ADB

ASIA: THE ROAD TO BECOMING A KNOWLEDGE ECONOMY

GAME OF CATCH-UP OR GAME CHANGERS?

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Contents

46th ADB Annual Meeting Knowledge Sharing and Partnership Events: Development through Empowerment

This paper acts as a curtain-raiser for an ongoing Asian Development Bank (ADB) study titled "Asia's Knowledge Economies: Next Policy Agenda" and provides initial findings and insights from this study. It assesses the current state of knowledge-based economies (KBEs) in a number of developing Asian countries compared to selected advanced countries in Asia and elsewhere. The paper analyzes the state of play in developing economies of the four pillars that are commonly associated with knowledge-based economic development: innovation, information and communication technology, education, and the economic and institutional regime. It identifies gaps that developing Asia must fill to catch up with advanced countries. At the same time, it also explores game-changing trends that put developing Asia in an advantageous position to move faster toward the global knowledge frontier.

This paper was prepared by Shanti Jagannathan, Senior Education Specialist, Regional and Sustainable Development Department, ADB (sjagannathan@adb.org), Donghyun Park, Principal Economist, Economic and Research Department, ADB (dpark@adb.org), and Seok Yong Yoon, Senior Public Management Specialist, Regional and Sustainable Development Department, ADB (syoon@adb.org) drawing on the work of ADB consultants, other ADB work and secondary resources. Carl Dahlman, Poh Kam Wong, Ron Perkinson, and Jae Moon are the four international consultants participating in this policy research project. The national experts working on the four in-depth country studies in India, Indonesia, the People's Republic of China, and Kazakhstan (forthcoming) are Arpita Mukherjee, Hafid Abbas, Yang Yao, and Oraz Jandosov respectively. Carmela Fernando Villamar and Marjorie San Pedro provided coordination and research support.

The paper was prepared under the overall guidance of Seethapathy Chander, Director General, Regional and Sustainable Development, ADB; Changyong Rhee, Chief Economist, Economic and Research Department, ADB; and Woochong Um, Deputy Director General, Regional and Sustainable Development Department, ADB. To provide strategic guidance to the study, ADB has established a high-level panel, which is co-chaired by Lawrence Summers, Charles W. Eliot University Professor, Kennedy School of Government, Harvard University and Kishore Mahbubani, Dean and Professor in the Practice of Public Policy, Lee Kuan Yew School of Public Policy, National University of Singapore. The other members of the panel are Bindu N. Lohani, Vice-President for Knowledge Management and Sustainable Development, ADB; Han Duck-soo, Chairman and CEO, 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; and Dominic Barton, Global Managing Director, McKinsey & Company.

The ADB study is expected to be completed by the end of 2013.

Knowledge Based Economies: What is required in Asia?

Catching up on lags and gaps

INVESTMENTS

- **Expanded "knowledge infrastructure"**
  - Extended ICT, digital infrastructure
  - Broadband connectivity through universal access and service programs
  - Mobile connectivity and mobile data
- **Strengthened R&D and innovation**
  - More but effective R&D investments
  - Rapid diffusion of commercial innovation
  - Support for entrepreneurship
- **Higher education and skill base**
  - Expansion of relevant tertiary education
  - Expanded pool of skilled professionals and technicians from polytechnics
  - ICT-based education pedagogy and delivery

POLICIES

- **Promote market mechanism for ICT**
  - Extend ICT affordability and faster spread
  - Expand ICT-based service delivery solutions
  - Develop applications for mobile broadband
- **Provide economic incentives for knowledge**
  - Strengthen IPR protection and easy patenting
  - Improve business environment, especially for young entrepreneurial firms
  - Improve governance and role of government in accessing and applying technologies
- **Help innovation to flourish**
  - Support both new and applied technologies
  - Ensure greater openness to domestic and foreign sources to increase innovation capabilities
  - Create incentives for innovating for local markets
- **Introduce flexible education systems**
  - Expand polytechnics for gray-collar workers
  - Support industry–university collaborations
  - Establish effective qualification frameworks for certification, accreditation, and quality assurance, including online courses

BPO = business process outsourcing, ICT = information and communication technology, IPR = intellectual property right, IT = information technology, R&D = research and development.

Advancing to frontier technologies

ASIA'S SPECIAL ADVANTAGES

- Expanding middle pyramid: 50% of global middle class, 40% of global consumer market by 2020
- Growing importance of intra-regional trade up from 54% in 2001 to 58% in 2011
- Fastest growing mobile penetration with 47% share of world mobile data traffic by 2017
- Boom in demand for frontier areas such as precision engineering semiconductors, biotech, and solar photovoltaic
- 7 of top 10 locations for outsourcing of global services for delivering IT, BPO, and voice services in 2011
- Rising prominence of frugal innovation
- Small-scale off-grid renewable energy solutions

GAME-CHANGING TRENDS

- Massive open online courses (MOOCs): cost-effective solutions for tertiary education
- Applications for mobile phones: 44 billion applications expected to be downloaded by 2016
- Use of social, mobile, analytics, and cloud (SMAC) in corporate and business applications
- Frugal and *jugaad* innovation for bottom-of-the-pyramid customers
- Converging information and manufacturing technologies and the rise of the "gray collar" tech worker
- Use of tablets, and game-based and simulation-based pedagogies in education
- Cloud computing and "on-demand" IT services, transforming business models

WHAT DOES A KNOWLEDGE-BASED ECONOMY MEAN FOR ASIA?

- Strategies for inclusive knowledge-based economic development required to counter inequality
- Initiatives to spread ICT-based solutions for development that link up remote areas and people
- Innovative financing models crucial to meet large investment needs, banking sector not enough
- Knowledge-based development matters for low- and middle-income countries, but specific strategies are required
- Focusing on the services sector will be beneficial, including knowledge-intensive services as a key driver of growth
- Rising prominence of creative industries needs to be tapped , particularly in mastering and spreading digital technologies for creative services
- Key objective of knowledge-based economies is to address energy security in the region

Introduction 1

Knowledge and innovation are widely acknowledged as key drivers of growth and economic development. Asia and the Pacific block has emerged as one of the major hubs of the world economy. The share of the Asia and Pacific region in global gross domestic product (GDP) increased from 21% in 1980 to 38% in 2012. The share of developing Asia in global GDP rose 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, Asia's continued ascent is predicated upon the ability of the region's countries to transform themselves effectively into knowledge-based economies (KBEs). The Asia 2050 report concludes that this potentially promising future of an "Asian Century" is plausible but is by no means preordained. Pursuing a development process driven by effective creation, dissemination, and application of knowledge will be essential to turn the growth potential into reality.

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), the share of Asia 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 projected to double by 2020 (OECD 2010). Asian consumers could also account for well over 40% 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.

The times are opportune for Asia to accelerate KBE development. 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.

2 Measuring Knowledge-Based Economies

There are many definitions of a knowledge-based economy. This paper adopts the following definition which combines World Bank and OECD descriptions:

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

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

- An economic and institutional regime to provide incentives for the efficient use of new and existing knowledge and the flourishing of entrepreneurship
- An efficient innovation 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
- An educated and skilled population to create, share, and use knowledge well
- Information and communication technology to facilitate the effective creation, dissemination, and processing of information

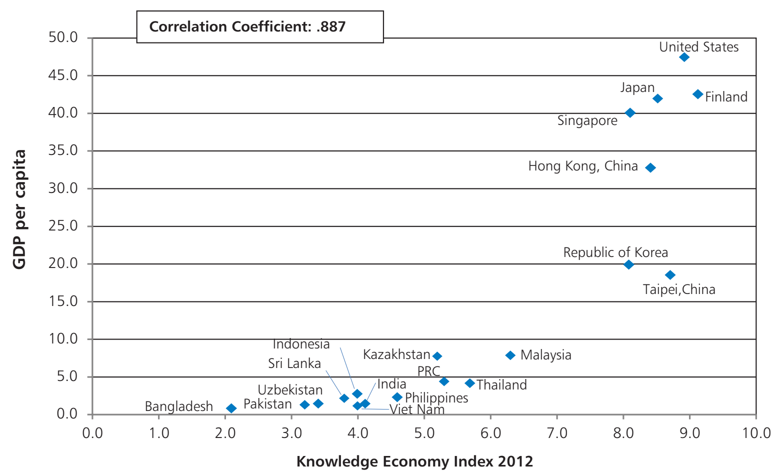
Why Does Asia Need Knowledge-Based Economies?

