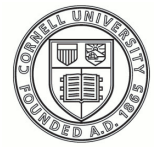

2014

Innovative Asia: Advancing the Knowledge-Based Economy - The Next Policy Agenda

Asian Development Bank

Innovative Asia: Advancing the Knowledge-Based Economy - The Next Policy Agenda

Abstract

[Excerpt] This study by the Asian Development Bank (ADB) seeks to analyze the ways in which Asia's middle- and low-income countries can tap knowledge-based economic development to maintain and strengthen the growth momentum and to move up global value chains. The ADB study uses the Knowledge Economy Index (KEI) rubric to benchmark the performance of developing economies in Asia against advanced economies of the world. It is clear that on all the four pillars of the knowledge economy—innovation, education and skills, ICT, and the economic incentive and institutional regime—developing economies in Asia significantly lag behind advanced nations. Policy makers in developing Asia need ensure appropriate investments and conducive policies across all the four pillars. The report traces the journey of the Republic of Korea, Singapore, and Finland as KBEs and the lessons developing economies can derive. However, going beyond this, the report also highlights a number of special advantages that Asia can effectively tap that will help them leapfrog to the knowledge frontier. The relative lack of legacy infrastructure in developing economies, particularly in information communication technology, could enable developing economies to leapfrog over certain technology cycles and access the latest technologies, such as moving to cloud computing solutions. Asia needs to effectively combine established wisdom from the experience of developed economies with contemporary knowledge and options that new technologies bring to strengthen KBE processes. An important dimension for developing economies in Asia to consider, given the rising inequality in the region, is making KBE processes inclusive. This report explores a number of opportunities in this direction.

Keywords

Asia, development, Knowledge Economy Index, KEI, knowledge-based economies

Comments

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The Next Policy Agenda

ASIAN DEVELOPMENT BANK

ADB

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6 ADB Avenue, Mandaluyong City
1550 Metro Manila, Philippines
Tel +63 2 632 4444
Fax +63 2 636 2444
www.adb.org

For orders, please contact:
Public Information Center
Fax +63 2 636 2584
adbpub@adb.org

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ADVANCING KNOWLEDGE-BASED ECONOMIES IN ASIA

CATCHING UP ON LAGS AND GAPS

POLICIES

Provide economic incentives for knowledge

- Strengthen IPR protection and easy patenting
- Improve business environment, especially for high-tech entrepreneurial firms
- Improve governance and role of government in accessing and applying technologies

Help innovation to flourish

- Support both new technologies and technology adaptation
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Introduce flexible education systems

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Promote market mechanism for ICT

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- Apply universal access and service programs for affordable broadband in rural areas and small towns

ADVANCING KNOWLEDGE-BASED ECONOMIES IN ASIA

USING SPECIAL ADVANTAGES

ASIA'S STRENGTHS

Cater to the consumption of expanding "middle pyramid"

- Projected Asia Pacific Share of Global middle class: 54% (2020); 66% (2030)
- Projected share of Asia Pacific middle class in global spending: 42% (2020); 59% (2030)

Benefit from the influence of growing intra-regional trade

- Share of intra-regional trade in total trade of Asia up from 54% in 2001 to 58% in 2011

Harness the power of mobile technologies

- Asia-Pacific share of world mobile data traffic projected to grow to 47% by 2017

Strengthen investments in key emerging technologies

- Boom in demand for frontier technology areas such as precision engineering semiconductors, biotech, and solar photovoltaic

Enhance capacities for innovation in high-value services

- Preferred location for IT-enabled services: 7 of top 10 locations for outsourcing of global services for delivering IT, BPO, and voice services are in Asia

Build on comparative advantage in creative industries

- PRC; Hong Kong, China; and India among top 10 exporters, accounting for over 30% of world exports of creative goods in 2008

POLICIES

- Promotion of technology adaptation for domestic markets and decentralized innovation hubs for local R&D
- A regional innovation strategy and regional R&D policies, eg, ASEAN Science and Innovation promotion
- Policies to facilitate rapid expansion of m-services such as m-health, m-education, and m-money
- Focus on skills development to address information technology-based manufacturing technologies and the rise of the "gray collar" tech worker
- Innovation strategies for the services sector, particularly higher-value IT-enabled services and knowledge-intensive services
- Use of massive open online courses (MOOCs) for cost-effective solutions for tertiary education and blended technical and vocational education delivery
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MARKET OPPORTUNITIES

- Global cumulative growth rate projected for technologies:
  - Low-end technologies-11%
  - Mid-range technologies- 10%
  - High-end technologies – 6%
- Annual growth rate of entry-level product innovations – 6% (for India and PRC – 10%)
- Mass market for cloud-enabled services: Cloud computing to generate 14 million jobs globally in the next 3 years—10 million in the PRC, India, and the Asia and Pacific region
- Learning games market projected to grow from $3.9 b currently to $8.9 b in 2017 and most will be from mobile apps
- 40 countries (including India and Indonesia) will have more people with mobile access than electricity at home; off-grid, on-net population will reach 138 million by 2015
- Data traffic from wireless and mobile devices will exceed wired data traffic by 2018 – projected at 61% of total traffic
- PRC and India have become net exporters of R&D services to the EU valued at €953 m and €734 m, respectively, in 2010

ADVANCING KNOWLEDGE-BASED ECONOMIES IN ASIA

AMPLIFYING GAME CHANGING TRENDS

POLICIES

- IPR policies for products for mid-range and bottom-of-the-pyramid markets in support of frugal and *jugaad* innovation for price-sensitive customers
- Policies for cheaper availability of smartphones; applications for mobile phones: 44 billion applications expected to be downloaded by 2016; increase mobile apps for development
- Policies to expand use of social, mobile, analytics, and cloud (SMAC) in corporate and business applications
- Promotion of use of tablets, and game-based and simulation-based pedagogies in education; using technology to move to personalized teaching and learning paradigms and for learning analytics
- Setting up of R&D centers of excellence (COEs) and putting national R&D services to effective use
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- Developing Innovative financing models for knowledge-based economies, deepening venture capital markets to complement bank-dominated financial markets in developing economies

Foreword

Asia has enjoyed such spectacular economic growth over the past 3 decades that we expect most of our developing member countries to have attained middle-income status by 2020. However, this means their development challenges will be more complex. First, they need to avoid becoming stuck in the middle-income trap. Second, they need to engineer a shift from mainly agricultural output and jobs to manufacturing and high-productivity services at a time when resources are becoming strained and skills of the workforce are reaching their limits. Building knowledge-based economies is therefore the most sustainable way of ensuring strong, long-term growth. It is with this thinking in mind that the Asian Development Bank prepared the study *Innovative Asia: Advancing the Knowledge-Based Economy.*

Building such an economy is difficult and multifaceted; it requires quality and accessible higher education, sound information infrastructure, strong research and development, persistent innovation, and the right economic institutions to support it all. Major countries in the Organisation for Economic Co-operation and Development, where more than 50% of gross domestic product is knowledge-based, have these attributes and successfully completed their structural transformations decades ago.

We have good examples in Asia also and lessons can be drawn from the experiences of Japan; the Republic of Korea; Singapore; Hong Kong, China; and Taipei,China, which all rank highly in the Knowledge Economy Index. The Republic of Korea, for one, has shown us that building a labor force capable of supporting sustained growth requires the correct mix of quality skills and knowledge. It has also exhibited the benefits of investing in information and communication technology (ICT) infrastructure. Singapore, similarly successful, has meanwhile shown the value of adopting and absorbing the latest technologies and building a highly efficient public sector that works seamlessly with the private sector to promote knowledge development.

Developing Asia is at a unique moment in history. Technological trends will help developing economies jump traditional development stages, redefining traditional patterns of growth and amplifying the potential that exists within these economies today. Moreover, strengthening information networks, particularly through mobile technologies that have the capacity to reach even the remotest customer in the poorest countries of the region, is a technology option that can serve both economic and social development needs. Rethinking education delivery using ICT platforms and tools to better prepare youth and employees for the changing demands of the workplace is another technology-based solution for growth with equity. There are also significant business opportunities in using innovative products and technologies to serve both price-sensitive customers at the bottom of the pyramid and the large and growing base of middle-class consumers.

True transformation into a knowledge-based economy does not mean merely the production of knowledge-intensive goods and services; rather, knowledge must be internalized and disseminated throughout the economy. Asia is home to some of the world's largest developing economies, but many countries—big and small—fall way below Organisation for Economic Co-operation and Development levels in rankings of knowledge-based economies. We need to close the gap between economic size and knowledge to be able to sustain Asia's growth. To do this, the choice of policy mix is critical.

My hope is that this study triggers a healthy debate on exactly how Asia should move forward as a collection of vibrant knowledge-based economies. We must understand the trade-offs and alternative scenarios at play. We need to identify the disruptive technologies which can change the rules of the game. We should also learn how to spur the entrepreneurial spirit needed for innovative thinking. A large part of that is encouraging critical thinking on how to create world-class tertiary education institutions, promote innovation, and strengthen ICT infrastructure in Asia in order to produce a workforce for the future. Finally, I hope that this study will convince both policy makers and the private sector to invest in research and development to allow Asian countries to leapfrog old technology.

We were fortunate to receive insights and guidance from the High-Level Panel for this study, led by Kishore Mahbubani of the Lee Kuan Yew School of Public Policy of the National University of Singapore and Lawrence Summers of Harvard University, together with eminent experts Dominic Barton, Han Duck-soo, Takatoshi Ito, K. Vaman Kamath, Justin Yifu Lin, Mari Pangestu, and Andrew Sheng.

The study's final report is presented in two volumes:

- Innovative Asia: Advancing the Knowledge-Based Economy – The Next Policy Agenda
- Innovative Asia: Advancing the Knowledge-Based Economy – Country case studies from the People's Republic of China, India, Indonesia, and Kazakhstan

In addition, the Asian Development Bank engaged the Economist Intelligence Unit to construct a new Creative Productivity Index. The report *Analysing Creativity and Innovation in Asia,* prepared by the Economist Intelligence Unit, highlights the importance of productivity and efficiency of various investments that contribute to knowledge-based economic development.

We hope this study will stimulate further discussion in the emerging economies of Asia on strategic choices and pathways to strengthen knowledge-based economic development for everyone.

Bindu N. Lohani
Vice-President, Knowledge Management and Sustainable Development
Asian Development Bank

Acknowledgments

High-Level Panel to Provide Strategic Guidance to the Study

Cochairs:

Kishore Mahbubani, Dean and Professor in the Practice of Public Policy, Lee Kuan Yew School of Public Policy, National University of Singapore
Lawrence Summers, Charles W. Eliot University Professor, Kennedy School of Government, Harvard University

Members:

Bindu N. Lohani, Vice-President for Knowledge Management and Sustainable Development, ADB
Dominic Barton, Global Managing Director, McKinsey & Company
Han Duck-soo, Chairman and Chief Executive Officer, Korea International Trade Association
Takatoshi Ito, Dean, Graduate School of Public Policy, University of Tokyo
K. Vaman Kamath, non-executive Chairman of the Board of Directors, ICICI Bank, and Infosys Technologies
Justin Yifu Lin, Honorary Dean, National School of Development, Peking University
Mari Pangestu, Minister of Tourism and Creative Economy, Indonesia
Andrew Sheng, President, Fung Global Institute

ADB Team

Management:

The study was implemented under the overall guidance of Bindu N. Lohani, Vice-President for Knowledge Management and Sustainable Development, ADB; Changyong Rhee, former Chief Economist, ADB; Woochong Um, Secretary, ADB (former Deputy Director General, Regional and Sustainable Development Department, ADB); S. Chander, Special Senior Advisor, Infrastructure and Public–Private Partnerships (former Director General, Regional and Sustainable Development Department); and Bart Edes, Director, Poverty Reduction, Social Development, and Governance Division, Regional and Sustainable Development Department, ADB.

Project Team:

The reports *Innovative Asia: Advancing the Knowledge Economy – Next Policy Agenda and Innovative Asia: Advancing the Knowledge Economy – Country Case Studies for the People's Republic of China, India, Indonesia, and Kazakhstan* were prepared by Shanti Jagannathan, Senior Education Specialist, Regional and Sustainable Development Department, ADB, Team Leader for this project. Members of the ADB team who worked on this study include Donghyun Park (co-Team Leader), Principal Economist, Economics and Research Department, ADB and Seok Yong Yoon,

Senior Public Management Specialist, Regional and Sustainable Development Department, ADB. Carmela Fernando Villamar provided coordination and research support throughout the study.

Consultants

Carl Dahlman, Jae Moon, Ron Perkinson, and Poh Kam Wong participated and contributed to this policy research study as a whole. The experts who contributed to the four country case studies are Yang Yao (People's Republic of China), Arpita Mukherjee (India), Hafid Abbas (Indonesia), and Oraz Jandosov (Kazakhstan). Rudai Yang and Binkai Chen (People's Republic of China), Tanu Goyal (India), Mohamad Fahmi (Indonesia), and Kassymkhan Kapparov (Kazakhstan) also contributed to the respective country reports.

Ross O'Brien provided editorial and infographic support.

Abbreviations

ADB	–	Asian Development Bank
ASEAN	–	Association of Southeast Asian Nations
BMS	–	biomedical sciences
COE	–	center of excellence
EIR	–	economic incentive and institutional regime
EU	–	European Union
GDP	–	gross domestic product
GEM	–	Global Entrepreneurship Monitor
ICT	–	information and communication technology
IFC	–	International Finance Corporation
IPR	–	intellectual property right
IT	–	information technology
ITeS	–	information technology-enabled services
ITRI	–	Industrial Technology Research Institute
KBC	–	knowledge-based capital
KBE	–	knowledge-based economy
KEI	–	Knowledge Economy Index
MNC	–	multinational corporation
MOOC	–	massive open online course
NOC	–	National University of Singapore Overseas College
NRI	–	Network Readiness Index
OECD	–	Organisation for Economic Co-operation and Development
PPP	–	purchasing power parity
PRC	–	People's Republic of China
R&D	–	research and development
SBIR	–	Small Business Innovation Research
SMEs	–	small and medium-sized enterprises
TEA	–	Total Entrepreneurial Activity
TFT-LCD	–	thin-film-transistor liquid-crystal-display
TVET	–	technical and vocational education and training
UAS	–	universal access and service

Executive Summary

Asia's emerging economies have enjoyed extraordinary economic success over the past quarter of a century. Much of the exemplary growth in developing Asia has come from its economies' long-held comparative advantage in labor-intensive goods. Emerging economies will, however, find it impossible to continue their success under the same growth models used so effectively over the last few decades, as technology accelerates and changes the ways countries produce and trade. With rising wages across the region, most developing Asian economies stand to lose their comparative advantage for labor-intensive manufacturing and will additionally feel the pressure of increasingly scarce and costly energy resources.

Strengthening knowledge-based economies (KBEs) is both an imperative and an opportunity for developing Asia. It is an imperative to sustain high rates of growth into the future and to avoid the middle-income trap. This requires productivity-led growth arising from innovation. Pursuing KBEs is also an opportunity where developing countries can tap beneficial global technology trends to step up competitiveness and move up in global value chains. In fact, developing countries stand to lose out significantly by not moving toward KBEs. Business investment in knowledge-based capital (KBC)—intangible assets such as data, software, patents, designs, trademarks, brand equity, new organizational processes, and firm-specific skills—has been increasing faster than investment in physical capital such as machinery and buildings in many countries of the Organisation for Economic Co-operation and Development (OECD). Studies of the European Union (EU) and the United States (US) reveal that business investment in KBC contributed 20%–34% of average labor productivity growth. By doing the same, developing economies can increase the value of their industries in global markets.

KBEs will also strengthen the ability of developing countries to better address poverty and inequality. While the percentage of people living below the poverty line in Asia has declined, income inequalities have increased. New knowledge-based paradigms of growth can help redress income inequality and rural-urban disparities. Science and innovation can support inclusive growth through job creation or through access to improved medicines, seeds, or clean water. The universal provision of information and communication technology (ICT) and broadband connectivity will open up opportunities to world-class resources in health and education, among other things, to the poorest communities. Support to growth and scaling up of frugal innovations will bring enormous economic and social spin-offs to bottom-of-the-pyramid consumers.

This study by the Asian Development Bank (ADB) seeks to analyze the ways in which Asia's middle- and low-income countries can tap knowledge-based economic development to maintain and strengthen the growth momentum and to move up global value chains. The ADB study uses the Knowledge Economy Index (KEI) rubric to benchmark the performance of developing economies in Asia against advanced economies of the world. It is clear that on all the four pillars of the knowledge economy—innovation, education and skills, ICT, and the economic incentive and institutional regime—developing economies in Asia significantly lag behind advanced nations. Policy makers in developing Asia need ensure appropriate investments and conducive policies across all the four pillars. The report traces the journey of the Republic of Korea, Singapore, and Finland as KBEs and the lessons developing economies can derive. However, going beyond this, the report also highlights a number of special advantages that Asia can effectively tap that will help

them leapfrog to the knowledge frontier. The relative lack of legacy infrastructure in developing economies, particularly in information communication technology, could enable developing economies to leapfrog over certain technology cycles and access the latest technologies, such as moving to cloud computing solutions. Asia needs to effectively combine established wisdom from the experience of developed economies with contemporary knowledge and options that new technologies bring to strengthen KBE processes. An important dimension for developing economies in Asia to consider, given the rising inequality in the region, is making KBE processes inclusive. This report explores a number of opportunities in this direction.

Economic Incentive and Institutional Regime

The economic incentive and institutional regime (EIR) is the set of regulations and institutions in a country that affect the incentives for carrying out economic activity. A robust EIR is a critical component of an effective knowledge economy.

Government as a friendly but effective regulator. The government's role as a regulator is critical since it provides stewardship over the economy. Governments that consistently execute focused, well-aligned KBE objectives see their economies progress faster. This ability to execute is particularly important where government action is required to mitigate the impact of clear market failures, such as to impose stringent intellectual property protection legislation, promote green growth, or redress social and income inequality. In addition, governments must assume a leadership role in developing a regulatory framework to ensure an effective finance sector, the lifeblood of start-ups and KBE-oriented industry sectors.

Cross-functional government agencies to supportknowledge-based economies. Advanced economies such as Finland, Singapore, and the Republic of Korea achieved fast and efficient coordination across government bodies through cross-functional agencies. The Economic Development Board has been instrumental in attracting foreign direct investment and in upgrading Singapore's economic structure. The Korea Institute of Science and Technology Evaluation and Planning supports projects that foster creative knowledge in science and technology that boost the country's competitiveness. In Finland, the Research and Innovation Council has been a high-level coordination body providing strategic direction to education, research, and innovation policy. In Singapore, the Agency for Science, Technology and Research is the lead agency for fostering world-class scientific research and talent for a vibrant knowledge-based and innovation-driven economy. Government leadership is crucial to advance a KBE, especially in the early stages of development. whereas at later stages, the private sector assumes a stronger role.

It is important to ensure that an economy's talent pools are used most productively. Emerging economy governments in particular face pressures to adopt legislation to protect worker welfare. However, excessive government control and regulation can also be a problem. It can impede the flow of knowledge and technology to a market, and can create bureaucracy, which constrains innovation and entrepreneurship. Governments in developing Asia could draw on best practices from advanced countries. Finland's development into a KBE illustrates the critical role government can play as a coordinator and as a provider of a vision for the future of the country, including the creation of specialized institutions to create consensus across all four pillars.

Establish strong intellectual property right laws and their enforcement. Advanced high-income economies have strong intellectual property rights (IPR) environments that are critical for innovation to flourish and bring commercial returns. Malaysia, Sri Lanka, and the PRC have strengthened their IPR regimes in the past decade and rank above the world average. However, it is more than legislation. Despite having IPR laws compliant with World Trade Organization standards, the PRC and India are perceived by foreign companies as countries with poor IPR protection. IPRs need to be accessible to innovators at the bottom of the pyramid and small entrepreneurs. With growing digital enterprises, IPR regimes also need to be flexible and adaptable to change. In addition to improving the domestic regulatory environment, developing economies also need strong policies to engage with the global economy through trade and foreign direct investment policies. The role of multinational corporations in bringing technology and knowledge into the countries needs to be strengthened through appropriate government policies.

Expand the finance sector. While Asia's economies are diverse and dynamic, their financial systems are largely bank-centered. KBE development in Asia will benefit from the deepening of venture capital resources in the region. In addition, facilitation of innovation funds, such as the Inclusive Innovation Fund in India, and promotion of social impact funds could help spread the benefits of innovation to target population groups. Developing new and creative instruments for financing would serve the development of KBEs well in Asia.

Education and Skills

An educated and highly skilled workforce is critical to a KBE. Ideas and technical expertise hold the key to the new global competitive challenge. KBEs have a strong demand for higher-level skills in the workforce. Evidence from OECD countries suggests that a growing proportion of employees with tertiary level qualifications are employed in knowledge-intensive industries along with a rising rate of financial and social returns attributed to tertiary education. Unemployment in OECD countries has been lower for people with a tertiary education. The average education and skill subindex score of the KEI of Asia and the Pacific is only a little over half the average score of the OECD. Mean years of schooling is lower in developing economies in Asia compared to OECD countries and tertiary enrollment levels are also much lower. Developing Asian economies are also struggling with poor quality of education and poor connection of education with labor markets and jobs.

Increase attainment levels in education. Developing Asia needs to increase education attainment levels as well as the proportion of scientists and engineers in the population to close the gap with advanced economies. Higher education and high level skills at the tertiary level are crucial for KBEs, where developing Asia needs to cover much ground.

Raise the bar on quality of education. In addition to increasing enrollments, there is need to focus on improving the quality and relevance of education and skills development to counter the problems of skills–jobs mismatches and rising graduate unemployment. The approach to quality improvement also needs to change—development of new curricula and courses needs to be far more agile and continuous to keep up with the pace of change. For an effective and high-quality tertiary education system, there is a critical need to increase the quality of education and student attainments at the secondary level. Greater emphasis on science and technological streams and on soft skills development at the secondary stage will help to build a tertiary education edifice that is of higher quality.

Diversify educational credentials and improve the prestige for technical and vocational education and training. A critical need in Asia is to diversify education systems to reduce the overemphasis on degree programs and to include a range of applied degrees, technical qualifications, and other credentials located in an effective national qualifications framework. Multiple entry and exit points and credit transfer frameworks are needed in a diverse platform of educational institutions that include community colleges, higher-order skills development institutions to support lifelong learning, and skills and qualifications upgrading. Countries that have done well to strengthen the status attached to technical and vocational education and training (TVET), such as Singapore and the Republic of Korea, offer good lessons for developing economies. The Republic of Korea's tailor-made education programs to cater to the human capital needs of specific industries and corporations led to successful employment and the creation of human capital that enterprises needed. There is need for a variety of higher-order vocational and polytechnic degrees and applied degrees in addition to academic qualifications.

Build nimble and responsive education systems. A key attribute required of education systems is to provide the necessary qualifications and competencies required in the marketplace. Far greater flexibility and adaptability is required in educational institutions to keep pace with the rapidly changing economic global environment and the talent and skills required. Studies reveal that there is a premium to skills—skilled people, compared to the unskilled, are more likely to get jobs, more likely to be unaffected by financial crises and other shocks, more likely to earn better wages, and more likely to stay longer in the workforce. Modular approaches to course development and updating as well as "just-in-time" and "on-demand" training will become more important in the future. Employers greater emphasis on life skills or soft skills in their employees than technical skills. This suggests that "learning to learn" pedagogies will take a more influential position.

Create a critical mass of world-standard tertiary education institutions. Tertiary institutions of world standard, research centers, and model campuses are needed to provide the requisite talent for priority sectors for KBEs in Asia. Such capabilities can be built from scratch, by upgrading existing institutions, by partnering with world-class universities, or a combination. Forging linkages with world-class universities will help developing Asia to jump-start research and development (R&D) programs that are benchmarked to global standards and establish best practices in governance of tertiary education systems. A greater focus on science, technology, engineering, and mathematical (STEM) disciplines at all levels of education is needed to augment talent for innovation. Developing economies have so far underexploited the potential of tertiary education institutions and industry–university collaborations as R&D centers and commercial incubators of innovation and technology. The colocation of high-quality technical universities with technology parks, along with links to large companies that can be potential customers of technologies, R&D collaborators, venture investors, technology transfer intermediaries, and knowledge-based service providers such as branding and advertising, would serve Asia well.

Expand centers of excellence in research and development. Emerging economies need to invest substantial resources in building centers of excellence (COEs) in R&D. COEs aim to produce original and potentially groundbreaking research and form a joint physical community of scientists, technologists, and industry experts. A COE in research brings together a critical mass of high-level scientists and/or technology developers, plays a dynamic role in the innovation system, enjoys high levels of international visibility and scientific and/or industrial connectivity, and is able to diversify its sources of finance. Such talent development in COEs can be allied to the priority economic sectors of the economy.

Policies for next-generation information and communication technology in education. There is now a clear transition to the next generation of ICT solutions in education. In recent times, a suite of technology-enhanced learning solutions such as web-based e-learning platforms, virtual and a smart classrooms, collaboration tools, online resources, digital library access, videos on demand, and syllabus-based virtual content creation have been tried with varying degrees of impact. But these lack a coherent framework and policy support within the education system. They need to be linked much more strongly to key educational goals and outcomes for students and teachers, rather than introduced as technology interventions alone. Adaptive learning and intelligent learning systems have great potential in helping to address shortfalls in learning achievements by tailoring education to the learning styles of individual students. Learning management systems are one of the fastest growing software sectors in recent years and it is now a billion-dollar plus industry with a wide variety of offerings.

Stimulate implementation of information and communication technology as a game changer. ICT in education is likely to be one of the most powerful tools for bringing about improvements in quality, relevance, equity, and transformational pedagogy. The "digital natives" of today's world learn in completely new ways that blend different modalities and institutional settings.

The onset of massive open online courses (MOOCs) has challenged the brick-and-mortar only type of educational institution. Anytime–anywhere learning and blended learning approaches will become the order of the day. ICT can play a transformational role in the pedagogy and delivery of education to include more innovative, creative, and interactive processes. The rapid proliferation of educational games and interactive learning materials can change the very face of a classroom. The US game-based learning market was worth $231.6 million in 2010 and is expected to grow at a compound annual growth rate of 12.3% and reach revenues of $413.2 million in 2015. Even more spectacular is the expected growth of the simulation-based learning market, which reached $990.2 million in 2010. The 5-year compound annual growth rate is 20.2% and revenues are expected to reach $2.48 billion by 2015. Smart classrooms, e-books, and educational games are also making inroads into developing economy contexts. The sooner emerging economies explore and implement promising ICT solutions in and for education that are most suited to their development needs, the higher the opportunities for substantial improvements to the quality of delivery of educational services.

Innovation

Innovation is the cornerstone of a KBE. The average score of the Asia and Pacific region on the innovation subindex of the KEI is nearly half the OECD average. Emerging economies in Asia spend far too less on R&D as a percentage of gross domestic product (GDP) and have far fewer R&D personnel such as scientists and engineers.

Increase research and development expenditure to at least 1.5% as a percentage of gross domestic product. Other than the People's Republic of China (PRC), none of the emerging economies have an R&D investment of 1.5% of GDP that countries such as the Republic of Korea, Japan, and Singapore undertook at middle-income levels. The study suggests that an allocation of at least 1.5% of GDP to R&D is required to undertake innovations that will help to advance beyond middle-income levels.

Promote high-impact research and development investments. In absolute R&D expenditures, the PRC and India have doubled their R&D investments and increased their share of global R&D. The PRC is set to overtake the US to become the world's largest R&D investor by 2020. The main recommendation for Asia is to increase not only R&D spending, but also its efficiency. This requires better systems for allocating public funds for R&D, particularly focusing on a few high-impact areas that will serve the economies well in terms of increasing their global competitiveness.

Steer policies to encourage frugal innovation and innovation for "middle pyramid" consumers. The report recommends that developing Asia will do well to orient their innovation policies to reap the benefits of expanding "bottom of the pyramid" markets. Innovations leading to "frugal" products have great potential for emerging economies in Asia which have already demonstrated success in this field. The Inclusive Innovation Fund set up in India is a good example. Equally, product innovations to serve the growing size of middle class consumers in Asia, who are expected to account for 42% of global middle-class spending will bring economic benefits. Between 2010 and 2015, the market for technologies serving these segments is expected to have a cumulative average growth rate of over 10%. Such innovations serve the needs of low-income and price-sensitive customers who live in rural areas, thus making KBE processes more inclusive. Public policies to support innovation to develop technologies and products and services suited to these markets such as decentralized innovation hubs in rural and peri-urban areas, low licensing fees for patents, increased funding for social impact investments, and public procurement policies that favor indigenous solutions would be of great benefit to developing economies.

Realize the potential of innovation in the services sector. Many traditionally non-tradable knowledge-based services sectors in the advanced economies—medical diagnostics, architectural designs, business accounting, and analytics—are increasingly offshored to lower-cost developing economies, and Asia's well-established information technology-enabled services (ITeS) and business process outsourcing (BPO) clusters are becoming the primary beneficiaries of these global flows. Of the 10 top locations for outsourcing of global services for delivering information technology (IT) BPO, and voice services, 7 were in Asia in 2011. To build upon on this offshoring opportunity, however, developing Asia needs to continue to invest in its innovation capacity in order to remain competitive.

Improve the ecosystem for innovation intermediaries. There is a need for public sector funding to ease bottlenecks that prevent new technologies from being commercialized by local start-ups. These would be proof-of-concept and patent application grants, innovation voucher schemes, and incentives for collaboration between firms and universities. The Small Business Innovation Research (SBIR) program in the US and the TEKES program in Finland can be adapted to developing economy contexts. Private financial service firms can be incentivized to provide funding for innovation-based start-ups; Israel's Incubation Support program and Singapore's Business Angel Scheme and Incubator Development Programme are good examples. Public investment in such intermediary instruments to promote commercialization of new technology is required ahead of market demand.

Strengthen and update intellectual property rights protection policies. Across developing Asia, there is need to strengthen IPR laws and their enforcement. In order to reach advanced economy and high-income status, developing economies need to increase domestic ownership of patents compared to multinational corporations patents and to support commercialization of technology by national economic actors. IPR laws need to keep pace with technology change, particularly in digital technologies. For instance, IPR policies are lacking for e-commerce in which

PRC and India have become regional heavy-weights. The explosion of e-tailing and digital products and services requires a new approach to innovation policies.

Increase investments in knowledge-based capital. Commercialization of innovation requires a market for knowledge-based assets and services. Growth in OECD economies is increasingly driven by investment in KBC with many companies investing more in knowledge capital than in physical capital. Policy frameworks in developing Asia mostly relate to physical capital, such as machinery, equipment, and buildings. There is a need for policies to support the growth of a market for knowledge assets and services such as copyrights, trademarks, and brand equity, to help companies to participate in high-value global chains and markets.

Create multiple innovation bases and hubs. There is a growing trend toward "innovation districts" that link technology, talent, and finance in a well-coordinated geographic location. Contemporary, young entrepreneurial firms need offices, research laboratories, and business incubators, but also the necessary social platforms for entrepreneurial growth such as social networking, mentoring, product development services, and urban amenities. Innovation districts are forming in many locations in the US (Cambridge, Detroit, Philadelphia, San Francisco, etc.), where existing clusters of advanced research universities, medical complexes, and technology and creative firms are sparking business expansion as well as residential and commercial growth. Asian economies should consider creating multiple innovation clusters that are colocated with industrial clusters and economic zones rather than one or two large Silicon Valley-type of innovation bases.

Information and Communication Technology

ICT is a key enabler of innovation and is a fundamental resource for a KBE. It has opened many new avenues for growth and employment. ICT is drawing more attention than ever before from policy makers and business alike, since ICT can promote inclusive growth while also bringing tangible economic value to businesses. Emerging economies in Asia on average fare much worse than the OECD countries in the ICT subindex of the KEI as well.

Increase the penetration of information and communication technology. ICT can be a pivotal force in transforming Asia's resource-based developing economies into knowledge-based ones. Studies suggest that a 10% increase in mobile phone penetration contributes to a 4.2-percentage-point increase in total factor productivity, and the impact of ICT on economic growth is greater in developing economies than in developed economies. Governments of advanced economies invested strongly in creating a nationwide ICT infrastructure, such as the Republic of Korea, ahead of actual demand. This contributed to the country's ability to put the infrastructure to good use through a large number of e-government and business applications.

Emerging economies in Asia are in a good position to leverage ICT for accelerating economic growth with social impact. Asian economies have taken leading roles in the production and use of ICT goods and services. In 2011, ICT accounted for nearly a quarter of developing Asia's exports, over twice the global average. In the last decade, developing Asian economies have become important players in the global ICT sector, and some Asian economies have considerably better ICT capacity (represented by the Network Readiness Index), than their per capita income would suggest. The development of a range of ICT applications will strengthen KBEs.

Tap the power of mobiles phones for development. Mobile technologies have spread at a spectacular speed in the Asia and Pacific region. In Asia alone, there are nearly nine mobile phones for every ten people, and the majority of these devices also serve as Asia's primary connection to the internet. At 3.5 billion mobile subscriptions, consumers in Asia and the Pacific now account for more than half of the world's total mobile service market. Just two markets, India and the PRC, account for nearly 2 billion mobile users. Moreover, Asia leapfrogged up the mobile service value chain and seized upon next-generation mobile broadband network infrastructure, faster than other developing regions. While overall mobile penetration levels in developing Asia mirror those in other emerging markets, the adoption of broadband mobile services (3G and 4G) has been much faster. The transition from voice traffic to data traffic on mobile devices has taken place at a dizzying speed. It is projected that there will be 788 million mobile-only internet users by 2015, a large proportion of them in the Asia and Pacific region. By 2015, it is projected that in 40 countries including India and Indonesia, there will be more people with mobile network access than with access to electricity at home. The off-grid, on-net population will reach 138 million by 2015. Mobile technologies can thus serve as a powerful tool to reach a range of development services to the last-mile user even in remote and poorer regions of developing Asia.

Mobile technology offers transformational opportunities for development. In 2015, it is forecast that Asia and the Pacific will account for nearly 30% of the global mobile data traffic. An estimated 2.5 billion people do not have access to bank accounts and the mobile phone can be an instrument of financial inclusion. According to Mobile Money for the Unbanked, in 2012, there were 30 million mobile money customers—mostly in the African region, where in 28 countries there are now more mobile money accounts than bank accounts. The Asia and Pacific region can advance on the same path, provided regulatory and other hurdles can be overcome. Mobile phones can provide educational material, health care, and market information, and facilitate m-commerce. Going forward, the main driver for change will be from mobile applications that serve mass markets. Appropriate policies such as market competition in telecom, development of applications in multiple local languages and visual media for people with little or no education, availability of low-cost smartphones, and tapping of the mobile network to supplement delivery of social services would help make KBE processes more inclusive and far reaching in developing Asia.

