ENGINEERS PER MILLION POPULATION, APEC MEMBER ECONOMIES, LATEST AVAILABLE YEARS

	Year	No.
Australia	1994	3,166
Brunei	1984	91
Canada	1993	2,656
Chile	1988	364
China	1995	350
Hong Kong, China	1995	98
Indonesia	1988	181
Japan	1994	6,309
Korea	1994	2,636
Malaysia	1992	87
Mexico	1993	157
New Zealand	1993	1,778
Papua New Guinea	-	-
Philippines	1992	157
Singapore	1995	2,728
Chinese Taipei [1]	1995	2,980
Thailand	1995	119
United States	1993	3,732

Note:
1. Number of researchers

Source:
UNESCO, Statistical Yearbook, 1997; for Chinese Taipei, data are drawn from its Statistical Data Book, 1997

TABLE 4

GROSS DOMESTIC EXPENDITURES ON R & D, ON A PURCHASING POWER PARITY BASIS, SELECTED APEC MEMBER ECONOMIES

	Percentage Share of OECD Total				Millions Current PPP$ [1]
	1981	1985	1989	1995 (or latest)	1995 (or latest)
Australia	1.0	1.0	1.1	1.4 [2]	5,536.0 [2]
Canada	2.2	2.2	2.1	2.5	11,057.7 [3]
Japan	14.4	15.7	17.5	19.9	81,514.8
Korea	-	-	-	3.7	15,132.3
Mexico	-	-	-	0.5	2,160.1
New Zealand	0.2	0.1	0.1	0.1 [2]	589.0 [3]
United States	46.9	48.2	45.3	43.8	184,665.0 [4]
Memo: Total OECD	100.0	100.0	100.0	100.0	409,120.2

Notes:
1. Current domestic expenditure converted to US$ from local currencies at purchasing power parity (PPP) exchange rates.
2. 1994
3. 1997
4. 1996

Source:

OECD, Main Science & Technology Indicators, various years

TABLE 5

PATENT GRANTS IN APEC MEMBER ECONOMIES AND RESIDENT SHARE OF TOTAL

	1993		1981	
	Total Patent Grants	Resident Share of Total	Total Patent Grants	Resident Share of Total
	No.	%	No.	%
Australia	12,728	9	6,434	8
Brunei	-	-	-	-
Canada	14,580	7	22,696	6
Chile	460 [1]	10	635	11
China	6,556	40	455 [3]	10
Hong Kong, China	1,438	1	654	3
Indonesia	4,027 [2]	2	-	-
Japan	88,400	87	50,904	83
Korea	11,446	40	1,808	13
Malaysia	1,281	1	1,150 [3]	1
Mexico	6,183	6	2,210	9
New Zealand	2,866	6	1,634	12
Papua New Guinea	-	-	-	-
Philippines	1,281 [3]	2	787	9
Singapore	1,395	-	416 [3]	0
Chinese Taipei	20,232	69	6,265	46
Thailand	451	20	330 [4]	8
United States	98,344	54	65,770	60

Notes:
1. 1992
2. Applications filed in 1992
3. 1985
4. Applications filed

Source:
WIPO, World Intellectual Property Statistics, Industrial Property Statistics, various years. For Chinese Taipei, data are drawn from its Statistical Data Book, various years.

TABLE 6

PATENTS GRANTED TO NON-RESIDENTS AS PERCENTAGE OF TOTAL GRANTS, APEC MEMBER ECONOMIES, 1992

Granting Economy	Economy of Residence								Total
	%								No.
	Aus.	Can.	Jap.	Kor.	Mex.	N.Z.	C.T.	U.S.	
Australia	n/a	1.3	13.0	0.1	0	0.6		41	12,899
Brunei									
Canada	1.1	n/a	14.0	0.1	0	0.1		48	18,332
Chile	0.2	2.2	1.5					39	460
China	0.7	0.9	20.0	0.2		0		19	3,966
Hong Kong, China	1.0	0.3	21.0	0.4		0.2		44	1,069
Indonesia									
Japan	0.1	0.1	n/a	0.0	0	0		6.6	92,100
Korea	0.1	0.3	41.0	n/a		0.1		15	10,502
Malaysia	5.0	1.1	18.0	0.4		0.5		40	1,134
Mexico	0.2	0.7	1.6		n/a			81	3,160
New Zealand	7.4	1.7	4.9	0.0		n/a		41	2,988
Papua New Guinea									
Philippines									
Singapore									
Chinese Taipei							n/a		21,264
Thailand	2.0	1.0	23.0					35	199
United States	0.4	2.0	22.5	0.6	0.04	0.04	0.9 [1]	n/a	97,443

Notes:

n/a: not applicable
1. 1991

Source:
WIPO, World Intellectual Property Statistics, Industrial Property Statistics, various years; data for Chinese Taipei are drawn from its Statistical Data Book, 1997.

TABLE 7

MAIN SOURCES OF R & D FUNDING IN APEC MEMBER ECONOMIES, SELECTED YEARS

	Year	Public Sector Funds	Private Sector Funds		Year	Public Sector Funds	Private Sector Funds
		% Contribution [1]				% Contribution [1]	
Australia	1994	48.1	45.7	Malaysia	1992	53.1	43.0
	1985	64.7	32.1			-	-
Brunei		-	-	Mexico	1993	73.4	14.3
		-	-		1984	14.9	0.9
Canada	1996	30.1	50.7	New Zealand	1993	54.7	33.9
	1985	41.7	41.7		1975	80.2	18.8
Chile	1995	68.5	20.2	Papua New Guinea		-	-
	1986	68.3	27.1			-	-
China	1987	60.9	39.1	Philippines	1992	37.2	23.3
		-	-		1982	76.8	14.9
Hong Kong, China	1995	91.0	2.8	Singapore	1995	31.4	62.5
		-	-		1984	49.0	43.0
Indonesia	1994	15.8	76.4	Chinese Taipei	1994	48.2	51.6
		-	-		1984	63.3	35.8
Japan	1991	18.2	81.7	Thailand	1995	79.7	12.2
	1983	21.0	78.9		1985	69.6	13.8
Korea	1994	15.9	84.0	United States	1995	35.5	59.4
	1986	19.0	80.9		1986	46.6	50.1

Notes:
1. Foreign & "other" sources comprise remaining percentage.