3

Sustaining the Ascent of Asia

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 paper, we also examine how countries at initially low levels of income used KBE development to advance, such as Singapore, the Republic of Korea, 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—innovation, information and communication technology (ICT), education, and economic and institutional regime (World Bank 2012). 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 in the four pillars of a KBE will improve overall economic performance. For example, a well-educated and skilled workforce will contribute more to economic growth when the economic and institutional regime supports entrepreneurship and the establishment and expansion of new businesses.

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



GDP = gross domestic product, PRC = People's Republic of China.
Source: World Development Indicators Database, World Bank (accessed 4 March 2013).

[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.

Increasing Productivity and Avoiding the Middle-Income Trap

Investment and growth in OECD economies are increasingly driven by knowledge-based capital (KBC) 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).

In recent years, Asia has enjoyed spectacular growth rates. So far, the region's growth has been based largely 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 productivity increase. There is a concern that Asian countries 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. Countries in a middle-income trap cannot compete with low-income countries that retain low labor cost advantages. At the same time, they are not yet able to compete effectively with advanced nations in high-tech products and services. Only four economies in Asia—the Republic of Korea; Taipei,China; Hong Kong, China; and Singapore—have moved up from middle income to high income.[3] Developing countries in Asia which seek to join them need to move away from growth based primarily on capital and labor to growth which relies more on productivity. KBE, in turn, is required to increase productivity, a key tool for sustaining and accelerating economic growth in the region.

KBEs are a vital ingredient in the region's transition to growth based on productivity increase

The 2012 Asia Business Outlook Survey of some of the world's largest multinationals operating in Asia (Economist Corporate Network 2013) revealed that firms expect Asia to generate a larger proportion of their revenues in 2013 but expect it to come from productivity gains. Growth in sales is expected to be much higher than growth in the workforce of these corporations. Wages are rising and marginal returns to capital are falling in many parts of Asia and the Pacific, portending a larger role for knowledge and productivity in economic growth.

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 industrial sectors, yet they can also benefit the agriculture and services sector.

While KBEs are often associated with middle- and high-income countries with an advanced industrialization and maturity of the services sector, the application of ICT, higher levels of skills, education, and innovation can bring higher productivity and efficiency and thus 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 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 biotech, 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,

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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.

business innovations have gained prominence, such as frugal and *jugaad* 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. The recent lawsuit between Apple and Samsung on patent infringment also raises the question of what can be considered innovation. While Apple was the originator of a completely new technology and product, Samsung brought incremental enhancements to the product and used successful business strategies to market it and carve a niche.

This paper makes the argument that while developing countries have a lot to catch up on with regard to investing in knowledge-based economic development, the trends in technologies offer ample opportunities to the developing countries to accelerate their progress to not only close the gap to advanced nations, but even emerge as leaders in technology, innovation, and new products and services that are more suited to emerging markets.

4 State of Knowledge-Based Economies In Asia: The Four-Pillar Framework

This section provides an overview of the KBE position of selected developing countries in Asia compared to advanced countries in Asia and elsewhere. It assesses the position of 12 Asian developing countries as KBEs—PRC and five Association of Southeast Asian Nations (ASEAN) member states (Indonesia, Malaysia, the Philippines, Thailand, and Viet Nam), four South Asian countries (Bangladesh, India, Pakistan, and Sri Lanka), two Central Asian countries (Kazakhstan and Uzbekistan)—in relation to seven comparator developed economies—five from Asia (Hong Kong, China; Japan; the Republic of Korea; Singapore; and Taipei,China) and two from outside the region (Finland and the United States).

The KEI includes sub-indices for the four pillars of education, innovation, ICT, and economic and institutional regime. (See Table 1)

Table 1 Four Pillars of the Knowledge Economy Index

Pillar	Indicator
Economic and institutional regime	• Tariff and non-tariff barriers • Regulatory quality • Rule of law
Education and skill of population	• Adult literacy rate • Gross secondary enrollment rate • Gross tertiary enrollment rate
Information infrastructure	• Telephones per 1,000 people • Computers per 1,000 people • Internet users per 1,000 people
Innovation system	• 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

Source: World Bank, Knowledge Assessment Methodology and Knowledge Economy Index) http://siteresources.worldbank.org/INTUNIKAM/Resources/KAM_v4.pdf

Table 2 shows the rankings of developed and developing countries in Asia. The developed Asian economies, such as Japan, Hong Kong, China; the Republic of Korea and Singapore, come somewhat close to the rankings of developed OECD countries such as the United States. Within Asia, the top ranked is Taipei,China, followed closely by Hong Kong, China; then Japan, Singapore, and the Republic of Korea. The lowest ranked is Bangladesh, followed by India and Pakistan. The poor ranking of India is due to low sub-indices on ICT and education. The PRC and the Southeast Asian economies rank in between, as do the two central Asian economies of Kazakhstan and Uzbekistan.

Table 2: KEI and Four KBE Pillars, 2012: Ranking of selected countries

Country	KEI Rank	KEI	EIR Rank	EIR Index	Innovation Rank	Innovation Index	Education Rank	Education Index	ICT Rank	ICT Index
Finland	2	9.33	2	9.65	3	9.66	11	8.77	6	9.22
United States	12	8.77	26	8.41	6	9.46	13	8.70	18	8.51
Taipei,China	13	8.77	35	7.77	9	9.38	8	8.87	9	9.06
Hong Kong, China	18	8.52	5	9.57	14	9.10	46	6.38	10	9.04
Japan	22	8.28	39	7.55	15	9.08	19	8.43	28	8.07
Singapore	23	8.26	1	9.66	4	9.49	79	5.09	15	8.78
Korea, Rep. of	29	7.97	53	5.93	21	8.80	4	9.09	29	8.05
Malaysia	48	6.10	61	5.67	42	6.91	75	5.22	52	6.61
Thailand	66	5.21	67	5.12	55	5.95	93	4.23	65	5.55
Kazakhstan	73	5.04	91	3.96	91	3.97	40	6.91	68	5.32
PRC	84	4.37	97	3.79	54	5.99	95	3.93	94	3.79
Philippines	92	3.94	76	4.32	93	3.77	85	4.64	108	3.03
Sri Lanka	101	3.63	88	4.04	108	3.06	86	4.61	111	2.80
Viet Nam	104	3.40	108	2.80	113	2.75	105	2.99	75	5.05
Uzbekistan	105	3.14	140	0.92	104	3.13	59	5.65	110	2.87
Indonesia	108	3.11	102	3.47	103	3.24	103	3.20	114	2.52
India	110	3.06	99	3.57	76	4.50	111	2.26	122	1.90
Pakistan	117	2.45	124	1.93	110	2.84	126	1.44	97	3.60
Bangladesh	137	1.49	131	1.51	135	1.69	120	1.75	140	1.01

EIR = economic and institutional regime, ICT = information and communication technology, KBE = knowledge-based economy, KEI = Knowledge Economy Index, PRC = People's Republic of China.
Source: Reconstructed using data from Knowledge Assessment Methodology 2012, Knowledge Economy Index and Knowledge Index. http://info.worldbank.org/etools/kam2/KAM_page5.asp

Countries have different strengths and weaknesses in the different pillars of the KEI, as presented in Table 2. This will be seen more clearly in the ensuing analysis in the four thematic sections that follow, where a wider range of sub-indicators are used to give a broader assessment of each of the four pillars.

Knowledge-Based Economy Pillar: Economic and Institutional Regime

The economic 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 knowledge-based economy. Policies and regulatory regimes related to industry, competition, and intellectual property rights 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, ICT, and education. For example, for the innovation area, EIR includes 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. The broader EIR also affects innovative activities in the other three pillars. For example, 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 developing countries in Asia have a much poorer ranking compared to the advanced countries on all parameters of the EIR except the macro environment (advanced countries are still suffering from the after-effects of the 2008 financial crisis). DMCs are particularly far behind developed countries on the business environment, even more than on governance, or openness to the world. (although Malaysia and Thailand do better than Japan and are similar to Taipei,China). There is great variation in the relative strengths and weaknesses of each DMC as well as in their overall rankings (Table 3). 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, the DMCs have a great deal of distance to cover compared to advanced economies (except Malaysia which is ranked above the Republic of Korea).