Ensure universal, affordable, and high-speed broadband. While mobile phones have near-universal coverage, the spread of broadband has not been as speedy in developing Asia. Comprehensive national broadband policies are needed for developing Asia to catch up with advanced economies. Universal, affordable, and high-speed broadband will be crucial to support the advancement of KBE sectors in developing Asia, such as e-commerce, digital enterprises, multimedia and web-based products and services, and entertainment and creative industries. Mobile-based internet will not be sufficient for the rapid proliferation of these industries. The availability of high-speed broadband in rural areas will serve as an important inclusive development strategy. The application of universal service funds (collected as a levy from service providers) to improve connectivity to areas where economic incentives are insufficient will help bridge the digital divide. Extending universal service funds, which remain significantly underutilized, to include high-speed broadband connectivity will serve the economic interests of rural populations.

Expand digital literacy and talent for information technology. There is an important need to develop the human resource capacity needed for a digital economy. On the one hand, a large number of people need to be imparted generic ICT skills, and, on the other, there is need to invest in higher-order and targeted skills for the ICT sector that will help economies to have a competent

workforce needed to optimize on applications. The national digital literacy initiative of India is a good example.

Adopt cloud computing technology choices. In making ICT penetration universal, developing economies can evaluate the costs and benefits of moving to cloud computing—trends suggest that by 2016, the bulk of IT spending will be cloud-based. Emerging economies in Asia would do well to anticipate future trends and invest in tomorrow's technologies, even if it entails higher costs, rather than in yesterday's technologies. A recent study shows that cloud computing will generate 14 million jobs globally in by 2016, 10 million in Asia alone. As mass markets develop for cloud-enabled services in Asia, prices should fall further, much like mobile services, further boosting productivity. This will enable new business development, productivity gains, shared and lower costs, on-demand services, and greater efficiency in markets.

Charting a Course for Knowledge-Based Economic Development Priorities in Developing Asia

Developing Asia at present has multiple opportunities and pathways to pursue KBE development. Each economy needs to shape its priorities and pathways based on its own factors and unique attributes. This report suggests that there are three general ways in which emerging economies of Asia and the Pacific can pursue KBE development in the current times:

- The first is learning from the KBE journey of advanced economies and making appropriate investments to catch up on lags and gaps and undertake policy reforms. This report benchmarks the state of play of the four pillars of the KBE in selected economies of Asia. The KBE journey of advanced countries, particularly the Republic of Korea, Finland, and Singapore, and key milestones of policy development are discussed to draw specific lessons for developing Asia.

- The second is exploiting the unique strengths and advantages of the Asia and Pacific region by pursuing strategies that amplify such strengths. These include demographic advantages of youthful populations in some of the countries, a large and growing middle-income population and expanding domestic consumer markets, competitiveness in the services sector and creative industries, and strong capabilities in IT and IT-enabled services.

- The third is leveraging game-changing trends in technology and business processes that can accelerate KBE development and enable emerging economies to even leapfrog technology cycles and catch up with the latest, such as putting mobile technologies to use more strongly for development, investing in cloud computing, using IT in manufacturing, and speeding up innovations for bottom-of-the-pyramid markets.

Some examples of these approaches are outlined in the report across the four pillars of the KBE. It is clear that an economic development process centered on knowledge requires developing economies of Asia to make substantial investments across the four pillars along the lines of advanced economies that are now KBEs. However, times are opportune for developing Asia in many ways. Timely and effective KBE strategies that draw on Asia's remarkable success in transforming itself into a center of gravity of the world economy will not only help developing economies catch up on the KBE frontier but also potentially lead to the development of new paradigms of innovation and development.

Introduction

Knowledge and innovation are widely acknowledged as key drivers of growth and economic development. The economies of Asia and the Pacific have been steadily growing in prominence in terms of share of global gross domestic product (GDP), which increased from 21% in 1980 to 38% in 2012, but they need to pursue knowledge-based economic development to sustain their high rates of growth. The share of developing Asia in global GDP has also risen sharply from 8% to 26% in the same period, and is expected to reach 30% by 2017 (IMF 2012). The *Asia 2050* report of the Asian Development Bank (ADB) projects that if Asia continues to grow on its recent trajectory, it could account for 52% of global GDP by 2050 in purchasing power parity (PPP) terms (ADB 2011). However, the *Asia 2050* report concludes that an "Asian Century" is by no means preordained: Asia's continued ascent is predicated upon the ability of the region's economies to transform themselves effectively into knowledge-based economies (KBEs). Pursuing a development process driven by effective creation, dissemination, and application of knowledge will be necessary to turn the growth potential into reality.

This report argues that it is absolutely essential for emerging economies in Asia to transition into KBEs to sustain their economic development, while preparing effectively for the future challenges of an increasingly connected global economy. In fact, pursuing KBE development could help emerging economies effectively position themselves better to capitalize on market opportunities by using their unique endowments and strengths. The times are opportune for Asia to accelerate KBE development. As a result of rapid growth, Asia is now home to a large and growing middle class. ADB estimates show that between 1990 and 2008 developing Asia's middle-class population more than tripled from 565 million to 1.9 billion (ADB 2010b). According to a recent report by the Organisation for Economic Co-operation and Development (OECD), Asia's share of in the global middle class (those living in households with daily per capita incomes of between $10 and $100 in PPP terms) is currently about a quarter but is projected to double by 2020 (OECD 2010). Asian consumers could also account for well over 42% of global middle-class consumption by 2020. Asia is expected to be the world's fastest-growing consumer market in the coming decade. Intra-regional trade within Asia has been steadily on the rise and is likely to further grow in prominence (Ernst & Young 2012; ADB 2009). The rapid expansion of the Asian middle class and the ensuing demand for more sophisticated, knowledge-intensive goods and services will fuel the rise of KBEs in the region. As a result, the patterns of both intra-regional and global trade will shift toward knowledge products. In short, the inexorable ascent of Asia in the world economy is giving the region a firm push toward the global knowledge frontier.

This report has a companion volume: *Innovative Asia: Advancing the Knowledge Economy – country case studies from the People's Republic of China, India, Indonesia, and Kazakhstan*. The Country case studies explore specific opportunities for KBEs in these countries and the policies and initiatives needed to strengthen KBEs.

In addition to these two reports, ADB, in collaboration with the Economist Intelligence Unit, has developed the Creative Productivity Index (CPI) which benchmarks a number of economies in Asia on creative productivity, an important attribute for strengthening knowledge-based economic

development (Economist Intelligence Unit and ADB 2014). This index gives policy makers a unique tool to assess how to foster creativity and innovation in Asia. A unique contribution of the CPI is to raise awareness of the productivity and efficiency of various investments that contribute to knowledge-based economic development. While many developing economies of Asia need to increase the quantity of their investments, whether for higher education and training, linformation and communication technology or research and development, they also equally need to address how effectively their investments and inputs are translating into outputs in the most effective and efficient manner. The CPI provides a valuable tool to measure such productivity.

Measuring Knowledge-Based Economies

A knowledge-based economy (abbreviated throughout this report as KBE) describes an economy that uses information resources—technologies, skills, and processes—to achieve and accelerate economic growth potential. This report adopts the following definition which combines World Bank and OECD descriptions:

A knowledge-based economy is one that has an economic incentive and institutional regime that stimulates the acquisition, creation, dissemination, and use of knowledge and information to improve its growth and welfare, as well as effective systems of education and skills, information and communication technology (ICT), research and development (R&D), and innovation.

In order to measure and monitor progress of economies as KBEs, the World Bank developed the Knowledge Economy Index (KEI), using a four-pillar framework (World Bank 2012b):

1. An **economic incentive and institutional regime to provide incentives** for the efficient use of new and existing knowledge and the flourishing of entrepreneurship
2. An **educated and skilled population** to create, share, and use knowledge well
3. An efficient **innovation and technological adoption system** of firms, research centers, universities, consultants, and other organizations to tap into the growing stock of global knowledge, assimilate and adapt it to local needs, and create new technology
4. **Information and communication technology** to facilitate the effective creation, dissemination, and processing of information

The study has assessed the current state of KBEs in a number of developing Asian economies and has benchmarked them with advanced countries using the four pillars of economic incentive and institutional regime, education and skills, innovation and technological adoption, and ICT infrastructure.

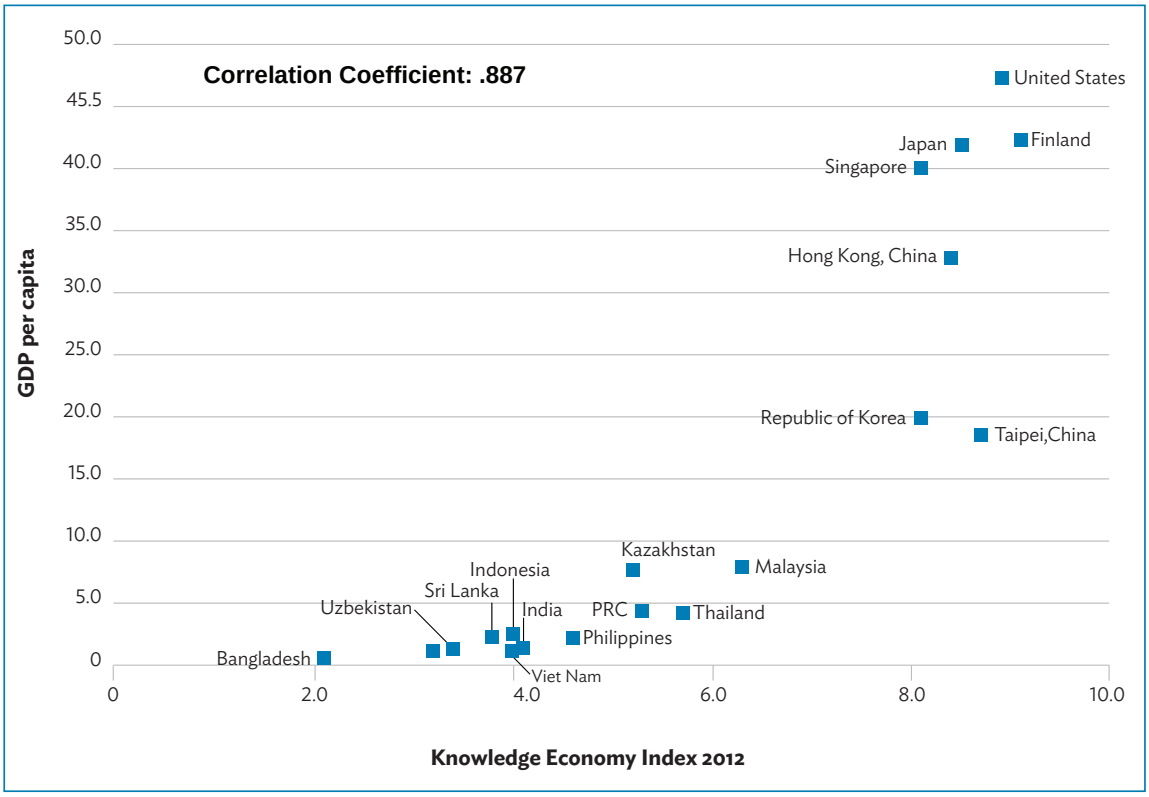
Countries that score higher on the KEI have higher levels of economic development and vice versa (World Bank 2007). It is clear that more advanced countries are stronger as KBEs. In this report, we also examine how economies at initially low levels of income used KBE development to advance, such as the Republic of Korea, Singapore, and Taipei,China. Higher KEI values are also associated with higher rates of future economic growth. Figure 1 shows a positive correlation between the KEI and GDP per capita. Causal links are difficult to establish between the KEI and per capita income. The KEI uses a set of proxy indicators for the four pillars of KBE—economic incentive and institutional regime, education and skills, innovation and technological adoption, and ICT infrastructure (World Bank 2012b). Different sets of proxy indicators for the four pillars of the KEI may yield different results with regard to the correlation between the KEI and GDP per capita;[1] however, progress along the four KBE pillars do help to improve overall

[1] The KEI is the simple average of the normalized scores across the four pillars on a scale from 0 to 10, where 10 is the highest decile among all countries. The World Bank's Knowledge Assessment Methodology actually includes 148 structural and qualitative variables for 146 countries. However, only the subset of 12 proxy variables is available for comparison of the most recent rankings (2012) with the rankings in 2000 or those in 1995.

economic performance. For example, a well-educated and skilled workforce will contribute more to economic growth when the economic incentive and institutional regime supports entrepreneurship and the establishment and expansion of new businesses.

In addition to the Knowledge Economy Index, the Global Competitiveness Index by the World Economic Forum is another powerful tool to measure relative position of countries in global markets. In this report, in addition to the KEI and its different subindices, we also look into the comparative performance of Asian economies in a few selected dimensions of the Global Competitiveness Index.

Figure 1 Correlation between Knowledge Economy Index and Gross Domestic Product per Capita ('000)



GDP = gross domestic product, PRC = People's Republic of China.
Source: World Bank World Development Indicators Database.

Why Does Asia Need Knowledge-Based Economies?

Over the last quarter of a century, driven mostly by cheap labor, developing Asia has been the largest contributor to the global economy. Sustaining Asia's growth trajectory would prove challenging, however, since the region's poverty levels remain high, and resources to tackle the problems are insufficient. The region's economies need to seek a different approach to not only sustain their economic progress but also accelerate it—and the KBE is the only platform that will allow them to do both.

The combination of structural changes in the global economy, persistent human capacity constraints, rising wages, and the prospect of diminished resources means that developing Asia is faced with a clear imperative: its economies must shift their bases of production to do much more, with much less.

The underpinning infrastructure and skills needed to achieve KBE development are largely, though not completely, lacking in the region. Commitment from governments to realign investment and resources around ICT infrastructure and human capital development has been the most successful strategy used by advanced economies to become a KBE. Developing Asian economies must follow suit if they too are to succeed.

Sustaining the Ascent of Asia and its Growth Rates

The development of KBEs is both an imperative and an opportunity for developing Asia. It is an imperative to sustain high rates of growth, and an opportunity for emerging economies to derive advantages from beneficial trending developments that allow them to move up faster in global value chains.

Over the last quarter of a century, driven mostly by cheap labor, developing economies in Asia have achieved unprecedented growth rates and made tremendous contributions to the global economy. Much of the exemplary growth in Asia has come from its economies' long-held comparative advantage in labor-intensive goods. Emerging economies will, however, find it impossible to continue their success under the same growth models used over the last few decades, as technology accelerates and changes the ways countries produce and trade. With rising wages across the region, most Asian economies stand to lose their comparative advantage for labor-intensive manufacturing and additionally will also feel the pressure exerted on increasingly scarce and costly energy resources.

Investment and growth in OECD economies are increasingly driven by knowledge-based capital, such as computerized information (software and databases), innovative property (patents,

copyrights, designs, and trademarks), and economic competencies (including brand equity, firm-specific human capital, networks joining people and institutions, and organizational know-how that increases enterprise efficiency). In some advanced economies such as Finland, the Netherlands, Sweden, the United Kingdom, and the United States (US), these investments in intangibles exceed investments in physical capital (OECD 2011, p. 24).

Sustaining Asia's growth trajectory, however, requires developing economies to seek different approaches to economic growth and progress, especially if they aspire to move from the middle-income to the high-income level. The KBE is an important platform that can enable them to sustain growth and even accelerate it.

Emerging economies in Asia, by exploiting information technology (IT) and knowledge-based industries, strengthening their economic incentive and institutional regime, and promoting effective innovation and human capital development will be able to accelerate their economic capabilities and enhance the well-being of their populations. Developing countries in Asia are uniquely positioned to use the KBE as a platform for sustainable growth and innovation in ways that may well change the global competitiveness landscape of the future.

Increasing Productivity and Avoiding the Middle-Income Trap

In recent years, Asia has enjoyed spectacular growth rates, largely based on labor and capital accumulation, but in the future productivity will have to play a greater role. KBEs are a vital ingredient in the region's transition to growth based on an increase in productivity. There is a concern that Asian economies that grew rapidly from low incomes to middle incomes will be caught in the middle-income trap[2] unless they move up the value chain. Economies in a middle-income trap cannot compete with low-income economies that retain low labor-cost advantages. At the same time, they are not yet able to compete effectively with advanced economies in high-tech products and services. Only four economies in Asia—Hong Kong, China; the Republic of Korea; Singapore; and Taipei,China;—have moved up from middle income to high income.[3] Developing economies in Asia that seek to join them need to move away from growth based primarily on capital and labor to growth that relies more on productivity. Knowledge will become increasingly important as a source of productivity growth. Many middle-income economies are not on course to converge with OECD economies in terms of per capita incomes. Productivity growth is a key tool in this regard (OECD 2014). While many countries in Asia have expanded their industrial base and increased the share of the services sector, they need to avoid being stuck in the middle-income trap—the KBE is an important way forward (ADB 2013b).

Increasing the Capacity to Keep Pace with Global Change

Emerging economies in Asia will find it impossible to continue their success under the same growth models used over the last few decades, as technology accelerates and changes the ways countries produce and trade, and many of the resources Asia needs to be competitive become more scarce. With wages rising across the region, most Asian economies stand to lose their

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2 See ADB (2010a); Park and Park (2010); and Eichengreen, Park, and Shin (2012, 2013).

3 Economies with a gross national income per capita of $12,476 or more by the World Bank's income classification.

comparative advantage for labor-intensive manufacturing. Additionally, the lightning speed of Asia's economic rise itself has created pressures on increasingly scarce and costly energy resources, and widened income gaps to the point of social instability. Increasing exposure to a changing external environment, including events such as the global financial crisis, requires developing economies to be far more responsive to global changes and not rely only on traditional sources of comparative advantage.

A deliberate KBE approach will enable developing countries to improve their capacity to keep pace with rapid technological change to tap opportunities for enhancing the value of key sectors: for instance, applying biotechnology to accelerate agricultural production or enhancing the value of much-needed exports through the use of IT.

Asian economies have been very successful in reducing the percentage of its people who live below the international poverty line.[4] However, along with fast growth, income inequality is also increasing in developing Asia. The Gini coefficient, a standard measure of income inequality that ranges from 0 (when everybody has identical incomes) to 1 (when all income goes to only one person) worsened in all Asian economies apart from the Philippines and Thailand (ADB 2012b). In addition to issues of inequality, fast growth in Asia has also been very resource-intensive, applying significant pressure on environmental sustainability. In addition to formulating environmentally sustainable growth paths, Asia needs to go beyond securing energy for all, to improving energy efficiency in industrial and residential use, as well as in transportation and leisure. It will also need to develop lower-cost alternative energy technologies, as well as technologies to reduce carbon emissions (ADB 2013b). Moreover, despite the speeding up of global trade and innovation networks[5] (or rather, because of it), the world is contending with increased pressure on its limited environmental resources: the dangers of disastrous climate change, and the risks of global pandemics and food shortages. Everything is happening faster, in real time, and on multiple fronts.

In this new, more demanding global context, becoming more of a knowledge-based economy rather than a material-based one is the most appropriate response. KBEs have a greater capacity to respond to the rapidly changing global dynamics. This is particularly relevant for developing economies of Asia.

Knowledge-Based Economies Can Benefit All Countries and Sectors

While investing in KBEs might seem to have obvious advantages for middle-income countries, they are also beneficial to low-income countries. Similarly, KBEs are associated with high-technology industry sectors, yet they can also benefit the agriculture and services sector.

While KBEs are often associated with middle- and high-income countries with advanced industrialization and a mature services sector, the application of ICT, higher levels of skills, education, and innovation can bring higher productivity and efficiency to (and potentially transform) low-income economies as well. Low-income economies can tap technology options to reduce the cost of delivery of government services. Similarly, e-learning can be used as a means

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4 The World Bank defines the global average of the poverty lines of all developing countries as $2 a day.

5 See Dahlman (2012).

of inclusive education. Recent global and regional trends in new technologies and innovation indicate that catching up need not be a linear process for developing Asia. KBEs can help to challenge the linear model of growth and provide opportunities for advancing more rapidly.

Principles of KBEs can be applied not just to industry but also to agriculture and services. The field of biotechnology, in which Asia is making rapid advances, is an example. Emerging economies in Asia are also reinventing the rules in innovation and technology. In addition to R&D-based innovations, business innovations have gained prominence, such as frugal and *jugaad*[6] innovation in serving low-income markets. The emergence of off-grid solar energy markets that are providing products and services uniquely tailored to the needs of a large mass of people who are in rural areas and are highly sensitive to prices is one example; the phenomenal penetration of mobile telephony in reaching customers in even the most disadvantaged locations within poorer countries in Asia is another. In addition to catching up with advanced countries, Asia can also use KBEs as a game changer in a globally connected world.

6 *Jugaad* refers to creative and entrepreneurial approaches that develop "good enough" solutions rather than focus on sophistication and perfection.

Asia's Relative Position in the Global Knowledge Economy

Developing Asia ranks lower than average on the various economic, social, and infrastructure indicators of the World Bank's KEI. Uniformly high scores across all KEI indicators are not absolute prerequisites to establish a KBE, but it is imperative that Asia's emerging economies do more to better their chances, particularly by deepening their ICT infrastructure and increasing their investment in education.

In accessing Asia's KBE potential, we review each economy's technology and education assets and related policy environments, using a framework devised by the World Bank—the aforementioned KEI. Twelve Asian economies are examined in this section: the People's Republic of China (PRC); Indonesia, Malaysia, the Philippines, Thailand, and Viet Nam in Southeast Asia; Bangladesh, India, Pakistan, and Sri Lanka in South Asia; and Kazakhstan and Uzbekistan in Central Asia. We compared their KEI levels with seven comparator developed economies: Finland; Hong Kong, China; Japan; the Republic of Korea; Singapore; Taipei,China; and the United States.

For a summary overview, we used the KEI[7] to provide comparisons over time. The KEI includes subindices for the four pillars of economic incentive and institutional regime, education and skills, innovation and technological adoption, and ICT infrastructure (Table 1).

Table 1: The Knowledge Economy Index Taxonomy

Pillar	Rationale	Indicators
Economic incentive and institutional regime	An economic incentive and institutional regime provides incentives for the efficient use of new and existing knowledge, and the flourishing of entrepreneurship.	• Tariff and nontariff barriers • Regulatory quality • Rule of law
Education and skills of population	An educated and skilled population creates, shares, and uses knowledge well.	• Adult literacy rate • Gross secondary enrollment rate • Gross tertiary enrollment rate
Innovation and technological adoption system	An efficient innovation system of firms, research centers, universities, consultants, and other organizations taps into the growing stock of global knowledge, assimilates and adapts it to local needs, and creates new technology.	• Royalty payments and receipts ($ per person) • Technical journal articles per million people • Patents granted to nationals by the United States Patent and Trademark Office per million people
Information and communication technology infrastructure	Information and communication technology facilitates the effective creation, dissemination, and processing of information.	• Telephones per 1,000 people • Computers per 1,000 people • Internet users per 1,000 people

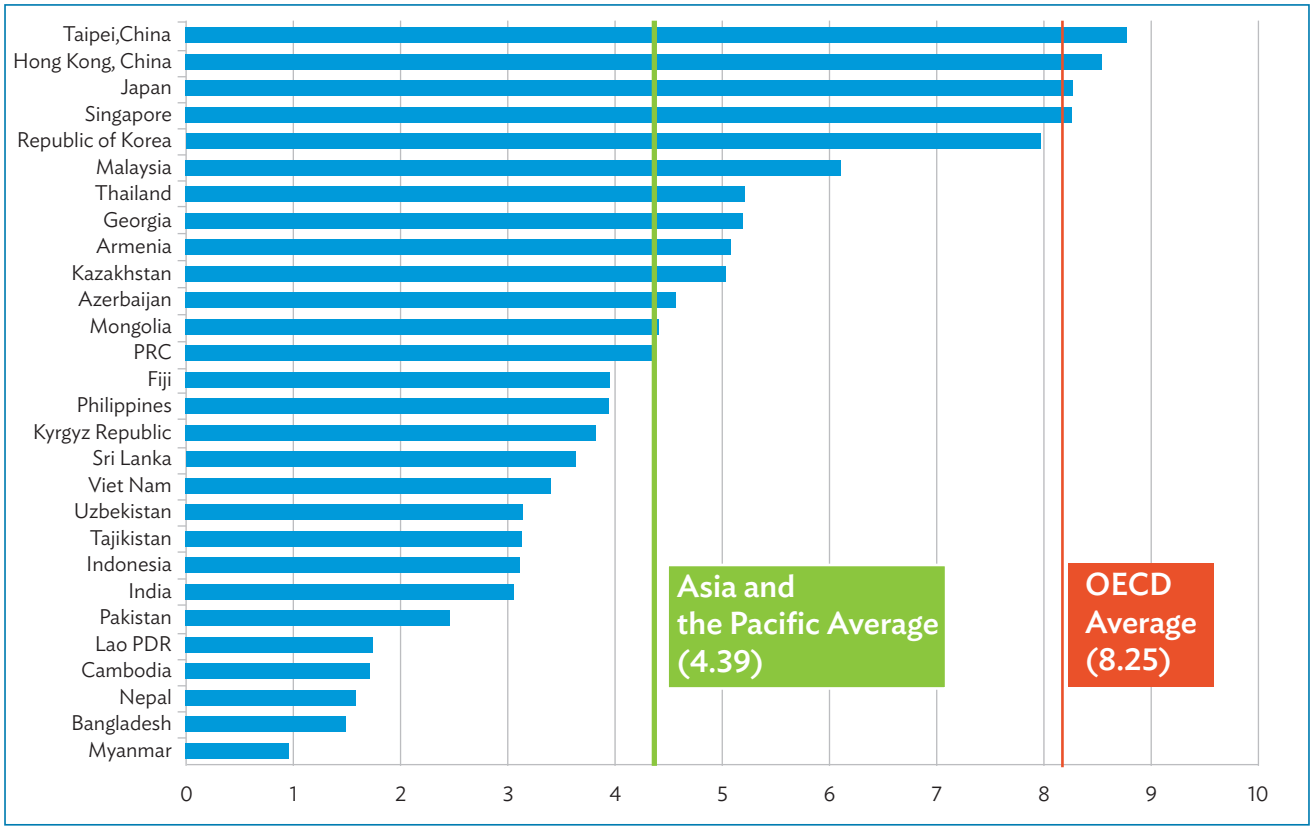
Note: The World Bank developed the Knowledge Economy Index (KEI), an indicator of the knowledge economy based on these four pillars and uses that index to benchmark economies.
Source: World Bank Knowledge Assessment Methodology and Knowledge Economy Index.

[7] See World Bank (2012b).

A comparison of various economies on the KEI reveals that emerging economies in Asia and the Pacific score far lower on the overall KEI as compared to OECD countries. In the section below, an assessment of the position of emerging economies of Asia and the Pacific is provided (Figure 2).

Intuitively, economies that score higher on the KEI have higher levels of economic development—and vice versa (World Bank 2007). Higher KEI values are also associated with higher rates of future economic growth. It is clear that more advanced economies are stronger as KBEs.[8] Regardless of which (or indeed whether) one promotes or presages the other, it is clear that most successful, advanced economies have most of their KEI pillars in place, and that the KBE they support plays a critical role in their economic development.

Figure 2: Knowledge Economy Index Scores: Selected Economies of Asia and the Pacific



Lao PDR = Lao People's Democratic Republic, OECD = Organisation for Economic Co-operation and Development, PRC = People's Republic of China.
Source: World Bank Knowledge Economy Index with data generation and analysis from ADB. http://info.worldbank.org/etools/kam2/KAM_page5.asp.

[8] The KEI is the simple average of the normalized scores across the four pillars on a scale from 0 to 10, where 10 is the highest. The World Bank's Knowledge Assessment Methodology includes 148 structural and qualitative variables for 146 economies.

Learning from Advanced Economies

Advanced economies have consistently focused on KBE development in order to reach high-income status. A number of countries in Asia are at or approaching middle-income levels. Further growth of middle-income countries must increasingly rely on high skill-intensive industries and a deeper stock of physical and human capital. Middle-income countries are squeezed between low-wage, low-income competitors that dominate labor-intensive mature industries and the high-income innovators that dominate industries undergoing rapid technological change. In other words, middle-income countries must successfully climb the development ladder and catch up with advanced countries in the transition to the high-income level.

In this section of the report, we also examine how economies that were once low income, such as the Republic of Korea, Singapore, and Taipei,China, leveraged one or more of the KEI pillars to build KBE competencies that contributed to their economic success. We also look at the role that a KBE plays in defining and driving growth in long-established advanced economies.

A working paper of the Asian Development Bank Institute (Tran 2013) highlights two areas as being important in making the transition from the middle-income to the high-income level. One is the timely shift of focus of policy and public sector investment in infrastructure and human capital so as to develop new technology- and knowledge-intensive industries. The other is high-quality institutions that generate and maintain a dynamic private sector that is innovative and sensitive to changes in international markets.

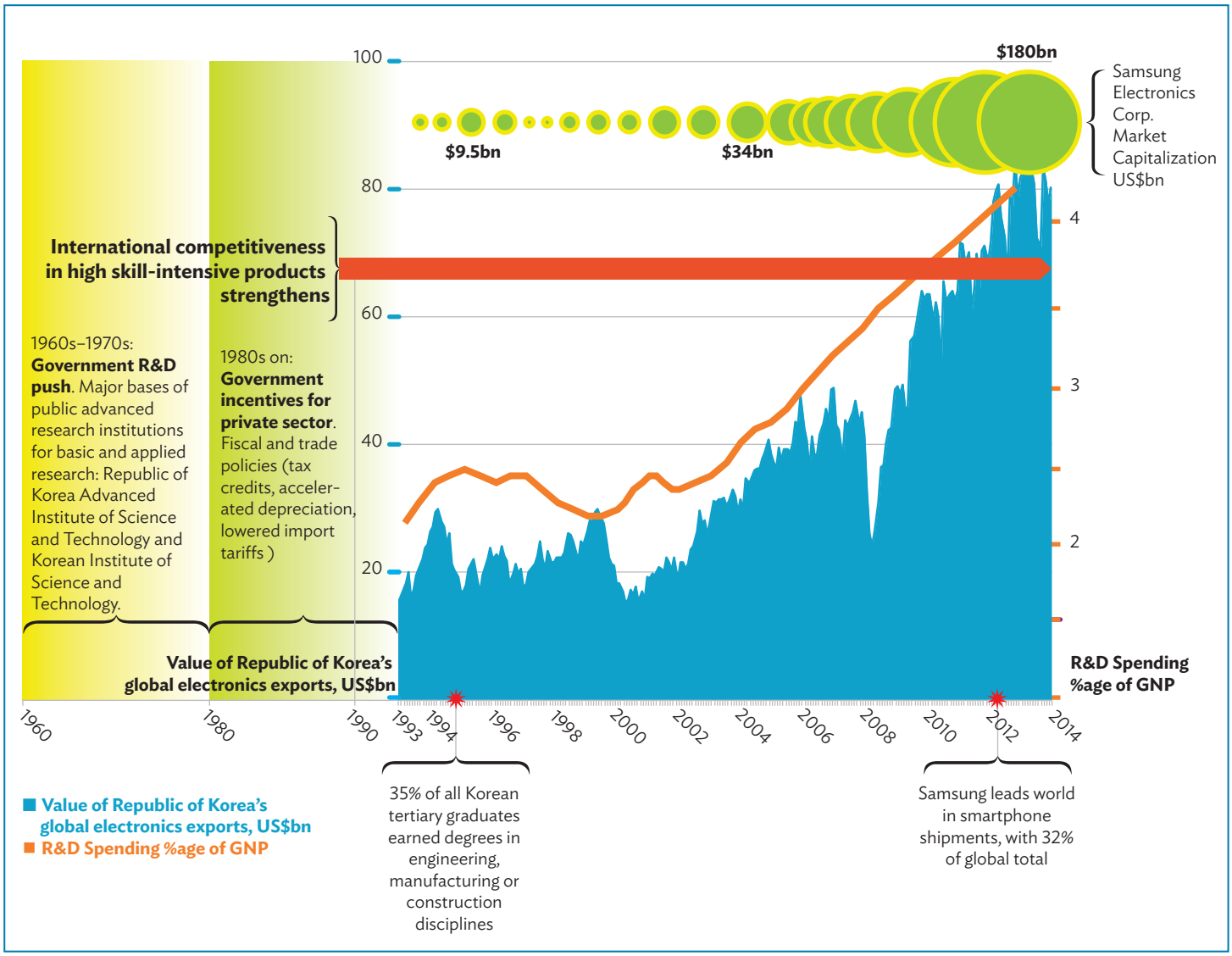
The United States has been a world leader in leveraging innovation to achieve broader economic aims. It has consistently invested heavily in R&D, higher education, and ICT. Japan's KBE growth journey is a story of rapid catch-up with the advanced countries through a process of importing advanced capital goods, licensing foreign technology, and encouraging foreign study. Strong investment in commercially oriented R&D together with a strong focus on exports of manufactured products tilted the economy's strengths toward high value-added sectors such as electronic hardware and components.

In this section, we highlight the journey of the Republic of Korea, Singapore, and Finland. The Republic of Korea and Singapore achieved remarkable transformation of their economies to high-income levels through systematic KBE development. Finland achieved a transformation from a natural resource- and agriculture-based economy into a knowledge economy at the very top of the global frontier.

Republic of Korea

The Republic of Korea made a remarkable transition to a knowledge economy in less than two decades. It started with a rapid industrialization process based on labor-intensive exports, import of capital goods from advanced countries, and technology licensing. Building on import of capital goods and licensed technology, the country's policy makers went on to supporting state champions in the private sector. During the 1960s and 1970s, the country set up major bases of public advanced research institutions for basic and applied research, such as the Korea Advanced Institute of Science and Technology and the Korea Institute of Science and Technology. R&D as a percentage of GDP has been steadily on the rise and increased from 0.5% in 1965 to 2.5% in 1997 and 3.7% in 2010. The country intends to increase this to 5.0% of GDP. There was explicit attention and investment in the ICT industry, which now puts the Republic of Korea far ahead of even advanced economies in terms of telecom infrastructure and usage. Coordination across 17 ministries for R&D and the ICT sector solidified the economy's position in the IT sector. Strong education reforms and links between tertiary and employer-based training built the human capital base needed for the country to advance as a knowledge economy. While initially the government invested significantly, the private sector started playing a more important role from the 1980s onward. Government incentives were provided through fiscal and trade policies (tax credits, allowing accelerated depreciation, lowering import tariffs, etc.). Even smaller companies invested in R&D—in some cases, R&D of small and medium-sized enterprises (SMEs) was as much as 10% of total sales. From the mid-1990s onward, the country's international competitiveness in high skill-intensive products had strengthened. Corporations such as Samsung, Hyundai, and LG, in collaboration with Korean ministries in charge of promoting technological innovation, entered into the thin-film-transistor liquid-crystal-display (TFT-LCD) industry providing a challenge to the Japanese companies that were leading the market. By 1999, the share of tertiary graduates in engineering, manufacturing, and construction was 35%. Currently, the country's higher education enrollment is among the highest in the world. See Figure 3 for various aspects of the Republic of Korea's KBE journey.