Source:

UNESCO Statistical Yearbook, 1997, 1994, 1970. For the People's Republic of China, data are sourced from Guide to China's S&T Policies. For Chinese Taipei, data are sourced from its Statistical Data Book, 1996.

TABLE 8

OUTPUT OF SCIENTIFIC PAPERS, SELECTED APEC MEMBER ECONOMIES

	1993 World Share (%)	1993 Index (1982=100)
U.S.	35.3	96
Japan	8.1	119
Canada	4.5	108
Australia & New Zealand	2.7	94
NIEs [2]	1.4	412
China	1.2	347
Memo: European Union	31.5	107

Notes:
1. Scientific production is measured by the number of papers in journals recorded in the Science Citation Index and Compumath databases established by the Institute for Scientific Information (ISI), Philadelphia U.S.
2. Hong Kong, China; Korea; Malaysia; Singapore; and Chinese Taipei.

Source:
UNESCO, World Science Report, 1996

TABLE 9

GOODS & SERVICES EXPORTS AND IMPORTS OF APEC MEMBER ECONOMIES AS A PERCENT OF GDP

	Exports of goods and services			Imports of goods and services		
	1970	1980	1995	1970	1980	1995
	% of GDP			% of GDP		
Australia	15	17	20	15	18	20
Brunei	-	-	-	-	-	-
Canada	23	28	37	21	26	35
Chile	15	22	29	14	26	27
China	3	11 [1]	21	-	8 [1]	19
Hong Kong, China	93	90	147	89	-	153
Indonesia	13	26 [2]	25	16	23 [2]	27
Japan	11	14	10	10	15	10
Korea	14	35	33	24	41	34
Malaysia	41	58	98	36	55	102
Mexico	8	12	31	10	14	29
New Zealand	22	29	30	25	31	29
Papua New Guinea	18	37	58 [3]	57	48	39 [3]
Philippines	19	22	36	19	28	45
Singapore	102	207	174	-	216	157
Chinese Taipei	30	53	49	30	54	47
Thailand	17	25	43	22	31	50
United States	6	10	11	5	10	12

Notes:
1. 1982
2. 1981
3. 1993

Source:
IMF, International Financial Statistics Yearbook, 1997; and UN, National Accounts Statistics: Main Aggregates and Detailed Tables, 1982. For Chinese Taipei, data are drawn from its Statistical Data Book, 1997.

TABLE 10

INWARD FDI STOCK AS A SHARE OF GDP, APEC MEMBER ECONOMIES, 1980 AND 1994

	1980	1994
Australia	8.9	28.3
Brunei	0.4	1.9
Canada	20.4	19.2
Chile	3.2	19.2
China	-	17.9
Hong Kong, China	6.3	20.5
Indonesia	14.2	26.5
Japan	0.3	0.4
Korea	1.8	3.3
Malaysia	24.8	46.2
Mexico	4.6	14.4
New Zealand	10.5	31.6
Papua New Guinea	27.1	39.4
Philippines	3.8	8.3
Singapore	52.9	72.8
Chinese Taipei	5.8	6.6
Thailand	3.0	10.1
United States	3.1	7.5

Source:
UNCTAD, World Investment Report, 1996

TABLE 11

IMPORTS OF CAPITAL AND HIGH-TECHNOLOGY GOODS, SELECTED APEC MEMBER ECONOMIES

	(% of GDP)		
	1980	1990	1994
China	1.9	4.4	8.3
Hong Kong, China	16.8	16.4	18.6
Indonesia	4.6	9.0	8.2
Korea	8.4	10.4	10.8
Malaysia	17.8	36.0	42.2
Mexico	4.5	7.9	16.8
Singapore	66.2	84.4	87.2
Chinese Taipei	10.3	13.8	14.8
Thailand	7.4	16.7	17.9

Source:
UN Industrial Development Organization, Industrial Development Global Report, 1996.

TABLE 12

TECHNOLOGY BALANCE OF PAYMENTS COVERAGE RATIO, SELECTED APEC MEMBER ECONOMIES [1]

	Coverage Ratio			
	1981	1987	1990	1995 or latest
Australia	0.05	-	0.36	0.52 [2]
Canada	0.20	0.98	1.00	1.27 [2]
Japan	0.70	0.76	0.91	1.43
Mexico	-	-	-	0.24
New Zealand	-	-	1.06	2.48
United States	7.10	5.38	5.31	3.96 [2]

Notes:
1. The "technology balance of payments" registers money paid and received for the use of patents, licenses, trademarks, designs, know-how and closely related technical services, and for industrial R & D carried out abroad, etc. The coverage ratio is the coefficient obtained by dividing receipts by payments
2. 1994

Source:
OECD, Main Science & Technology Indicators, various years

TABLE 13

IMPORTS FROM U.S. AND JAPAN AS A PERCENT OF TOTAL DOMESTIC IMPORTS OF APEC MEMBER ECONOMIES, 1994

	From United States	From Japan
	% of total domestic imports	
Australia	21.9	15.4
Brunei [1]	5.9	4.1
Canada	66.7	5.4
Chile	24.7	6.6
China	9.9	22.0
Hong Kong, China	7.7	14.8
Indonesia [1]	9.5	27.8
Japan	22.6	-
Korea	22.5	24.1
Malaysia	16.3	27.3
Mexico	74.5	5.0
New Zealand	18.7	13.9
Papua New Guinea [1]	3.9	9.2
Philippines	18.4	22.4
Singapore	15.0	21.1
Chinese Taipei	20.3	29.6
Thailand [1]	11.5	29.2
United States	-	16.5