Table 3 The State of the Economic and Institutional Regime: Selected Countries

Country	IP Protection (IPR from WEF rank of 144)	Governance (WBGI with higher % as positive)		Openness to World (KOF Foundation Index of Globalization 2012 rank of 208 economies)	Business Environment (Doing Business 2013 rank of 185 countries)	Entrepreneurship		Macro Environment (WEF rank 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

IP = intellectual property, IPR = intellectual property right, WBGI = World Bank Governance Indicators, WEF = World Economic Forum.
Source: World Bank Governance Indicators (accessed 25 November 2012).

Key Economic and Institutional Regime Issues for Developing Asia

Improving Governance and the Role of Government

Governance is an area in which DMCs are weak compared to advanced countries. While areas such as political stability/absence of violence, and corruption are much harder to address, rule of law, regulatory quality, and government effectiveness are more easily amenable to improvement as countries develop their institutions and increase government capacity.

The government has an important regulatory role, such as protection of intellectual property. A proactive government role is critical to address, on the one hand, potential market failures, such as promoting innovation for green growth, and, on the other, to strengthen inclusion and equity, such as addressing loss of employment from technological upgradation and improving access to finance. An important aspect of the EIR is transparent and conducive policies for the existence of a vibrant private sector. Therefore, striking the right balance between the public and private sectors is crucial and the Republic of Korea presents a good example of this as described in Box 1.

An important aspect of the EIR is transparent and conducive policies for the existence of a vibrant private sector

Box 1 The Role of Government in Developing the Republic of Korea's Knowledge Economy

In the early development phase, the government played a strong role in formulating explicit plans to develop specific industrial sectors to catch up with developed economies. 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 showed weaknesses in the strong government-led industrialization strategy. 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 was coordinated with government research institutes, the ministry of telecommunications and information technology, and the private sector. The Republic of Korea 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 from 2.5% of GDP to 3.7% 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. Most recently, newly elected President Park Geun-hye has set up the Ministry of Science, ICT and Future Planning to help the Republic of Korea achieve its ambitious goals.

Source: Suh and Chen (2007); Ministry of Knowledge website (accessed 13 January 2013); Ministry of Science, ICT and Future Planning website.

Tapping into Rapidly Growing Global Knowledge

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 2). Many developing Asian countries can do more to tap into global knowledge through various means.

Box 2 The People's Republic of China's Systematic Tapping of Global Knowledge

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 non-tariff 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. Over the period 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)

As countries increase their expenditures on R&D and aspire to become KBEs, they need stronger IPR regimes to also stimulate the domestic creation of knowledge

Improving the Business Environment, Intellectual Property Rights, and Fostering Entrepreneurship

Another critical area for KBE in Asian economies is the wide dispersion in the business environment and protection of intellectual property rights (IPRs). There is a clear difference between developing Asian economies and advanced economies.

Kazakhstan improved its Doing Business rating by seven places between 2011 and 2012 by making reforms in the ease of starting a business and improving access to credit as part of attracting foreign direct investment, and promoting the development of new firms. 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.

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

Knowledge-Based Economy Pillar: Innovation

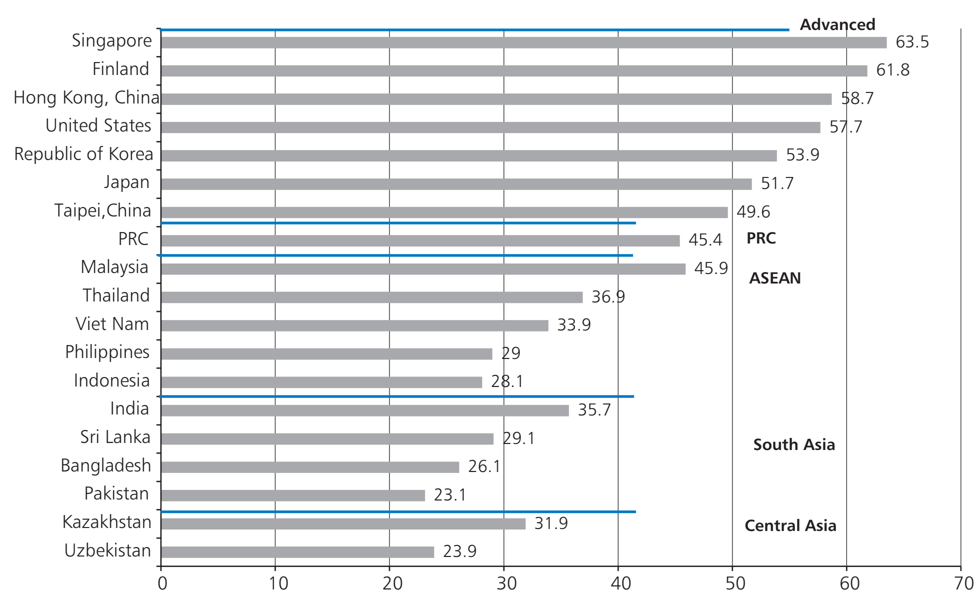
An effective innovation system that creates and diffuses new knowledge is integral to KBEs. There is by now a considerable body of empirical literature showing that investment in innovation activities contributes significantly to economic growth, not just among the more developed economies, but also among developing economies (see, e.g., Fagerberg and Srholec 2008).

There are different measures for the state of innovation. Here we take the widely used measure of the Global Innovation Index (GII) by INSEAD, incorporating submeasures that include not just knowledge creation, but also its diffusion and impact, as well as a subindex on creative industry output. Figure 2 reveals that the innovation systems of developing Asia are significantly less developed than the advanced economies of the Finland; Hong Kong, China, Japan; the Republic of Korea; Singapore; and Taipei,China.

Some countries have substantially increased their R&D expenditures. For example, the PRC is now the second largest spender on R&D in the world in PPP terms. It has also emerged as a leader in registering patents. Although R&D expenditures in developing countries have increased in recent years, there is still substantial catching up to do for many countries. Developing countries in Asia have far fewer R&D personnel throughout the economy as compared to advanced nations. The resultant lower intensity of output of R&D activities, as measured by the number of scientific publications and patents granted per million people respectively, 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. 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.

The innovation systems of developing Asia are significantly less developed than the advanced economies

Figure 2 Global Innovation Index (GII) 2012



ASEAN = Association of Southeast Asian Nations, PRC = People's Republic of China.
Note: The GII is the simple average of the input and output sub-indeces. Data for Taipei,China are for 2010.
Source: INSEAD, Global Innovation Index 2012.

Key Innovation Issues for Developing Asian Economies

Technology-Applying vs. Technology-Creating Capabilities

While innovation policies in more advanced economies tend to focus on R&D and its commercialization, developing economies need to focus on policies to enhance R&D capabilities to both absorb and apply existing technologies in new ways and to create new technologies. The rapid technological catch-up of Japan and the Asian advanced economies—the Republic of Korea; Singapore and Taipei,China—all involved significant investment in the former, before shifting emphasis to the latter (Wong and Ng 2001). The policy issue is one of prioritizing and sequencing the type of learning activities over time.

For example, throughout the 1970s and 1980s, Singapore has been relatively successful in facilitating the diffusion and application of technologies from advanced countries by leveraging foreign multinationals (Wong and Singh 2008). It is only in the 1990s that Singapore started to invest heavily in funding R&D at local universities and establishing public R&D institutions.

A "consortium" approach to innovation will be beneficial in harnessing the strengths of small and medium enterprises

Promoting Indigenous Firms vs. Leveraging Foreign Firms in Innovation Capability Development

The experiences of Japan; the Republic of Korea; Singapore and Taipei,China show diversity in innovation strategy. While Japan and the Republic of Korea show relatively high emphasis on developing indigenous firms' innovation capabilities, Singapore and to some extent Taipei,China have relied more on leveraging foreign global multinational corporations to transfer technology and develop innovation capabilities through R&D offshoring (Wong and Ng 2001). India and Indonesia have pursued policies to promote national champions, especially in industries deemed strategic.

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 (Box 3).