Figure 3: The Republic of Korea's Journey to a Knowledge-Based Economy



Source: Joonghae Suh and Derek H. C. Chen (Editors), Korea as a Knowledge Economy: Evolutionary Process and Lessons Learned. Korea Development Institute and the World Bank Institute, August 2007.

Singapore

Singapore similarly transformed itself, from an entrepôt to a KBE. The journey of its development process went through a series of economic transformations, each roughly a decade in length: labor-intensive growth in the 1960s, skill-intensive growth in the 1970s, capital-intensive growth in the 1980s, technology-intensive growth in the 1990s, and knowledge and innovation economy-based growth from 2000 onward. The initial years witnessed economic growth driven by foreign direct investment (FDI), and, in the 1990s, there was an orchestrated move to focus on technology to transform into a KBE. The country initially promoted FDI to access high technology and participation in global trade and then moved to domestic R&D capabilities. Like the Republic of Korea, its R&D expenditure was 0.5% of GDP in the initial years and has steadily grown to

2.3% of GDP.[9] The country intends to increase it to 3.5% of GDP by 2015. The Economic Development Board coordinated investment in R&D and technical education and promotion of high-tech industries for Singapore's future strength. There was active promotion of ICT both in hardware and use in government, industry, and society. The economy invested heavily in upgrading technical education and subsidized multinational corporation (MNC) training to raise the skill levels of its workforce. Partnerships with world-leading educational institutions enhanced the availability of talent pools for a KBE. There was deliberate investment to building on Singapore's strengths as a trading economy. Competitiveness in trading services was built up and ICT investments in trade and logistics have made the country emerge at the top in the World Bank's Logistics Performance Index rankings in 2012.

Manufacturing moved up the value chain with new capabilities in semiconductors and aerospace engineering. During 1991–1995, the National Technology Plan to boost R&D activities and investments was put in place. During the 2000s, manufacturing clusters further diversified to include biomedical sciences. Output and value added for manufacturing tripled in the last two decades.

The 1990s also saw the growth of the services sector with the setting up of the Services Promotion Division in the Economic Development Board. The country diversified into the services sector, and, in 1997, the competitiveness committee included services with manufacturing as twin engines of growth for the economy. Singapore soon emerged as a hub of services and further developed new high-growth services capabilities. Today, Singapore is a leading business and financial hub in Asia and is ranked among top global financial centers.

Singapore gradually and steadily fostered an education environment that embraced facilitating science and technology, creating local talent. In 1991, Singapore established the National Science and Technology Board to raise its capabilities in science and technology. The number of research scientists and engineers grew from 28.2 per 10,000 workers in 1990 to 87.9 per 10,000 workers in 2001.[10] In 2000, the Biomedical Research Council and the Science and Engineering Research Council were formed. In 2002, the National Science and Technology Board was renamed Agency for Science, Technology and Research (A*STAR) to increase emphasis on training research personnel to transition to a KBE. The $500 million Biopolis was created in 2003 to provide world-class biomedical R&D facilities with shared research for the public and private sectors, and Fusionopolis, the science and engineering research hub, was added in 2008. The colocating of public sector research institutions and corporate labs has served the economy very well. Figure 4 outlines the various steps and initiatives taken in Singapore to strengthen KBE processes.

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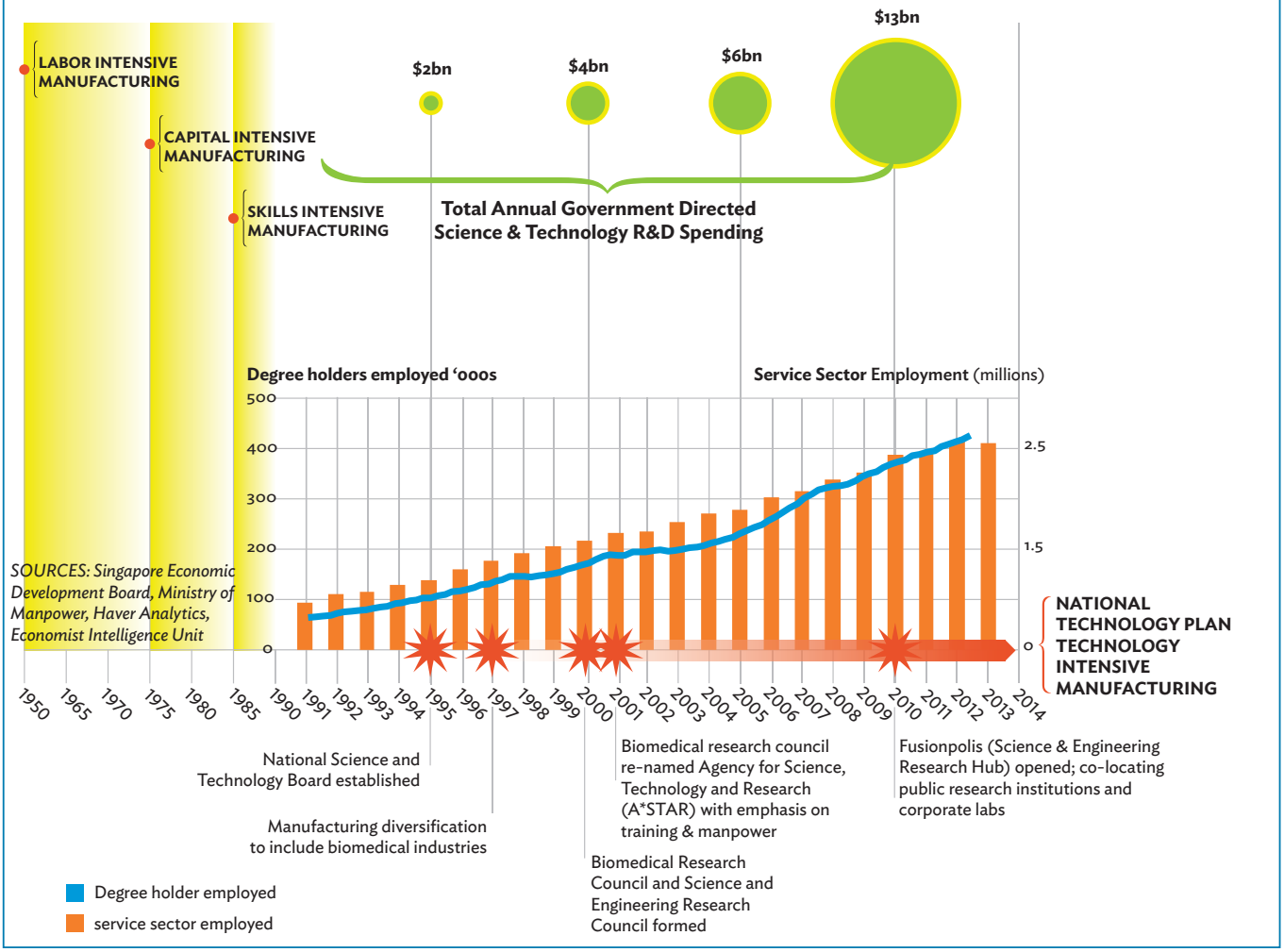
9 See National Research Foundation webpage at http://www.nrf.gov.sg/research/r-d-ecosystem/r-d-investments (accessed 31 July 2014)

10 See note 9.

Figure 4: Singapore's Journey to a Knowledge-Based Economy



Sources: Agency for Science, Technology and Research, 2011. Science, Technology & Enterprise Plan 2015, Singapore Economic Development Board, Haver Analytic,s and Economist Intelligence Unit with data generation and analysis from ADB. http://www.a-star.edu.sg/portals/0/media/otherpubs/step2015_1jun.pdf" www.a-star.edu.sg/portals/0/media/otherpubs/step2015_1jun.pdf

Finland

As late as the 1950s, Finland was still an agriculture-based economy. By the 1980s, a "microelectronic revolution" had taken root and the economy was deriving benefit from strong technological capabilities. From the 1990s onward, the country has been firmly established as an innovation-based knowledge economy. A key characteristic of the Finnish approach to development of the knowledge economy has been the broad-based and engaging approach to formulating the education, research, and innovation policy agenda (World Bank 2014).

The Government of Finland has played an active role in developing the country's capabilities in digital and mobile communications during the 1970s and 1980s. Substantial investment by the government has been crucial for the country to create a domestic base of technology and

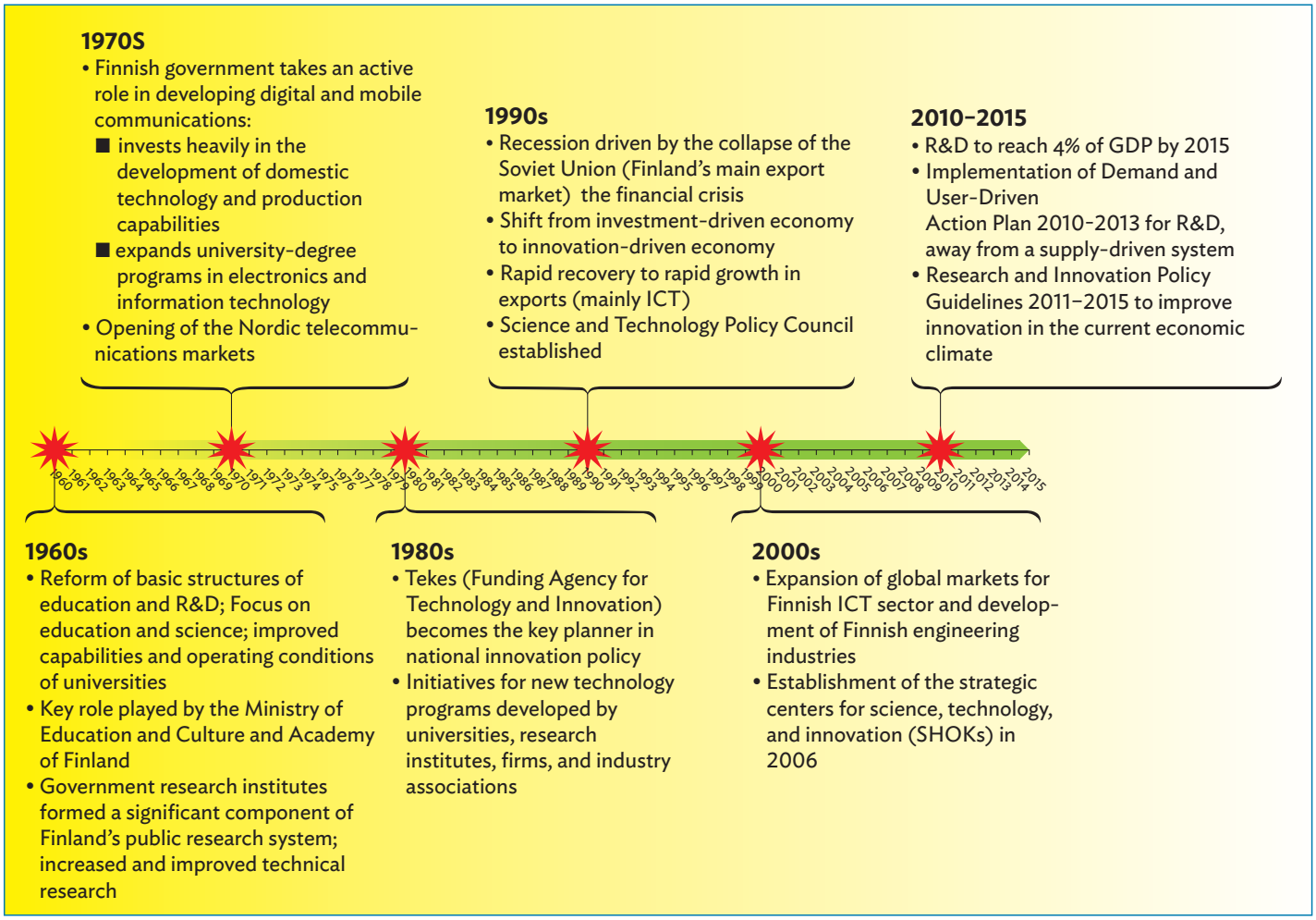
production capacities in these frontier technology fields. Government funding has been channeled to research in these areas in partnership between public agencies and private enterprises and universities. The state also had a role in expanding university degree programs in electronics and information technology and in directing technologically demanding government procurement to domestic firms (Sabel and Saxenian 2008, 55; cited in World Bank 2014 report).

The support to the ICT sector in Finland was located in a multipronged approach that linked funding for R&D, enhanced education and human capital development specifically for the sector, support to state technology agencies and other institutions, and the central focus on ICT as a competitive sector for the economy. State interventions were thus coordinated and holistic in partnership with private entities and research bodies. The ICT sector was identified as the key area to enhance competitiveness with appropriate microeconomic policies. The Science and Technology Policy Council (STPC) firmly set an agenda for economic growth in Finland led by ICT and for the creation of an underpinning "national innovation system." As a consequence, more funding was made available for R&D and higher education institutions in this area. Even during the recession of the 1990s, public investments were targeted at the ICT sector, as mobile communications continued to grow. Even in the midst of severe economic crisis and government austerity measures, public expenditures for education, R&D, and innovation were maintained. Such conscious efforts and decisions proved to be instrumental in enabling growth of the ICT sector. From the mid-1990s onward, Finland enjoyed extraordinary growth fueled largely by the ICT sector.

By far the most prominent area of public policy that enabled Finland's transition to a knowledge economy was in its development of the education sector and in building human capital for a knowledge economy. Finland's transformation from a poor agrarian society to a leading knowledge economy is the development of human resources through education, which led to the adoption and assimilation of new knowledge and enabled innovation (Kokkinen 2012). As a result of such consistent efforts, educational achievement among the population is high. In addition, education has led to productive employment—as the employment rate is especially high among highly educated people. In 2010, 69% of the population between 15 and 64 years of age were employed, and approximately 84% of persons with tertiary degrees were employed. In 2010, more than 90% of doctors were reported to be employed (World Bank 2014).

Key institutions that supported the transformation of Finland to a knowledge economy include Sitra, the Finnish Innovation Fund founded in 1967 as a part of the Bank of Finland, which is an independent public foundation operating directly under the Finnish Parliament; Tekes, the Funding Agency for Technology and Innovation, which has been financing R&D and innovation activities in both companies and research institutions; the strategic centers for science, technology, and innovation (SHOKs), which are public–private partnerships for speeding up innovation processes and bringing together academic research and private R&D activities; and the Innovative Cities (INKA) program, which aims to create internationally attractive local innovation hubs and to intensify cooperation between the public and private sectors. Figure 5 provides a historical time line of various policies and initiatives undertaken in Finland to position the economy as a leading KBE.

Figure 5: Finland's Journey to a Knowledge-Based Economy



Source: Halme, Kimmo; Lindy, Ilari ; Piirainen, Kalle A.; Salminen, Vesa; White, Justine (Editors), Finland as a Knowledge Economy 2.0: Lessons on Policies and Governance, World Bank 2014.

Key Lessons from the Journey of Advanced Economies

Economies that have been successful in orienting themselves around knowledge-based industries, whether Asian or not, have done two things well: they have been committed to a broad-based strategy across the KEI pillars, and they have focused that attention through a sense of urgency.

Asia needs to develop more explicit and stronger strategies for KBEs. Advanced economies with high overall KEI scores—including Finland, Japan, the Republic of Korea, and the United States—are generally economies that achieved economic success through coordinated policy efforts, and emerging Asian countries that explicitly guide improvement across all four pillars of the KEI will not only derive benefits from the synergies between the pillars, they will also accelerate their overall KBE efforts.

Enabling systematic and sustained investments in KBEs The key areas for emerging economies to address, learning from the experience of advanced economies, are systematic and continued investment and policies to build R&D capability; investments in creating a deeper stock of human capital and improving education systems that provide the capabilities needed to enhance

competitiveness of key knowledge-intensive sectors; and putting in place appropriate economic, institutional, and incentive structures that help to tap investments from a dynamic private sector.

Orchestrating high-value merchandise goods and services. Moving up the value-added scale in merchandise goods and services requires greater investment in innovation, education and training, advanced ICT infrastructure and applications, and logistics. Expanding the quality and relevance of higher education, applied research, and industry–university collaborations is critical. Investments in telecom and ICT infrastructure that permeates the economy are crucial for a KBE, one that also bring many spin-offs such as delivery of government services, improved governance, linking economic corridors, trade in services, and links with global supply chains.

Important role of the government in steering KBE development. In the KBE journey of advanced economies, the government played a strong role in steering and supporting various elements required for a KBE—and this was particularly true in the early stages of KBE development. Public sector investments to stimulate demand in the early stages were crucial in bringing private sector investments subsequently. Examples would be the development of the finance sector and venture capital sector. Effective interdepartmental coordination across cross-functional agencies and ministries with a clear long-term vision for KBE was also a key factor in the success of advanced nations in becoming a KBE.

The private sector follows the government to invest in KBE. Governments and the private sector in emerging economies in Asia must commit more investment to education and training. Policy attention must be devoted to tracking and understanding new advances in different fields of technology to identify possible roles that the nation's industries and institutions can play in their development. Technology-enabled solutions must be sought not only as effective ways of producing and delivering goods and services, but also as responses to pressing social needs such as inclusive growth and sustainable development.

Removing constraints to innovation and enabling KBE asset creation. The strategies that emerging economies in Asia need to achieve these KBE goals fall into two broad categories. The first is a set of policies that remove constraints to innovation and entrepreneurship, such as bureaucracy, cumbersome regulations, and corruption. The second is to commit investment into KBE-enabling infrastructure, assets, and programs in a clear and predictable medium- to long-term horizon. This includes (but is far from limited to) investments in education and training systems to provide ICT-focused knowledge and skills, and programs that can re-skill people to take advantage of new business opportunities and technologies. Emerging economies need to pay specific attention to ways in which KBE processes could also serve inclusive growth. Governments have to develop more flexible and effective ways of financing essential KBE activities and explicitly use KBE to address their challenges: persistent poverty, increasing income inequality, and the need for environmentally sustainable development.

In the next section, the report addresses the "state of play" of each of the four pillars in selected Asian economies, and reviews the key guidelines that developing economies could consider in order to strengthen their KBE pillars. The subsequent section then discusses how policy makers in developing economies should be guided in making appropriate choices—and whether they can make speedier progress, by leveraging technologies and exploiting Asia's unique advantages.

This report makes the argument that while developing Asian economies still have much to do in investing in KBE development, there are now ample opportunities for them to accelerate their progress—not only to close the gap with advanced nations, but even to emerge as global KBE leaders, in new innovative products and services more suited for emerging markets.

The Four Knowledge Economy Pillars: the State of Play in Developing Countries of Asia

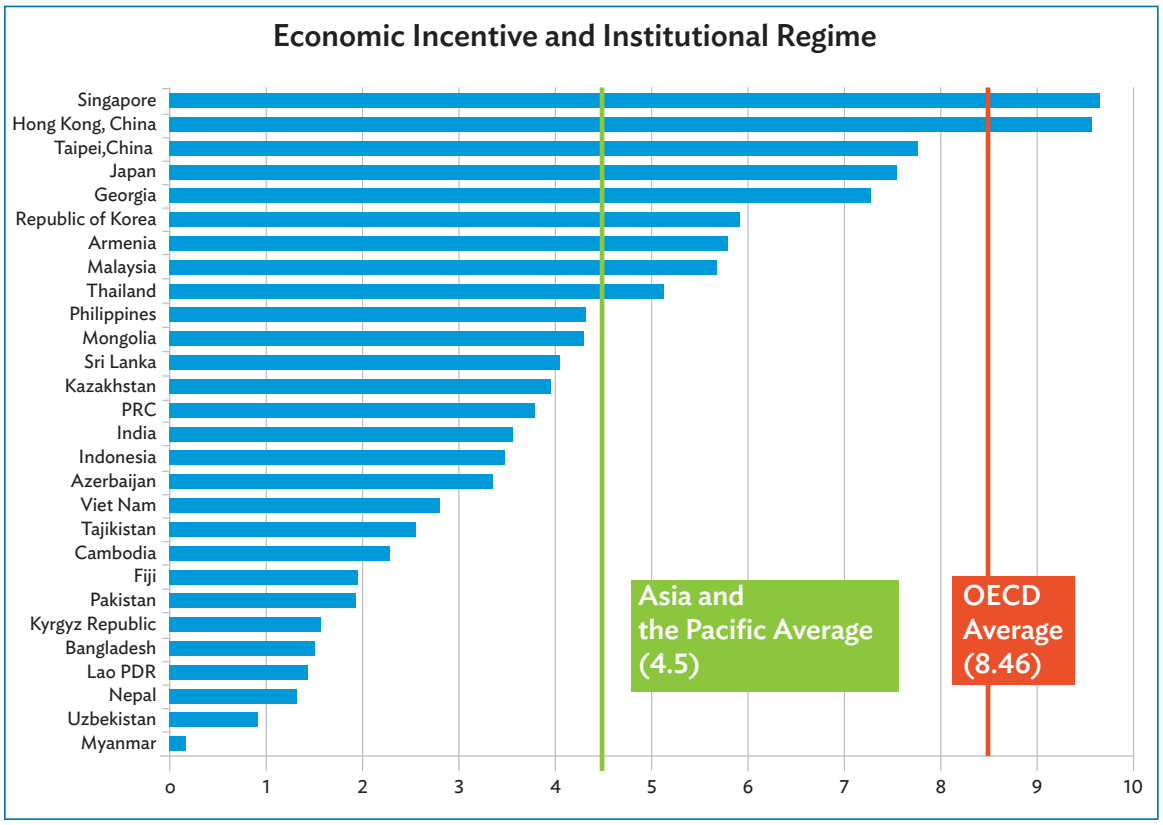
Economic Incentive and Institutional Regime Pillar

The economic incentive and institutional regime (EIR) is the set of regulations and institutions in a country that affects the incentives for carrying out economic activity and is critical for an effective KBE. Policies and regulatory regimes related to industry, competition, and IPR can encourage or impede KBEs. The EIR, on the one hand, operates at the macro level of the whole economy and, on the other, affects regulations in each of the other three pillars—innovation, education, and ICT. The macro parameters are cross-cutting in nature. In terms of affecting the other pillars of a KBE, EIR, for example, affects the innovation pillar through issues such as rules about intellectual property produced in universities and public research institutes and their commercialization. In education, they include the governance of the education system, accreditation and certification, and regulation of the private sector. In ICT, policies on pricing of ICT infrastructure and services, privacy, and content are examples. A poor macro environment or poor governance will make it less attractive to invest in R&D, education, or ICT. Similarly, an EIR that restricts interactions with the rest of the world limits access to global knowledge and technology transfer. A poor business environment restricts entrepreneurship, the start of new firms, and innovation. The EIR subindex scores for developing Asia are well below the OECD average (Figure 6).

The developing economies in Asia have a much poorer ranking compared to the advanced economies on all parameters of the EIR except the macro environment (advanced economies are still suffering from the aftereffects of the 2008 financial crisis). Developing economies remain far behind developed countries in their business environments (although there are exceptions: Malaysia and Thailand, for instance, do better than Japan and are similar to Taipei,China). The high-income OECD countries have simpler regulatory processes with stronger legal institutions compared to developing Asia. On intellectual property protection, which is a very important policy to allow KBEs to flourish, developing economies have a great deal of distance to cover compared to advanced economies (except Malaysia, which is ranked above the Republic of Korea). Table 2 gives an overview of the position of selected Asian economies in EIR.

An effective EIR is fundamental to guide the efforts of an economy's public and private sector to allocate resources efficiently and to provide strong incentives to improve productivity and to

Figure 6: Economic Incentive and Institutional Regime Subindex Scores



Lao PDR = Lao People's Democratic Republic, OECD = Organisation for Economic Co-operation and Development, PRC = People's Republic of China.
Source: World Bank Knowledge Economy Index with data generation and analysis from ADB. http://info.worldbank.org/etools/kam2/KAM_page5.asp.

develop new goods and services to better serve the needs of consumers and enterprises. The EIR establishes and supports stable macroeconomic conditions, and provides effective governance and incentives to promote competition and improve overall economic performance. It also establishes flexible capital and labor markets, which allows an economy to constantly redeploy resources to the most efficient use. A hallmark of an EIR that supports robust KBE development is a strong IPR regime—an essential incentive for firms and individuals to innovate with confidence. Advanced economies typically (but by no means in many cases) have established structures to promote market structures that are both competitive and have strong institutions to provide IPR protection. Without these, KBE efforts can drift or fail; like in the experience of the former Soviet Union's KBE, which had great strengths in R&D and higher education, but failed in global markets due to its poor EIR.

Not only does an economy's EIR serve as the defining framework for its domestic economy, it also provides a critical structure for its growth in an increasingly globalized and interdependent system of trade. International trade as a percentage of global GDP increased from 38% in 1990 to 63% in 2007 at the outset of the global financial crisis.[11] The rapid growth of global trade led to an escalation in competitive pressures for all producers, which in turn forced a radical dispersion of global value chains as manufacturers and service firms sought comparative advantage for

[11] See World Bank World Development Indicators database.

Table 2: The State of the Economic Incentive and Institutional Regime: Selected Asian Economies

Economy	IP Protection (IPR from WEF rank out of 144)	Governance (WBGI with higher % as positive)		Openness to World (KOF Foundation Index of Globalization 2012 rank out of 208)	Business Environment (IFC Doing Business 2013 rank out of 185)	Entrepreneurship		Macro Environment (WEF rank out of 144)
		Government Effectiveness	Rule of Law			Global Entrepreneurship Index 2012	New firms/1,000 working-age population 2009	
Finland	1	100	100	17	11	0.45	3.37	24
Singapore	2	99.1	93.4	5	1	0.47	7.4	17
Hong Kong, China	11	94.3	90.6	NA	2	0.32	19.19	1
Japan	18	87.7	86.9	55	24	0.34	1.28	124
Taipei,China	22	83.4	82.6	NA	16	0.48	NA	28
United States	29	88.6	91.1	37	4	0.6	NA	111
Malaysia	31	81	66.2	29	12	0.25	2.55	35
Republic of Korea	40	86.3	80.8	60	8	0.35	1.72	10
PRC	51	60.7	40.4	73	91	0.20	NA	11
Sri Lanka	55	52.6	53.1	118	81	NA	0.29	127
Indonesia	60	46.9	31	87	128	0.2	0.18	25
India	63	54.5	52.6	110	132	0.14	0.12	99
Philippines	87	55.9	34.7	84	138	0.15	0.19	36
Kazakhstan	92	45.5	31.5	76	49	0.18	2.59	16
Thailand	101	59.7	48.4	54	18	0.18	0.59	27
Pakistan	106	22.3	20.7	108	107	0.14	0.03	139
Viet Nam	123	45	38.5	130	99	NA	NA	106
Bangladesh	131	19.9	28.6	154	129	NA	NA	100
Uzbekistan	NA	24.6	5.2	170	154	NA	0.78	NA

IFC = International Finance Corporation, IP = intellectual property, IPR = intellectual property right, NA = not available, PRC = People's Republic of China, WBGI = World Bank Worldwide Governance Indicators Data, WEF = World Economic Forum.
Source: World Bank Worldwide Governance Indicators (accessed 25 November 2012).

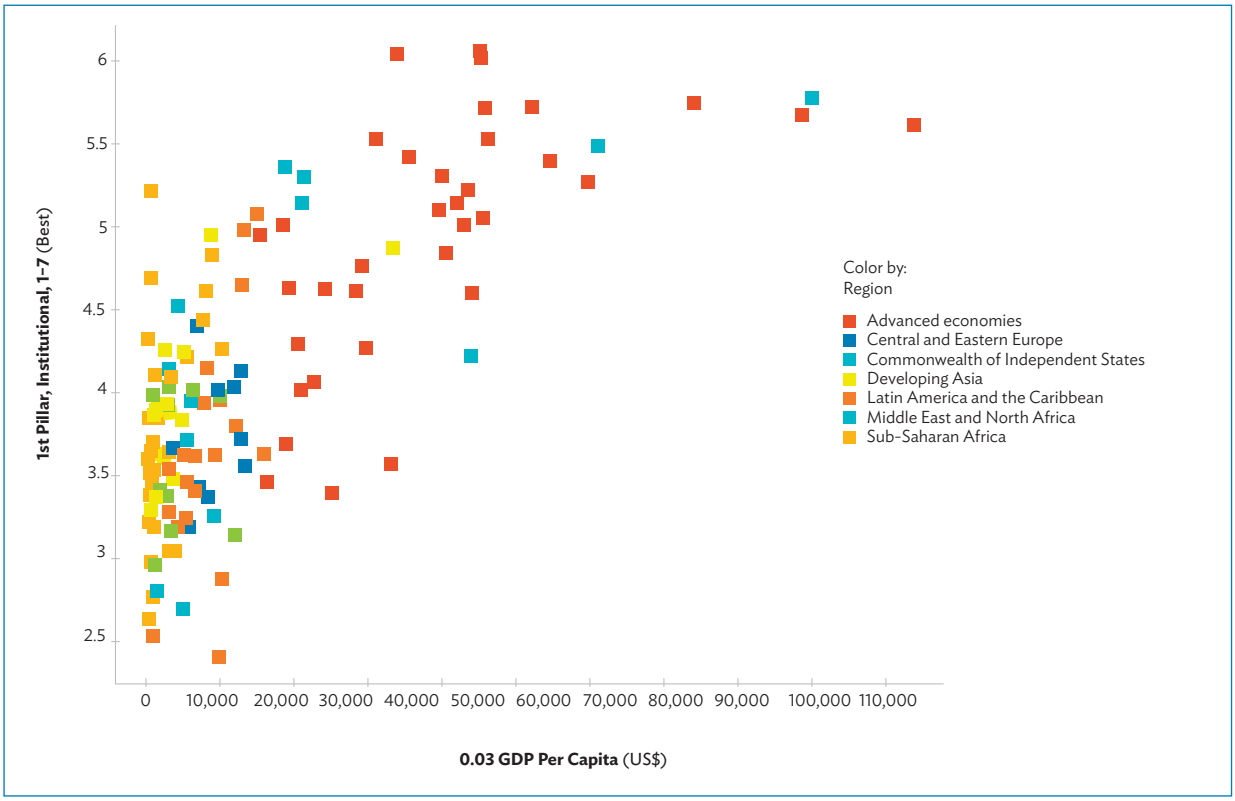
specific tasks in other countries to preserve margins and enhance efficiencies. Typically, this meant that producers sought cheaper destinations (increasingly offshore, in the case of producers of advanced economies) to build components and assemble goods, while keeping higher-value processes (such as R&D, design, or branding) closer to home (OECD 2013a). Similarly, service companies competing globally find cost-arbitrage locations for lower-value processes ("back office" administration), while maintaining closer control over higher-value management and advisory services. The greater the value, the more these processes depend upon the knowledge base and skill level of the human capital of the country.

Globalization allows countries to compete in ways that are both increasingly value-added and agile. Without institutions that preserve and enhance these assets, and support ongoing investment, a country will be unable to leverage its knowledge assets competitively.[12]

In evaluating the real effectiveness and relative global competitiveness of developing Asia's EIR, this section goes beyond the proxy indicators used in the KEI and uses additional analytical frameworks, such as components of the World Economic Forum's Global Competitiveness Index and the investment climate, as measured by the International Finance Corporation's Doing Business Indicator.

When taking account of the economy's World Economic Forum institution pillar rankings relative to its GDP per capita, it is clear that there is a strong correlation between how effective an economy's public and private institutions are, and how economically advanced it is (Figure 7). Unsurprisingly, the best performing Asian economies are those that have historically leveraged the strength and influence of their institutions to achieve economic development goals: Singapore; Hong Kong, China; and Taipei,China. With the exception of Malaysia, most other developing Asian economies fall into an undifferentiated pack toward the mean of the institution pillar rankings.

Figure 7: Correlations between Institutions and Gross Domestic Product per Capita



Source: World Economic Forum Global Competitiveness Index 2013 Data Platform.

12 Industrial policy has come back into fashion after the global financial crisis even in advanced countries. However, it has evolved from a focus on product markets (trade barrier and subsidies to specific products and industries, and state-owned enterprises), to factors of production (training subsidies, investment allowances, and R&D subsidies), to systemic competition (interventions to coordinate policies, develop networks, and facilitate the redeployment of capital and people). See Warwick (2013).

Key Guidelines for Developing Asia in Economic Incentive and Institutional Regime

a. Improving Governance and the Role of Government

Governance is an area in which developing Asian economies are weak compared to advanced countries. Yet some areas of governance are difficult for emerging economies to address—such as the creation of political stability, or reducing violence and corruption—others are more easily amenable to improvement. These include enhancing the rule of law, regulatory quality, and government effectiveness. As countries develop their institutions and increase government capacity in these areas, they also help build foundational support for KBE development.

The government clearly has an important regulatory role to play in supporting KBEs, such as in the protection of intellectual property. A proactive government is needed to address potential market failures (such as promoting innovation for green growth) and to strengthen inclusion and equity, such as addressing loss of employment from technological disruption or improving access to finance. Yet a strong EIR also requires a vibrant private sector; therefore, striking the right balance between the public and private sectors is crucial. The Republic of Korea presents a good example of this, as described in Box 1.

Governments that consistently execute focused, well-aligned KBE objectives see their economies progress faster. This ability to execute is particularly important where government action is required to mitigate the impact of clear market failures, such as to impose stringent intellectual property protection legislation; to promote green growth; or to redress social and income

Box 1: Effective Government Fueling the Knowledge Economy in the Republic of Korea

The Government of the Republic of Korea has for decades formulated explicit plans to develop specific industrial sectors to first catch up with developed economies, and then in many economic sectors, exceed them. Massive investments were made in secondary and tertiary education and in technological capability. When the country had difficulty in accessing foreign technology, research and development (R&D) increased to develop the country's own frontier innovation. The share of R&D expenditures to gross domestic product (GDP) increased from 0.5% in 1965 to 2.5% by the 1990s.

The 1997 financial crisis exposed some weaknesses in the Republic of Korea's strong government-led industrialization strategy, but rather than abandon the approach, the government redoubled its efforts. As part of the recovery, the government embarked upon a systematic strategy for a knowledge-based economy. The government improved the soundness and efficiency of the financial system, increased flexibility of the labor market, and strengthened rule of law. Detailed plans to develop the information technology industry were coordinated with government research institutes, the ministry of telecommunications and information technology, and the private sector. The country became one of the largest producers of integrated chips, wireless phones, flat screen televisions, and other digital electronics. The government reformed education and training to develop high-caliber scientists and engineers needed for the knowledge economy. R&D increased to 3.7% of GDP in 2010.