Notes:

1. For Brunei, Indonesia, Papua New Guinea and Thailand, total world imports are measured on the IMF's Direction of Trade Statistics (DOTS) basis. For other economies, imports are measured on the IMF's International Financial Statistics (IFS) basis

Source:
IMF Direction of Trade Statistics Yearbook, 1995. Chinese Taipei data are sourced from Asian Development Bank, Key Indicators of Developing Asian and Pacific Countries, 1995

TABLE 14

PERCENTAGE OF APEC MEMBER ECONOMIES' INWARD STOCK OF DIRECT INVESTMENT SOURCED FROM THE UNITED STATES AND JAPAN, 1993

	From United States	From Japan
	% of total stock of inward FDI	
Australia	30	15
Brunei	n/a	n/a
Canada	65	4
Chile	n/a	n/a
China	9	9
Hong Kong, China	28	34
Indonesia	5	21
Japan	41	-
Korea	29	40
Malaysia	11	22
Mexico	n/a	n/a
New Zealand	n/a	n/a
Papua New Guinea	n/a	n/a
Philippines	44	20
Singapore [1]	18	7
Chinese Taipei	27	29
Thailand	17	33
United States	-	22

Note:

1. 1991

Source:
Data for China; Hong Kong, China; Indonesia; Korea; Malaysia; Philippines; Singapore; Chinese Taipei, and Thailand are drawn from UNCTAD, World Investment Report, 1995, 1982, and 1983. For other economies, the data are drawn from the OECD International Direct Investment and Statistics Yearbook.

TABLE 15

STUDENTS FROM APEC MEMBER ECONOMIES ENROLLED IN THIRD-LEVEL EDUCATION IN THE UNITED STATES, 1995/96

Home APEC Economy	Third-Level Students Enrolled in the United States	
	No.	As Percentage of Third-Level Enrolment in Home Economy
Australia	2,244	0.2
Brunei	26	1.9
Canada	23,005	1.1 [1]
Chile	1,016	0.2
China	72,315	1.8
Hong Kong, China	12,018	13.9
Indonesia	12,820	0.6 [1]
Japan	45,531	1.5 [1]
Korea	36,231	1.5
Malaysia	14,015	8.1
Mexico	8,687	0.6 [1]
New Zealand	848	0.4
Papua New Guinea	35	0.2
Philippines	3,127	0.2 [1]
Singapore	4,098	6.5 [1]
Chinese Taipei	33,530	7.2 [2]
Thailand	12,165	0.8 [1]
Total Foreign Students from APEC member economies in the United States	453,787	

Notes:
1. Total third-level enrolment figure is for 1994.
2. This covers 1990/91 and is based on data collected by the U..S. National Science Board.

Source:
UNESCO, Statistical Yearbook, 1997; and U.S. National Science Board, Science and Engineering Indicators, 1995

TABLE 16

INFORMATION TECHNOLOGY (IT) MARKETS IN SELECTED APEC MEMBER ECONOMIES, 1994

	Market Share, 1994 1994	Market Growth1987-94 (Percentage)	IT/GDP, 1994 1994
North America			
United States	41.4	8.7	2.8
Canada	2.9	13.5	2.4
Mexico	0.7	25.3	0.9
Oceania			
Australia	1.7	9.5	2.4
New Zealand	0.3	14.4	3
East Asia			
Japan	16.9	11.5	1.7
Korea	1.4	19.0	1.6
China	0.6	22.6	0.5
Hong Kong, China	0.4	23.6	1.2
Chinese Taipei	0.4	11.7	0.8
Singapore	0.3	17.2	1.9
Malaysia	0.2	16.8	1.3
Thailand	0.2	16.2	0.6
Indonesia	0.2	24.2	0.4
Philippines	0.1	25.5	0.5
World	100	9.9	1.8
1994 World Market	$US 455 million		

Source:
OECD, Information Technology Outlook, 1997.

TABLE 17

SOME MEASURES OF COMPUTERIZATION IN APEC MEMBER ECONOMIES

	Total Number 1995	Per 100 Inhabitants 1995	Computer Power [1] Estimated World Share 1993	Estimated Facsimile Machines 1995
	(thousands	(number)	(percentage)	(thousands)
Australia	4,979	27.58	1.90	475.0
Brunei	8	2.87	-	2.0
Canada	5,700	19.25	2.94	525.0
Chile	540	3.78	0.15	15.0
China	2,600	0.21	0.55	270.0
Hong Kong, China	720	11.63	0.24	284.9
Indonesia	730	0.37	0.17	85.0
Japan	19,100	15.25	6.93	8,000.0
Korea	5,420	12.08	0.87	375.0
Malaysia	800	3.97	-	58.1
Mexico	2,400	2.61	0.85	180.0
New Zealand	800	22.27	0.28	65.0
Papua New Guinea	-	-	-	0.8
Philippines	770	1.14	0.18	35.0
Singapore	515	17.24	0.19	55.6
Chinese Taipei	1,773	8.32	0.88	430.0
Thailand	680	1.52	0.25	60.0
United States	86,300	32.80	48.57	14,052.0

Notes:

1. Computer power is measured in MIPS (millions of instructions per second).

Source:
ITU, World Telecommunications Development Report, 1996/97; Computer Industry Almanac. [year]

TABLE 18

INDUSTRIAL AUTOMATION EXPENDITURES SELECTED APEC MEMBER ECONOMIES, 1991 [1]

	U.S.$ (Billions)	Percentage of World Exports	Share of Industry Gross Fixed Capital Formation
North America			
United States	40.0	29.9	20.9
Canada	3.0	2.2	9.5
Mexico	1.1	0.9	-
Oceania			
Australia	1.1	0.8	-
East Asia			
Japan	27.3	20.4	-
Korea	2.9	2.1	-
Chinese Taipei	1.3	1	-
Singapore	0.6	0.5	-
Hong Kong, China	0.2	0.2	-
World Total	133.9	100	-

Note:
1. Automation expenditures comprise computer-ordered design, computer-aided engineering, computer-aided production equipment, automated materials handling, test inspection, communications and control, and software.