Innovating for Local Markets

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

Box 3 Taipei,China: Industrial Innovation Consortium Approach

In Taipei,China, the Industrial Technology Research Institute (ITRI) pioneered the *consortium development* approach to upgrading the technological capabilities of many existing industries (Matthews 2002). By working with a consortium of small and medium-sized enterprises (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 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, and the WiMAX and lithium battery industry.

Source: See ITRI official website for more details.

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. The case of Simpa Networks (Box 4) illustrates the power of such frugal and *jugaad* innovations in developing Asia (Radjou, Prabhu, and Ahuja 2012).

Policies to encourage local enterprises to exploit their local knowledge to innovate, rather than just trying to imitate what comes out of the advanced economies, should be given special attention, especially for countries that have large domestic markets, as is the case for the PRC, India, and Indonesia. The PRC's recent success in becoming the global leader in electric bicycle technology is a good illustration of this (Box 5).

Box 4 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 prepaid 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, 2013. http://www.adb.org/news/pay-you-go-model-expands-solar-energy-access-rural-india

Box 5 How the People's Republic of China Became the World Leader in the Electric Bicycle Industry

Since the mid-2000s, the People's Republic of China (PRC) has become the world leader in the emerging electric bicycle ("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 bicycles in 2005 itself, the only country in the world to have done so.

A combination of factors contributed to success in this emerging industry (Ruan et al. 2012; Weinert 2007). First, some of the existing strong base of local assemblers of gasoline 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 the banning of the sale of gasoline motorcycles. Fourth, the central government established a national e-bike standard in 1999. Following this national standard enactment, 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. Increase in the export tariff rebate further strengthened the PRC's position in the global e-bike industry.

Source: Ruan et al. (2012).

Knowledge-Based Economy Pillar: Education and Training

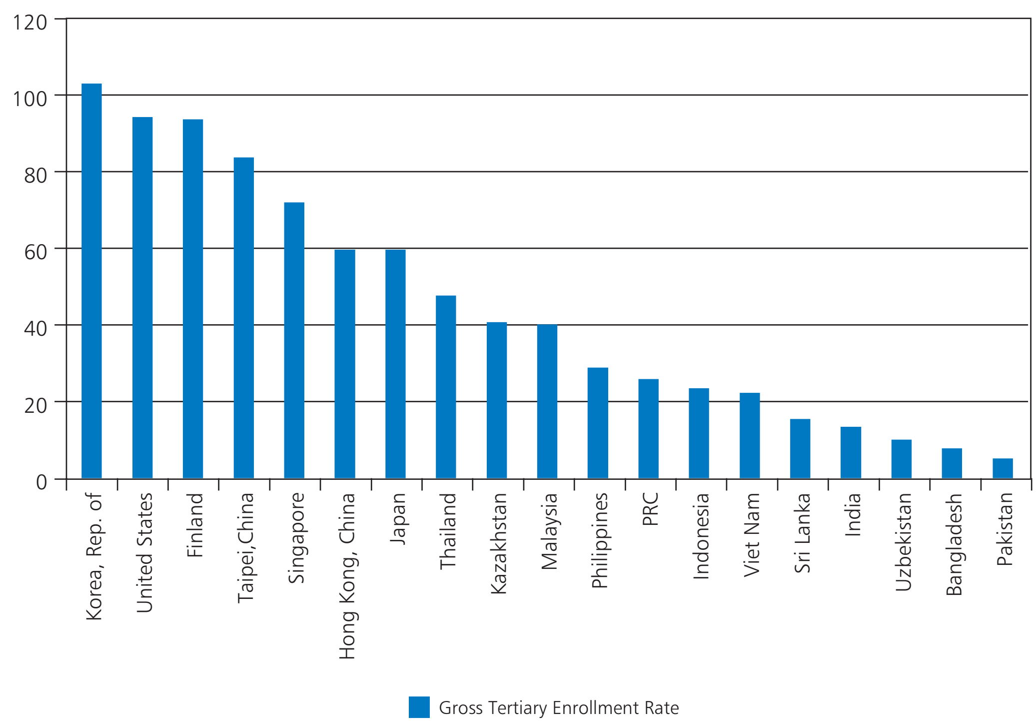
In a knowledge-based economy, innovative ideas and technical expertise hold the key to the new global competitive challenge. KBEs have a strong demand for higher-level skills in the workforce. Evidence from OECD countries shows that there has been a growing proportion of employees with tertiary level qualifications 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 countries lag advanced nations in tertiary education enrollment. Except for Hong Kong, China; the Republic of Korea; and Taipei,China, other Asian countries fall behind OECD countries in increasing the coverage and access to higher education for the main age participation group of 18–24-year olds (Figure 3).

Research in science and technology will need to increase across Asian economies. Tertiary institutions must become more entrepreneurial and innovative to finance research

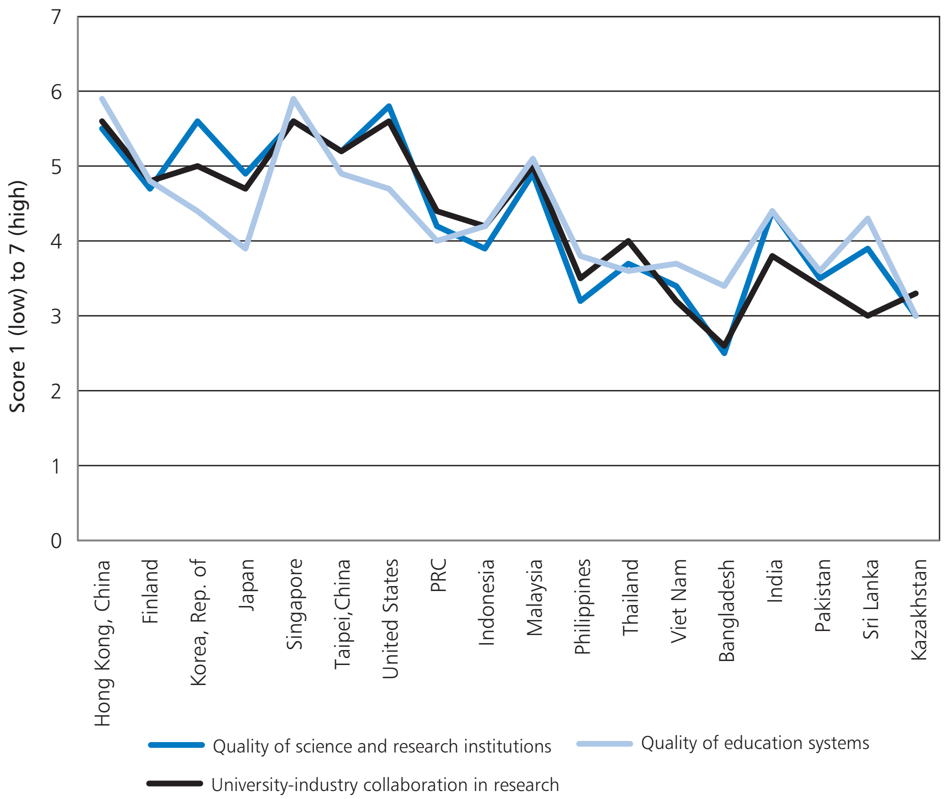
With regard to education system quality in Asia compared to the rest of the world, there is a distinct correlation between the low quality of science and research institutions and the status of university/industry collaboration in R&D across the region (Figure 4). Research in science and technology will 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.

Figure 3 Gross Tertiary Enrollment Rate of Developed Economies and Developing Asian Economies



PRC = People's Republic of China.
Note: World Economic Forum ratios are based on 2010 or latest data available. World Bank Knowledge Assessment Methodology ratios are based on 2009 data. In each case, the highest ratio between the two sources is used.
Source: World Economic Forum (2012); World Bank (2012).

Figure 4 Quality of Tertiary Education in Asia: Correlation of Education System Quality, Quality of Science Research Institutions, and University–Industry Collaboration in R&D



PRC = People's Republic of China, R&D = research and development.
Source: World Economic Forum (2012).

Key Issues for Education and Training

The education systems worldwide are 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 (Altback and Salmi 2011). While increasing the number of tertiary graduates is an important priority, diversifying and 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.