In 2008, the government integrated the former Ministry of Commerce, Industry and Energy, Ministry of Information and Communications, and part of the Ministry of and Science and Technology and Ministry of Finance and Economy into a new Ministry of Knowledge. The recently set up Ministry of Science, ICT and Future Planning seeks to help the Republic of Korea achieve its ambitious goals.

Sources: Suh and Chen (2007); MOTIE (2011); MSIP (2014).

inequality. In addition, governments must assume a leadership role in developing a regulatory framework to ensure an effective finance sector, the lifeblood of start-ups and KBE-oriented industry sectors. Establishing flexible labor markets is also important for ensuring a nation's talent pools are used most productively—although in this, emerging economy governments in particular face pressures to temper labor markets with legislation to protect worker welfare (again, in the service of minimizing inequality). However, excessive government control and regulation can also be a problem—it can impede the flow of knowledge and technology to a market, and creates bureaucracy, which squelches innovation and entrepreneurship. The example of Singapore provides an example of how the government can provide strong leadership (see Box 2).

Box 2: Orchestrated Government Policies in Singapore

The Government of Singapore initially focused its economic development efforts on promoting labor-intensive export production. Singapore attracted foreign direct investment (FDI) by offering greenfield sites to overseas manufacturers, promising a free-trade economic environment with a stable (and wage-controlled) labor supply. This strategy attracted 10% of the $900 million in FDI coming into Asia (Pereira 2006). The government soon realized, however, that low wages were insufficient to sustain its comparative advantage, and began investing heavily in upgrading technical education and developed a program for subsidizing the training programs of multinational companies in order to raise the level of skills in the economy. It also invested in the Singapore's trade service infrastructure, particularly in seaports, airports, and international logistics. In 2010, Singapore ranked second out of 155 economies in the World Bank's Logistics Performance Index.[a]

The Government of Singapore is noted for its very strong capabilities based on meritocracy and lack of corruption. As a small country with a highly competent civil service and elected officials, Singapore has long been able to achieve fast and efficient coordination across government areas through cross-functional agencies. One such agency is the Economic Development Board, which has been instrumental in attracting FDI and in upgrading Singapore's economic structure. Singapore moved more toward a high-value service economy. It has become a major financial center as well as a health and education hub for East Asia. In 2005, the government championed the introduction of information and communication technology (ICT) use into the economy, exploiting applications and digital channels for improving government service delivery to constituents. Many of these complemented Singapore's core competencies in international trade servicing, such as electronic customs clearance for container vessels, and artificial intelligence programs and automation to improve the efficiency of loading and unloading containers.

Higher education investment, particularly in KBE-relevant disciplines, was another focus: to complement the National University of Singapore, the government upgraded the Nanyang Institute of Technology in 1991. Today, Nanyang Technological University, as it is now known, is the largest engineering school in the world. An explicit strategy to attract globally renowned universities to Singapore has seen such collaborations as the Wharton School with Singapore Management University; the Singapore Institute of Technology, established in 2009 between the Singapore's five polytechnics and foreign technical universities; and the Singapore University of Technology and Design set up in 2012 with the Massachusetts Institute of Technology and Zhejiang University. In addition, various foreign universities have set up foreign campuses in Singapore.[b]

continued on next page

Box 2 continued

In 2003, it started the development of Biopolis, a bio-science city,[c] and Tuas Biomedical Park. Both of these initiatives include attracting top global researchers. In addition, the government has launched a new initiative, Fusionopolis, a physical sciences sequel to Biopolis, to foster the development of ICT and multimedia businesses.[d] Singapore maintains a robust knowledge-based economy, with strong research capabilities, and one of the most business-friendly market environments in the world, despite the government's large involvement in the economy.

[a] Norway, Ireland, Finland, and Hong Kong, China were ranked 10, 11, 12, and 13, respectively. The Republic of Korea was ranked 23, the People's Republic of China 27, Malaysia 29, and Israel 31, showing how important trade logistics has been part of their success. India, on the other hand, was ranked 47. See http://siteresources.worldbank.org/INTTLF/Resources/LPI2010_for_web.pdf

[b] These include Central Queensland University; James Cook University Singapore; University of Adelaide; Southern Cross University of New Brunswick; Queen Margaret University; Temple University; The City University of New York; Baruch College; University of Nevada, Las Vegas; Aventis School of Management; Curtin University of Technology; and the University of Wales Institute, Cardiff.

[c] See http://www.edb.gov.sg/etc/medialib/downloads/pdf.Par.36709.File.tmp/Biopolis%20Factsheet.pdf (accessed 3 April 2011).

[d] See http://www.a-star.edu.sg/tabid/862/default.aspx (accessed 4 April 2012).

Source: Agency for Science, Technology and Research (2013).

b. Tapping into Global Knowledge to Engage with the Global Economic System

The ability to effectively tap into global knowledge is a crucial objective for the EIR. Japan and the Republic of Korea initially relied mostly on trade, technology licensing, and foreign education. Singapore and Hong Kong, China relied on trade and direct foreign investment. A large part of the PRC's very rapid development and moving up the technology ladder has been through the extensive use of all forms of accessing global knowledge (Box 3). Many developing Asian economies can do more to tap into global knowledge through various means.

A developing economy can use appropriate EIR policies to help its domestic economy engage effectively with the global economy. MNCs account for more than 60% of total global R&D (Jaruzelski and Dehoff 2008), and the value added they collectively produce is more than 25% of the world's total and two-thirds of world trade (UNCTAD 2005). With the growing importance of global trade, it is important for emerging economies to tap into the global R&D of MNCs through appropriate policies. By increasing their presence in global value chains through cultivation of relationships with MNCs, developing economies also provide themselves with an entry point into the global knowledge system.[13] A recent ADB study (2013a, p. 32) categorized Asia's various economies according to the extent each participated in global value chains, termed the "Factory Asia" model. It found that all economies in East, Southeast, and South Asia were to some degree on the path to global value-chain integration, though policy adjustments were needed to complete this journey, regardless of their industrialization level. The recommendations in the Factory Asia report, while focused on manufacturing, are also instructive for developing Asian economies set on developing their services sectors. Particularly relevant is the need to make extensive use of all forms of the global knowledge that is "imported" through increased participation in the Factory Asia model; the PRC has been exemplary in this

[13] To a large extent the key point is that countries need to participate actively in global trade. The main conclusion of the growth report was that successful developing countries "took what the world knew, and exported what it wanted" (World Bank 2012c, 22).

Box 3: Systematic Tapping of Global Knowledge in the People's Republic of China

The People's Republic of China (PRC) has been very effective in tapping knowledge through different means:

- **Trade.** In 1980, imports and exports were only 21% of gross domestic product (GDP) in the PRC. By 2007, trade was 76% of GDP. By initially protecting its industries from imports, the PRC developed basic technological capability. Then, by opening up to foreign investment in special economic zones with near free-trade status, it was able to get access to world-class technology and inputs. By joining the World Trade Organization, the PRC committed to a major program of reduction of tariff and nontariff barriers and opening up to foreign investment.
- **Foreign direct investment.** Currently, the PRC has the largest stock of foreign direct investment among developing countries, which has been more valuable for advanced technology and management than capital.
- **Technology licensing.** The PRC has been aggressive in licensing foreign knowledge through formal technology-licensing agreements.
- **Foreign education.** From 1980 to 2000, the PRC sent over 300,000 students abroad. They acquired frontier academic knowledge from many of the best universities in the world. Many returned and brought back both the academic knowledge and practical work experience.
- **Diaspora.** Many high-technology industrial parks located in the PRC have been set up explicitly to attract overseas Chinese. Many of the more than 100 high-tech parks in the PRC cater specifically to the diaspora.
- **Copying and reverse engineering.** While there are no hard data on this, the PRC has been very effective at tapping foreign knowledge through copying and reverse engineering.

Source: Based on Dahlman (2012).

measure.[14] Developing Asian economies also need to leverage service value-chains as part of their KBE strategies.

The role of government and supportive regulation are also crucially important in areas such as green innovation, digital enterprises, and promotion of the penetration of broadband connectivity. Developing economies in Asia need to concentrate as much on information infrastructure as on physical infrastructure.

c. Improving the Business Environment and Intellectual Property Rights Regime

While many of the business environment constraints are persistent and systemic, it is possible for developing Asian economies to effect significant improvement with relatively straightforward regulatory change. Box 4 describes how Kazakhstan significantly improved its business environment in a single year.

A strong IPR regime is particularly important for advanced economies at the global frontier as a reward for the effort required to develop new products, processes, or services. Countries at an earlier stage of development generally benefit by copying or reverse engineering, and adapting

[14] See also Dahlman (2010) for a comparison of the PRC's innovation strategy with that of Brazil, India, the Republic of Korea, and the Russian Federation.

Box 4: The Year of Improving Dramatically: 2011 Business Environment Reforms in Kazakhstan

Kazakhstan improved its Doing Business rating by seven places between 2011 and 2012 through a few key regulatory and bureaucratic reforms. It overhauled its business registration process, resulting in its "ease of starting a business" position jumping 30 places, from 55 in the world to 25. It also improved its ranking in "access to credit" with its score in this category moving from 97 to 83 globally (World Bank and International Finance Corporation Doing Business 2013).These reforms were part of a coordinated strategy of the Government of Kazakhstan to attract foreign direct investment and promote the development of new firms. Kazakhstan has been very open to foreign direct investment in its energy and mining sectors as a means to help it diversify the economy. Inward foreign investment increased from an average of $3.5 billion per year in 2005–2007 to $11 billion–$14 billion in 2009–2011. Of the $13 billion in 2011, $9 billion were in greenfield projects (UNCTAD 2012).

technology that has already been developed elsewhere (Mascus 2012). This was also done historically by the now advanced economies. However, as countries increase R&D spending and aspire to become KBEs, they need stronger IPR regimes to also stimulate the domestic creation of knowledge.

An appropriate IPR regime is an important element of the overall EIR for a KBE, to provide incentives to develop indigenous knowledge-based products and services, as well as to encourage the transfer of global knowledge through FDI (Mascus 2012).

Intellectual property protection regimes in developing economies have historically been ranked poorly. At the same time, nearly all of Asia's high-income economies have strong IPR environments: Singapore; Hong Kong, China; and Japan even rank above the US. The implication is clear: Asia's advanced economies have achieved their successes based on successful KBE development, which requires them to invest in, and profit from, the creation and dissemination of IPR-intensive goods and services. Some developing countries have also seen significant improvement: Malaysia, Sri Lanka, and the PRC have all strengthened their IPR regimes over the last decade—and now rank above the world average.

Intellectual property protection is more than just legislation. The PRC improved its intellectual property laws to be compliant with World Trade Organization standards,[15] and has undergone a sharp increase in patent registration over the last 5 years since 2008—the PRC now has the world's largest number of patent applicants. Nevertheless, foreign companies and foreign governments still consider the PRC's IPR protection inadequate.

d. Improving the Efficiency of Capital and Labor Markets

The economist and political scientist Joseph Schumpeter popularized the notion that economic development is a process of "creative destruction"—as new technologies arise, they make existing products and modes of production obsolete (Schumpeter 1943). Flexible capital and labor markets are required, to be able to continuously redeploy the assets of declining industries

[15] India also revised it laws to conform to World Trade Organization laws, but it has not had an increase in intellectual property registration anywhere near that of the PRC, which has taken the global lead in intellectual property registrations in the world.

into new, rising industries. Increased international competition has in fact accelerated the process of creative destruction.

Most Asian economies have undergone transformative (and often continuous) industrial restructuring as part of their rapid development. Yet most of them also still need to increase their flexibility and the efficiency of their capital and labor markets. While the PRC benefits from its very high savings rate and has nimbly deployed capital and human resources to become the world's leading manufacturer of exports, its financial system shows increasing signs of inefficiency. Its capital output ratio has risen from 3 in the 1980s to 5 in the last decade. Households now receive negative returns on their savings, as micromanaged lending rates keep returns well below the rate of inflation. This has resulted in inefficient allocation of funds: the PRC's state-owned firms only comprise a third of the country's GDP, but receive over two-thirds of its loans.

In the PRC's labor market as well, there are signs of diminishing returns on present allocation methods. A state-influenced (if not specifically controlled) allocation of workers to specific jobs to achieve market-determined outcomes has over the last 30 years allowed for an impressive reallocation of labor, from low productivity agriculture to industry. This has created perhaps the largest migration in recent human history. Over 10% of the PRC's population, perhaps as many as 200 million workers, has migrated to take up manufacturing and service jobs, predominately in coastal provinces. However, this has also caused significant problems for the migratory population in terms of adequate access to public services such as health and education.

Other Asian developing economies face different challenges in improving flexibility in their labor and financial markets. In India, excessively strong labor legislation, enacted to protect the rights of poor workers, makes it virtually impossible for any sizable firm to fire or reallocate workers. This has proven to be a serious impediment to much-needed foreign investment in labor-intensive manufacturing industries. In addition, legislation protects small craft industries in certain sectors, by preventing enterprises with more than five workers from entering. Both these factors have contributed to India's remarkably low participation in the labor-intensive, manufacturing-based export sectors. Manufacturing has not increased its share of employment as is typical as developing countries industrialize, and much of India's rapidly increasing labor force has entered the services sector, mostly in low-productivity and informal positions. Additionally, although India's capital markets are relatively well developed, its bankruptcy laws make it very difficult to reallocate capital to more productive uses: resolving insolvencies in India takes on average 4.3 years and costs 9% of the estate, which puts India at 116 out of 185 economies in the Ease of Doing Business Index.[16]

Capital and labor flexibility are particularly crucial for a KBE. Financial underdevelopment and lack of financial inclusion limits the availability of credit and financing to all types of firms, but particularly to new entrants and entrepreneurs, who often play a critical role in innovation. Expanding financial access to SMEs and entrepreneurs is vital for dynamic efficiency in which new products, services, and industries bring about structural change and deliver large welfare gains over time. Expanded access also facilitates the entry of new producers into the market and thereby stimulates a competitive environment which is conducive for productivity growth.

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[16] With a rank of 144, Indonesia is worse: It takes 5.5 years and costs 19% of the estate, and the recovery rate is only 14%. Singapore has a rank of 2: It only takes 0.8 years, the cost is only 1% of the estate, and the recovery rate is 91%. See World Bank and IFC (2013).

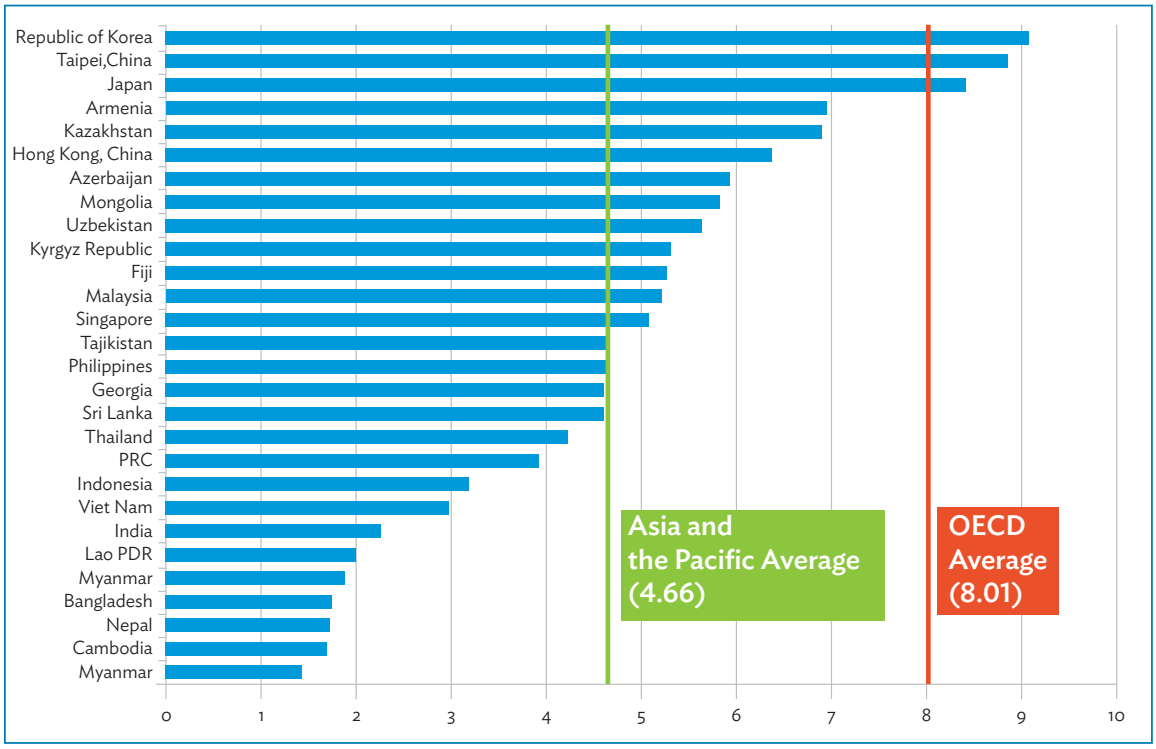
Education and Skills Pillar

In a KBE, innovative ideas and technical expertise hold the key to the new global competitive challenge. KBEs have a strong demand for higher-level skills in the workforce. Evidence from the OECD suggests that a growing proportion of employees with tertiary level qualifications are employed in knowledge-intensive industries along with a rising rate of financial and social returns attributed to tertiary education. Unemployment in OECD countries has been lower for people with a tertiary education.

Despite considerable progress in increasing access to education, many Asian economies lag behind advanced nations in tertiary education enrollment. Except for the advanced economies of Hong Kong, China, the Republic of Korea, and Taipei,China, emerging Asian economies fall behind OECD countries in the education and skills subindex of the KEI (see Figure 8).

The Global Competitiveness Index includes higher education and skills as part of the efficiency enhancers subindex of competitiveness.[17] Figure 9 shows the position of economies in the higher education and skills pillar and confirms that the overall state of play in the education subindex of the KEI in Figure 8.

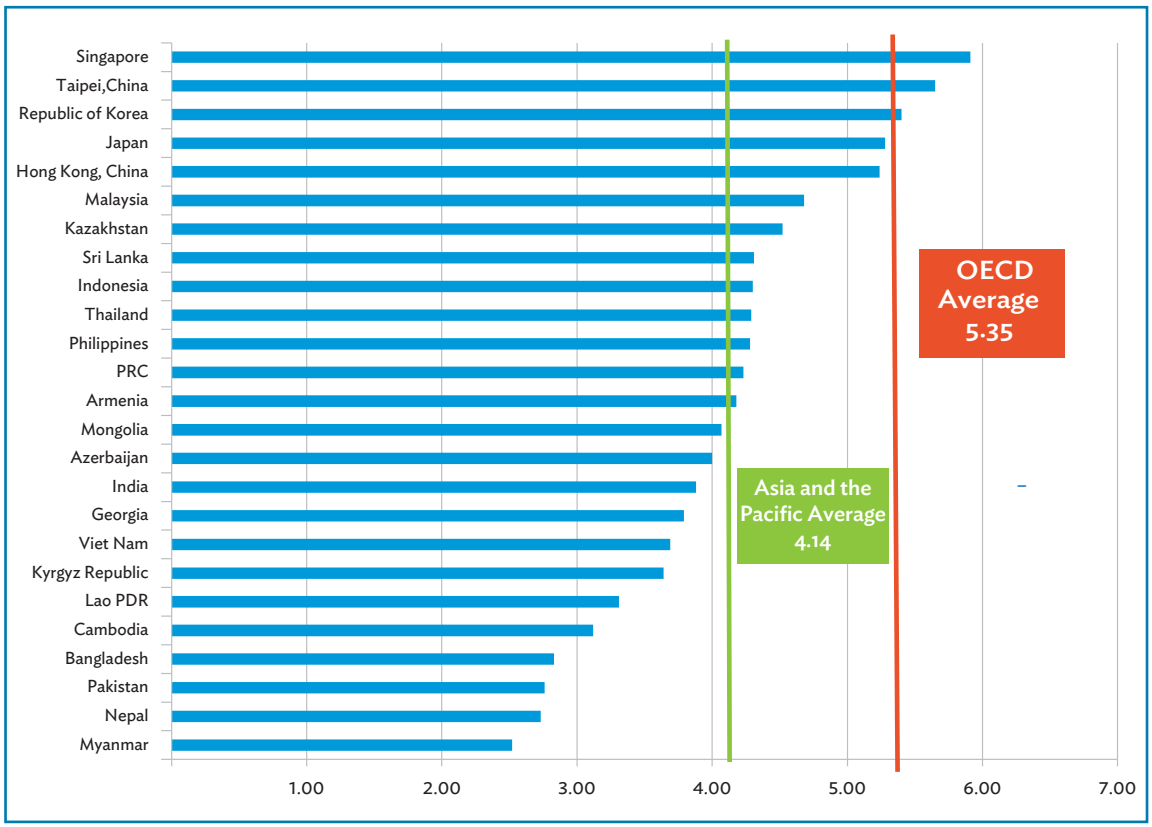
Figure 8: Education and Skills Subindex Scores



Lao PDR = Lao People's Democratic Republic, OECD = Organisation for Economic Co-operation and Development, PRC = People's Republic of China.
Source: World Bank Knowledge Economy Index with data generation and analysis from ADB., http://info.worldbank.org/etools/kam2/KAM_page5.asp

[17] The Global Competitiveness Index includes 12 pillars grouped into three subindices: the subindex on Basic Requirements has 4 pillars – Institutions, Infrastructure, Macroeconomic Environment and Health and Primary Education; the subindex on Efficiency Enhancers has Higher Education and Skills, Goods Market Efficiency, Labor Market Efficiency, Financial Market Development, Technological Readiness and Market Size; the subindex on Innovation and Sophistication Factors has Business Sophistication and Innovation.

Figure 9: Higher Education and Skills as a Source of Competitiveness

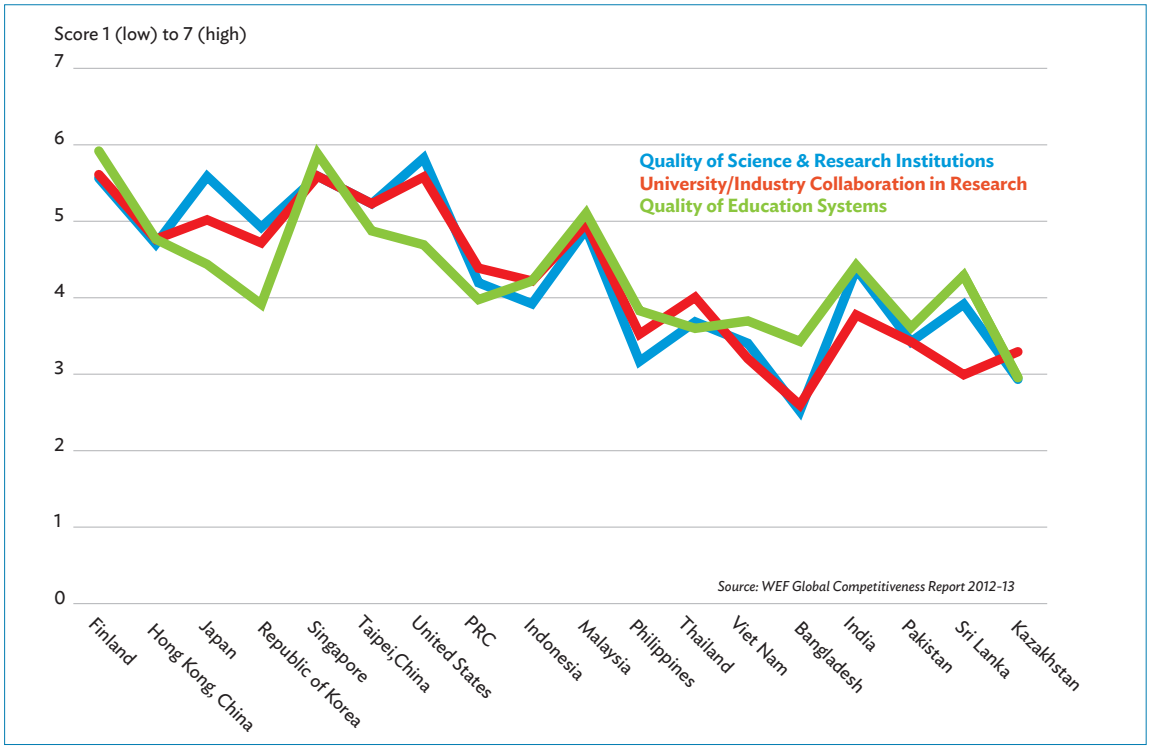


Source: World Economic Forum Global Competitiveness Index Data Platform with data generation and analysis from ADB. http://www.weforum.org/issues/competitiveness-0/gci2012-data-platform/

With regard to the education system quality in Asia compared to the rest of the world, there is a distinct correlation between the low quality of science and research institutions and the status of university–industry collaboration in R&D across the region (Figure 10). Research in science and technology will need to increase across Asian economies. Tertiary institutions must become more entrepreneurial and pursue innovative ways to engage with the private sector for financing and resourcing of research.

Education systems worldwide are being challenged more than ever to provide highly skilled knowledge workers to support growth, technological advancement, and global connectedness. The implications of "massification" of higher education have been immense, with major financial and infrastructure challenges, issues of quality, and potentially diminishing returns in labor markets with more university graduates than the economy can sustain (Altbach and Salmi 2011). While increasing the number of tertiary graduates is an important priority, combining the capabilities of the workforce in innovative and productive ways is crucial. An empirical investigation of the skill formation strategies of 30 leading companies across seven countries found that skill and human resource issues had become more important to corporate competitive advantage (Brown, Lauder, and Ashton 2007). A recent report by Barber, Donnelly, and Rizvi (2013) argues that an avalanche is coming in higher education and that deep, radical, and urgent transformation is required in higher education. A new paradigm for this sector is called for more than any other pillar.

Figure 10: Quality of Tertiary Education in Asia: Correlation of Education System Quality, Quality of Science and Research Institutions, and University–Industry Collaboration in R&D



R&D = research and development.
Source: WEF Global Competitiveness Report 2012–2013.

Human capital of higher order is required in enterprises for effective and efficient use of R&D, while the overall quantum of R&D personnel in companies is low in developing countries, as is their capacity. There is need to build capabilities for R&D but also for venture capital investing experience and mentoring for early start-ups. The success of high-tech start-ups will depend on such human capital support, in addition to finance. This requires training systems to incorporate on-the-job skill updating and "upskilling" in partnership with employees. The teaching of innovation and entrepreneurship is important for emerging economies to develop the human capital required for knowledge economies. Building problem-solving and critical thinking into curriculum development in tertiary institutions across Asia is crucial. In general terms, entrepreneurs in Asia are "entrepreneurs by necessity" (not having found suitable employment, therefore turning into entrepreneurs by necessity for livelihood) rather than innovators by first choice.

Key Guidelines for Developing Asia in Education and Skills

a. Increasing Education for Employment and Employability

A major area in which education systems are failing to adequately meet the demands of current times is in producing "employment-ready" people. In 2010, the PRC recorded about 2.0 million unemployed graduates, which was over a third of the graduating population of 6.1 million (Xinzhen 2009). In India, graduate unemployment was reported at 4.8 million out of a total unemployed population of 44.5 million (Ernst & Young 2010). Graduate unemployment is also an issue in advanced countries such as the Republic of Korea, which has a very high enrollment ratio for tertiary education, as well as countries such as Malaysia and the Philippines. The 2012 Manpower Global Talent Mismatch survey (ManpowerGroup 2012) points out that 45% of employers surveyed in Asia (up from 28% in 2006) reported difficulty in filling positions due to a lack of suitable talent in their markets, compared to a global average of 34%. With unemployment standing at 200 million in 2012, of which 75 million represent unemployed youth, there is a need for education systems to be much more in step with what the market needs. It appears that employers, education providers, and youths have different perceptions of the reality: while 72% education providers believed that new graduates are ready to work, fewer than half of youths and employers surveyed by McKinsey & Co. (2012) believed that new graduates are adequately prepared for entry-level positions.

It is also apparent now that it is not enough to prepare students for employment, but equally if not more important to prepare them for "employability." Employers look for well-educated employees but also seek a workforce that can be imaginative, creative, and collaborative. Educational institutions are currently poorly geared to deliver such skills and competencies. The way students develop higher-order competencies and skills is through a balance of teaching, demonstration, practice, rote learning, synthesizing knowledge, and problem solving (Gamino et al. 2010).

b. Developing More Flexible Systems of Education, Training, and Lifelong Learning

Flexible and balanced systems of education, training, and lifelong learning are required to accommodate a diversified student profile, offering greater choice of learning pathways for lifelong learners at both the tertiary university and tertiary non-university levels. Education systems in Asia need to contend with many imbalances between the demand and supply of skilled workers: by 2020, it is estimated that there would be a shortage of 38 million–40 million high-skilled (college-educated) workers, a shortage of 45 million medium-skilled (secondary education) workers, and a potential surplus of 90 million–95 million low-skilled workers (McKinsey Global Institute 2012). The skill levels of the future workforce clearly need to move in the upward direction. At the same time, the paradox of graduate unemployment and skills mismatch calls for education and training systems that are adaptable and responsive.

Knowledge and skills are necessary but not sufficient. Firms in KBEs increasingly require "competence" rather than just certified qualifications—a mix of "hard" and "soft" skills. New formal vocational and academic education and training need to give rise to a wide variety of highly skilled technical and professional talent. A key attribute required of education systems is to develop more flexible and responsive programs to provide the necessary qualifications and competencies required in the marketplace. Countries that have done well to strengthen the status attached to higher vocational studies, such as Singapore and the Republic of Korea, offer good lessons for developing economies. The Republic of Korea's tailor-made education programs to cater to the human capital needs of specific industries and corporations led to

successful employment and the creation of human capital that enterprises needed. There is need for a variety of higher-order vocational and polytechnic degrees and applied degrees in addition to academic qualifications.

For students and employers, the credibility of a degree continues to be important. On the one hand, there is evidence from the OECD and elsewhere that tertiary degrees bring higher wage returns; on the other hand, degrees have a higher "signaling value" as compared to diplomas and certificates. Singapore presents a good example of resolving this by promoting a system that values both degrees and professional qualifications. The Singapore Committee on University Education Pathways Beyond 2015 has recently recommended adding 3,000 university places by 2020, but these are likely to be on a new "applied degree" pathway which would have a close connection with the economy and produce students equipped with a strong theoretical foundation and a keen understanding of its real-life applications (Singapore Ministry of Education 2012). The popularization of community colleges and associate degrees in Canada is another example of linking education and training with the world of work, yet retaining the signaling value of qualifications. Higher education institutions in developing Asia need a range of credentials. The establishment of well-functioning and forward-looking national qualifications frameworks will be beneficial in this domain.

c. Catering to the Rise of Tech in Manufacturing and the Gray-Collar Worker

In recent years, manufacturing and IT have been seen to be converging with computers and microprocessors increasingly being used in manufacturing. Such manufacturing technologies are likely to become much more widespread within manufacturing environments, resulting in a rising demand for technical workers who will have to play a more hands-on role in installing, adjusting, and maintaining manufacturing technology devices. This in turn is expected to blur the distinction between factory-floor manufacturing workers and tech workers. Traditionally, white-collar occupations belonged to managers and engineers, typically with 4-year university degrees. Blue-collar occupations consisted of factory floor workers who mostly had technical and vocational education and training (TVET) certificates or diplomas. With the assimilation of technologies, a third group—gray-collar or tech workers—has emerged in the contemporary manufacturing environment. These tech workers program, operate, troubleshoot, and maintain the increasing number of computer- and network-driven manufacturing devices. They constitute the new "knowledge workers" in the shop floor, and education and training systems have a crucial

Box 5: New Manufacturing Technologies and the Gray-Collar Worker

New technologies in manufacturing

- Computer numerical control (CNC) machine tools to control the motion of routers, drills, milling machines, turning centers, and automatic welding machines
- Robotics (1,575,000 industrial robots estimated to be in operation by the end of 2015)
- "Cellular" manufacturing in autonomous teams for complex products or components
- Machine vision systems to automate the inspection of products and components and guide robots
- Additive manufacturing technologies or 3-D printing adding materials in layers to create the desired 3-D product or component

continued on next page

Box 5 *continued*

What do employers say?

- 81% agreed that manufacturing technologies are increasingly computer-based, and require skills to manage and operate as computers do.
- 79% agreed that there is a need for certification of workers with the needed skills to manage and optimize specific manufacturing technologies.
- Over 90% also agreed that they view their manufacturing workers as knowledge workers, and that they are full partners in solving problems, improving processes, and satisfying customers.
- 64% agreed that their manufacturing processes require higher levels of skills than in the past.
- 84% agreed that educational institutions in the country need to do a better job of educating the manufacturing workforce on new technologies.

Source: Davenport (2013).

role to play (Box 5). The low prestige associated with TVET qualifications can be ameliorated by a new cadre of qualifications that match the higher-order skills and training and the compensation to be paid to such workers.

d. Expanding Public–Private Partnerships

Expanding public–private partnerships in higher education can be a way of enhancing research investment where private enterprises can benefit from the assistance that university-based research and knowledge transfer can provide. The PRC has established technology zones that benefit from tax reductions for R&D in innovative technologies, for example, in software engineering and nanotechnology providing incentives for private sector investment in R&D in partnership with universities.[18] IBM established 150 centers of excellence (COEs) with selected tertiary institutions across India in 2009. The focus was on advancing software development with the objective of creating a new generation of IT innovators to benefit the industry (IBM NMAM Centers of Excellence 2013).

Public–private partnerships are also starting to strengthen capacity in higher TVET programs responsive to the needs in Asian markets. Corporations have invested not only in workplace training but also in corporate university or academic units that are responsive to job placement and workplace training needs (ADB 2012c). The Infosys Global Education Center in Delhi is an example where coursework and testing are conducted online, and industry works with chambers of commerce to strengthen skills required in the workplace. The setting up of a state-of-the-art Games Solution Centre at Nanyang Polytechnic in Singapore is an example of a tripartite collaboration in training, capacity building, and entrepreneurship development (Box 6).

[18] Drawn from Yang, Hou, and Wang (2013).

Box 6: The Games Solution Centre, Nanyang Polytechnic in Singapore

The Games Solution Centre (GSC) was launched in partnership among the Media Development Authority (MDA) of the Government of Singapore, Nanyang Polytechnic, and Sony Computer Entertainment (Asia) as a resource center for game-based enterprises. The center will help rapid prototyping and development of an environment for small and medium-sized game enterprises at no cost on a first-come–first-served basis to lower entry barriers for game developers. According to the Department of Statistics of Singapore, the game sector's value-added increased at a compound annual growth rate of 50.5% from S$7.7 million in 2004 to S$59.6 million in 2009. This type of industry–government collaboration within a tertiary technical institution is expected to benefit more than 500 game companies and developers over the next 3 years. Game developers will have access to resources, commercialization opportunities, and mentorship available at the center to accelerate the development of their games.