Source:
Automation Forum, Global Industrial Automation Profile, Washington, D.C., 1993

TABLE 19

NUMERICALLY CONTROLLED MACHINE USE, SELECTED APEC MEMBER ECONOMIES, 1987 AND 1991

	1987			1991		
	NC Units	Share of Machines in Economy	Share of Major Users' Total	NC Units	Share of Machines in Economy	Share of Major Users' Total
Japan	22,661	55.6	25.7	38,934	59	35.5
U.S.	15,474	46.4	23.4	15,316	43	13.8
Korea	2,341	22.1	2.7	5,305	35.5	4.2
Chinese Taipei	-	21.3	1.1	2,880	37.4	1.7
Major User Total	46,682	43.2	100	89,021	47.2	97.3

Notes:
1. Major Users include, in addition to the APEC member economies in this table, the following European economies: Germany, France, United Kingdom, Spain, Italy, and Switzerland.

Source:
UN Industrial Development Organization, Industry and Development Global Report 1993/94, (Vienna: UN), 1993

TABLE 20

INDUSTRIAL ROBOT USE, SELECTED APEC MEMBER ECONOMIES, 1994

	Stock of Robots	Robot Densities [1]	
		All Types of Robots	Advanced Robots
Australia	2,063	22.7	18.2
Japan	377,025	337.9	277.8
Korea	7,200	23.3	18.6
Singapore	3,950	112.2	64
Chinese Taipei	3,297	13.3	-
United States	55,000	32.5	29.3

Note:
1. Number of robots per 10,000 people employed in the manufacturing industry

Source:
UN and International Federation of Robotics, World Industrial Robots, 1994-96

TABLE 21

TELECOMMUNICATIONS ACCESS IN APEC MEMBER ECONOMIES, 1995

	Main Lines		Cellular Subscribers		Local Telephones Digitalization
	Growth Rate 1990-1995	Per 100 Inhabitants	Growth Rate 1990-1995	Per 100 Inhabitants	Percentage
Australia	3.4	50.96	65.6	12.77	62.0
Brunei	14.2	23.99	82.5	12.63	53.0
Canada	2.7	58.97	34.7	8.75	92.0
Chile	17.0	13.20	69.9	1.38	100.0
China	42.8	3.35	188.0	0.30	99.2
Hong Kong, China	5.8	52.96	42.9	12.90	100.0
Indonesia	25.3	1.69	64.6	0.11	93.0
Japan	2.3	48.80	63.7	8.15	84.0
Korea	7.0	41.47	83.0	3.66	63.0
Malaysia	16.0	16.56	58.7	4.34	95.0
Mexico	10.4	9.58	58.6	0.7	88.0
New Zealand	3.2	47.85	48.3	10.80	98.8
Papua New Guinea	7.7	1.01	-	-	55.0
Philippines	18.2	2.09	119.3	0.73	70.0
Singapore	6.3	47.85	41.8	9.77	100.0
Chinese Taipei	7.8	43.07	56	3.62	91.5
Thailand	21.3	5.86	76.6	1.83	86.9
United States	3.8	62.57	44.9	12.84	73.0

Source:
ITU, World Telecommunication Development Report, 1996/97

TABLE 22

TELEVISION ACCESS IN APEC MEMBER ECONOMIES, 1995

	TV Receivers per 100 Inhabitants	TV Households as % of total households	Cable Television Subscribers as % of total households	Home Satellite Antennas as % of TV Households
Australia	64.1	95.1	-	-
Brunei	60.9	98.0	-	14.0
Canada	64.7	98.0	76.2	2.7
Chile	28.0	91.5	23.1	-
China	25.2		13.6	0.3
Hong Kong, China	35.9	94.2	6.3	0.1
Indonesia	14.7	57.9	-	3.9
Japan	61.9	80.4	29	20.7
Korea	32.1	99.3	19.6	3.8
Malaysia	23.1	72.9	-	1.6
Mexico	19.2	86.5	7.6	-
New Zealand	50.6	85.3	-	-
Papua New Guinea	16.6	68.4	-	-
Philippines	12.6	56.7	5.3	0.4
Singapore	36.2	88.2	5.8	-
Chinese Taipei	31.7	96.5	64.3	2.7
Thailand	22.7	93.8	1.8	0.8
United States	77.6	3.1	65.2	4.0

Source:
ITU, World Telecommunication Development Report, 1996/97

TABLE 23

INTERNET USE IN APEC MEMBER ECONOMIES, 1996

	Number of Hosts (thousands)	Growth Rate 1993-1996 (percentage)	Hosts per 100 Inhabitants (number)
Australia	514.8	79.1	2.8
Brunei	0.2	-	0.1
Canada	603.3	91.2	2.0
Chile	15.9	126.2	0.1
China	19.7	-	a
Hong Kong, China	49.2	104.8	0.8
Indonesia	9.6	-	a
Japan	734.4	158.0	0.6
Korea	66.3	94.7	0.2
Malaysia	4.2	112.9	a
Mexico	29.8	103.0	a
New Zealand	84.5	144.6	2.3
Papua New Guinea	-	-	a
Philippines	3.6	-	a
Singapore	28.9	118.4	1
Chinese Taipei	34.7	63.2	0.2
Thailand	9.2	222.4	a
United States	10,112.9	89.9	3.8