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 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 (Manpower Group 2012) points out that 45% of employers surveyed in Asia (compared to 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 youth have different perceptions of the reality: in a survey by McKinsey, while 72% education providers believed that new graduates are ready to work, fewer than half of youth and employers surveyed believed that new graduates are adequately prepared for entry-level positions (McKinsey & Company 2012).

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).

The skill levels of the future workforce clearly need to increase. At the same time, the paradox of graduate unemployment and skills mismatch calls for adaptable and responsive education and training systems

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.

For students and employers, the credibility of a degree continues to important. On the one hand, there is evidence from 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 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 nexus with the economy and produce students equipped with a strong theoretical foundation and a keen understanding of its real-life applications (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 qualification frameworks will be beneficial in this domain.

Rise of Tech in Manufacturing and the Gray-Collar Worker

In recent years, manufacturing and information technologies are 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

Box 6 New Manufacturing Technologies and the Gray-Collar Worker

New technologies in manufacturing	What do employers say?
• 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	• 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 that workers have 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).	Source:Davenport (2013a)

Education and training systems need to focus on the rise of the "gray-collar" or tech workers—a third category of workers in addition to white and blue collar workers—who use computer- and network-driven manufacturing devices

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 role to play (Box 6). 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.

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.[4] IBM established 150 centers of excellence with selected tertiary institutions across India in 2009. The focus was on advancing software development with the objective of creating a new generation of information technology 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 not only invested in workplace training but also in corporate university or academic units that are responsive to job placement and workplace

[4] Drawn from Yang, Hou, and Wang (2012).

training needs (ADB 2012a). 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 7).

Box 7 The Games Solution Centre, Nanyang Polytechnic in Singapore

The Games Solution Centre (GSC) was launched in partnership between the Media Development Authority (MDA) of the Government of Singapore, Nanyang Polytechnic, and Sony Computer Entertainment (Asia) as a resource centre 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: Website of Media Development Authority, Government of Singapore
http://www.mda.gov.sg/NewsAndEvents/PressRelease/2011/Pages/20111028_Game.aspx

ICT can play a transformational role in the pedagogy and delivery of education to include more innovative, creative, and interactive processes

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

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. (See Box 8)

Box 8 Tecnológico de Monterrey, 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).

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 can change the very face of what a classroom looks like. Digital games are considered to be the largest and fastest growing market segment of the multibillion-dollar entertainment industry. The global market is already worth billions of dollars. 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 (CAGR) 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 CAGR is 20.2% and revenues are expected to reach $2.48 billion by 2015

The rapid proliferation of educational games and interactive learning materials can change the very face of what a classroom looks like

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 amongst students as well as self-paced learning environments. More extensive use of electronic media will help to accommodate the learning behavior of the multi-tasking "digital generation" (ADB 2012 d).

The onset of massive open online courses (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 has introduced 328 different courses from 62 universities in 17 countries for which there are 2.9 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 (Box 9).

Box 9 Technologies to Watch in Education

Mainstream in 1 year or less
- Massive open online courses (MOOCs)
- Tablet computing

Mainstream in 2–3 years
- Games and gamification
- Learning analytics

Mainstream in 4–5 years
- 3-D printing
- Wearable technology

Source: New Media Consortium (2013).

Knowledge-Based Economy Pillar: Information and Communication Technology

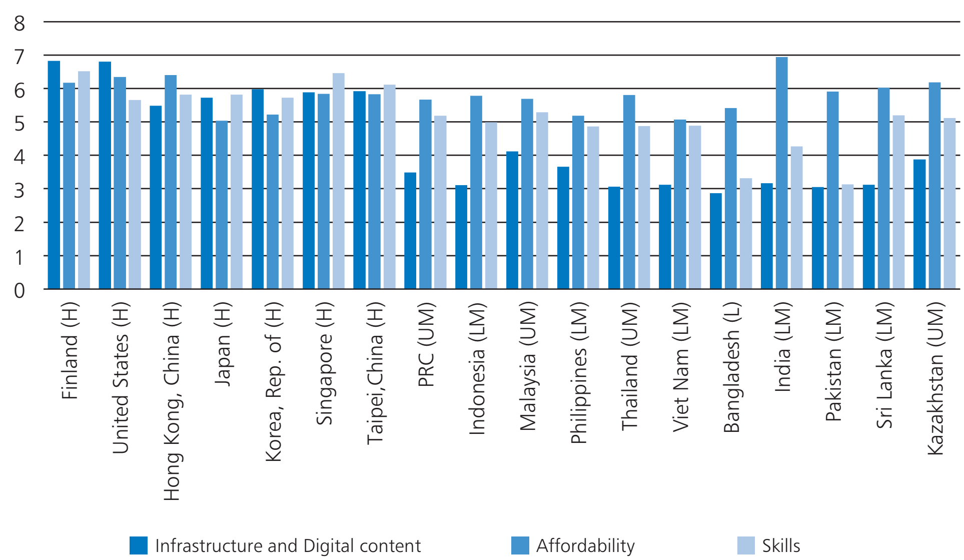
The world has become more connected, networked, and interdependent than ever before primarily due to the development and diffusion of ICT,[5] which plays a pivotal role as an enabler in transforming resource-based economies into knowledge-based ones. ICT integrates and magnifies sustainable development activities by acting as the "growth catalyst." Further, ICT induces a chain reaction—an avalanche effect—in multiplying the impact of development in whatever context it is employed. Thus, many governments in the region are increasingly devoting their strategic efforts to ICT for development (ICTD) to balance the twin objectives of fostering inclusive growth and supporting economic development needs of society.

[5] 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.

The Network Readiness Index of the World Economic Forum reflects the level of ICT infrastructure, affordability, and skills. It appears that a wide gap in ICT readiness exists between developing and advanced economies. In particular, the gap in infrastructure is more striking than the gap in affordability and skills. (See Figure 5)

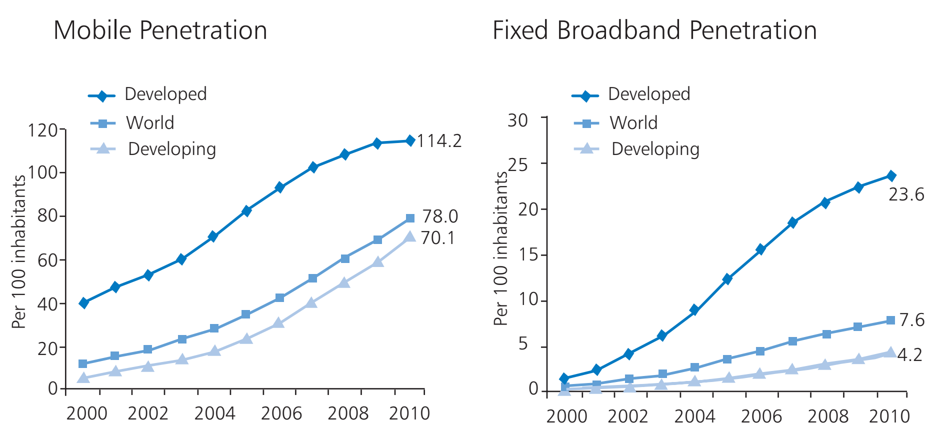
Developing countries have progressed much faster in mobile telephony. The developing world has reached 70% coverage in terms of mobile phones (per 100 inhabitants) with a growth rate of around 20%. By contrast, broadband coverage of the population is much lower in developing countries with less than 5% (per 100 inhabitants) having access to broadband networks and that too mostly in urban centers. (See Figure 6)

Figure 5 Infrastructure, Affordability, and Skills



H = High Income, LM = Lower Middle Income, PRC = People's Republic of China, UM = Upper Middle Income.
Source: Estimated by ADB consultants based on data collected from World Economic Forum (2012).

Figure 6 Rate of mobile and broadband penetration in developed and developing economies



Source: International Telecommunications Union, 2011.

The world of ICT has been transforming very rapidly in terms of technology and business. Therefore, successful models in developed countries often have less relevance for developing countries compared to other sectors of the economy. For example, the e-Community Center model for public access to ICT facilities in developing countries is considered a practical and effective model to deliver ICT access and services to remote and rural areas . However, this model has rarely been used in developed countries where an individual or a household internet connection is more popular. Thus, developing countries would do well to take more innovative approaches to ICTD, especially in building up the capacities needed to use ICT infrastructure effectively.