Source: MDA website at http://www.mda.gov.sg/NewsAndEvents/PressRelease/2011/Pages/20111028_Game.aspx

e. Leveraging the Potential of Information and Communication Technology to Extend Access and Improve Quality of Education

In advancing toward KBEs, linking ICT with education is likely to be one of the most powerful tools for bringing about improvements in quality, relevance, equity, and transformational pedagogy. The "digital natives" of today's world learn in completely new ways that blend different modalities and institutional settings. The game-based and simulation-based learning markets in the US are growing at a fast rate. The onset of massive open online courses (MOOCs) has challenged the brick-and-mortar-only type of educational institution. The onset of MOOCs has made spectacular headway within a very short span of time. In little more than a year, Coursera, one of the leading companies developing and hosting MOOCs, currently has 718 different courses from 110 partner institutions including universities across both developed and developing countries with about 8.7 million registered users. Interestingly, science, engineering, and technology disciplines have been leading in MOOC offerings. Mathematics, science, and IT courses account for 59% of the courses offered in 2013. Anytime–anywhere learning and blended learning approaches will become the order of the day. The sooner emerging economies explore and implement promising ICT solutions in and for education, the higher the opportunities for game-changing improvements to education systems and the quality of delivery of educational services.

Education systems of Asia will need to facilitate more innovative and efficient forms of delivery of education by optimizing the use of ICT-based education. The use of ICT-based distance education delivery on a more affordable basis can help tertiary education become more open and affordable. Tecnológico de Monterrey (ITESM) is an example of this (Box 7).

In addition, ICT can play a transformational role in the pedagogy and delivery of education to include more innovative, creative, and interactive processes. The rapid proliferation of educational games and interactive learning materials is changing the very nature of the classroom. Digital games are considered to be the largest and fastest growing market segment of the multibillion-dollar entertainment industry, and there is a large and growing interest in the applicability of games in education. The US game-based learning market was worth $231.6 million in 2010 and is expected to grow at a compound annual growth rate of 12.3% and reach revenues of $413.2 million in 2015 (New Media Consortium 2013). Even more spectacular is the expected growth of the simulation-based learning market, which reached $990.2 million in 2010. The 5-year compound annual growth rate is 20.2% and revenues are expected to reach $2.48 billion by 2015.

Box 7: Tecnológico de Monterrey in Mexico

Tecnológico de Monterrey (ITESM; Monterrey Institute of Technology and Higher Education) is recognized as one of the more entrepreneurial universities in Latin America. Universidad Virtual (UV) and Tec Milenio, the budget delivery model, have been international leaders in distance education through the use of information and communication technology (ICT)–based distance delivery. UV now has offices in 10 Latin American countries with 1,430 learning centers.

ITESM had an additional 144,000 continuing education enrollments where UV provides the dominant delivery modes of satellite and internet delivery. Now a conventional master's degree from ITESM costs a total of around $18,000. UV offers the same program online for around half the cost with credentials that are highly valued by employers in Mexico and in Latin America.

The Tec Milenio University is ITESM's "budget" university with 40 campuses throughout Mexico providing blended online and face-to-face instruction for about 21,000 students from marginalized socioeconomic backgrounds at the senior high school, undergraduate, and postgraduate levels. Tuition fees in Tec Milenio are up to 50% lower than the fees charged for UV programs, highlighting how ICT-based distance delivery can deliver a quality and more affordable product that can reach lower socioeconomic groups in society.

Source: Tecnológico de Monterrey (2005).

Although no firm evidence is yet available on the impact of educational games on academic performance, they are believed to foster higher-order thinking skills, such as planning, reasoning, and strategizing (Pearson 2012). This means that education planners concerned with introducing ICT in educational institutions through the provision of computers and software would do well to consider the application of educational games. Use of interactive educational gaming can contribute significantly to engaging the students in the classroom, thereby reducing dropout rates and providing opportunities to improve learning of concepts through gaming. The advent of the smart classroom with connectivity has the potential to change pedagogic practices in educational institutions that can be supportive of much greater creativity among students as well as self-paced learning environments. More extensive use of electronic media will help accommodate the learning behavior of the multi-tasking "digital generation" (ADB 2012a). Developing Asia would benefit from ensuring a more structured and systematic assimilation of the next-generation digital resources and tools that are already sweeping the education system. Some of these are captured in Table 3.

There is need to enhance ICT capacities of tertiary institutions by benchmarking their syllabus against leading worldwide institutions and introducing ICT certification courses, establishing ICT incubators, improving university–industry collaboration, and deploying demonstration technologies such as e-learning systems. There is a great need to implement widespread and comprehensive initiatives for IT skills of the workforce, possibly in the form of national digital literacy missions as undertaken by India. Virtual academies can provide opportunities for students to undertake "anytime–anywhere" and self-paced learning. The Microsoft Virtual Academy for IT training and the California Virtual Academies for K-12 curriculum are examples of this. Virtual academies can also set up portals for creating, maintaining, and sharing knowledge for higher degree of South–South cooperation. The development of a regional cloud, e.g. across the South Asian Association for Regional Cooperation or the Association of Southeast Asian Nations (ASEAN), for universities to host, deliver, and support ICT-based educational content across Asia would be highly valuable.

Table 3: Evolving Use of Information and Communication Technology in Education

Established Older Technology	New Technology Departures	Educational Features And Position Benefits	Challenges In Using the Technology
Computers and computer labs	Smart classrooms Virtual classrooms Tablets Connectivity	ICT integrated in the classroom and into the pedagogy	Adequate teacher training, content development
CD-ROMs	OERs Cloud-based resources Mobile resources	Expanded access to educational resources; IT services on demand; collaboration tools in education	Reliable connectivity, managing appropriate content linked to curriculum
Distance learning, TV, DVDs	On-line learning Web-based collaborative tools for teachers and students Digital libraries Videos on demand MOOCs Social media	Best educational resources available poor environments Self-paced learning Anytime-anywhere learning	Certification of courses and student learning; blended education platforms and quality of course materials; access to specialized content
Electronic courses, curriculum	Intelligent learning systems, educational games, maker labs Simulation-based training	Adaptive learning and individualized learning; learning with simulation of factories, hospitals, and other work environments; creative learning	Higher-order digital skills required from teachers and faculty; ability of education systems to blend multiples modalities of pedagogy and curriculum
Education management information systems (EMIS)	Learning analytics Big data in education Learning Management Systems	Real-time analysis of student learning, online examinations	Training of teachers and administrators and system development

ICT = information and communication technology, MOOC = massive open online course, OER = open educational resource.
Source: Compiled by author.

f. Investing in Science and Technology Talent Development

The tertiary education system is central to ensuring that research universities are able to undertake the task of training the professionals, high-level specialists, scientists, and researchers needed by the economy and in generating new knowledge in support of national innovation systems.

International open innovation centers in Asia, along the lines of those in the US and Europe, will be beneficial not only in contributing to scientific research but also for brain circulation, capacity building, network expansion, commercialization of research, and cost sharing. Minatec in France hosts 400 companies from 35 countries to participate in the international open innovation research center on micro- and nano-electronics. The Minatec micro- and nanotechnologies innovation cluster was founded by the Grenoble Institute of Technology and CEA, the French Atomic Energy Commission, with support from the state and local government authorities.

Minatec brings together organizations specializing in micro- and nanotechnologies—universities, basic and applied research laboratories, and industrial R&D businesses—with the goal of sharing knowledge and technology to design micro- and nano-devices, right from materials development to applications. Similar bases can be created in Asian countries, which also need to consider the growing mobility of scientific talent and forge talent exchange programs in science and technology with other countries.

The role of tertiary institutions as commercial incubators of technology and innovation is fast gaining ground. While good examples are available in advanced Asian economies such as the Republic of Korea, recent trends need to be tracked. As an example, the University of Southern California Viterbi School of Engineering, in partnership with the venture capital firm Kleiner Perkins Caufied & Byers and the talent and literary agency United Talent Agency, announced the Viterbi Startup Garage, an early-stage technology accelerator designed to provide financial and strategic support to student and alumni entrepreneurs. The US National Science Foundation supports the University Innovation Fellows program implemented as a joint venture between the National Collegiate Inventors and Innovators Alliance and Stanford University to provide training to undergraduate and graduate students to conduct research and use resources to bring innovation and venture activity to their campuses. These types of partnerships need to be exploited by Asia's tertiary education institutions.

The colocation of high-quality technical universities with technology parks, along with links to large companies that can be potential customers of technologies, R&D collaborators, venture investors, technology transfer intermediaries, and knowledge-based service providers such as branding and advertising, would serve Asia well.

g. Establishing World-Class Universities and Centers of Excellence in R&D

Developing Asia needs to create a critical mass of world standard educational institutions and increase the number of institutions that can be classified as COEs. There is a widespread push toward world-class status for universities around the world. Institutions of such caliber should have (i) a high concentration of talent of both faculty and students, (ii) abundant resources for a rich learning environment and for advanced research, and (iii) a favorable governance system that includes autonomy, strategic vision, innovation, and flexibility. A World Bank report suggests three basic strategies to establish world-class universities (Salmi 2009):

- Picking winners: Upgrade a small number of existing universities that have the potential of excelling
- Hybrid formula: Encourage a number of existing institutions to merge and transform into a new university with the necessary synergies corresponding to a world-class institution
- Clean-slate approach: Create and establish new world-class universities from scratch

The development of world-class universities that have strong links with leading universities globally is particularly important for developing Asia. By attracting global talent and collaborating with leading research universities, the National University of Singapore has emerged as a global research hub in graphene and membrane technology. Likewise, the PRC's recent rapid rise as a leader in the field of nanotechnology has been facilitated by researchers in the PRC, many of whom are returnees, who bridge scientific worlds by publishing scientific papers with both domestic and international colleagues. It is important, however, that this does not come at the cost of ensuring a diverse education system of acceptable quality catering to populations in developing economies. Developing Asia also needs to consider establishing a number of COEs in universities and research institutions to enhance their scientific and technological capabilities.

In order to keep pace with technological change, emerging economies also need to invest substantial resources in building COEs in research and technological development. COEs aim to produce original and potentially groundbreaking research, undertake excellent frontline research, and form a joint physical community of scientists, technologists, and industry experts.[19] A COE in research brings together a critical mass of high-level scientists and/or technology developers, plays a dynamic role in the innovation system, enjoys high levels of international visibility and scientific and/or industrial connectivity, and is able to secure diverse sources of finance beyond public funding over time. The private sector could also start COEs in a public–private partnership mode. Bruker, a leading provider of high-performance scientific instruments such as magnetic resonance imaging (MRI) products, set up a COE in Singapore's Biopolis. Within a decade, Biopolis has established a reputation as a world-class biomedical research hub and put Singapore on the scientific world map. The biomedical sciences industry has generated economic wealth, created jobs, and improved human health and the quality of life. Since 2000, manufacturing output of biomedical sciences has increased by nearly fivefold from $6 billion in 2000 to $29.4 billion in 2012. Employment in the biomedical sciences manufacturing industry grew 2.5 times, from 6,000 to 15,700 in the same period. In 2012, the value added of the biomedical sciences industry rose to $15.3 billion, contributing 25.5% of total manufacturing value added (Agency for Science, Technology and Research 2013).

Asia can also learn from the experience of the EU Framework Programme for Research and Technological Development. The program started with the aim of closing the technology gap with the US and Japan, and to promote European competitiveness, especially in energy and IT. It has evolved to become a larger and more powerful instrument for funding and coordinating scientific research as well as more industry-orientated technology efforts across Europe. The scale of the program has grown from ECU2.75 billion for the first framework program (FP1 1984–1988) to €51 billion for the seventh framework program (FP7 2007–2013) (European Policy Evaluation Consortium 2011). FP7 was a key tool to respond to Europe's needs in terms of jobs and competitiveness, and to maintain leadership in the global knowledge economy. Horizon 2020 (2014–2020) succeeded FP7 and is a key tool in implementing the Innovation Union flagship initiative of the EU. The main objectives are to promote excellent science that raises the level of excellence in Europe's science base and to ensure world-class research to secure Europe's long-term competitiveness by

- supporting future and emerging technologies and ensuring world-class research infrastructure (including e-infrastructures);
- supporting industrial leadership aimed at making Europe a more attractive location to invest in research and innovation;
- providing European companies—particularly innovative SMEs—with financing to help them grow; and
- addressing societal challenges such as health, food security, clean energy, and smart and green transportation.

Horizon 2020 is complemented with a Competitiveness and Innovation Framework Programme that focuses on SMEs and supports innovation activities particularly to promote greater use of ICT and increased use of renewable energy and energy efficiency. This EU model can be taken into consideration in the ASEAN region, particularly under the ASEAN Science and Technology Initiative.

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[19] See Danish National Research Foundation webpage.

Innovation and Technological Adoption Pillar

Innovation, for purposes of this report, refers to the scope of activities that lead to the creation and diffusion of *new* and *better* products and processes, and the concomitant accumulation of *intellectual assets* to capture returns from the value they create. An effective innovation system is composed of firms, research centers, universities, and other intermediaries that engage in three knowledge-intensive activities: monitoring and accruing technologies and processes from the growing stock of global innovation, assimilating and adapting them to local needs, and creating new knowledge-based innovations (World Bank 2007, p. 24).

An effective innovation system that creates and diffuses new knowledge is integral to KBEs. There is considerable research that shows that investment in innovation activities contributes significantly to economic growth for nations at all stages of their development (see, e.g., Fagerberg and Srholec 2008; Wong, Ho, and Autio 2005).

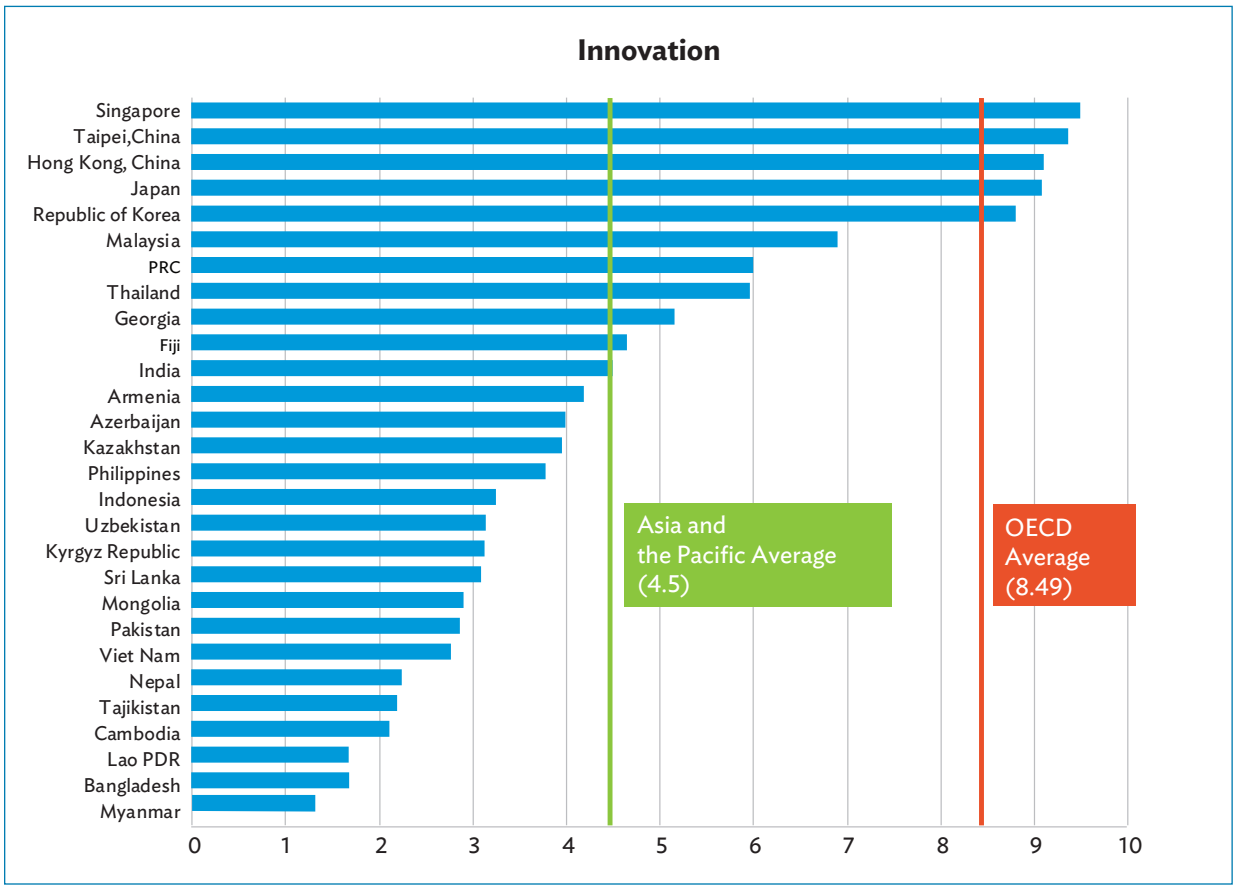
The analysis of the innovation pillar takes a broad view of the concept, covering not only science and technology R&D activities that create and commercialize new knowledge, but also activities that adapt existing technology and business processes in new ways (OECD 2005). Indeed, adapting the technology and processes of advanced economies to the unique market conditions of emerging economies is a vital form of innovation (Juma and Lee 2005; Wong and Singh 2012), and one, given the character of Asia's economic development, that is particularly important.

Research from the OECD in recent years has highlighted that the capability to innovate and to bring innovation successfully to market will be a crucial determinant of global competitiveness (OECD 2007). Innovation is crucial to increasing productivity, which in turn will increasingly assume a larger role as a driver of growth. Countries in Asia that have done well in growth have a better world ranking in the innovation subindex than in the overall Knowledge Economy Index. While causality is difficult to establish, the fastest growing economies in Asia also increased their innovative capacities significantly. The PRC, India, and Indonesia made impressive improvements in their world innovation ranking in 2012 compared to 2000. Developing Asia has benefited from FDI-oriented innovation activities flowing into its economies. Asia's share (excluding Japan) of global patents has increased from less than 0.3% in 1981 to 4.7% by 2000 and to 9% by 2011 (Wong, Ho, and Wong 2013). Asia (again, excluding Japan) accounted for almost 25% of global R&D spending in 2012, with the PRC alone accounting for 13.7%, exceeding Japan's levels (Battelle 2012). Despite such progress, developing economies in Asia fall substantially behind OECD economies on the innovation subindex of the KEI (Figure 11).

The Global Competitiveness Index of the World Economic Forum includes an innovation and sophistication factors subindex which includes the pillars of business sophistication and innovation. Taking stock of the state of play of economies in Asia in the innovation and sophistication factors subindex reveals that it is by and large in conformity with the relative position of economies in the innovation subindex of the Knowledge Economy Index.

Although some emerging economies in Asia have substantially increased their R&D expenditures, a key ingredient for innovation (for example, the PRC is now the second largest spender on R&D in the world in PPP terms and the world leader in registering domestic patents), they still significantly lag behind advanced countries in their innovative capacities. Emerging economies in Asia rank far below advanced economies in relation to all indicators of R&D activities—total expenditure and business expenditure on R&D as a percentage of GDP, as well as total

Figure 11: Innovation Subindex Scores

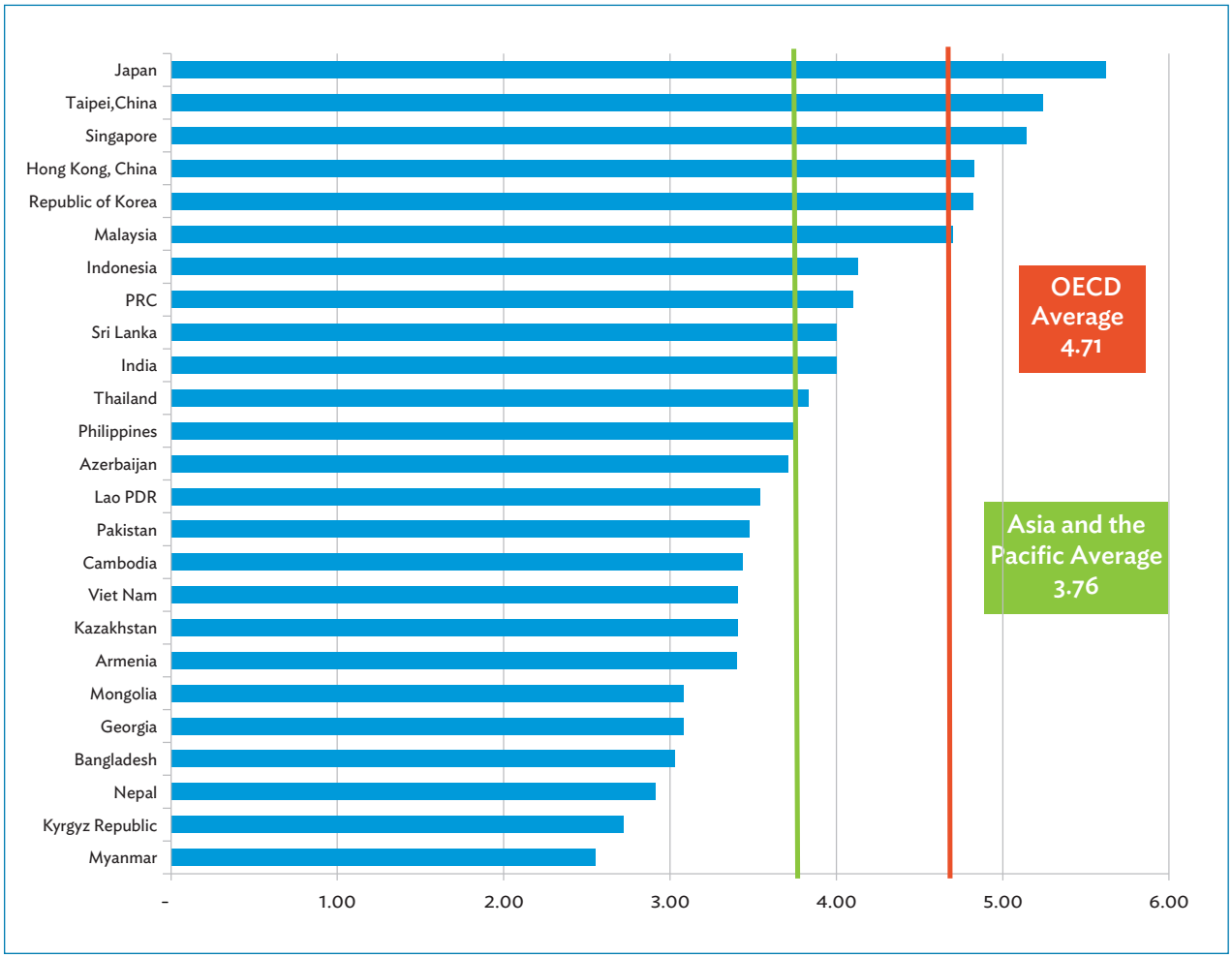


Lao PDR = Lao People's Democratic Republic, OECD = Organisation for Economic Co-operation and Development, PRC = People's Republic of China.
Source: World Bank Knowledge Economy Index with data generation and analysis from ADB. http://info.worldbank.org/etools/kam2/KAM_page5.asp

and R&D personnel in business. The resultant lower intensity of output of R&D activities, as measured respectively by the number of scientific publications and patents granted per million people, is evident. Developing Asian economies also have markedly lower levels of *indigenous* ownership of the patents produced—the share of US patents granted to organizations domiciled in developing Asian economies in 2006–2011 is smaller than 30%, versus over 90% for Japan and the Republic of Korea and over 75% for Finland and Taipei,China, respectively. The exception is the PRC, where domestic organizations generated 43% of the patents granted by the United States Patent and Trademark Office, close to the 45%–46% level achieved by Singapore and Hong Kong, China. India and the PRC have doubled their R&D spending between 2007 and 2012 to reach $200 billion and $40 billion, respectively, which accounted for nearly 20% of global R&D spending and puts them in a good position for the future.

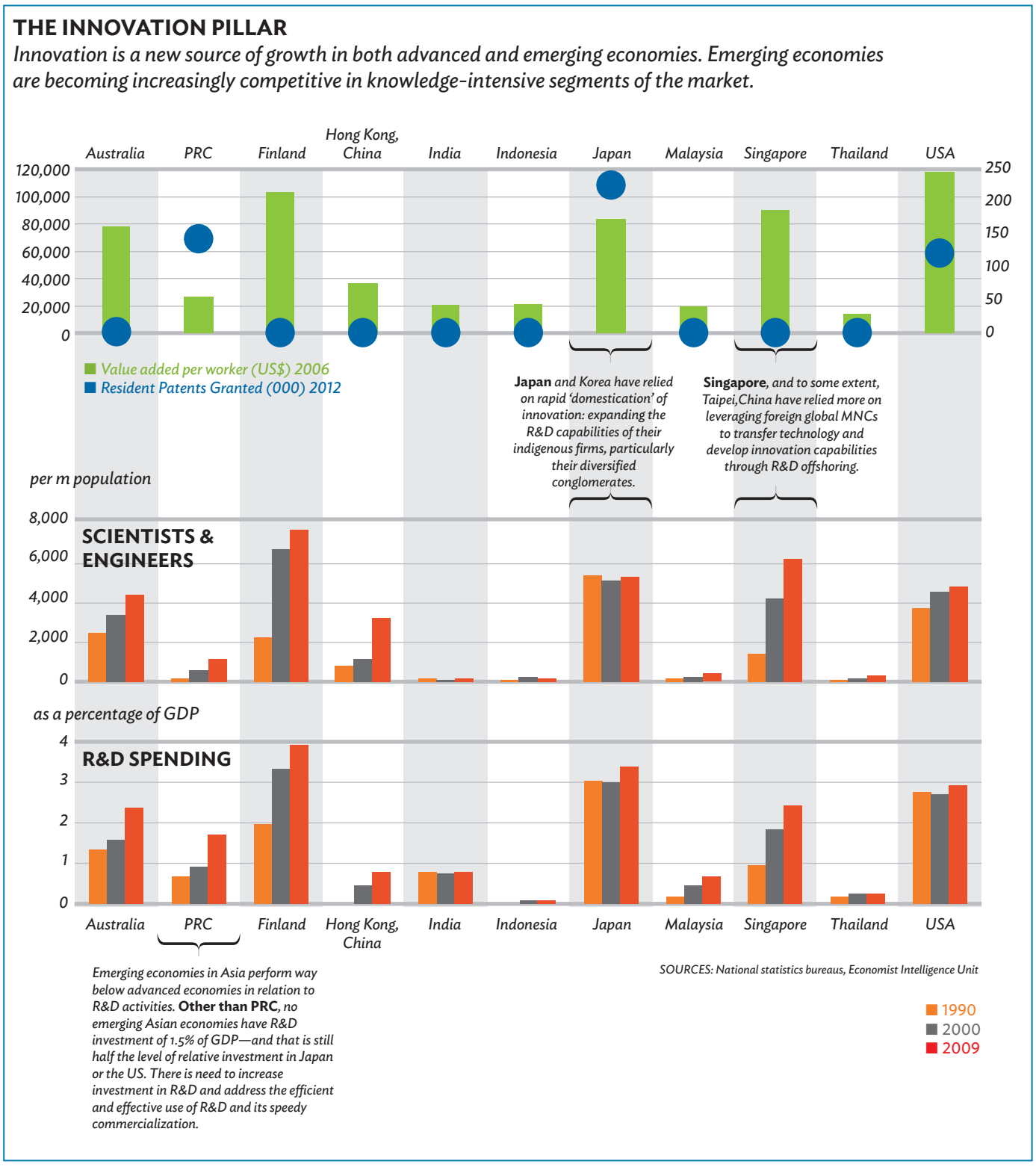
Other than the PRC, none of the emerging economies have R&D investments of the order of 1.5% of GDP that countries such as Japan, the Republic of Korea, and Singapore undertook at middle-income levels. Figure 13 reveals differences between developing economies of Asia and advanced countries on innovation indicators. On the one hand, there is need to increase investment in R&D, but on the other, there is an important need to address the efficient and effective use of R&D and its speedy commercialization.

Figure 12: Innovation and Sophistication Factors Subindex – State of Play of Asia



Source: World Economic Forum Global Competitiveness Index Data Platform with data generation and analysis from ADB. http://www.weforum.org/issues/competitiveness-0/gci2012-data-platform/

Figure 13: Innovation Pillar: Comparative Picture of Selected Asian Economies



Key Guidelines for Developing Asia in Innovation

a. Tapping Effectively into Global Knowledge

Fostering innovation in an emerging economy is, by necessity, a balancing act: knowledge from global markets needs to be attracted and exploited, while conditions need to be established to encourage the production of new indigenous innovations. The rapid technological catch-up achieved by Japan, the Republic of Korea, Singapore, and Taipei,China was based on specific strategies to acquire and assimilate technological knowledge from overseas, before shifting emphasis to indigenous knowledge creation (Wong and Ng 2001). Less developed economies in Asia need to prioritize the effective absorption of global knowledge, while middle-income economies like the PRC and Malaysia need to move into technology creation capabilities to overcome the "middle-income trap." For the former, key reforms in terms of investment and intellectual property right (IPR) protection policies will be important to improve access to global knowledge through FDI. For the latter, a proactive approach to tapping into global knowledge will be needed, such as attracting overseas diasporas to return (Saxenian 2007), developing joint R&D with advanced countries, and opening up their universities to foreign faculty and students.

b. Promoting Indigenous Innovation Capability Development

Making the leap from innovation assimilation to innovation creation can be accomplished in diverse ways. Asia's advanced economies have demonstrated two ways to go about it: Japan and the Republic of Korea have relied on rapid "domestication" of innovation: expanding the R&D capabilities of their indigenous firms, particularly their diversified conglomerates. Singapore and, to some extent, Taipei,China have relied more on leveraging foreign global MNCs to transfer technology and develop innovation capabilities through R&D offshoring (Wong and Ng 2001). Taipei,China has sought to promote indigenous technological capability development by leveraging on its numerous small and medium-sized enterprises (SMEs) through a government-orchestrated "consortium" development approach. See Box 8 on the successful approach of Taipei,China to foster innovation among SMEs.

A common challenge facing Asia's developing economies is that their indigenous firms are predominantly small and medium-sized enterprises (SMEs), and thus lack the scale and resources to pursue significant innovation activities. The experience of Taipei,China shows how this can be overcome: through policy and institutions that coordinate and consolidate innovation across SME clusters—or an "innovation consortium strategy." The Industrial Technology Research Institute (ITRI) pioneered the consortium development approach to upgrading the technological capabilities of many existing industries (Mathews 2002). By working with a consortium of SMEs rather than with individual firms, ITRI was able to achieve scale economy in research and development (R&D) activities, synergizing on relevant expertise from different member firms while providing overall coordination of activities. In addition, by engaging the targeted recipient SMEs early in the R&D process, ITRI was able to shorten the subsequent diffusion process. Participating firms were provided preferential access to the intellectual property arising from the R&D at very low licensing fees, but because multiple firms were involved, competition was induced among these firms in a race to commercialize them.

The first successful demonstration of this R&D consortium approach is the development of IBM-compatible personal computer (PC) technologies in 1983 that helped many firms in

Box 8: Team Approach to Innovation: Industrial Technology Research Institute Industrial Innovation Consortium Programs in Taipei,China

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The first successful demonstration of this R&D consortium approach is the development of IBM-compatible personal computer (PC) technologies in 1983 that helped many firms in Taipei,China enter the "PC-clone" manufacturing industry. The subsequent ITRI Notebook PC consortium enabled Taipei,China to emerge as the world leader in laptop computer manufacturing, a position it continues to hold today. A similar consortium approach has helped accelerate the technological development of several other industries including the bicycle and golf club manufacturing industry, the inkjet printer industry, the thin-film-transistor liquid-crystal display (TFT-LCD) display industry, the wire-cutting machine industry, the WiMAX industry, and the lithium battery industry.

Source: ITRI (2014).

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c. Innovating to Compete Both in Global and Domestic Markets

As developing economies shift from applying existing technologies to developing new technological capabilities, not only do they compete with advanced countries directly in global markets, but they also build new products and services purpose-build for their own domestic markets. This affords them new export market opportunities to other emerging markets—and even in advanced economies. While innovating for emerging markets once was associated with lower-quality products achieved through cost reduction, recent developments have shown that innovators in emerging Asia can develop cutting-edge technologies at lower costs as well (see Box 9 on the electric bike industry in the PRC). This "reverse innovation" phenomenon has been increasingly embraced by global MNCs as well (Govindarajan and Trimble 2012).

Box 9: Leading Domestic and Global Markets: Electric Bikes Industry in the People's Republic of China

Since the mid-2000s, the People's Republic of China (PRC) has become the world leader in the emerging electric bikes ("e-bikes") industry, one of the fastest growing industries in the world today. It is now the largest producer and consumer. In 2010, the PRC produced 28.8 million e-bikes, accounting for over 90% of the world market and also emerged as the world's largest consumer market for e-bikes, with sales of e-bikes exceeding those of gasoline-powered motorcycles in 2005 itself. The PRC is the only country in the world that has managed to accomplish this.

A combination of factors contributed to the success in this emerging industry (Ruan et al. 2012; Weinert 2007). First, some of the existing strong base of local assemblers of gasoline-powered motorcycles and manufacturers of components began to explore new market diversification opportunities. Second, the central government identified e-bikes as one of the 10 major technology projects under the Ninth Five-Year Plan, and the National Torch Program provided public research and development funding to local enterprises. Third, a number of cities announced a ban on the sale of gasoline motorcycles. Fourth, the central government established a national e-bike standard in 1999. Following the enactment of this national standard, nine provinces in the PRC began granting e-bike licenses the same year, which stimulated many new entries into the industry. By 2004, as more cities banned gasoline motorcycles coupled with the rectification of a new Road Transportation Safety Law giving e-bikes the right to use nonmotorized vehicle lanes, the e-bike market took off. An increase in the export tariff rebate further strengthened the PRC's position in the global e-bike industry.

Source: Ruan et al. (2012).

As developing economies learn to shift from applying existing technologies to developing new technologies, this need not mean competing with the advanced countries directly in global markets. Indeed, one area where local firms (and local public research institutes) in emerging markets may be able to achieve success in mass markets compared to their more technologically advanced competitors from the advanced economies is investing in innovation that better fits the specific needs of mass markets. These markets tend to be in rural areas with lower technological sophistication and lower price affordability, such as the large number of consumers at or near to the bottom-of-the-pyramid markets, which are generally defined as markets prevailing among the poorest socioeconomic groups living on less than $2.50 a day. The case of Simpa Networks (Box 10) illustrates the power of such frugal or *jugaad* innovations in developing Asia (Radjou, Prabhu, and Ahuja 2012).

d. Promoting Innovation Activities for Inclusive Growth

Inclusive innovation is a priority for emerging economies in Asia that need to address inequality and poverty, although they have made good progress in reducing the number of poor. Rural innovation initiatives are required to bolster inclusive growth development efforts. In recent years, such a focus on innovation relevant to poor and rural communities has led emerging economies to develop frugal innovation. India, in particular pioneered the concept of *jugaad* innovation (Radjou, Prabhu, and Ahuja 2012).