Note:

(a) Less than 0.1

Source:
ITU, Challenges to the Network: Telecommunications and the Internet, Sept. 1997

TABLE 24

GROSS DOMESTIC SAVINGS AND INVESTMENT AS A PERCENT OF GDP, APEC MEMBER ECONOMIES, SELECTED YEARS

	1970		1980		1995	
	Gross Domestic Savings	Gross Domestic Investment	Gross Domestic Savings	Gross Domestic Investment	Gross Domestic Savings	Gross Domestic Investment
	(percentage)					
Australia	27	27	24	25	22	23
Brunei	-	-	-	-	-	-
Canada	24	22	25	24	21	19
Chile	20	19	20	25	29	27
China	29	28	35	35	42	40
Hong Kong, China	25	21	34	35	33	35
Indonesia	14	16	37	24	36	38
Japan	40	39	31	32	31	29
Korea	15	24	25	32	36	37
Malaysia	27	22	33	30	37	41
Mexico	19	21	25	27	19	15
New Zealand	22	25	20	21	26	24
Papua New Guinea	6	42	15	25	39	24
Philippines	22	21	24	29	15	23
Singapore	18	39	38	46	-	33
Chinese Taipei	18	22	24	31	16	23
Thailand	21	26	23	29	36	43
United States	18	18	19	20	15	16

Source:
World Bank, World Development Report, 1982, 1983, 1997

TABLE 25

HEALTH INDICATORS, APEC MEMBER ECONOMIES, SELECTED YEARS

	Infant Mortality Rate (per 1000 live births)		Life Expectancy (Index)	Population with access to: Health Services (%)	Safe Water (%)	Sanitation (%)
	1970	1996	1994	1985-93	1990-96	1990-96
Australia	17	6	0.89	+	+	+
Brunei	-	8	0.83	-	-	-
Canada	18	6	0.90	+	+	+
Chile	77	15	0.83	97	86 [1]	-
China	69	39	0.73	88	67	24
Hong Kong, China	19	5	0.90	-	100	-
Indonesia	118	51	0.64	93	62	51
Japan	14	4	0.91	+	+	+
Korea	46	10	0.77	100	93	100
Malaysia	45	12	0.77	-	78	94
Mexico	72	34	0.78	93	83	72
New Zealand	17	8	0.86	+	+	+
Papua New Guinea	112	64	0.52	96	28	22
Philippines	71	37	0.70	71	86	77
Singapore	21	6	0.87	-	100	-
Chinese Taipei	17	5	-	+	+	+
Thailand	-	35	0.74	90	89	96
United States	20	7	0.85	+	+	+

Note:
+ at or close to 100%
- n/a
1. Chile's figure for safe water is a 1991 value.

Source:
World Bank, World Development Report, 1995; United Nations Development Program, Human Development Report, 1997; for Chinese Taipei, data are drawn from its Statistical Yearbook 1996

TABLE 26

EDUCATION INDICATORS, APEC MEMBER ECONOMIES, SELECTED YEARS

	Adult Illiteracy Rate %	Enrolment Rates (%)						Primary Pupil/ Teacher Ratio 1994/95 or latest
		Primary		Secondary		Tertiary		
	1995	1970	1995	1970	1995	1970	1995	
Australia	a	115	108	82	147	25	72	17 [1]
Brunei	12.0	-	107 [1]	-	71 [1]	0.8 [1]	-	15 [2]
Canada	a	101	102 [1]	65	106 [1]	42	103 [1]	16
Chile	5.0	107	99	39	69	13	28	27 [2]
China	19.0	89	120 [2]	24	69 [2]	1	6 [2]	24 [3]
Hong Kong, China	8.0	117	96	36	75	11	20	24 [4]
Indonesia	16.0	80	114 [1]	16	48 [1]	4	11 [1]	23
Japan	a	99	102 [1]	86	-	31	32 [1]	19
Korea	a	103	101	42	101	16	52	32 [4]
Malaysia	17.0	87	91 [2]	34	58 [2]	4	-	20 [2]
Mexico	10.0	104	115 [1]	22	58 [1]	14	14 [1]	29 [1]
New Zealand	a	110	100	77	93	29	58	17
Papua New Guinea	28.0	52	80	8	14	2	3	33 [1]
Philippines	5.0	108	111 [1]	46	80 [1]	28	27 [1]	34
Singapore	a	105	107	46	-	8	34	26
Chinese Taipei	a	101	101 [2]	75 [7]	96 [2]	18	48 [2]	22 [2]
Thailand	6.0	83	87	17	55	13	20	22 [5]
United States	a	-	102	-	97	56	81	16

Notes:
Enrolment rates are for gross enrolment
a Illiteracy is less than 5 percent
1 1994
2 1996
3 1996/97
4 1995/96
5 1990/91

Source:

UNESCO, Statistical Yearbook, 1997; for Chinese Taipei, data are drawn from its Statistical Yearbook, 1996

TABLE 27

PREDICTED VS. ACTUAL EDUCATIONAL ATTAINMENT
IN KOREA AND CHINESE TAIPEI, 1960

	Primary Enrolment Ratio		Secondary Enrolment Ratio		Literacy Rate	
	Predicted	Actual	Predicted	Actual	Predicted	Actual
Korea	0.57	0.94	0.10	0.27	0.31	0.71
Chinese Taipei	0.62	0.96	0.12	0.28	0.36	0.54

Source:
Dani Rodrik, "Getting Interventions Right: How South Korea and Taiwan Grew Rich," Economic Policy, April 1995