Key Issues for Information and Communication Technology

Promoting Market Mechanisms for Information and Communication Technology Development

There is a role for the government to increase market competition and liberalize the telecommunication sector to increase affordability and universal usage. Box 10 describes the contribution of deregulation and market competition to the rapid penetration of mobile phones in India. Regulatory frameworks for ICT need to become more market-friendly, and institutional arrangements need to become more transparent and accountable to promote the development and diffusion of ICT.

Although the establishment of an open, competitive and market-oriented regime is central to effective ICT development, the main challenge of ICTD programs in rural areas is to achieve sustainable results in the medium to long term. In many countries, ambitious initiatives of ICTD have often proven unsustainable after initial up-front funding sources were exhausted. More recently, however, the prospects for establishing viable ICT-based enterprises in rural areas have become increasingly favorable. Lower costs, higher potential revenues, and more extensive integration of ICT in social and economic activities are creating the foundation for long-term sustainable business

Box 10 Market Liberalization, Tariff, and Mobile Phone Penetration in India

As part of economic reforms in India, the liberalization of the telecommunications sector was promoted in the 1990s. The sector was under a public monopoly, but the Indian government gave up its monopolistic position and introduced market competition by allowing domestic as well as foreign companies to enter the telecommunications services sector. The liberalization aimed to promote investment and improve productivity and the growth rate of the sector. India removed the long-standing requirement of prior experience in the telecommunications market for applications for a license. This opened the door widely for market entry to many new service providers. The entry of private and foreign players led to significant expansion in the telecommunications network, the introduction of new technologies, and striking improvement in productivity. As a consequence, India now has one of the largest telecommunications networks in the world. The number of operators in fixed telephony increased from two in 1999 to seven in 2009. The number of operators in national and international long-distance increased from 1 to 26 and from 1 to 124, respectively, between 1999 and 2009. In particular, the number of operators in mobile phones jumped from 2 to 39 in the same period. As the figure indicates, India's government continued to allow new mobile phone operators to enter the market as well as introduced various deregulatory policies. The mobile phone tariff dropped from 16.93 rupees in 1999 to 0.48 rupees 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: Planning Commission (2012); Kathuria and Kedia-Jaju (2011).

models. Mobile phones have become a powerful channel for public, social, and private services for government-to-person and person-to-person contact in developing countries.

Accelerating Broadband Penetration through Universal Access and Service

ICT penetration in Asian developing economies has been driven by mobile phones in the last decade. However, the penetration rates of broadband, internet, and computers still remain quite low in developing economies, even though internet use has begun to grow rapidly in recent times. More strategic initiatives for ICT infrastructure need to be introduced and implemented to expand broadband networks for high-speed internet as has been done by some advanced countries in Asia, such as Singapore and the Republic of Korea. In addition, the extensive penetration of mobile phones needs to be used constructively with relevant mobile applications for development.

Through universal access and service programs, developing countries can extend the benefits of ICT services to otherwise unserved or underserved people and businesses

Developing countries need to capitalize on both mobiles and broadband. The ubiquitous mobile phone has tremendous reach and is already being tapped for applications such as telemedicine, development communication, e-learning and market information to remote and rural communities. For certain higher order applications, broadband access and computers are required such as advanced education and training, on-line commerce, business outsourcing to rural areas, call centers, and creative industry services using advanced digital technologies. The increased use of smartphones and data traffic through mobile phones is changing ways in which people access the internet. These patterns need to be explored further for appropriate infrastructure expansion and service delivery platforms.

Through universal access and service (UAS)[6] programs, developing countries can ensure that the benefits of ICT services can ultimately be obtained by otherwise unserved or underserved people and businesses. Compared to other parts of the world, the notion of UAS is nascent and not well developed in Asia. UAS programs have been introduced for rural and remote areas where the population density is too low or infrastructure investment is too high to get the minimum return on investment. A good example is the initiative of the government of Viet Nam to implement "Program 74" which aims to universalize basic telecommunications services for poor and rural communities. Program 74 not only provides access to telecommunications services for more than 20 million people in rural areas for economic and social development, but also encourages enterprises to aggressively invest in infrastructure networks and service development for the rural market. (Tuan (2011).

Promoting ICT Applications for Inclusive Growth

ICT can be used as a vehicle to promote inclusive growth to empower underserved citizens to participate in various social and economic activities. To promote inclusiveness, governments need to find innovative solutions to extend ICT infrastructure as well as develop appropriate services and applications. Although market-based solutions are optimal, the conditions may not yet be ripe to use them in developing countries. Possible approaches that can be effective include (i) public–private partnerships; (ii) government procurements of ICT; and (iii) the involvement of local authorities and communities, particularly to increase local ownership for long-term sustainability. Well-targeted applications such as e-learning, mobile finance, community services through a shared platform, e-health (telemedicine) are some of the avenues that have great potential. Developing countries need to continue to expand these inclusiveness-oriented services by creating an environment in which both public and private sectors are motivated to develop and offer them.

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[6] As defined by the International Telecommunication Union (2012), 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."

Implications for Asia 5

The preceding sections suggest that the developing countries of Asia despite considerable progress in advancing KBEs, have some way to go to catch up with advanced countries. Asian countries must prioritize a wide range of KBE-related investments, learn relevant lessons from the experiences of economies at the knowledge frontier, and shape their own unique paths to advance their KBEs.

In this section, we explore the implications of advancing KBEs in Asia in the context of its key structural challenges and vice versa.

Countries in Asia need to make conscious and deliberate choices that make KBEs more inclusive

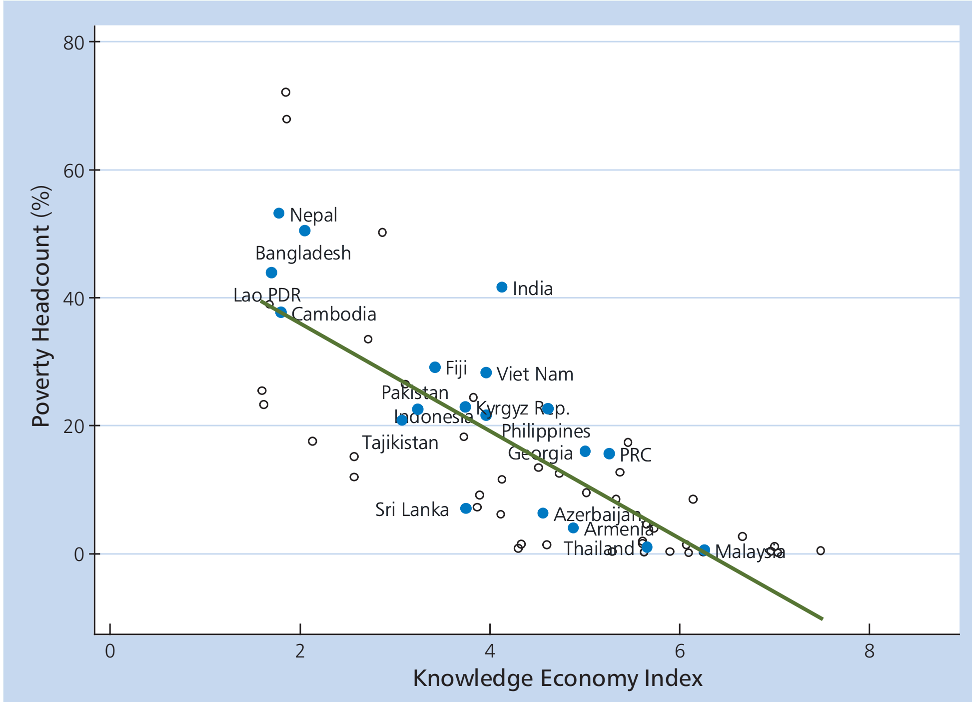
Inclusive Knowledge-Based Economy

While it is clear that KBEs can speed up growth and reduce poverty, developing countries 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 countries 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 Union 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 7 shows the strongly negative correlation between the KEI and poverty rate for OECD and non-OECD countries for which data are available. Much of the correlation is likely to be driven by per capita GDP. That is, richer countries are likely to be more knowledge-intensive and have less poverty. Nevertheless, the sheer strength of the correlation suggests that knowledge may be beneficial for poverty reduction. All the more so since knowledge can empower the poor and make them more productive.