These types of innovative activities to serve mass markets at the bottom of the pyramid are radically altering the global R&D landscape. While countries such as India and the PRC are already acquiring prominent positions in terms of their share in R&D investments, they are also helping to redefine the innovation marketplace. The new landscape with the emerging economy innovation hubs and local engineering has inaugurated a new class of competitive products designed,

Box 10: Simpa Networks' Off-Grid, Pay-as-You-Go Solar Energy Solutions in India

Simpa Networks is a company that offers a simple, meter-based, prepaid energy service using an innovative pricing system to provide access to affordable and clean energy for underserved consumers in India. The Asian Development Bank has made a $2 million equity investment in Simpa Networks, as a result of which more than 60,000 households in rural India will have better access to electricity by 2015 as Simpa Networks scales up the sales of its off-grid, pay-as-you-go solar energy solutions. Rural consumers with low and uncertain incomes find it difficult to pay the up-front cost of a solar energy system. Simpa Networks' customers make a small initial down payment for a high-quality solar home system and then prepay for their energy service, topping up their systems like a mobile phone service. Each payment also adds toward their final purchase price. Once fully paid, the system unlocks permanently and continues to produce electricity. The technology is also offered to solar micro-grid developers and companies selling solar home systems as a very flexible prepaid metering, customer, and revenue management solution.

Source: ADB (2013c).

engineered and priced for the low- to mid-range market segments. In many industries and sectors, they are the world's fastest growing segments. For example, strong demand in emerging and developed countries is boosting sales of medium and low-end mechanical engineering technologies above world market averages.

It is estimated that the aggregate market growth rate for high-end technologies globally will be 6% annually between 2010 and 2015—but growth for mid-range and low-end technologies will likely be much higher, estimated at 10% and 11% annually, respectively (Roland Berger Strategy Consultants 2012). Frugal products pitched to low- and mid-range consumers are thus growing profit centers in emerging markets, which are also likely to make a mark in global markets. Companies such as GE Healthcare, Proctor & Gamble, and other MNCs that have innovated products for bottom-of-the-pyramid markets are using such products not only to build market share in emerging markets but also to target niche markets for mid-range products in advanced nations. Policy makers in emerging economies need to support indigenous firms with local market knowledge and skills to exploit such opportunities. Indeed, many innovative solutions have been pioneered by local entrepreneurs in the PRC, India, and other developing economies. See Box 11 on grassroots innovations by local entrepreneurs. Public policies can build on these successes by channeling more public funding of R&D toward policies that focus on technologies relevant to low-income population segments. Public policies to promote and support social entrepreneurship will also help, such as the promotion of social impact investing.

An important avenue for innovation financing is the development of innovation intermediaries such as proof of concept labs, early stage financing, mentoring, business development support, market scoping, and testing. Innovation assets such as branding and marketing are crucial to benefit from innovative activity. Interestingly, it is estimated that rapidly growing middle-income economies such as the PRC and India today invest more in branding than high-income countries did when they were at a comparable stage of development (WIPO 2013). For frugal products or otherwise, such support through branding will further enhance the economic value of the innovation.

Emerging economies can also bolster such gains through R&D services. The PRC and India have become net exporters of R&D services to the European Union (EU) as their growing R&D competence and status attract more R&D projects. Between 2005 and 2010, the value of EU imports of R&D services from the PRC quadrupled to €953 million, while imports from India

Box 11: Grassroots Innovations from Indigenous Inventors

Jugaad innovations in India and frugal innovations in other developing economies like the People's Republic of China are often created by local inventors who are not highly educated but have used their knowledge of local contexts, their creativity, and patient experimentation to achieve. An example is MittiCool, a low-cost refrigerator made of clay that requires no electricity, is biodegradable, and produces no waste (Radjou, Prabhu, and Ahuja 2012). It was invented by an uneducated clay potter after an earthquake had devastated his village. Another example is a "rain gun," a cost-effective water sprinkling innovation for farming by a 70-year-old farmer in Kerala, India. With the help of Rural Innovations Network (RIN), a business incubator for indigenous technologies, the invention was further developed and commercialized (Banerji 2004).

There have been increasing efforts to document and develop comprehensive databases of such local grassroots innovations in developing economies, by national as well as international agencies. In India, the Honeybee Network and Society for Research and Initiatives for Sustainable Technologies and Institutions has been cataloging innovations developed by farmers, artisans, and rural women at the grassroots level. Since 2000, this work has been co-opted by India's National Innovation Foundation (NIF). The China Innovation Network at Tianjin University is developing a similar registry of indigenous innovations in the People's Republic of China, while Fundacao Banco de Tecnologias Sociais in Brazil is developing a database of indigenous innovations in Latin America.

Source: Jugaad Innovation (2011) and author compilation.

increased from €507 million to €734 million. A previous EU external R&D services trade surplus is now a deficit of €659 million for India and €454 million for the PRC (Eurostat 2012).

e. Nurturing "Innovative Entrepreneurs"

In recent years, there is growing attention to greater public policy focus on the growth of *innovative* entrepreneurship, ranging from policies to facilitate market entry and enable risk financing, to educational policies that inculcate entrepreneurial mind-sets.

The Global Entrepreneurship Monitor (GEM) surveys in recent years rate developing Asian economies relatively highly in their Total Entrepreneurial Activity (TEA), but they find that a significant proportion of this activity stems from "necessity" (undertaken by those who lack the skills to get well-paid jobs) rather than "opportunity" (undertaken by highly educated entrepreneurs). As highlighted by Wong, Ho, and Autio (2005), it is this latter type of opportunity-driven entrepreneurial activities that contributes most positively to economic growth. To become a KBE, an economy must have not only a large number of people with a high level of knowledge but also a propensity among such people to become entrepreneurs.

There is thus a particular need for developing Asia to get its most highly skilled and educated people to develop an entrepreneurial mind-set and skills, to commercialize this advanced knowledge and grow their economies faster. The promotion of such innovative entrepreneurship would involve changes in all four KBE pillars in most developing economies, in the following ways:

- through injecting entrepreneurial dimensions to higher education—and in the training of scientists and engineers in particular (see Box 12 on the National University of Singapore Overseas College program)
- through public policies that improve funding for innovation-based start-ups

Box 12: Inculcating Entrepreneurial Mind-Sets through Experiential Learning: The NUS Overseas College Program in Singapore

Singapore's leading university, the National University of Singapore (NUS), traditionally produced graduates who readily found employment in multinational corporations and the public sector. In 2000, NUS initiated an experimental "immersive" educational program, the NUS Overseas College (NOC), to inculcate an entrepreneurial mind-set among the university's undergraduate students. Twice a year, a select group of third-year students were sent on year-long internships in high-tech start-up companies in Silicon Valley, while also taking courses on entrepreneurship at Stanford University. The NOC program has been replicated in six other entrepreneurial hubs around the world—Philadelphia in 2002, in partnership with the University of Pennsylvania; Shanghai in 2003 with Fudan University; Stockholm in 2005 with the Royal Institute of Technology (KTH); partnering with various institutions in India in 2008; Beijing in 2009 with Tsinghua University; and in Israel in 2011. A local version of the program (called iLEAD) involving internship with high tech start-ups in Singapore was also started in 2007.

The program has had a transformational impact on the students involved. Surveys have shown that an NOC returnee is more than five times as likely to start his or her own ventures within 2 years of graduation than the average NUS graduate. They are also significantly more likely to choose to work in young entrepreneurial firms or pursue unconventional career paths.

Source: NUS (2014) and author compilation.

- by removing institutional and regulatory barriers to starting businesses (Ho and Wong 2007): reducing regulatory compliance costs, tackling corruption, and removing regulations that prevent researchers at universities from engaging in start-up activities
- by implementing policy changes to make ICT infrastructure more available and more affordable

f. Enhancing Financing for Innovation

Innovation systems require innovative financing solutions, beyond the straightforward funding of R&D activities. In particular, for the developing Asian economies, there is a need for public sector funding to bridge the so-called "valley of death," which prevents new technologies and knowledge from being commercialized by local start-ups and SMEs. Such funding can take the form of proof-of-concept and patent application grants, innovation voucher schemes, and incentives for collaboration between firms and universities. Policies that have been found to be effective in advanced economies include the SBIR program in the US (see Box 13) and the TEKES program in Finland, both of which can be adapted to developing economy contexts. Private financial service firms can also be incentivized to provide funding for innovation-based start-ups. Examples include business angel investment co-matching schemes and incubator development programs that attract and leverage foreign scientists and investors (e.g., Israel's Incubation Support program [Trajtenberg 2002] and Singapore's Business Angel Scheme and Incubator Development Program [Wong and Singh 2012]).

Impact investment funds are a recent form of financing for innovation particularly suitable for emerging markets. While structured like conventional venture capital funds, impact investment funds differ in that they invest in ventures that generate measurable social and environmental impact as well as financial returns. The Global Impact Investing Network estimated in 2009 that the impact investment market could grow to $500 billion by 2014, and a recent study

Box 13: Bridging the "Valley of Death": The Small Business Innovative Research Scheme in the United States

The commercialization of innovative technologies coming out of university labs and public research institutes drives growth in high-tech industries in knowledge-based economies like the United States (US). However, even in these advanced economies, with sophisticated private venture capital industries, there is often inadequate private risk capital available for the very early stages of technology commercialization. Innovative start-ups seeking to convert university research and development (R&D) into products and services in the marketplace often face cash-flow challenges at this stage, known as the "valley of death."

The Small Business Innovation Research (SBIR) scheme seeks to bridge this valley. It provides crucial early-stage funding for independent high-tech start-ups through a competitively awarded program that mandates all federal R&D agencies with over $100 million of funding to allocate a percentage (since 1997, 2%) toward SBIR projects. The SBIR scheme is a two-phase program: Phase I awards grants of up to $100,000 for a start-up's feasibility study, and Phase II provides grants of up to $750,000 to fund the prototyping and development work to test their commercialization potential. Many recipients of SBIR grants have become successful high-tech firms listed on Nasdaq: Qualcomm, Ortel, Curagen, and Avant Immunotherapeutics.

The SBIR scheme now represents the single largest source of early-stage funding for technology commercialization in the US; in 2010, close to 4,300 small businesses received Phase I awards, and over 1,900 received Phase II awards. The success of the SBIR scheme in stimulating technology commercialization by small firms has led to similar programs in Israel, Finland, Sweden, and Australia. Singapore also implemented a SBIR-like program in 2008.

Source: Wessner (2008).

commissioned by ADB also highlighted growing opportunities for impact investing in developing Asia (ADB 2011). While most high-profile impact investing funds (e.g., the Acumen Fund and the Omidyar Network) originate from advanced countries, the number of local impact investors is growing fast. The opportunity thus lies in channeling more funds from the rich world seeking to do good, including many private charities, official development assistance organizations, and international development agencies, into the hands of such local impact investors.

Information and Communication Technology Pillar

The world has become more connected, networked, and interdependent than ever before, primarily due to the development and diffusion of ICT,[20] which plays a pivotal role as an enabler in transforming resource-based economies into knowledge-based ones. ICT is a key enabler of innovation and is a fundamental resource for a KBE. It has opened many new avenues for growth and employment. ICT is thus drawing more attention than ever before from policy makers and business alike, since ICT promotes inclusive growth while also bringing tangible economic value

[20] ICT typically includes hardware, software, network, and media used for collecting, storing, processing, and presenting various forms of information, including voice, text, data, and images.

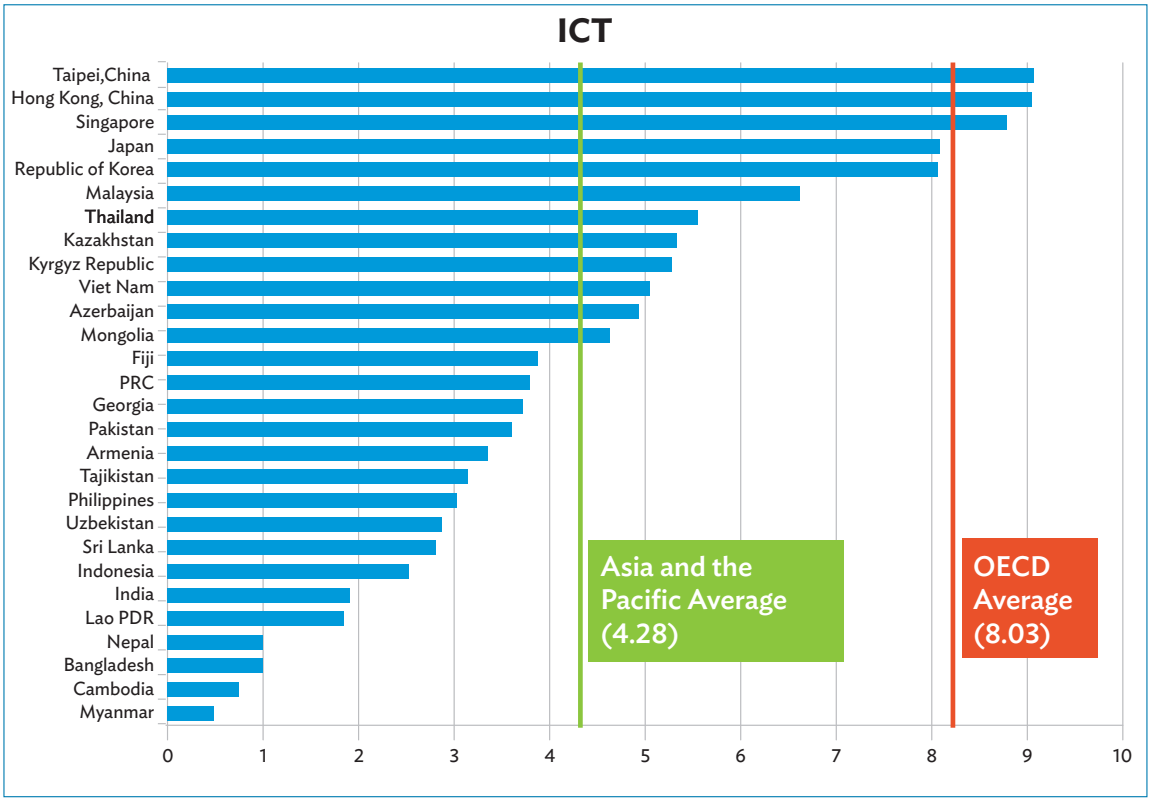
to businesses. Building and strengthening digital ecosystems becomes increasingly important for emerging economies.

Emerging economies in Asia fare much worse than the OECD countries in the ICT subindex of the KEI as well. See Figure 14 for a comparative position of developing economies of Asia on the ICT subindex.

A recent study suggests that a 10% increase in mobile phone penetration contributes to a 4.2-percentage-point increase in total factor productivity (Deloitte 2012), and another argues that the impact of ICT on economic growth is greater in developing economies than in developed economies (Qiang 2009; see Figure 15).

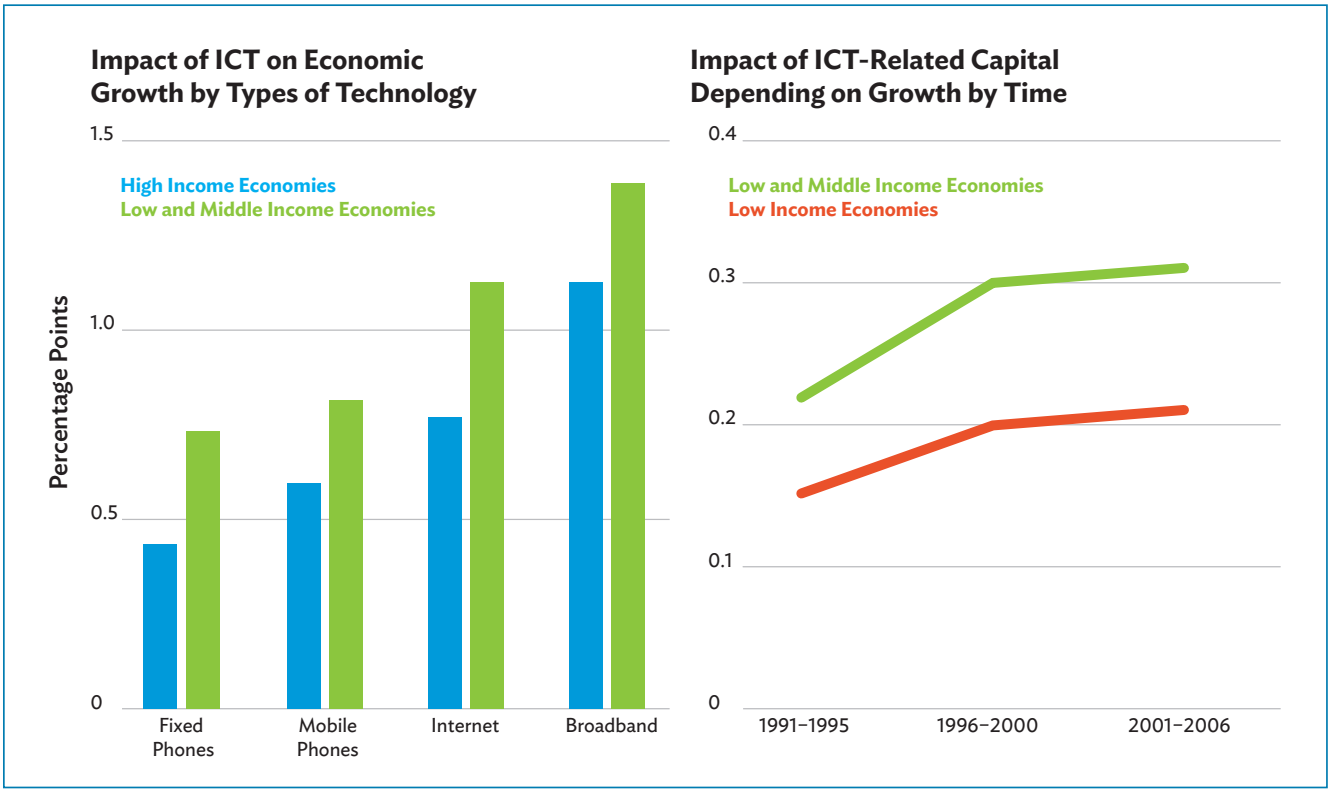
In the private sector, the ICT industry and ICT applications contribute to economic competitiveness through productivity growth, cost reduction, innovation, and easing of geographical constraints. ICT is also a potential enabler to transform the government sector by improving the quality of government and empowering citizens. ICT helps make governments more efficient, effective, transparent, and accountable by reengineering administrative processes, improving public service

Figure 14: Information and Communication Technology Subindex Scores of the Knowledge Economy Index



ICT = information and communication technology, Lao PDR = Lao People's Democratic Republic, OECD = Organisation for Economic Co-operation and Development, PRC = People's Republic of China.
Source: World Bank Knowledge Economy Index with data generation and analysis from ADB. http://go.worldbank.org/JGAO5XE940

Figure 15: Information and Communication Technology (ICT) as a Growth Catalyst: Impact of ICT on Economy by Kinds of ICT and by Time



ICT = information and communication technology.
Note: The Y-axis represents percentage point increase in economic growth per 10 percentage point increase in telecommunications penetration.
Sources: Qiang (2009) and Haacker (2010).

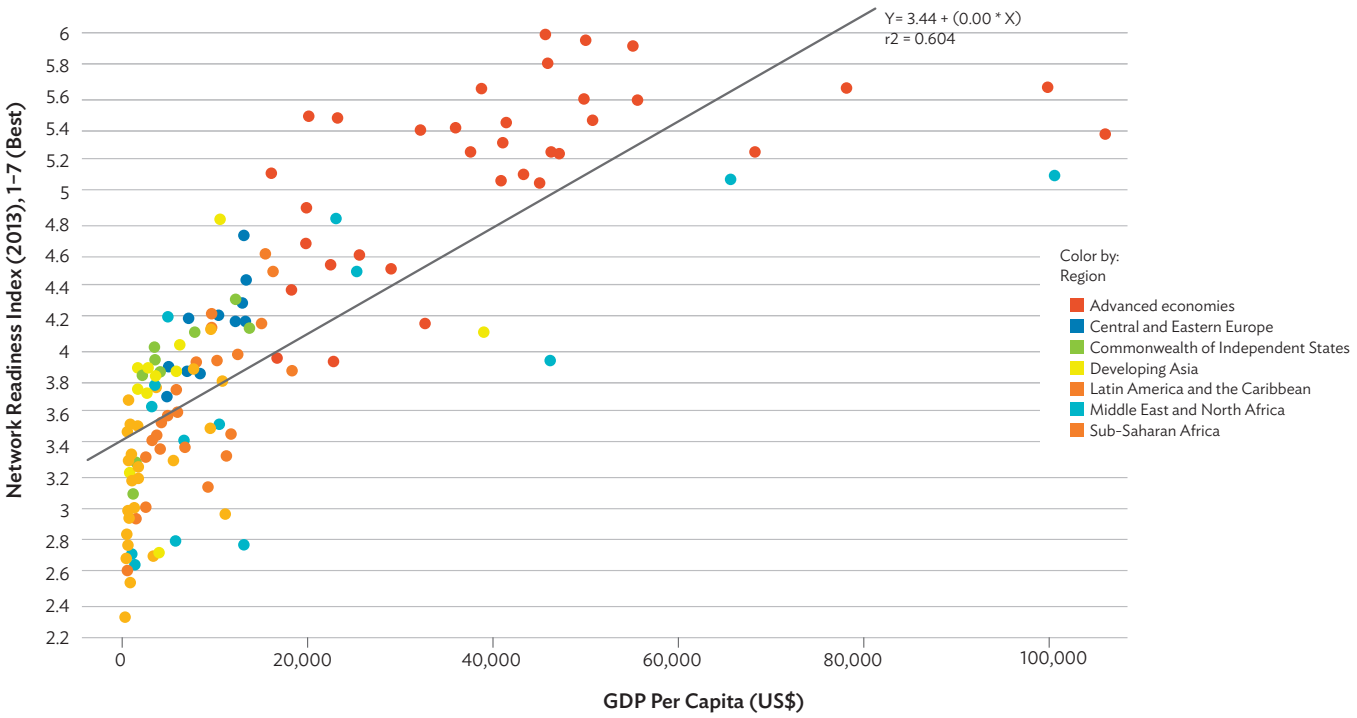
delivery, and promoting citizen engagement and participation in policy-making processes. There is also evidence of a positive association between e-government development and reduction of corruption (Anderson 2009). Citizens' use of e-government also helps restore and improve trust in government, as e-government services and the provision of information improve citizens' perceptions of the efficiency, transparency, and effectiveness of government and enhance their sense of participation and empowerment (Welch, Hinnant, and Moon 2005; Tolbert and Mossberger 2006).

Yet, while Asia is in this globally unique position to leverage ICT for accelerating economic growth and increasing social welfare (and indeed, it already has), critical adoption challenges still remain. These include accelerating the advancement of broadband ICT infrastructure, increasing Asia's e-government channels, as well as adopting more ICT applications for inclusive growth.

In the last decade, developing Asian economies have become important players in the global ICT sector, and some Asian economies have considerably better ICT capacity (represented by the Network Readiness Index in Figure 16 than their per capita income would suggest. Malaysia in particular is an outlier, in large part because of aggressive ICT initiatives the Government of Malaysia has undertaken for the creation of an ICT-based knowledge economy since the mid-1990s (see Box 14).

Asian economies also have taken leading roles both in the production and use of ICT goods and services. Some developing Asian economies, such as Malaysia, the PRC, and India, have done

Figure 16: Correlation between Gross Domestic Product per Capita and Network Readiness Index



ICT = information and communication technology, Lao PDR = Lao People's Democratic Republic, OECD = Organisation for Economic Co-operation and Development, PRC = People's Republic of China.
Source: World Economic Forum Global Information Technology Report 2013 Data Platform.

Box 14: Information and Communication Technology as a Knowledge-Based Economy Engine in Malaysia

Malaysia was largely an agriculture-based economy at independence and remained a resource-based economy until the early 1990s. In its 6th Malaysia Plan (1991–1995), however, the government began to implement a series of information and communication technology (ICT) policy initiatives, including the establishment of the National Information Technology Council in 1994 and the Multimedia Super Corridor (MSC) initiative in 1996, aimed at building a competitive cluster of local ICT companies and a sustainable ICT industry based on a platform of advanced network infrastructure investments. A Malaysian Public Sector ICT Strategic Plan in 2003 promoted e-government and ICT applications for public service delivery, and the Malaysian Information, Communication and Multimedia Services 886 Strategy, implemented between 2006 and 2010, allocated RM12.88 billion ($3.55 billion) for ICT-related programs. Strong, comprehensive, and holistic government initiatives helped grow its domestic electronics, data center, and IT-enabled services sectors. In 2011, the share of ICT goods in Malaysia's total exports was almost 30% (UNCTAD 2013).

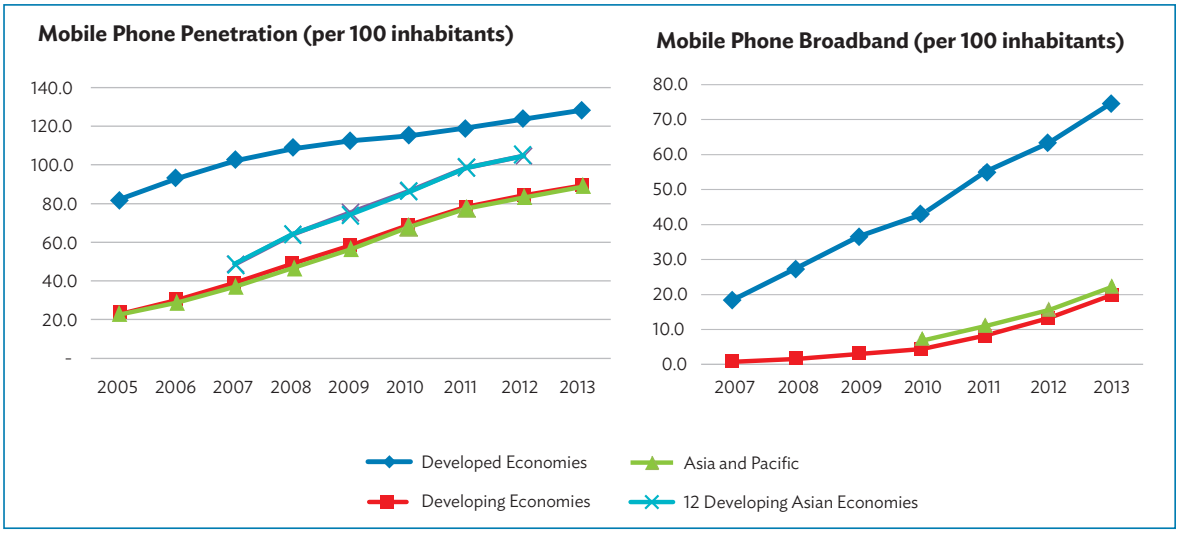
Sources: Digital Review of Asia Pacific (2010); World Economic Forum (2013); INSEAD and WIPO (2013); UNCTAD (2013).

well in ICT goods and service exports. In 2011, ICT accounted for nearly a quarter of developing Asia's exports, over twice the global average. Information technology-enabled services (ITeS), which include knowledge process outsourcing (KPO) and legal process outsourcing (LPO), are also an increasingly significant sector for India and the Philippines; their share of global ITeS revenues is almost 40% and 15%, respectively (Sudan et al. 2010).

At 3.5 billion mobile subscriptions, consumers in Asia and the Pacific now account for more than half of the world's total mobile service market. Just two markets, India and the PRC, account for nearly 2 billion mobile users. Moreover, Asia among all emerging economic regions leapfrogged up the mobile service value chain and seized upon next-generation mobile broadband network infrastructure. While overall mobile penetration levels in developing Asia mirror those in other emerging markets, the adoption of broadband mobile services (3G and 4G) has been much faster (Figure 17).

As ICT infrastructure is increasingly pervasive in Asia, so too is its usage and utility at all levels in society—citizens, firms, and governments.[21] While government adoption of ICT is often used as a catalyst for its wider deployment in society, affordability and access in poorer economies means this impact is not always immediate. The Network Readiness Index (NRI) of the World Economic Forum and INSEAD (Figure 18) shows that Asia's least developed economies not only have much lower usage rates, but also have a massive gap between ICT usage in institutions (government and business) and usage among individuals. While the disparity in affordability between developing and developed economies has continued to narrow, infrastructure in less

Figure 17: Growth of Mobile Phones and Mobile Broadband in Developing and Developed Economies



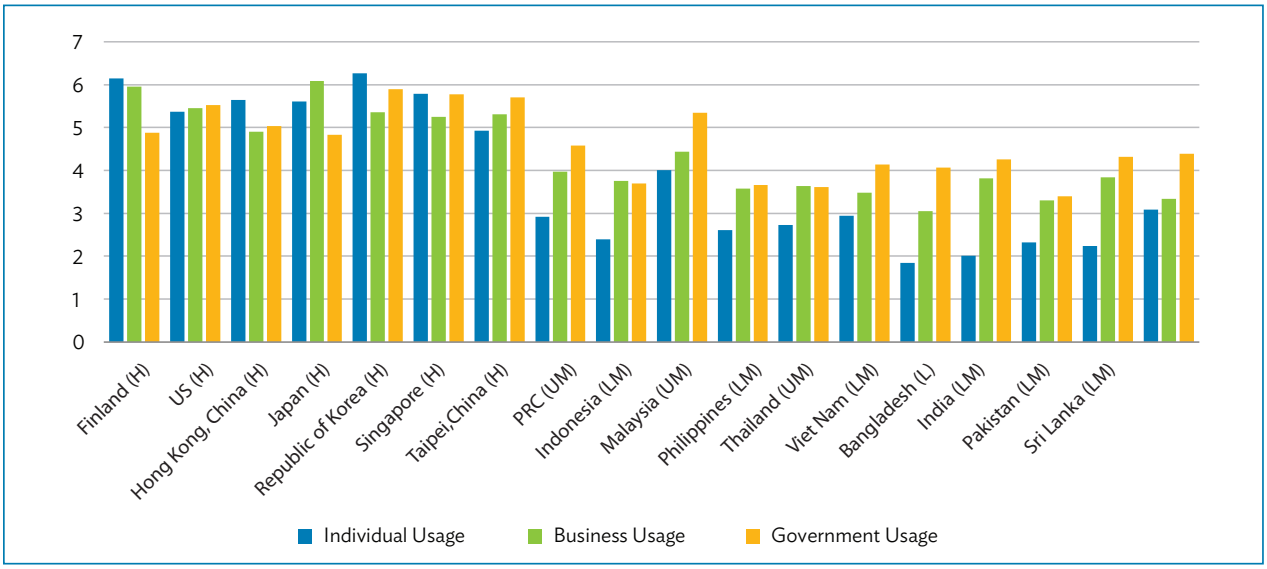
Source: Data obtained from ITU (2014a). The values for 2012 and 2013 are estimates. The 12 developing Asian economies are Bangladesh, the People's Republic of China, India, Indonesia, Kazakhstan, Malaysia, Pakistan, the Philippines, Sri Lanka, Thailand, Uzbekistan, and Viet Nam.

[21] Individual usage includes the number of mobile phone subscriptions, individuals using the internet, households with a personal computer, households with internet access (fixed and mobile broadband subscriptions), and the use of social networks. Business usage includes businesses' technology absorption capacity and technological novelties. Government usage reflects government policies and vision for ICT and online government services.

developed economies continues to lag and needs to be a policy priority in Asia's less-developed markets.

E-government is an important tool for public institutions' use of ICT to both deliver "front office" services to its constituents more quickly and transparently, and create "back office" operation efficiencies. Developing economies have been particularly interested in ICT-enabled administrative reform and public service delivery to improve the quality of government. Many Asian countries, such as the Republic of Korea and even Kazakhstan, perform far better than many other economies of similar income levels (Figure 18), thanks to their governments' proactive and strategic initiatives as well as (particularly in the Republic of Korea) strong infrastructure investments.

Figure 18: Information and Communication Technology Usage by Individuals, Businesses, and Governments



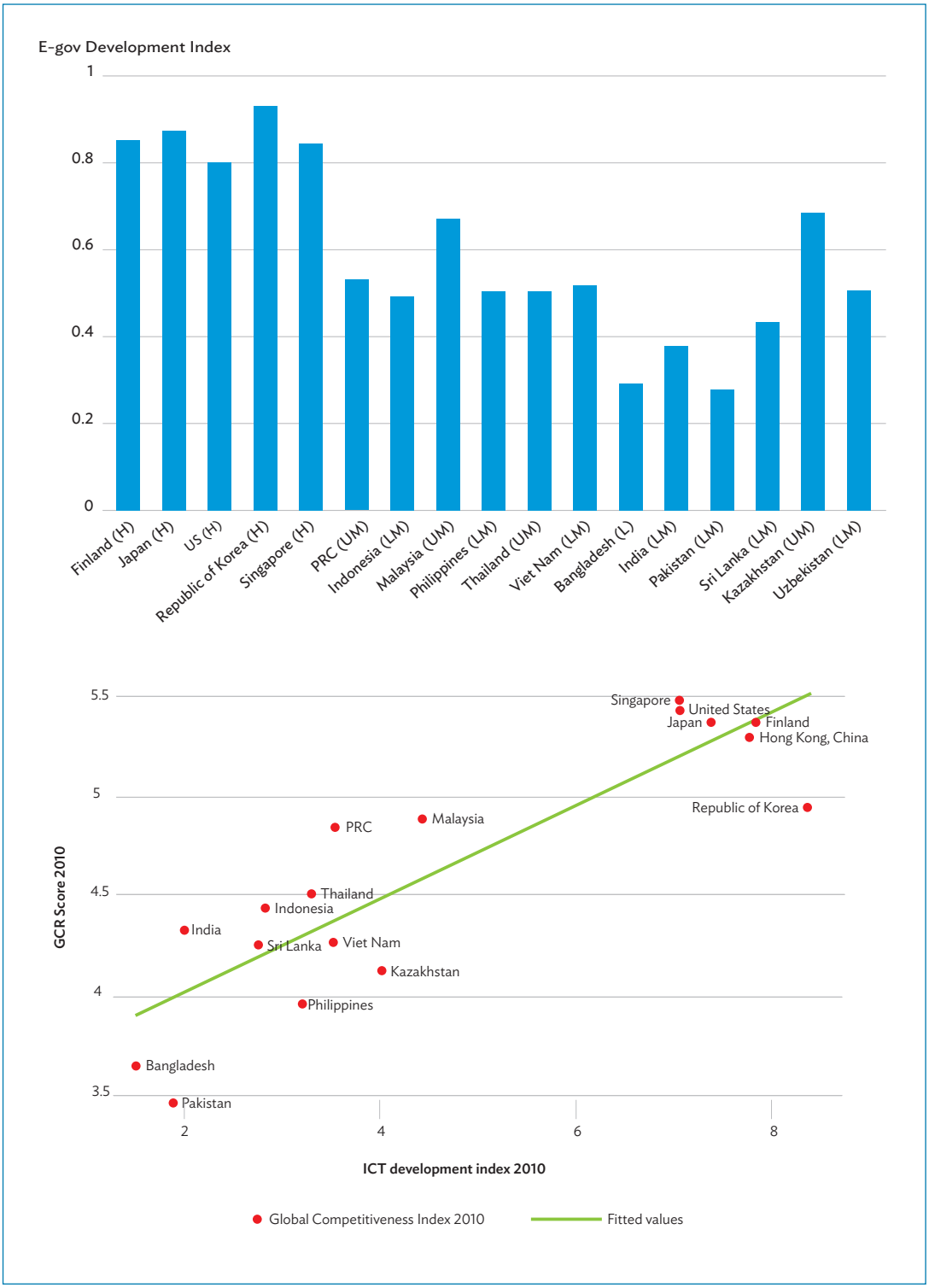
Note: H- high income; UM- upper middle income; LM-lower middle income; L-low income
Source: Data obtained from World Economic Forum (2013).