TABLE 28

INFRASTUCTURE IN APEC MEMBER ECONOMIES, EXCLUDING TELECOMMUNICATIONS

	Electric Power		Paved Roads		Water		Railways	
	Prod-uction	System Losses	Road Density	Roads in Good Condition	Pop. with Access to Safe Water	Losses	Rail Traffic Units	Diesels in Use
	(Kwh per capita)	(% of Output)	(km/mill Persons)	(% of paved roads)	(% of Total)	(% of Total)	(per '000 $ of GDP)	(% diesel inventory)
	1992	1992	1992	1988	1991	1986	1992	1992
Australia	9,221	7	16,221	+	100	-	75	81
Brunei								
Canada	18,309	7	11,451	-	100	-	325	91
Chile	1,646	11	808	42	86	-	42	57
China	647	7	-	-	71	-	847	82
Hong Kong, China	6,051	11	268	-	100	-	-	-
Indonesia	233	17	160	30	42	29	27	75
Japan	7,211	4	6,426	+	-	-	147	88
Korea	2,996	5	1,090	70	78	-	146	88
Malaysia	1,612	9	-	-	78	29	30	76
Mexico	1,381	14	1,019	85	78	-	73	75
New Zealand	9,086	8	15,725	-	97	-	64	90
Papua New Guinea	-	-	196	34	33	-	-	-
Philippines	419	13	242	31	81	53	-	-
Singapore	6,353	5	993	-	100	8	-	-
Chinese Taipei								
Thailand	1,000	10	841	50	72	48	75	72
United States	12,900	8	14,453	+	-	-	344	90

Note:
+ sign indicates that 85 percent or more of roads are in good condition

Source:
World Bank, World Development Report, 1995

TABLE 29

DUN & BRADSTREET RISK INDICATORS, APEC MEMBER ECONOMIES, 1995, 1996 & 1997

	February 1995	February 1996	October 1997
Australia	DB1d	DB1d	DB1d
Brunei	-	-	-
Canada	DB1d	DB1d	DB1d
Chile	DB2b	DB2b	DB2b
China	DB3a	DB3a	DB3a
Hong Kong, China	DB2b	DB2b	DB2b
Indonesia	DB3a	DB3a	DB3a
Japan	DB1c	DB1c	DB1c
Korea	DB2b	DB2b	DB2b
Malaysia	DB2b	DB2b	DB2b
Mexico	DB3b	DB3d	DB3d
New Zealand	DB1d	DB1d	DB1d
Papua New Guinea	DB3d	DB4a	DB4b
Philippines	DB3c	DB3c	DB3a
Singapore	DB1c	DB1c	DB1c
Chinese Taipei	DB2a	DB2a	DB2a
Thailand	DB2d	DB2d	DB3b
United States	DB1b	DB1b	DB1b

Note:
DB1 highest credit worthiness
DB2 sound credit worthiness
DB3 credit worth
DB4 adequate credit risk
DB5 questionable credit worthiness
DB6 poor credit worthiness
DB7 lowest credit worthiness
Each indicator ranges from a to d, with 'a' representing slightly less risk than 'b', etc.

Source:
Dun & Bradstreet International, International Risk and Payment Review, February 1995, February 1996, and October 1997

TABLE 30

INSTITUTIONAL INVESTOR CREDIT RATINGS, APEC MEMBER ECONOMIES, 1994 - 1997

	March 1994		March 1995		March 1996		March 1998	
	Rating	Global Ranking [1]	Rating	Global Ranking [1]	Rating	Global Ranking [1]	Rating	Global Ranking [1]
Australia	68.9	22	70.9	21	71	22	73.7	21
Brunei	-	-	-	-	-	-	-	-
Canada	81.9	10	80.2	12	79.9	13	83.1	12
Chile	53.6	34	55.6	34	59.2	31	63.2	27
China	58.0	31	57.6	30	56.4	33	57.6	32
Hong Kong, China	66.0	26	67	26	65.4	26	62.9	28
Indonesia	51.7	37	51.9	40	51.8	39	49.9	46
Japan	91.0	2	91.9	2	91.0	3	90.8	4
Korea	69.5	21	71.4	20	72.0	21	64.4	25
Malaysia	66.6	24	68.6	23	68.4	25	64.5	24
Mexico	46.9	42	46.9	44	41.2	51	45.2	52
New Zealand	66.1	25	68.2	24	70.3	23	73.4	22
Papua New Guinea	32.8	58	32.4	64	33.0	63	33.2	75
Philippines	30.5	61	35.4	58	38.1	59	43.3	55
Singapore	81.4	11	83	10	82.8	10	82.9	13
Chinese Taipei	79.0	12	79.7	13	78.9	15	75.5	20
Thailand	61.1	27	63.5	27	63.4	27	52.3	41
United States	89.7	3	90.4	4	90.9	4	92.6	2

Note:
1. Global ranking is out of 135 ranked economies.