Figure 7 Knowledge Economy Index and Poverty Rate ($1.25 a day), 2005



Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China.
Source: Estimated by the authors based on World Bank and CEIC data.

Developing countries can adopt mitigating measures to make KBEs inclusive, for example, ensuring that special support is provided to disadvantaged communities to access education and ICT connectivity, but they can also promote KBEs that are inclusive by design. Innovation relates to inequality in three ways: (i) through direct impact on income distribution (innovation favors the highly skilled and risk takers); (ii) as solutions for improving the welfare of lower and middle income groups ("frugal innovation"); and (iii) through innovations by lower income groups themselves, i.e., grassroots activities (Paunov 2013). Frugal innovation and *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 its 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.

Box 11 illustrates how an inclusiveness lens can be applied to the innovation, education and training and ICT pillars of KBEs.

Box 11 Promoting Inclusiveness across the KBE Pillars

Innovation	Education and training	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 non-exclusive licenses, wider use of patents, and regulation of monopolistic practices. • Provide incentives to increase choice of technologies that have higher employment intensity, other things being equal.	• Increase opportunities for access to education and training in science, technology, engineering, and math disciplines for the disadvantaged. • 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 technician 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 training institutions.	• Promote 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. • Encourage use of ICT in education through e-learning, game-based education, and online courses to reduce costs, improve efficiency and foster interactive pedagogy. • Promotion of devices such as low-cost tablets for developmental purposes, particularly for education (students and teachers).

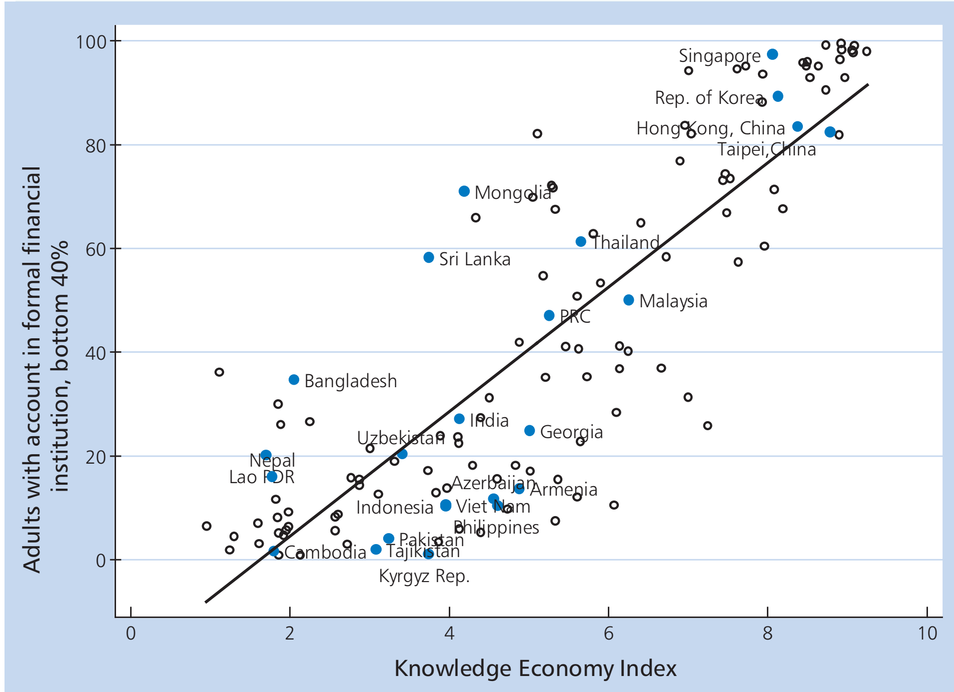
ICT = information and communication technology, R&D = research and development.
Source: Authors.

Financing of Knowledge-Based Economies

Asia’s financial underdevelopment could 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 big reason that Silicon Valley emerged in the United States. 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

Figure 8 Knowledge Economy Index and Financial Inclusion, Adults with Accounts in Formal Financial Institution, 2005 (% of GDP)



Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China.
Source: Estimated by the authors based on World Bank data.

Higher financial inclusion will be supportive of KBEs

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. Figure 8 shows a positive relationship between the KEI and financial inclusion. This is a correlation rather than a causation, and the strength of the correlation suggests that financial inclusion has at least some positive effect on KBEs.

Given the extent of financing required for advancing KBEs, developing countries need to use innovative financing modalities.

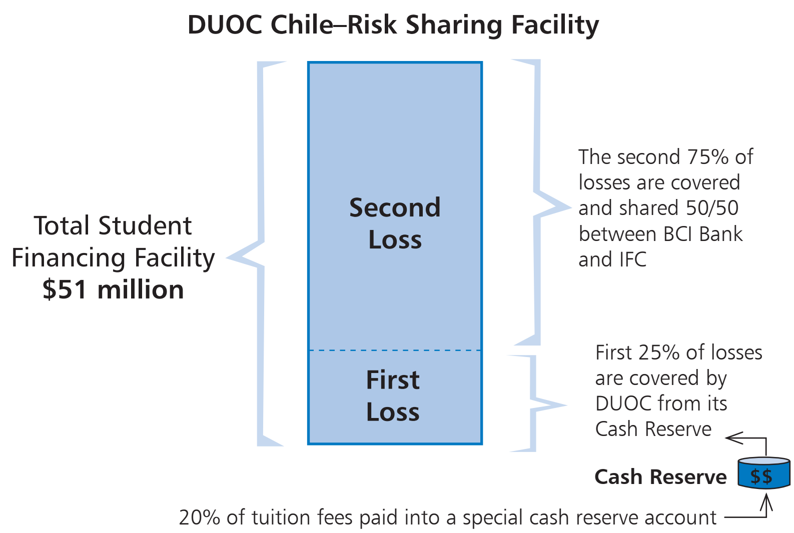
Enhancing Financing for Innovation

To support the development of innovation systems, the developing economies of Asia need to develop 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/public research institutes. Policies that have been found to be effective in advanced economies, including the Small Business Innovation Research (SBIR) program in the United States, 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 (e.g., Israel's incubation support program and Singapore's Incubator Development Programme).

Supplementing Financing for Education

Articulating alternative and innovative forms of financing and leveraging private sector investment in Asia's systems of higher education will be critically important if necessary education sector reforms are to be effectively resourced and implemented. Duoc UC in Chile provides a relevant case where 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 able 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 (Figure 9).

Figure 9 Increasing Access to Tertiary Education through a Risk-Sharing Facility



BCI = Banco de Crédito e Inversiones, IFC = International Finance Corporation.

Innovative financing that leverages private investments is needed to substantially increase access to education and ICT

Financing of Information and Communication Technology

The government has a strong role to play in developing strategic informatization and universal telecommunications programs and harnessing adequate 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 are 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 non-banking sector innovative financing models used for financing physical infrastructure could possibly be replicated for information infrastructure expansion as well .

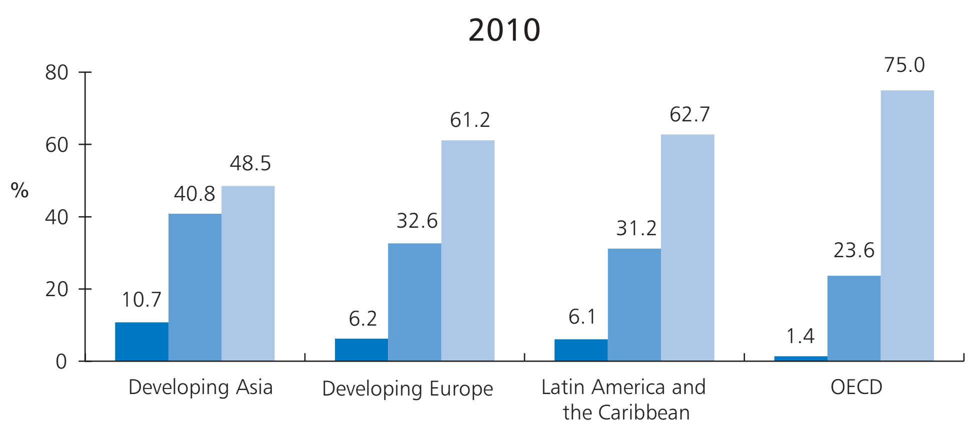
The Rise of Services and Knowledge-Based Economies

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 travelled in the past by advanced economies, with agriculture's dominance giving way, and then industry giving way to services. Figure 10 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 productivity of services

The advent of KBEs, in particular human capital and ICT investments, will lift 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 2012a). 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 countries, such as for ICT, still lags that of advanced countries. 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, for example, ICT can provide market and weather information to farmers.