Key Guidelines for Developing Asia in Information and Communication Technology

a. Aligning Policy Tools for Extensive Application of Information and Communication Technology

For ICT to be used by Asian economies in a transformative way, policy makers in those markets need to select policy tools among alternatives and make appropriate policy mixes considering their own circumstances. For example, the traditional evolutionary sequence of telecommunications service development through fixed telephony cannot be applied to certain developing economies, particularly those with dispersed populations (such as Mongolia) or scattered island territories (as in Indonesia or the Philippines). Advanced countries have used ICT effectively for e-governance (Figure 19). Broadly speaking, ICT promotion strategies are

Figure 19: E-Government Performance and the Impact of Information and Communication Technology Infrastructure in Asia



PRC = People's Republic of China, US = United States. Source: Data obtained from United Nations (2012). Calculated by author.

enabled by two different types of policy tools, depending on whether they are to address supply-side issues in the economy (enabling infrastructure development), or whether they are being used to stimulate ICT demand by addressing affordability, skills, and content development (Table 4).

Table 4: Information and Communication Technology Policy Options

Infrastructure	Affordability, Skills, and Content
• Market competition and investment in ICT infrastructure • Spectrum allocation • Reducing infrastructure deployment cost • Core network expansion • Increasing broadband availability (universal services)	• Market competition and affordability of devices and applications • ICT skill development • Development of online and local content, applications, services • Consumer protection and empowerment

ICT = information and communication technology.
Source: Modified from World Economic Forum (2013, p. 46).

b. Promoting Market Competition in the Information and Communication Technology Sector

Telecommunications service sectors around the world largely began as natural monopolies; fixed-line telephone operations were infrastructure-intensive services, seen by the state as being best delivered by state-owned or state-franchised single carriers. Since the 1980s, however, to reduce the cost of telecommunications services and expand service access, governments in most countries have steadily pursued regulatory reform programs for the privatization and liberalization of the sector. The World Bank (2012a) indicates that competitive markets are likely to have a 31% higher mobile phone penetration rate than that of non-competitive markets. While most Asian markets are fairly liberalized (particularly and significantly in the provision of mobile telecom services), governments need to continue to assess the level of their ICT market maturity and monitor the effective level of market competition in order to improve affordability and accelerate ICT penetration.

Although privatization has not been fully implemented, India has significantly liberalized its telecommunications service markets. Liberalization and market competition have led to significant reductions in the average service tariff per outgoing minute, from 16.93 Rupees in 1999 to 0.48 Rupees in 2012 (see Box 15). Competitive mobile communications markets have has pushed India's phone penetration to practically ubiquitous levels. Close to 1 billion mobile subscriptions were on India's networks at the end of 2013; a decade ago there were not even 22 million. Services have been diffused widely; urban mobile penetration is nearly 170%, and even in India's vast rural markets, penetration is 46% (Cellular Operator Association of India statistics 2014).

With the growth of the telecommunications market, developing countries will need to promote more proactive liberalization policies as has been done in the Republic of Korea and India. Institutional arrangements, particularly telecommunications regulatory bodies or legal arrangements for e-commerce and financial transaction, also need to become more transparent and accountable. Some issues related to restriction on social media or weak IPR policies also need to be effectively addressed to promote the development and diffusion of ICT and ICT-enabled services.

Box 15: Market Liberalization, Tariff, and Mobile Phone Penetration in India

In the 1990s, India promoted the liberalization of its telecommunications sector as part of economic reforms to promote investment and improve productivity and growth of the sector. India removed the long-standing requirement of prior experience in the telecom market for applications for a license. The entry of private and foreign players led to significant expansion in the telecommunications network: fixed telephony and mobile operators increased from 2 each in 1999 to 7 and 39, respectively, in 2009. Within the same time frame, the state-owned international carrier VSNL was relieved of its monopoly status, and 124 new international carriers were licensed; the resulting competition substantially dropped international leased line and call tariffs, and spurred investment in submarine cable systems bringing 1 terabyte of capacity to the country. As a consequence, India now has one of the largest telecommunications networks in the world, and liberalization of the international and long-distance markets was a core stimulant to the country's vital information and communication technology-enabled services. The Government of India continued to allow new mobile phone operators to enter the market as well as introduced various deregulatory policies. The mobile phone tariff dropped from Re16.93 in 1999 to Re0.48 in 2012, making it one of the lowest telecom tariffs in the world and increasing the number of mobile phones from 1.2 million in 1999 to 934 million in 2012.

Source: Government of India, Planning Commission (2013); Kathuria and Kedia (2011).

c. Advancing Information and Communication Technology Infrastructure for Better Access

Developing Asian economies need to actively address the issue of the digital divide by improving its ICT infrastructure. Asia's mobile phone penetration is, as mentioned, practically ubiquitous, and has become the primary means for most developing Asian consumers to access the internet. Yet the penetration of broadband internet access to homes and businesses is still low across Asia, and the role of government remains critical in the initial stages of building a country's broadband infrastructure, particularly when the existing market mechanism is not ready to function.

Strategic initiatives for ICT infrastructure need to be introduced and implemented to expand broadband networks for high-speed internet in developing economies, as has been done by some advanced countries in Asia. The Government of the Republic of Korea also played a critical role in building its country's national infrastructure assets, through its Framework Act of National Informatization established in 1995. The act created the National Informatization Promotion Fund[22] for ICT infrastructure (which included a 5-gigabit-per-second broadband infrastructure investment), e-government ICT R&D project investments, and social inclusion initiatives like the internet education project connecting 10,400 primary and secondary schools (Suh and Chen 2007).

Through universal access and service (UAS)[23] programs, developing economies can guarantee that the benefits of their ICT infrastructure investments also benefit underserved consumers

[22] The fund was established with contributions from the government (about 40%), private telecommunications companies (45%), and interests and other miscellaneous sources (14%). The government spent $5.33 billion between 1994 and 2003 for ICT R&D (38%), informatization promotion (20%), ICT human resource development (18%), broadband infrastructure and promotion (15.1%), and infrastructure for the ICT industry (7%) and standardization (3%).

[23] As defined by the International Telecommunication Union (2014b), universal access "is when everyone can access the service somewhere, at a public place, thus also called public, community or shared access," while universal service "describes when every individual or household can have service using it privately, either at home or increasingly carried with the individual through wireless devices."

and businesses. UAS schemes are relatively underdeveloped in Asia, although the principles of universal access informs liberalization policies, and many Asian regulators have "soft" UAS requirements folded into the award of service licenses issued to private carriers. UAS programs are usually introduced for rural and remote areas, where low population density makes a minimum return on infrastructure investment difficult. This was the case in Viet Nam, where a basic telecommunications services program targeting some 20 million people in rural areas was implemented (see Box 16 for a description of the "Program 74" initiative).

Box 16: Program 74: Universal Telecommunications Service in Viet Nam

Viet Nam's Ministry of Information and Communications launched "Program 74," a D1 trillion ($70 million) Viet Nam Public Utility Telecommunication Service Fund, with the goal of providing 70% of the nation's rural communities with a public internet access point by 2010. Program 74 has provided about 20 million people in rural areas with access to internet and telecom resources for economic and social development, and has provided critical investment funds for state-dominant telecom network operations to encourage infrastructure network build-out to rural areas. As of June 2010, Program 74 had achieved

- access for 75,623 new internet subscribers,
- internet network maintenance support serving 275,307 subscribers, and
- investment in 4,054 public internet access points across 1,100 villages.
- Overall, Program 74 helped internet subscription density grow from 7.6% in 2004 to 30.7% by 2009.

Source: Tuan (2011).

d. Promoting Information and Communication Technology Applications for Inclusive Growth

Asian economies must pursue other strategies to use ICT applications for inclusive growth. In particular, they need to capitalize on Asia's rich mobile service networks. They must further increase penetration of smartphones and high-speed mobile internet access, as a delivery platform for mobile-based banking, health care, and education services in remote and rural communities.

E-learning in particular could be a practical solution for Asian inclusive education initiatives, to overcome physical distance and education gaps between regions. According to the Ambient Insight's Regional Report (Adkins 2012), there were over 78,000 enrolled students in the distance learning programs in Mumbai University in 2012. ChinaEdu in the PRC enrolled over 311,000 online students in 2011 (197,000 of them in full-degree programs, a nearly 30% increase over the previous year). The company has entered into collaborative alliances with 13 universities, ranging from 15 to 50 years in length, and it has also entered into technology agreements with 8 universities. In addition, ChinaEdu performs recruiting services for 23 universities through a nationwide learning center network.

Mobile money and related payment, banking, and financing services have been innovative tools for financial inclusion, particularly to unbanked communities in Asia. There are reportedly more mobile bank accounts in Afghanistan than accounts in "brick and mortar" banking institutions.

Mongolia's XacBank, a commercial bank with a social inclusion mission, services a large number of its 600,000 customers via a network of 400 mobile banking agents. Countries with large remittance economies—Bangladesh and the Philippines, in particular—have become world pioneers in mobile money transfer technology usage.

In the health-care sector, applications have been developed for health education and awareness, remote health-related data collection and monitoring, communication and training, diseases and epidemic outbreak tracking, and diagnostics and treatment support (Vital Wave Consulting 2009). M-health applications and telemedicine allow for the delivery of health-care services, particularly in such geographically challenging markets as Indonesia, the PRC, and India (Box 17).

Box 17: Remote Medical Monitoring via Mobile Technologies

Remote medical monitoring via mobile phones opens new possibilities for providing outpatient services in emerging countries where access to hospital beds and clinics is limited. Remote medical applications include communications to monitor health conditions, maintain caregiver appointments, or ensure medication regimen adherence, all of which can enhance effective treatment programs and improve survival rates in the developed world, particularly for chronic diseases. For example, in Thailand, the Chiang Mai Public Health Department of implemented a pilot program where tuberculosis patients were given mobile phones so that health-care workers (themselves former tuberculosis patients) could call these patients on a daily basis to remind them to take their medication. Medicine compliance rates reached 90% due to this remote monitoring application.

Source: Vital Wave Consulting (2009).

ICT can also be used as a vehicle to promote inclusive growth to empower underserved citizens to participate in various social and economic activities. This has been seen in India's "e-Choupal" programs[24] launched in June 2000 by a leading private agricultural trading company, e-Choupal became the largest internet-based rural initiative in India. Over 4 million farmers in over 40,000 villages access information services through 6,500 kiosks in 10 states (Mukherjee 2012).

e. Promoting E-Government and Public Sector Reform

E-government service initiatives are doubly useful for Asian governments attempting to improve their KBEs. Not only do digital channels for public service delivery increase efficiency and accountability, Asian governments can use the infrastructure and applications deployed to increase ICT awareness and usage in the economy as a whole. Considering these positive ICT spillover effects, some governments (including the Republic of Korea and Singapore) have taken a preemptive approach to introducing e-government projects, but these are the exception in developing Asia; most economies are still far behind in their e-government performance. Governments in the region need to strategically use e-government initiatives as a catalyst for greater use of ICT throughout other sectors.

[24] e-Choupal is an initiative of a large industry conglomerate in India to install computers with internet access in rural areas of India to offer farmers up-to-date marketing and agricultural information.

The most effective e-government initiatives embrace both goals, by allowing governments to digitize administrative procedures while stimulating investment in ICT infrastructure. The Korea Information Infrastructure (KII) Plan launched in 1994 created multiple ICT infrastructure platforms that were developed later by private telecommunications providers using public and private funds, and helped solidify the country as the most densely broadband-connected on the planet.

Developing Asian economies also need to use e-government initiatives as an effective reform tool, by associating e-government initiatives with a comprehensive government reform agenda in areas such as procurement, social security, custom services, tax administration, and emergency management. Online services and e-government programs can also help narrow a country's digital divide: India's unique national identification project *Aadhaar* is expected to function as a digital identity network, which will enhance transparency, efficiency, and effectiveness of government service delivery, while empowering underprivileged citizens.[25]

f. Matching IT Ambitions with Local Needs and Local Capacity

Asian economies should use the latest-generation technologies to leapfrog into the optimal usage stage for local requirements. Mobile broadband is a good example. In nearly every Asian economy, mobile broadband access is several times higher than the level of fixed broadband penetration, at both the top and the bottom ends of the ICT spectrum. In super-wired Republic of Korea, where fixed broadband penetration is 38% of the population, mobile broadband is over 106%; in Viet Nam, the fixed and mobile broadband penetration rates are 5% and 19%, respectively (Broadband Commission for Digital Development 2013). Smartphones are prevalent across Asia because the region's regulatory regimes have been largely liberalized around competitive service offerings for two decades. This means that most Asian countries can easily take advantage of excellent 3G and even 4G service rollout, which is swiftly changing the ways Asian consumers are connected and informed.

Emerging technologies such as cloud computing may also offer developing economies opportunities to overcome limitations of desktop-based technologies, often constrained by the high cost of packages software, poor power supply, and poor computer capacity (Goundar 2013): it is estimated that organizations could attain as much as 29% in IT cost savings from the adoption of cloud computing technologies. Developing Asian economies particularly need mobile-based cloud applications for targeted local needs such as m-banking, m-education, m-health, and m-agriculture. One study (Halewood and Surya 2012) notes that ICT applications for agriculture increase farmers' incomes substantially.

The main challenge of ICT for development (ICTD) programs is achieving sustainable results. Optimal choices of appropriate technologies ensure both cost-efficiency and maximized economic and social impacts. To promote inclusiveness, governments need to find innovative solutions to extend ICT infrastructure as well as develop appropriate services and applications. Asian developing economies are also encouraged to take advantage of free and open source software (FOSS) for application services in e-health, e-learning, and others (Sowe, Parayil, and Sunami 2012).

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[25] For more details, see http://uidai.gov.in/

g. Human Capital for an Increasingly Digital World

Developing ICT human capital is another primary challenge for many Asian economies. ICT skills are highly associated with the diffusion of ICT as well as competitiveness of ICT manufacturing and ITeS industries. India's ITeS are about 40% of total service exports (Sudan et al. 2010). The Philippines' ICT sector has also been growing rapidly in terms of volume of revenue and employment for the last decade. Its revenue from ITeS is expected to grow to $16 billion in 2013 from $100 million in 2001, while employment grew to over 900,000 in 2013 (Agcaolli 2012).

To effectively tap into growing global ITeS and ICT manufacturing industries, Asian countries need to secure a stable and sufficient ICT talent pool through tertiary education and vocational training programs. TVET needs to be strategically designed through collaborative partnerships among educational and training institutions, industry, and government. Good examples of such partnerships are the Penang Skill Development Centre (PSDC) in Malaysia (Box 18), the Chittagong Skills Development Centre in Bangladesh, and the International Institute of Information Technology (IIIT) corporate school programs[26] of Andhra Pradesh in India (Sudan et al. 2010).

To boost human capital in the ICT sector, governments must develop more of these partnerships. Governments also need to develop and offer informal ICT-related programs via community centers and public libraries to underprivileged populations as part of digital divide programs.

Advanced Asian countries (particularly Japan, the Republic of Korea, and Singapore) have made several strategic attempts to tap into global ICT sectors to enhance the core component of their KBE development, and drive economic growth and welfare overall. Asia has become a major link in the world's ICT supply chains, both as a producer and consumer of ICT goods and services. Development of infrastructure, promotion of application and services, and ICT human capital development still remain key challenges to developing Asian economies as they grow toward their KBE objectives. To address those challenges, developing Asia must make the smartest, swiftest choices available in accelerating ICT usage through leapfrogged technology adoption and increased investment in ICT-relevant skills.

Box 18: Tripartite Model for Information and Communication Technology Skill Development

The Penang Skills Development Centre (PSDC), established in 1989, is Malaysia's first industry-led training center. The center has trained more than 150,000 people through more than 7,000 courses. The center contributes to the economy of four free trade zones and four industrial estates in Penang; about 775 factories have hired more than 170,000 PSDC-trained workers. The center has been replicated in Mauritius, Mexico, and Thailand. PSDC offers many training courses for information and communication technology skill development which is one of three major training areas.

Sources: Sveiby (1999); PSDC (2009).

[26] IIIT initiated a training program in Hyderabad in 1998 with an initial financial and facility support by the state government of Andhra Pradesh. IIIT established corporate schools on the campus of IBM, Signal Tree, Motorola, Oracle, and Satyam, among others (Sudan et al. 2010).

A Possible Road Map for the Knowledge-Based Economy in Emerging Economies of Asia and the Pacific

Seizing the Opportunity for Knowledge-Based Economic Development

Pursuing a KBE agenda is essential for developing economies of Asia to tackle their daunting development challenges, and to advance their growth and improve social welfare. KBEs are both an imperative for sustained economic growth and an opportunity that can position Asia's developing economies much higher in the global value chain in a shorter period of time. Asian economies are uniquely placed to accelerate KBEs in the context of the advent of transformational technologies and business processes. On the one hand, Asia is already reaching dominant positions in world markets, and, on the other, it is tapping into unprecedented opportunities provided by new technologies that will further fuel growth and development. This is particularly true in the ICT field where developing economies, thanks to their relative lack of legacy infrastructure, and relative wealth of youthful, aspiring human capital, can use KBE strategies to "leapfrog" to using advanced technology and knowledge-intensive processes for exponential growth gains. Leapfrogging is the notion that a company or an economy having poorly-developed technology or economic bases can move themselves forward rapidly through the adoption of modern systems without going through intermediary steps.[27]

Often, leapfrogging is a latecomer's privilege: Asian economies at lower stages of economic development can draw upon best practices from advanced economies, and since they have been lacking in infrastructure investments over time, they do not have to replace legacy investments when they are able to invest, simply skipping to the head of the current technology queue. In addition, newer generations of technology (particularly ICT) are usually cheaper and exponentially more powerful. This allows developing economies to advance their KBE goals faster and to compete in global KBE markets with differentiated products and services.

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[27] The concept of *leapfrogging* was originally used in the context of economic growth theories and industrial organization innovation studies with a specific focus on competition among firms. It is based on Schumpeter's notion of "gales of creative destruction." Schumpeter posits that big, dominant firms are more likely to innovate than smaller ones that lack market power, but also that innovations are "gales of creative destruction" that render market power ephemeral in high-innovation industries. The leapfrogging hypothesis proposes that companies holding monopolies based on incumbent technologies have less incentive to innovate than potential rivals, and therefore they eventually lose their technological leadership role when new radical technological innovations are adopted by new firms, which are ready to take the risks. When the radical innovations eventually become the new technological paradigm, the newcomer companies leapfrog ahead of former leading firms.

The current context of developing economies also provides a specific backdrop to KBE strategies, whether in terms of the need to address the rural and urban divide, reduce poverty and exclusion, address energy security, or build strong financial institutions. This section highlights some of the specific areas that KBE strategies need to address.

Developing Asia Has a Solid Foundation

Over the past decade, Asia's emergence as a manufacturing powerhouse has led to a boom in demand for precision engineering products (Economist Intelligence Unit 2012b).[28] As information and manufacturing technologies come together, a further boost to KBEs is inevitable with prospects of manufacturing firms in Asia moving up the value chain to produce more sophisticated products.

While Asia still has to catch up with advanced economies in terms of R&D spending as a share of GDP, absolute R&D investments by Asia have grown impressively. Asia's share of R&D investments has risen from 33% to nearly 40% between 2009 and 2013 with those of the PRC rising from 10% to nearly 18%. At the current rates of growth and investment, the PRC's total funding of R&D is expected to surpass that of the US by about 2022 (Battelle 2013). Firms in KBEs look beyond R&D to drive innovation. They invest in a wider range of intangible assets, such as data, software, patents, designs, new organizational processes, and firm-specific skills, collectively referred to as knowledge-based capital (KBC). In many OECD countries, business investment in KBC has already been increasing faster than investment in physical capital such as machinery and buildings for a number of years, and in some countries business investment in KBC significantly exceeds investment in physical capital. Business investment in KBC helps boost growth and productivity. Studies of the EU and US economies show business investments in KBC have contributed between 20% and 34% of average labor productivity growth (OECD 2013b). The PRC and India today invest more in branding than high-income countries did when they were at a comparable stage of development (WIPO 2013). India and the PRC have become net exporters of R&D services to the EU as their growing R&D competence and status attract more R&D projects. Between 2005 and 2010, the value of EU imports of R&D services from the PRC quadrupled from €211 million to €953 million, while imports from India increased from €507 million to €734 million—meaning that while once the EU maintained an R&D services trade surplus, it now has deficits, in the order of €659 million with India and €454 million with the PRC (Roland Berger Strategy Consultants 2012). Asia's KBC investments put its economies in a good position to reap productivity gains and enable the economies to position their products and services higher up on the global value chain. India and the PRC could also put their scientific talent to work more for its domestic goals and objectives in innovation and technological development.

ICT has advanced in Asia with a unique footprint. The story of penetration of mobile technology in Asia has been nothing short of spectacular, and the trend continues unabated. Asia's penetration of mobile devices already exceeds 90% of its population (according to Economist Intelligence Unit data), and the consultancy eMarketer estimates that over 1 billion of Asia's 3 billion mobile phones in service are smartphones. As a result, IP traffic is steadily moving toward non-computer devices; by 2018, wired devices will only account for 39% of IP traffic, while Wi-Fi and mobile

[28] Precision engineering components and machinery form the backbone of many industrial processes, including in the automotive, aerospace and defense, consumer electronics, solar energy, and medical device sectors.

devices will account for 61% of IP traffic. Globally, mobile data traffic is projected to increase elevenfold between 2013 and 2018. Mobile data traffic will grow at a compound annual growth rate of 61% between 2013 and 2018 (CISCO 2014). Thus, emerging economies in Asia that have achieved spectacular mobile telephony penetration, where in fact mobile phones have reached the last mile to cover even rural and remote locations, are well positioned to tap this connectivity for larger developmental outcomes.

Between 2001 and 2010, IT services spending in Asia doubled from $45.6 billion to $90.7 billion and are forecast to reach $141.3 billion by 2016 (Economist Intelligence Unit 2012a). The spike in the number of internet users and deepening mobile penetration in Asia are key drivers for IT services. This has created major opportunities for video game and application developers, and other software providers. Many Asians, particularly in remote areas, will be increasingly connecting to the internet, primarily through mobile devices, boosting demand for higher-value mobile services, including applications for social services.

Asia's cloud computing market is poised to expand. It is anticipated that firms, particularly SMEs will switch to "on-demand" IT capabilities available via cloud computing services at more economical costs than third-party IT services. These trends will radically alter the playing field for information technology services. As per AT Kearney's services location index for 2011, 7 (the PRC, India, Indonesia, Malaysia, the Philippines, Thailand, and Viet Nam) of the top 10 locations for outsourcing of global services for delivering IT, business process outsourcing, and voice services are in Asia (AT Kearney 2011). Cloud computing will be particularly conducive to enterprises engaged in web-based applications, social media, and internet gaming. A recent study shows that cloud computing will generate 14 million jobs globally in the next 3 years—10 million in the PRC, India, and the Asia and Pacific region. As a mass market develops for cloud-enabled services, prices will fall, much like for mobile services, and will transform traditional business models and boost productivity.

The demand for social media services is set to grow rapidly given the popularity of social networking in Asia. India and Indonesia have the world's second and fourth largest Facebook user base in the world with 114 million and 63 million users, respectively. Companies in Asia are increasingly using social media monitoring and marketing tools to engage with their customers. Location-based mobile services are also likely to enjoy strong growth in Asia, as consumers in the region increase their use of search, maps, and navigation services that rely on location information.

Not only are the new digital technologies modernizing and improving the cost-effectiveness of business and economic activities, they are also bringing fundamental changes that are shifting well established paradigms and conventional wisdom. The advent of MOOCs, and the rise of social, mobile, analytics, and cloud (SMAC) are examples of possible game-changers that can help developing Asia advance faster as knowledge economies. For example, MOOCs are challenging the notion that traditional brick-and-mortar universities are the only channel for high-quality tertiary education. There is great scope for blending and complementing classroom teaching with online education services. SMAC will soon reinvent the rules of corporate and business strategy and thereby demand critical investments in human capital and intangible assets to increase competitiveness. Not only are these opportunities, they will also become the imperatives of the future.

Asia is taking pole positions in some key frontier technology areas, such as semiconductors and photovoltaics. The growing demand for personal computers, mobile phones, tablets, and other consumer electronics in Asia has been a major driver of the semiconductor market. In 2010, the global semiconductor market grew by $72 billion, with Asia accounting for more than half of that growth. The growing global interest in renewable energy is boosting demand for, among other things, solar photovoltaic cells, which use semiconductors. Asian manufacturers dominate the global industry in the production of solar photovoltaic cells. Combined photovoltaic production in the PRC, Taipei,China, and Japan increased from less than 700 megawatts in 2004 to 16,800 megawatts in 2010, accounting for about 70% of the 24,000-megawatt global production that year (Earth Policy Institute 2001). Further innovations will reduce the cost per watt and potentially make solar energy cost-competitive with traditional energy sources.

These trends challenge the linear path of progress and enable economies to jump technology cycles—though conducive policies and appropriate incentives are required for economies to take advantage of these trends.

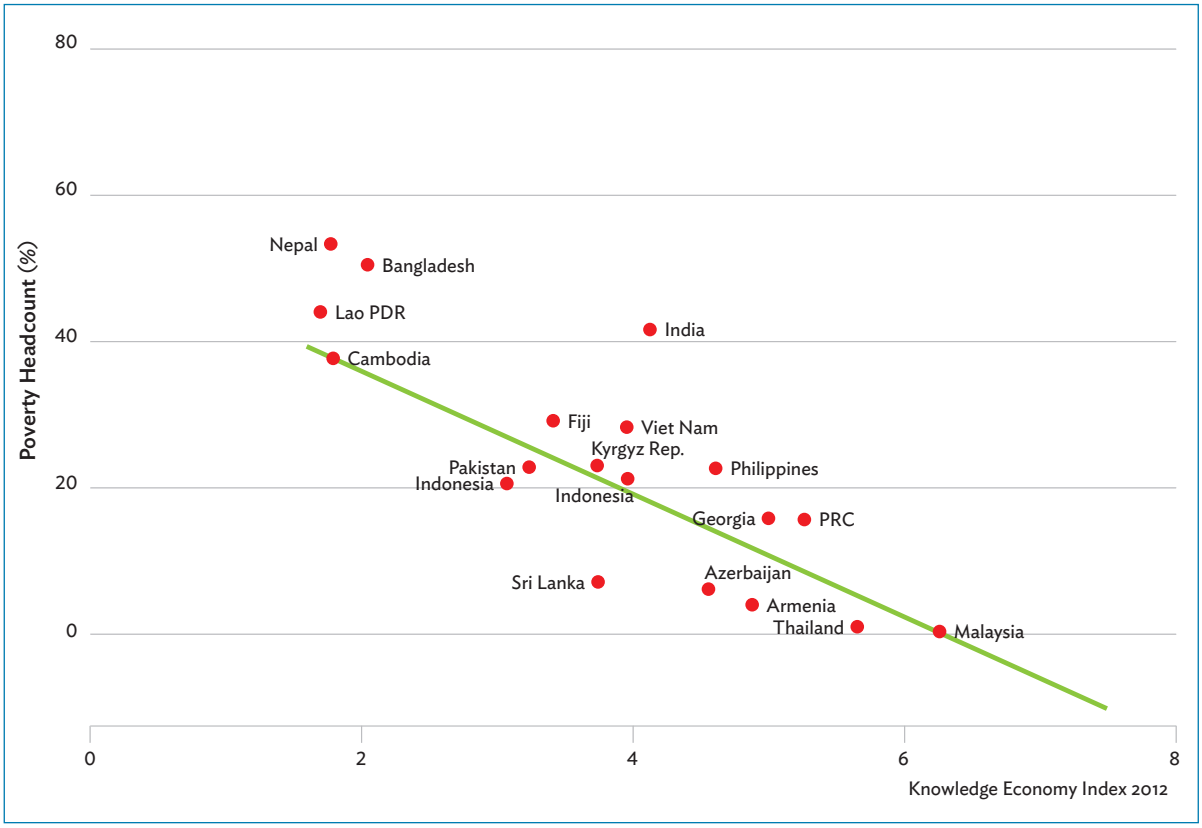
Promoting an Inclusive Approach to Knowledge-Based Economies

While it is clear that KBEs can speed up growth and reduce poverty, developing economies in Asia must act to make KBEs more inclusive. This is because there are concerns that without mitigating measures KBEs may widen inequality. Asia's remarkable growth dramatically raised general living standards and equally dramatically slashed poverty. The proportion of Asians living at or below the $1.25-a-day poverty line fell from 51.8% in 1990 to 20.8% around 2008 (ADB 2012b). However, many Asian economies have been experiencing increasing inequality in recent years. Eleven Asian countries, accounting for 82% of the region's 2010 population, have seen per capita expenditure, as measured by the Gini coefficient, grow more unequal.

KBEs could either increase or reduce inequality. On the one hand, KBEs could increase the wage gap between better educated, highly-skilled workers and less educated, unskilled workers as the former are better able to take advantage of the opportunities available in a knowledge-oriented economy. In such a case, there could be wage polarization, primarily due to the expansion of earnings at the top of the distribution relative to those lower down and the inability of labor (especially lower-paid labor) to capture an adequate share of productivity gains (European Commission 2010). Similarly, acceleration of broadband and internet connectivity for the privileged few will exacerbate inequalities for those who cannot access such productivity-enhancing tools. At the same time, however, the advent of KBEs can reduce inequality. For example, ICT lowers the cost of information and knowledge, and thus makes information and technology accessible to broader segments of the population. Bottom-of-the-pyramid innovations can empower the poor and make them more productive. Countries in Asia need to make conscious and deliberate choices that make KBEs more inclusive.

Figure 20 shows the strongly negative correlation between the KEI and poverty rate for OECD and non-OECD economies for which data are available. Much of the correlation is driven by per capita GDP—that is, richer countries are likely to be more knowledge-intensive and have less poverty. Nevertheless, the strength of the correlation suggests that knowledge may be beneficial for poverty reduction, all the more so since, intuitively, increasing knowledge bases can make poor populations more productive.

Figure 20: Knowledge Economy Index and Poverty Rate ($1.25 a day), 2005



Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China.
Sources: World Bank, PovcalNet (http://iresearch.worldbank.org/PovcalNet/index.htm?2)and Knowledge Assessment Methodology 2012 (http://www. worldbank.org/kam); CEIC Data Company (databases accessed 7 March 2013); Author's estimates.

Developing countries can adopt mitigating measures to make KBEs inclusive, such as ensuring that special support is provided to disadvantaged communities to access education and ICT connectivity. Additionally, developing country policy-makers can also design KBE programs in inclusive ways. Innovation helps mitigate inequality in three ways:

- through direct impacts on income distribution (innovation provides economic opportunity for the highly-skilled and risk-takers);
- as solutions for improving the welfare of lower- and middle-income groups (such as products and services designed under "frugal innovation" parameters); and
- through innovations by lower-income groups themselves, i.e., grassroots activities (Paunov 2013).

Frugal innovation or *jugaad* innovation, which gained ground in India, is a means to promote inclusiveness. In developing countries in Asia, innovation of business models and products and services that respond to the specific characteristics of the market are examples of inclusive KBEs.

While higher levels of innovation and spread of ICT per se may be beneficial to economic growth and welfare, special attention and public policies are needed to ensure that their fruits are enjoyed by as many as possible. As publicly funded research turns into profitable economic

activity, it is important to explicitly encourage greater competition for its wider diffusion. The evolution of innovation and costs of health care could be an example. The revolutionary advances in biomedicine, largely derived from publicly funded science, have given new hope to patients but may not mean that more patients can access or afford the latest medical care. Moreover, established global pharmaceutical companies can possibly set prices above those that are competitive. In this case, innovation ends up strengthening the power of established companies and keeps prices high to the detriment of inclusiveness (Brookings Institution 2012). While innovation requires patents and other intellectual property rights that give firms the incentive to invest in new products and technologies, governments must nevertheless seek creative policy solutions that ensure the access of the poor to the fruits of innovation.

Table 5 illustrates how an inclusiveness lens can be applied to the innovation, education and skills, and ICT pillars of KBEs.

Table 5: Promoting Inclusiveness Across the Functional Pillars

Promoting Inclusiveness in Knowledge-Based Economies		
Innovation	**Education and Skills**	**ICT**
• Support the transition of low-productivity firms in the informal sector to modern innovation-based sectors with greater access to market information, finance, and skills. • Provide financing for R&D of small and medium-sized enterprises and support collaboration with universities/institutions. • Support entrepreneurs to develop products and services with innovative pricing to serve lower-income markets profitably. • Provide incentives for grassroots innovations and promote frugal innovation with financing and teaching of entrepreneurship. • Enable rapid diffusion of R&D in public goods, e.g., health care, to enable availability of drugs at reasonable prices by encouraging competition through appropriate policies such as nonexclusive licenses, wider use of patents, and regulation of monopolistic practices. • Offer incentives to increase choice of technologies that have higher employment intensity, other things being equal.	• Increase opportunities for access to education and skills in science, technology, engineering, and mathematical disciplines for the disadvantaged. • Put special focus on reducing dropouts and increasing full cycle completion of senior secondary education to improve equity of access to tertiary education. • Enhance the prestige and wage returns for professional and technical qualifications through associate degrees. • In addition to few elite world-class universities, support investments for the "massification" of minimum quality standards across the education spectrum. • Create centers of excellence and business incubators in universities in smaller towns and cities. • Invest in increasing entrepreneurial education in universities, colleges, and technical and vocational institutions.	• Promote the spread of broadband connectivity through affordable and reliable models to consumers in rural areas through shared services platforms or community centers. • Develop profitable business models to scale up ICT-based applications for agriculture and fishing, health and education, and mobile banking. • Develop practical and large-scale mobile applications, taking advantage of the widespread penetration of mobile telephony, particularly mobile money. • Finance "bundled" infrastructure development that combines physical and ICT infrastructure through public–private modalities. • Use ICT in education through e-learning, game-based education, and online courses to reduce costs and improve efficiency. • Promote devices such as low-cost tablets for developmental purposes, particularly for education (students and teachers).