Source:
Institutional Investor, March 1994, March 1995, March 1996 & March 1998

TABLE 31

TELECOMMUNICATIONS STAFF & REVENUE

	Staff (000's)	Revenue as a % of GDP
Australia	76.9	3.2
Brunei	0.9	2.3
Canada	81.1	1.9
Chile	11.0	2.3
China	479.5	1.3
Hong Kong, China	38.4	3.3
Indonesia	39.8	1.3
Japan	221.5	1.6
Korea	62.1	1.8
Malaysia	28.8	2.4
Mexico	49.0	2.3
New Zealand	9.1	3.4
Papua New Guinea	2.1	2.8
Philippines	19.4	1.3
Singapore	6.6	3.0
Chinese Taipei	35.8	2.2
Thailand	34.9	1.3
United States	625.0	2.4

Source:
ITU, World Telecommunications Development Report, 1996/97

TABLE 32

ECONOMIC GROWTH AND INFORMATION STATUS

	Per Capita GNP Annual Average Growth 1980 - 93		R&D	Open-ness	Human Capital	Gross Domestic Investment Annual Average Growth
	Ranking	Rating [1]	Rating [2]	Rating [3]	Rating [4]	Rating [5]
High Growth Group						
China	1	H	L	L [6]	L	H
Korea	1	H	M	H	H	H
Chinese Taipei	2	H	M	H	H	H
Thailand	3	H	L	H	L	H
Singapore	4	H	L	H	M	M
Hong Kong, China	5	H	L	H	M	M
Medium Growth Group						
Indonesia	6	M	L	H	L	H
Chile	7	M	L	H	M	H
Malaysia	8	M	L	H	L	H
Japan	9	M	H	H	H	M
Low Growth Group						
United States	10	L	H	H	H	L
Australia	11	L	M	H	H	L
Canada	12	L	M	H	H	L
New Zealand	13	L	L	M	H	M
Papua New Guinea	14	L	L	L	L	L
Mexico	15	L	L	M	L	L
Philippines	16	L	L	M	M	L
Brunei	17	L	L	n/a	M	n/a

Notes: See below.

Source:
UN Human Development Report, 1996; IMF International Financial Statistics, 1995; J. Sachs and A. Warner, Economic Reform and the Process of Global Integration", Brookings Papers on Economic Activity 1, 1995, Sources for Tables referred to in notes.

Notes to Table 32

1. Based on World Bank calculations
   - H Average annual growth rate exceeds 5 percent
   - M Average annual growth rate of 2 to 5 percent
   - L Average annual growth rate under 2 percent

2 Based on R & D as a percent of GNP. Used average for 1981 and latest year available, as provided in Table 1.
   - H R & D as percent of GNP exceeds 2 percent
   - M R & D as percent of GNP is between 1 and 2 percent
   - L R & D as percent of GNP is under 1 percent

3 Based on timing of trade liberalization as calculated in Sachs and Warner, 1995
   - H Economy was open by 1980
   - M Economy was closed for a significant portion of '80-93
   - L Economy was closed at end of 1993

4 Based on data in Table 26
   - H Secondary enrolment rate exceeded 60 % in 1992
   - M Secondary enrolment rate was between 60 & 80 % in '92
   - L Secondary enrolment rate was below 60% in 1992

5 Based on World Bank date
   - H Average annual growth rate of domestic investment exceeded 6%
   - M Average annual growth rate of domestic investment between 3.5 & 6 % t
   - L Average annual growth rate of domestic investment below 3.5 percent

6 The classification of China as a closed economy is subject to major qualifications, as noted by Sachs & Warner and discussed in the text.

TABLE 33

PRODUCTION OF INFORMATION AND COMMUNICATION TECHNOLOGY GOODS, SELECTED APEC MEMBER ECONOMIES, 1994

	Millions $US	Share of World Total	Growth (%) 1985-94
Australia	2,799	0.4	12.8
Canada	7,141	1.0	6.1
Hong Kong, China	7,127	1.0	11.4
Indonesia	3,595	0.5	23.8
Japan	216,350	30.4	11.5
Korea	35,010	4.9	21.2
Malaysia	20,731	2.9	31.1
Philippines	3,974	0.6	16.4
Singapore	31,032	4.4	24.5
Chinese Taipei	22,800	3.2	16.6
Thailand	9,368	1.3	36.1
United States	201,093	28.3	3.3

Source:
OECD, Information Technology Outlook 1997

TABLE 34

OUTGOING INTERNATIONAL TELEPHONE TRAFFIC, APEC MEMBER ECONOMIES, 1995

	Minutes	Growth, 1990-95 (%)	Minutes per Inhabitant
Australia	950.0	12.1	52.6
Brunei	30.7	18.2	108.0
Canada	2958.9	9.7	99.9
Chile	136.0	24.1	9.5
China	1339.1	30.8	1.1
Hong Kong, China	1691.8	18.3	273.3
Indonesia	205.9	21.4	1.1
Japan	1638.0	11.8	13.1
Korea	557.3	25.0	12.4
Malaysia	369.2	21.4	18.3
Mexico	945.0	17.9	10.3
New Zealand	307.5	16.1	85.6
Papua New Guinea	23.9	4.5	5.6
Philippines	172.3	10.0	2.6
Singapore	773.0	18.9	258.8
Chinese Taipei	593.0	19.6	27.8
Thailand	221.9	18.4	3.7
United States	15,657.2	14.3	59.5

Source:
ITU, World Telecommunications Development Report, 1996/97

TABLE 35
Summary Of APEC Member Economies' Commitments under WTO Agreement on Basic Telecommunications, 15 February 1997

Economy	Foreign ownership limitation	Other major commitments
Australia	None	Unrestricted competition as from July 1997. End of limits on numbers of carriers from that date.
Brunei Darussalam	Reserved for exclusive operator	Commits to undertake policy review in 2010
Canada	46.7% direct and indirect investment in the voting capital	Commits to remove restrictions on landing rights for submarine cables. Exclusive rights on satellite facilities and earth stations to serve the North American market will be eliminated from April 2002.
Chile	None	Full competition in national long-distance and international markets for all basic telecommunication services.
Hong Kong, China	None	Competition in local market for most telecommunication services and for infrastructure after June 1998. Allows call-back and other alternative calling procedures.
Indonesia	35% except personal communication services which only require a joint-venture with a local company	A policy review will take place when current licenses expire: in 2001 for local service, 2006 for long-distance and 2005 for international. Service competition for packet-switched data, telex and Internet subject to use of networks of existing operators.
Japan	20% in KDD and NTT. 100% in all other suppliers	Open market access in most market area, including a commitment to eliminate prohibitions on international simple resale. Foreign ownership restrictions limited to KDD and NTT.
Korea	20% in Korea Telecom (33% from 2001). 33% in all other suppliers (49% from 2001)	Competition in fixed network services and full competition in resale of telecommunication services including voice resale as from 1999.