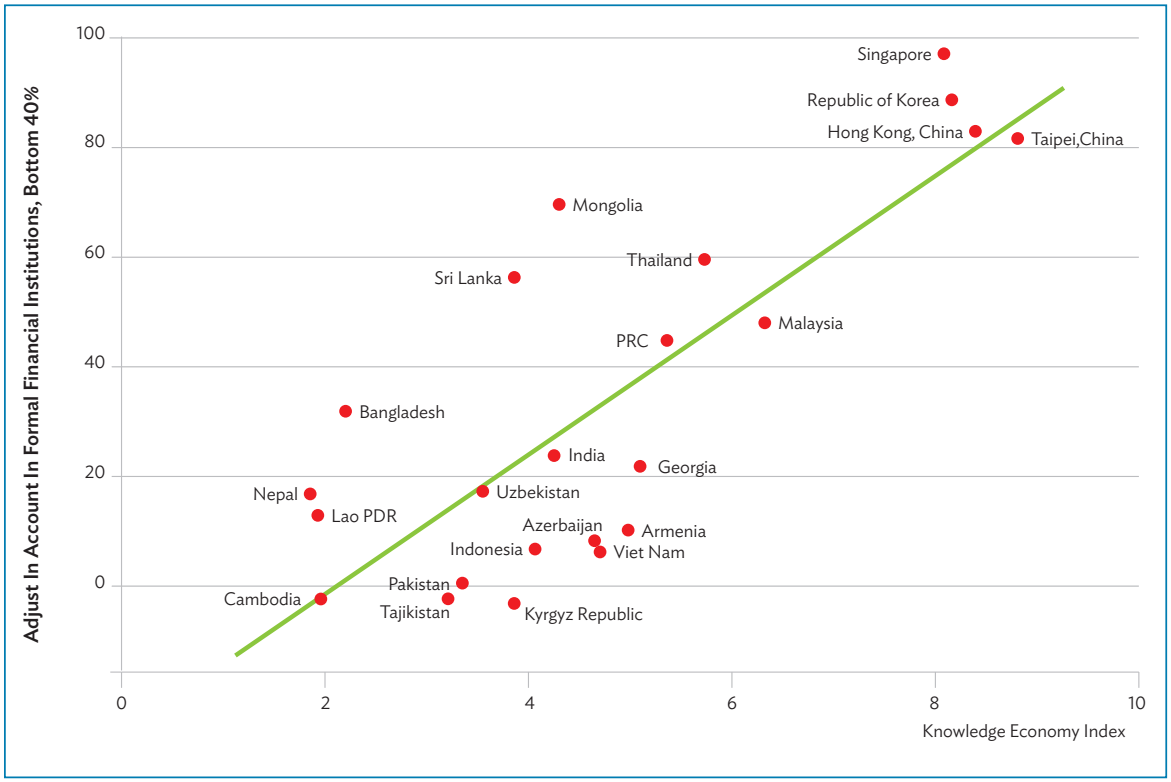
ICT = information and communication technology, R&D = research and development.
Source: Authors.

Financing of Knowledge-Based Economies

Asia's financial underdevelopment has been, and could continue to be, a major barrier to the development of KBEs. In particular, the relative underdevelopment of capital markets in Asia's bank-centered financial systems can hamper innovation that requires long-term risk financing. The presence of sophisticated financing mechanisms, such as venture capital, is a major contributing factor to the success of Silicon Valley in the US: venture capital facilitates the trading, diversification, and management of risk, which is critical for innovation.

Lack of financial inclusion is another significant barrier to KBEs in Asia**.** In a narrow sense, financial inclusion or inclusive financing refers to the poor and disadvantaged groups having access to basic financial services such as banking and payment services. In a broader sense, it refers to the availability of credit and financing to all types of firms, including new entrants, as opposed to only large well-established firms or state-owned firms. New entrants and entrepreneurs often play a critical role in innovation. Expanding financial access to SMEs and would-be entrepreneurs is vital for dynamic efficiency, so that new products, services, and industries can bring about structural change, and deliver large welfare gains over time. Expanded access also facilitates the entry of new producers into the market and thereby stimulates a competitive environment that is conducive for productivity growth. Figure 21 shows a positive relationship between the KEI and financial inclusion. This is a correlation (rather than a causation), although the strength of the correlation suggests that financial inclusion has some positive effect on KBEs.

Figure 21: Knowledge Economy Index and Financial Inclusion, Adults with Accounts in Formal Financial Institutions, 2005 (% of GDP)



Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China.
Sources: World Bank, Global Findex (Global Financial Inclusion Database) http://databank.worldbank.org/Data/Views/VariableSelection/SelectVariables.aspx?source=1228 and Knowledge Assessment Methodology 2012 (http://www. worldbank.org/kam) (both databases accessed 7 March 2013).

Given the extent of financing required for advancing KBEs, developing economies need to use innovative financing modalities. To support the development of innovation systems, the developing economies of Asia require new forms of innovation financing. This includes going beyond funding of R&D to the financing of activities to commercialize knowledge generated from R&D activities as well as adapting and applying new knowledge from overseas. In particular, for the developing Asian economies, there is a need for greater public sector funding to bridge the so-called "valley of death" that prevents new technologies and knowledge from being commercialized, especially by local start-ups and small and medium-sized indigenous firms. This can take the form of proof-of-concepts grants, patent application grants, innovation voucher schemes, and incentives for collaboration between industry and universities and/or public research institutes. Policies that have been found to be effective in advanced economies, including the SBIR scheme in the US, the Tekes program in Finland, and the ITRI Innovation Consortium program of Taipei,China, can be adapted to the developing economy contexts. In addition, there is a need to develop the private financial subsectors that provide funding for innovation-based start-ups, including business angel schemes and incubator development programs that attract and leverage foreign scientists and investors, such as Israel's incubation support program and Singapore's incubator development program.

Alternative and innovative forms of financing, and private sector investment in Asia's systems of higher education will be critically important to effectively resource and implement necessary education sector reforms. Duoc UC in Chile provides a relevant case: a large network of tertiary campuses with more than 50,000 students established a risk-sharing structure with a local bank for student financing. A first-loss cover of 25% by Duoc's cash reserve was used to leverage $51 million for student loans. Once the facility was established, Duoc's foundation provided additional financial assistance to poor students from its cash reserve to support social equity.

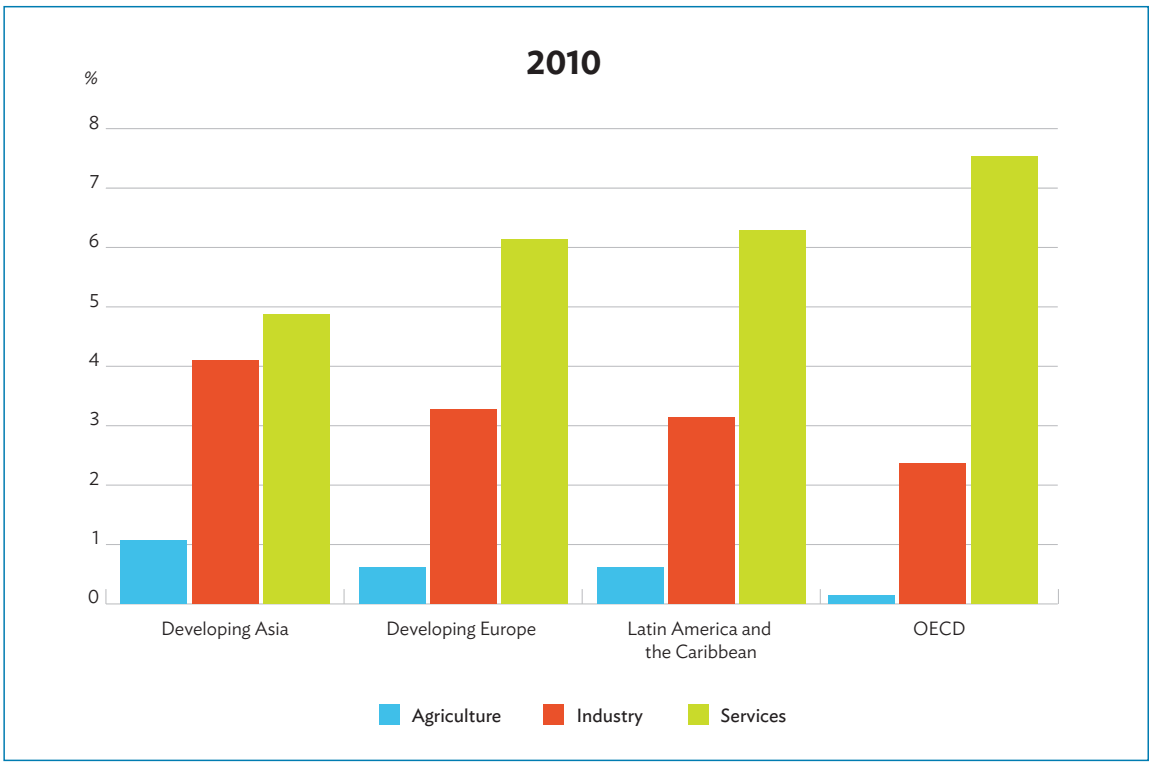
The government has a strong role to play in developing strategic informatization, universal telecommunications programs, private partnerships for financing ICT infrastructure, and promoting e-government projects. The Republic of Korea's full-fledged national informatization plan and Viet Nam's universal telecommunications programs are good examples. The government needs to play a proactive role in expanding the ICT infrastructure, including access to broadband in remote areas to accelerate broadband penetration in collaboration with private companies. Expanding network infrastructure and services for the disadvantaged population which is often not commercially feasible is a crucial role for the government. Governments need to ensure that their initiatives and subsidized programs do not stifle private initiatives or disrupt business incentives. Models of nonbanking sector innovative financing models used for financing physical infrastructure could possibly be replicated for information infrastructure expansion as well.

The Dominant Role of Services in Knowledge-Based Economies

Services are set to play a bigger role in Asia's economic future. Services already loom large in the region's economic landscape—accounting for 48.5% of regional output in 2010—but they will loom even larger in the coming years. Asia is following in the same path traveled in the past by advanced economies, with agriculture's dominance giving way, and then industry giving way to services. Figure 20 shows that while the share of industry in developing Asia's output has surpassed OECD levels in 2010, the share of services remains far below.

The advent of KBEs, in particular human capital and ICT investments, will lift the productivity of services. While services are growing in relative importance in size, they suffer from low labor productivity, which lags far behind that of advanced economies. For most economies in the region, labor productivity is less than 20% of the figure in advanced economies (ADB 2012c). It languishes at around 10% in the PRC and India. Enabling the shift from traditional services to knowledge-intensive services such as ICT, finance, and professional business services is essential to closing the productivity gap, in addition to modernizing traditional services. The shift, in turn, requires educating and training highly skilled workers, who are currently in short supply in Asia. In addition, infrastructure for services in developing economies, such as for ICT, still lags that of advanced economies. A highly productive services sector has a lot of positive spillovers for industry and agriculture. For example, business services such as industrial design and marketing can upgrade the industry sector. Services can also benefit agriculture, as when ICT-based information services can provide market and weather information to farmers.

Figure 22: Rising Share of Services in Output



OECD = Organisation for Economic Co-operation and Development.
Source: ADB (2012c).

Manufacturing or "manu-services" are emerging as a potential new source of competitive advantage in KBEs. A total of 28% of UK manufacturers are reported to have adopted "manu-services," while manufacturers estimate that they generate 15%–20% of their revenue from services (The Work Foundation 2011). Manu-services involve a fundamentally different business model, in which firms interact more closely with the customer, produce bespoke goods, and create packages of complementary services to fit each customer's needs. By integrating a range of services into the manufacturing process, businesses can open up a whole new area of growth.

Manu-services tend to be associated with longer contracts and higher revenues. The manu-services sector is projected to be a productive, export-facing anchor for the UK economy by 2020. Other countries, including the PRC, are rapidly expanding their "manu-services" activities. Research suggests that the proportion of manufacturers in the PRC offering services increased from 2% to 20% between 2007 and 2011 (Neely, Benedetinni, and Visnjic 2011).

Coordinating manufacturing and services in this fashion is expensive and complex. However, exploration of these avenues is important for a KBE in adding further value to manufacturing.

Pursuing Knowledge-Based Strategies in Creative Industries

Technology innovation need not be the only driver for advancement in knowledge economies. Creative industries[29] are gaining prominence globally, and this is another area where developing Asia has demonstrated strength. The creation of the Ministry of Future Creative Science in the Republic of Korea and the Ministry of Tourism and Creative Industries in Indonesia acknowledge the importance of creativity for science and economic value of nations. Taipei,China recently announced a strategy to generate more than 20% growth in its creative industries, backed by a $840 million venture capital fund to spur creative businesses over the next 4 years.

Creative industries constitute a new dynamic sector in world trade. While developed countries lead both export and import flows, developing economies have increased their share in world markets for creative products year after year and accounted for 43% of world exports of creative goods in 2008 (UNCTAD 2010). The PRC; Hong Kong, China; and India were among the top 10 exporters accounting for over 30% of world exports of creative goods in 2008 (with the PRC's share being 20%). Figure 23 also reveals the strong position of Asia in creative output.

Powering Knowledge-Based Economies for Energy Security in Asia

Finding the energy required to power its rapid economic growth will present a daunting challenge for Asia. Developing Asia's GDP will more than quadruple over 2010–2035, and by 2050 the region will account for over 50% of global GDP. This promising vision is often called the "Asian Century" and is a growth scenario articulated in *Asia 2050*. Such economic expansion, however, will require huge amounts of energy. Asia accounted for 34% of world energy consumption in 2010, and this share is projected to increase to 51% by 2035 (Figure 24). Asia's energy consumption is projected to double between 2010 and 2035, and its oil imports are projected to triple during the same period. Even as Asia struggles to find the energy supplies it needs to fuel its growth, it still faces other equally daunting challenges such as

- achieving energy security in an environmentally sustainable way: Asia's carbon dioxide emissions are set to double between 2010 and 2035; and
- ensuring affordable access to the poor: almost half of the world's people without electricity live in Asia today.

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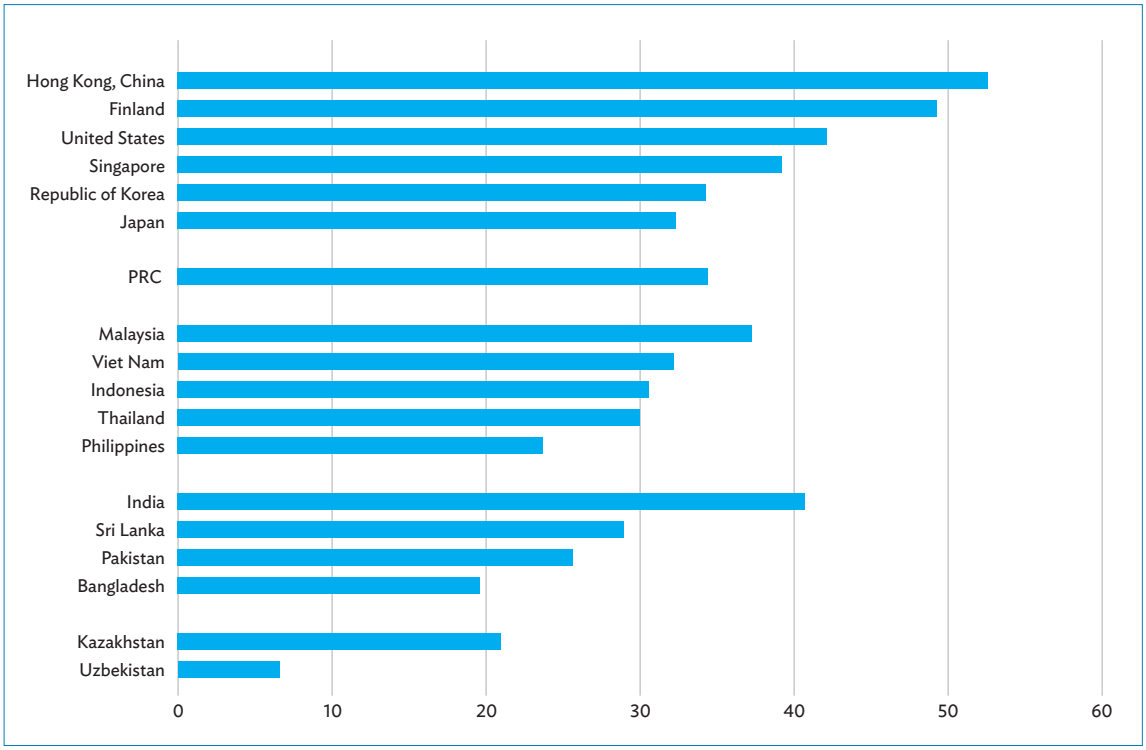
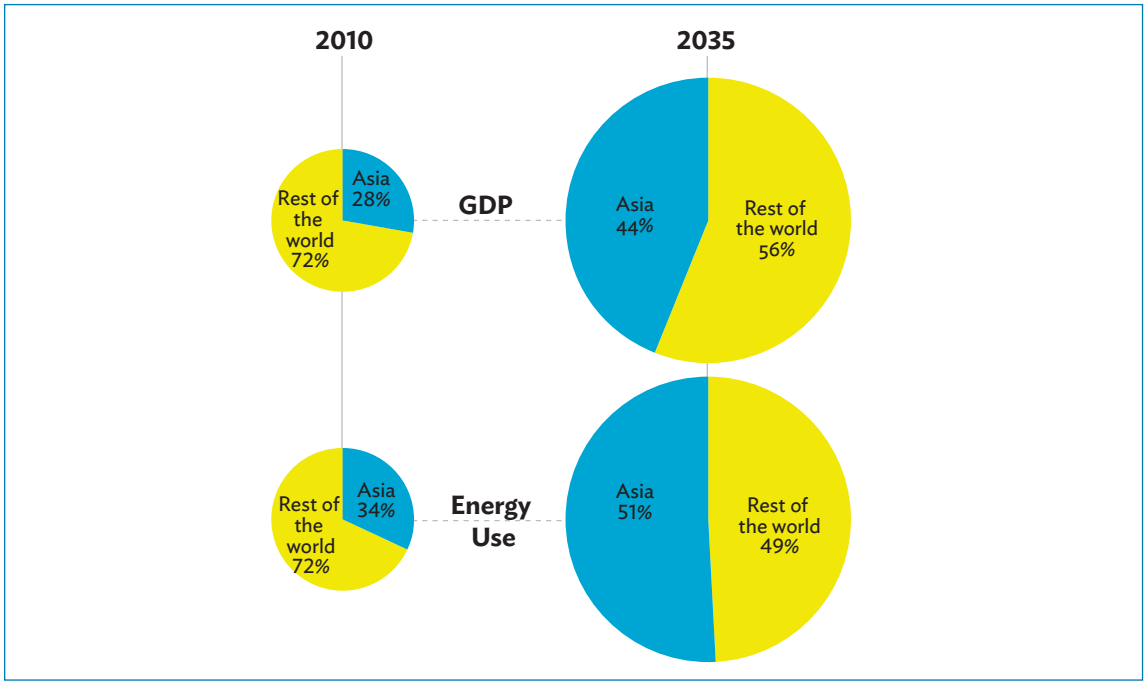
[29] The Department for Culture, Media and Sport of the United Kingdom identified the following as part of creative industries: advertising, architecture, art and antiques, computer games, crafts, design, designer fashion, film and video, music, performing arts, publishing, software, and television and radio.

Figure 23: Creative Output Index, 2012



ASEAN = Association of Southeast Asian Nations, PRC = People's Republic of China.
Source: Calculated from the Creative Intangibles, Creative Goods and Services and Online Creativity indices of INSEAD, Global Innovation Index 2012.

Figure 24: Asia's Growing Share of Gross Domestic Product and Primary Energy Consumption, 2010–2035



Sources: International Energy Agency (2012); Lee, Park, and Saunders (forthcoming).

Achieving Asia's energy security will depend on three pillars: adequate and reliable physical supply, environmental sustainability, and affordable access. This imperative also provides a crucial link between Asia's energy requirements and its KBE development, for two interconnected reasons. Not only must Asia invest in new knowledge and technology to achieve its long-term energy security goals, it must use the region's pressing energy demands as a catalyst for innovation around knowledge-intensive technologies and processes that can propel its KBE industries toward global success.

In the short run, energy security goals can be met through other means. Asian economies can use policy shifts—such as removing price subsidies—to adjust or curb demand. They also have some options to expand supply; the PRC, for instance, sits atop the world's largest reserves of shale gas. However, in the long run, Asia's only viable path to energy security is to upgrade its knowledge and technology base in both demand and supply. Green and smart cities, and clean transport can enable Asia's urbanization in an environmentally sustainable, affordable way. Some Asian economies are already world leaders in certain renewable energy sectors, but most still need to do more to bring down costs. Asian economies are also pursuing better, more advanced nuclear power technologies, and carbon capture and storage technologies. In short, there are very high returns to advancing Asia's knowledge base in the energy area, and in so doing, Asian economies strengthen a critical component of their KBEs.

Conclusions and Way Forward

Charting a Course for Knowledge-Based Economic Development in Developing Asia

Developing Asia in the present times has multiple opportunities and pathways to pursue KBE. Each economy needs to shape its priorities and pathways based on a number of factors. However, this study argues that there are three general ways in which emerging economies of Asia and the Pacific can pursue knowledge-based economic development in the current times:

- the first is learning from the KBE journey of advanced economies and making appropriate investments to catch up on lags and gaps and undertake policy reforms;
- the second is exploiting the unique strengths and advantages of the region by pursuing strategies that amplify such strengths; these include large consumer markets, growing R&D capabilities, extensive mobile penetration, etc.; and
- the third is leveraging game-changing trends in technology and business processes that can enable emerging economies to possibly leapfrog technology development cycles and catch up with the latest, such as putting mobile technologies to use more strongly for development, investing in cloud computing, IT in manufacturing and speeding up innovations for bottom of the pyramid markets.

Table 6 attempts to outline these across the four pillars of the KBE.

Table 6: A Possible Framework for KBE Development in Developing Asia

LEARNING from advanced economies	EXPLOITING unique strengths	LEVERAGING technology trends for leapfrogging
ECONOMIC INCENTIVE AND INSTITUTIONAL REGIME		
Government to coordinate KBE promotion across various agencies; government financing of various knowledge-based economic infrastructure and initiatives is crucial to open the way for private sector funding	Government support to accelerate commercialization of innovation in **high social impact sectors**, e.g., off-grid solar and wind power technologies	Promote investment **to build knowledge capital for creative industries** such as trademarks, brand equity, and market scoping services for small and medium-sized entrepreneurs in niche product segments
Promote high tech start-ups with incentives and support mechanisms; develop policy frameworks to attract private investments in knowledge-based enterprises	**Provide R&D financing for SMEs**; support entrepreneurs to develop products and services with innovative pricing to serve lower-income markets profitably	Enable rapid diffusion of **R&D in public goods**: health care to enable availability of drugs at reasonable prices by encouraging competition through appropriate policies such as nonexclusive licenses, wider use of patents, and regulation of monopolistic prices
Strengthen **intellectual property rights regimes**	Provide incentives to increase choice of technologies with **higher employment intensity**	Promote the spread **of affordable broadband connectivity to consumers in rural areas** through shared services platforms or community centers
Develop capital markets, including venture capital and angel investing networks	Finance "bundled" infrastructure development that combines physical and ICT infrastructure with inclusive finance and banking infrastructure through public–private partnerships	Enable social impact investing, decentralized and smaller Silicon Valley–type environments for diffusion of innovation capabilities
EDUCATION		
Increase tertiary education enrollments and access to technical and vocational education and training and skills development; match human resource development with the economic and industrial competitiveness objectives of the nation	Provide established/large university campuses with **greater financial and administrative autonomy** to serve the needs of a knowledge economy; strengthen critical thinking and soft skills	Introduce **blended models of education delivery**, particularly leveraging massive open online courses (MOOC) models

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Table 6 *continued*

LEARNING from advanced economies	**EXPLOITING unique strengths**	**LEVERAGING technology trends for leapfrogging**
Promote a **diversified education system**: enhance the prestige of technical and vocational education and training and its market value through cooperation between training institutions and employers; develop a spectrum of qualifications and applied degrees that straddle technical, professional, and academic qualifications	Measures to **incentivize industry giants to set up leading research labs** in universities and develop joint research programs; establish industry–university collaborations in identified industry and economic corridors so that R&D can be commercialized faster and talent development is linked to economic priorities	Expand the **use of ICT to transform the pedagogy** of education and training to make it more student-centered and supportive of creativity; develop just-in-time and "on demand" training and anytime–anywhere learning to improve responsiveness to changing market needs
Support the establishment of technology incubation centers and technology accelerators; strengthen entrepreneurship education in tertiary institutions and training institutions	Attract **diaspora participation** to support high-tech start-ups; develop higher education clusters to serve the needs of specific industries	Create and/or strengthen **network of decentralized education and training institutions** to become a breeding ground for barefoot innovators with favorable patenting incentives
Develop **world-class universities in partnership** with leading universities in the rest of the world; develop centers of excellence in major disciplines for science and technology and frontier areas of interest to the country	Support **decentralized R&D** that is linked to key development challenges; strengthen applied R&D and partnerships with local businesses	**Reengineer education for "digital natives"** by assimilating latest ICT for pedagogy and delivery, such as game-based and simulation-based teaching and learning, as well as mobile-based learning and "upskilling"
INNOVATION		
Increase investment in R&D to advanced economy levels: R&D/GDP ratio in excess of 1.5% is the order middle-income economies should consider	**Innovation to increase competitiveness** in knowledge-intensive services sector. Even today. seven of the top 10 countries in the Global Services Location Index are in Asia, and this provides a platform for them to move to higher value-added IT-enabled services	**Innovation hubs** in emerging economies is giving rise to a new class of competitive products which are designed, engineered, and priced for low- to mid-range market segments. Emerging markets need to step up investments in technologies and IPR creation relevant to such 'frugal' innovations
Middle-income economies need to **expand domestic R&D capabilities** and technological development to move to the next level; low-income economies import technologies and adapt R&D initially to build a base for domestic capabilities	Measures **to incentivize investment in building knowledge capital**—such as brand equity, trademark, and marketing—for niche sectors of competitiveness (such as creative goods)	**Green innovation** to increase energy and food security: build on the expansion of decentralized renewable energy solutions (particularly solar), and agriculture innovations

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LEARNING from advanced economies	EXPLOITING unique strengths	LEVERAGING technology trends for leapfrogging
Expand quantity and quality of innovation infrastructure: science and technology parks, innovation hubs, and R&D labs and incubators	Support start-up entrepreneurial firms for digital enterprises, e-commerce, and IT-enabled services sectors	Innovation super clusters in such industries as biotech, nanotechnology, advanced genomics, and advanced materials
Expand financing for innovation—develop capital markets, including venture capital markets, angel investing networks, and innovation intermediaries	**Support product development** for different domestic market segments, particularly those with social impact	**Public funding for R&D** for technologies relevant to low-income consumers; support the development of social enterprises
ICT		
Improve network readiness and invest in ICT infrastructure for universal access and coverage	Implement **national digital literacy plans**; ramp up digital skills in the workforce; promote public–private partnerships to ensure higher-order IT skills	Invest in **next-generation mobile broadband infrastructure** using universal access and service funds to ensure high-speed broadband connectivity
Promote market **competition and liberalization** in the telecom sector to ensure widespread ICT benefits, particularly mobile telephony	Support the creation of appropriate **mobile "apps" for social and economic empowerment** of citizens	Enable availability of **cheap smartphones** for m-health, m-education, and m-money; support entrepreneurship and inclusive business opportunities using mobile applications
Bridge the digital divide with **universal access and service funds**; adopt a national broadband policy; public investment in ICT infrastructure ahead of market demand	Develop and expand provision of **training for e-commerce, digital, creative, and entertainment enterprises**; support entrepreneurship and business development for these enterprises for both local and domestic markets as well as international markets	Invest in **cloud computing and on-demand IT services**, in anticipation of global IT adoption trends
Augment use of **ICT to strengthen e-governance** and service delivery	Draw on Asia's leading role in the production and use of ICT goods and services to **expand the ICT industry for knowledge-intensive jobs** in Asia; expand exports of ICT and IT-enabled services from Asia	Develop high-tech **ICT innovation and commercialization hubs** encompassing a suite of different market applications to enable Asia to emerge as a world leader in high-end ICT goods and services

ICT = information and communication technology, IT = information technology, R&D = research and development, SMEs = small and medium-sized enterprises.
Source: Compiled by author.

While the pathways may be tailored to suit the specific needs and priorities of individual countries, it is crucial that developing countries in Asia need to strengthen their KBEs. By becoming more knowledge-based, developing economies will be less reliant on natural resources and labor cost advantages. KBE provides economies and industries with the tools and processes needed to take optimal advantage of technologies and knowledge. Moreover, successful KBEs constantly restructure themselves in response to rapidly changing market conditions. Given below are some general guidelines to consider for advancing knowledge-based economic development in developing Asia:

1. KBE is an appropriate and possibly one of the most powerful tools for developing Asia to tackle the major growth and development challenges. KBE strategies will allow Asian economies to do the following:

    - **Managing exposure to a changing and volatile external environment.** KBE strategies can help Asia's export-dependent developing economies not only effectively manage change, but also exploit globally dispersed supply chains for competitive strength;
    - **Benefiting from rapid technological change.** Keeping pace with technology shifts through FDI and domestic technological capability development will prevent the loss of competitiveness in key areas of manufacturing and services;
    - **Avoiding the middle-income trap.** As developing Asia begins to lose comparative advantage from low-cost labor, a KBE will open up new avenues of growth;
    - **Tackling persisting poverty, income, and regional inequality.** KBE investments such as in education and ICT that are undertaken with an equity lens can help reduce poverty and contribute to inclusive growth; and
    - **Promoting environmental sustainability.** Asia needs to blend alternative growth paradigms for both sustainable and competitive development; green innovation could be an important avenue for both.

2. For rapid and effective development of KBE strategies, it is crucial to address all the four pillars in a coordinated fashion. While all four pillars of a KBE— economic incentive and institutional regime, education and skill, innovation, and ICT infrastructure—do not have to advance at the same speed simultaneously, an effective KBE strategy fires on all the four pillars. The strong synergies between the pillars mean that overinvesting in one or two pillars alone will not allow the economy to realize the KBE benefits that result from comprehensive investment across all four pillars. India's $100 billion IT-enabled services sector is a good example: despite the country's still-poor IT infrastructure and institutions, India leverages pockets of skills and innovation to create a globally competitive IT services sector, which constitutes over a fifth of its total exports, and over 5% of its GDP (based on Economist Intelligence Unit data). However, the sharp rise of its ITeS sector is beginning to plateau; data from India's National Association of Software and Services Companies show that while IT-business process management revenues grew at an annual average of 13% between 2009 and 2013, it forecasts that 2014 revenues will only grow 8%, to $118 billion. Domestic revenues currently are expected to be flat, at $31 billion, as its IT-literate labor pool has not expanded as quickly.

3. A successful KBE is best analyzed through a framework which takes into account its four pillars: a country's EIR, its innovation system, its education and skill levels, and its ICT infrastructure. As discussed, many developing Asian economies have individual pillars that perform well by global standards—particularly their relative ICT infrastructure

levels. However, none of the developing economies in the region has excellent performance in all of them. Real KBE growth in Asia can only be achieved through extensive investment, focused management, and coordinated resource allocation of the institutions in each of the pillars, as successful advanced KBEs have done over the past three decades.

4. Government policy and leadership are crucial in a KBE strategy. Asian KBE leaders, the Republic of Korea and Singapore, for example, started their economic development with well-coordinated industrial policies led by government. The Research and Innovation Council of Finland played the role of a high-level body to coordinate education, research, and innovation policies. Government leadership requires higher-order capacity to steer policies and initiatives for cutting-edge KBE outcomes. In the Republic of Korea, the government played a very strong role in the early stages of KBE development, paving the way for private sector leadership and investment in later years. However, its strategic oversight continues even today—the government recently established the Ministry of Science, ICT, and Future Planning to sustain the Republic of Korea's leading position as a KBE.

5. Emerging economies of Asia have considerable opportunities to redefine KBE strategies, tailoring them to capitalize on their unique strengths and advantages. Asia-specific KBE strategies will not only accelerate their own development, but could create new KBE models that are more inclusive. While using best practices and tools of advanced KBEs, developing economies also have the opportunity to boost their KBEs by "leapfrogging" technology cycles, focusing attention on innovation that uniquely serves the needs of fast-growing emerging economies. These include product and service innovations for bottom-of-the-pyramid customers, green innovation for sustainable development, and leveraging ICT-enabled services and processes to increase social inclusion.

6. Developing countries of Asia need to focus attention of developing diverse and innovative financing mechanisms to ensure adequate funds required for investing in the four pillars of the KBE. Asia will surely benefit from the deepening of "traditional" financing resources such as venture capital resources, but it must also develop new and unique financing structures, particularly those geared toward social inclusion, which can be mobilized cheaply and quickly. Both the government and the private sector need to develop suitable financing mechanisms.

It is clear that an economic development process centered on knowledge requires developing economies of Asia to make substantial investments across all the four pillars, along similar paths to those of advanced economies that are now KBEs. However, for developing Asia to use KBEs to raise its competitive advantage, the region must also pursue its own unique path. Timely and effective KBE strategies that build upon Asia's remarkable success in transforming itself into a center of gravity for the world economy will allow economies in the region to do two things: transform themselves into a KBE faster and lead the development of new, world-leading innovation.

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Innovative Asia: Advancing The Knowledge-Based Economy
The Next Policy Agenda

This study outlines policy actions required in developing countries of Asia to advance as knowledge-based economies. The study uses the four pillars of the Knowledge Economy Index to benchmark the performance of developing economies in Asia against advanced economies of the world. It analyzes opportunities by which Asia's middle and low income countries can tap new technology trends to move up global value chains and towards high-income levels.

About the Asian Development Bank

ADB's vision is an Asia and Pacific region free of poverty. Its mission is to help its developing member countries reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to approximately two-thirds of the world's poor: 1.6 billion people who live on less than $2 a day, with 733 million struggling on less than $1.25 a day. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

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ASIAN DEVELOPMENT BANK
6 ADB Avenue, Mandaluyong City
1550 Metro Manila. Philippines
www.adb.org