Economy	Foreign ownership limitation	Other major commitments
Malaysia	30% in existing licensed public telecommunication operator	Final offer allows foreign ownership of up to 30 per cent of existing licensed public telecommunication operator.
Mexico	49% Higher for cellular	Commitment to competition in local voice services, data and private leased circuits.
New Zealand	None, except no single foreign shareholder in TCNZ may hold more than 49.9%	Open market in all basic telecommunication services and all market segments.
Papua New Guinea	Reserved for exclusive operator	All telecommunication services are reserved to the exclusive operator until 2002. Offers to review and announce additional licenses by 2000.
Philippines	40%	Commitment to competition in telephone, data and cellular mobile.
Singapore	49%	Competition in facilities-based telecommunication services from April 2000 with the licensing of up to two additional operators. Open markets for cellular and other mobile services as from April 2000. Commits to resale of public-switched capacity for most basic services.
Thailand	20%	Commits to introduce market access and national treatment in telephone, telex, telegraph and fax, as from 2006.
United States	None (indirect) Radio licenses, 20% (direct)	Commits to open markets for all basic telecommunication services in all market segments including unrestricted access to common carrier radio licenses that are indirectly foreign-owned. Commits to removing restriction on landing rights for submarine cables. COMSAT monopoly over access to INMARSAT and INTELSAT capacity is retained.

Source:
Adapted from WTO. China and Chinese Taipei are not WTO members.

TABLE 36
Selected APII Pilot Projects and Related Cooperative Activities

Project	Status	TEL Steering Group	Lead Economy & Institute
A. Cooperation Promotion			
1. APII Cooperation Center	On-going	DCSG	Korea
2. APII technology Center	On-going	DCSG	Japan
3. APEC TEL WG Website	On-going	BFSG	Korea
4. Catalogue of APII Development and Financial Resources	On-going	DCSG	USA
B. Technology and Network			
5. APII Test-bed Project	On-going	DCSG	Japan, Korea, Singapore
6. X-400 Network Interoperability Testing	completed	BFSG	AOEMA
7. ATM Trial Network	On-going	DCSG	Chinese Taipei
C. Applications Development			
8. Interactive Medical Curriculum (IMC)	On-going	DCSG	Australia
D. Electronic Commerce			
9. APEC ED/Internet Pilot Project	On-going	BFSG	Japan
10. APEC SME Electron Commerce Study	On-going	BFSG	Australia, Canada
11. INGECEP Pilot Project	On-going	BFSG	Japan
12. APEC/PECC E-Commerce Seminar	completed	BFSG	Various APEC economies
E. Education and Training			
13. Distance Learning Pilot Project	completed	HRDSG	Canada
14. Model Vocational Education & Training Framework for Telecommunications	completed	HRDSG	Australia
15 Multimedia HRD System Network Technology Project	On-going	HRDSG	Japan
F. Policy Dialogue and Studies			
16. APEC Study on Interconnection	On-going	LSG	USA
17. APEC/PECC Communications & Information Policy Forum	completed	BFSG	Various APEC economies
18. APEC/PECC Content/Information & Applications Seminar	On-going	BFSG	Various APEC economies
19. Mutual Recognition Arrangement	On-going	LSG	USA
20. Seminar on Universal Access	completed	DCSG	
21. Harmonized Electromagnetic Compatib-ility Management (EMC) Project	On-going	DCSG	Australia
22. Global Positioning System (GPS) Technologies in the APII	On-going	DCSG	USA
23. Study on the Impact of APII	On-going	BFSG	Korea

Source: Adapted from 17th Telecommunications Working Group Meeting Documents. March, 1998, Brunei Darussalam.

Second, there is a need to promote infrastructure development through a balanced strategy that focuses both on the liberalization needed to facilitate efficient private markets in information products and on the cooperative arrangements needed to address the concerns of lower-income economies. APEC Ministers have recognized the need for this two-pronged approach and they have encouraged trade and investment liberalization along with a broad range of cooperative actions. APEC has helped to build support for recent multilateral agreements in the telecommunications sector, while also pursuing other initiatives to make telecommunications a model sector in achieving the goals established by Economic Leaders at Bogor. Economic and technical cooperation is based on the objectives and principles of the APII contained in the Seoul Declaration and includes programs to promote the information society generally and projects to support development in particular areas such as electronic commerce.

While efforts have been made to encompass all communities within the APII, more could conceivably be done to reassure low-income economies that they will significantly participate in the direct benefits from development of a regional information infrastructure. Most of the pilot projects within APEC to promote development of information technologies and applications are currently led by a few advanced economies. Greater efforts could be devoted to designing projects that are of interest to, and attract the participation of, lower-income APEC members. Similarly, education and training within APEC could be further directed towards meeting the needs of lower-income economies that lack an adequate supply of well-trained information managers and workers. This would require that APEC training programs reach beyond the public sector to address certain important private sector training needs within APEC member economies. Developing member economies for their part must put a special emphasis on putting in place the policy frameworks to promote the evolution of the information society.

There is a need for ongoing efforts to ensure that APEC initiatives to promote the APII appropriately balance the need for liberalization and other market-based reforms with the need for cooperation and support for those economies with less developed information infrastructure. Current Ecotech initiatives need to be reviewed to determine whether existing programs of technical cooperation and human resource development need to be adjusted to focus more sharply on the requirements of developing economies.