Figure 10 Rising Share of Services in Output



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

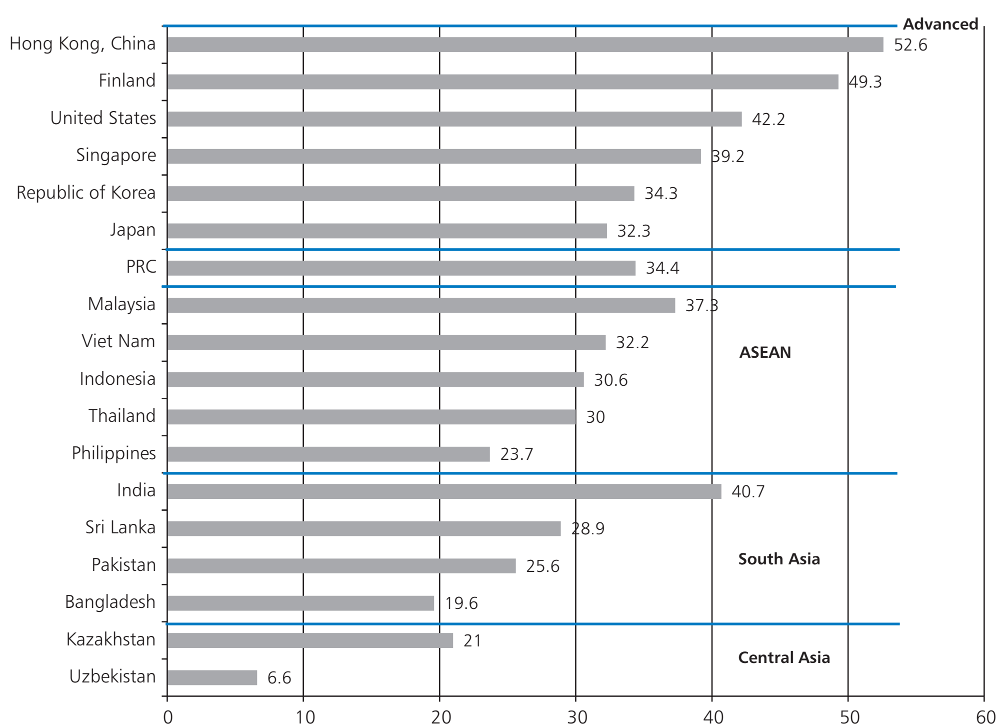
Growing Prominence of Creative Industries and Knowledge-Based Economies

Technology innovation need not be the only driver for advancement in knowledge economies. Creative industries[7] are gaining considerable prominence in recent times and this is another area where developing Asia has demonstrated strength. The creation of the Ministry of Science, ICT and Future Planning in the Republic of Korea and the Ministry of Tourism and Creative Economy 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 countries 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 of 20%). Figure 11 also reveals the strong position of Asia in creative output.

Creative industries constitute a new dynamic sector in world trade. Asian countries are well positioned in terms of creative output

Figure 11. Creative Output Index 2012



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

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7 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, TV and radio.

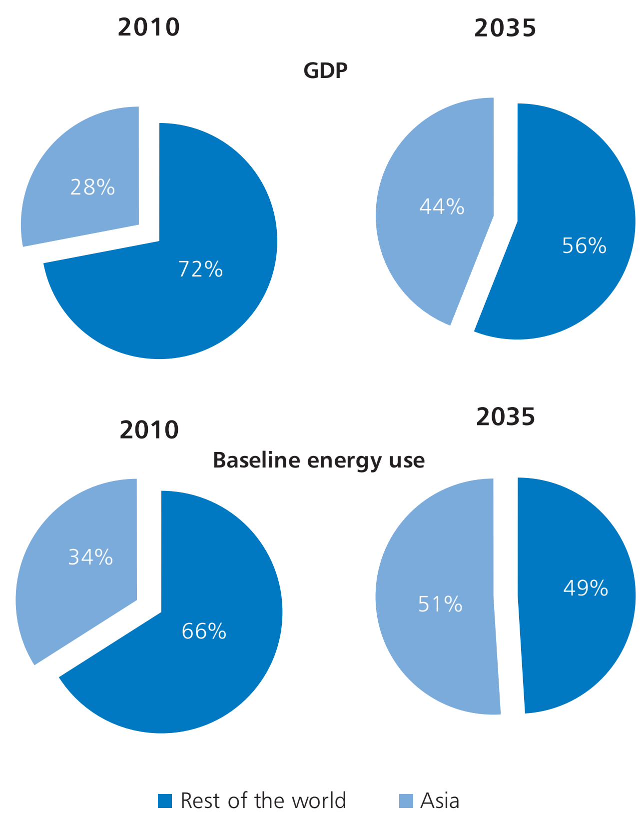
Energy Security and Knowledge-Based Economies in Asia

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 the period 2010–2035, and by 2050 the region may account for over 50% of global GDP. This promising vision of Asia's 21st century is often called the "Asian Century" growth scenario articulated in Asia 2050. Such economic expansion, however, requires 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 12). 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 if Asia were to find the energy supply it needs to fuel its growth, it still faces the equally daunting challenges of doing so in an environmentally sustainable way while ensuring affordable access to the poor. Asia's carbon dioxide emissions are set to double between 2010 and 2035, and almost half of the world's people without electricity live in Asia. Therefore, achieving Asia's energy security will depend on three pillars: adequate and reliable physical supply, environmental sustainability, and affordable access.

Investing in new knowledge and technology is the only way to achieve Asia's energy security in the long run.

Investing in new knowledge and technology is the only way to achieve Asia's energy security in the long run. In the short run, Asian countries can aggressively curb demand, for example, by removing price subsidies. They also have some options to expand supply. For example, the PRC sits atop the world's largest reserves of shale gas. However, in the long run, the only viable path to energy security is for Asia to upgrade its knowledge and technology base in both demand and

Figure 12 Asia's Growing Share of Gross Domestic Product and Primary Energy Consumption, 2010–2035



Source: ADB (2013).

supply. For example, green, smart cities and clean transport can power Asia's urbanization in an environmentally sustainable, affordable way. Some Asian countries are already world leaders in some segments of renewable energy, but they need to do more to bring down costs. Asian countries are also pursuing better, more advanced nuclear power technologies as well as carbon capture and storage (CCS) technologies. In short, there are very high returns to advancing Asia's knowledge base in the energy area.

Knowledge-Based Economies and Game-Changing Trends

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, is tapping into unprecedented opportunities provided by new technologies that will further fuel growth and development. In this section, we highlight, for further future exploration, some of these trends that can be "game changers" for developing economies.

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 2012a).[8] 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.

Asia can take advantage of game-changing trends in the advent of transformational technologies to advance faster as KBEs

ICT has advanced in Asia with a unique footprint. The story of penetration of mobile in Asia has been nothing short of spectacular, and the trend continues unabated. The number of mobile-connected devices is expected to exceed the population on earth by the end of 2013. Mobile data traffic will grow at a compound annual growth rate of 66% between 2012 and 2017 and Asia and the Pacific will account for by far the largest share of the market at 47% (CISCO 2013).

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 2012b). The spike in the number of internet users and deepening mobile penetration in Asia are key drivers for information technology 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" information technology 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 of the top 10 locations for outsourcing of global services for delivering information technology, business process outsourcing, and voice services, are in Asia (India, Indonesia, Malaysia, the Philippines, the PRC, Thailand, and Viet Nam). 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 (Asia Cloud Computing Association 2012). As a mass market develops for cloud-enabled services, prices will fall, much like mobile services, and transform traditional business models and boost productivity.

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8 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.

The demand for social media services is set to grow rapidly given the popularity of social networking in Asia. With about 40 million people, Indonesia has the second largest number of Facebook users in the world (after the United States), followed by India at 32 million users. 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.

The new digital technologies are not only modernizing and improving the cost-effectiveness of business and economic activities, they are 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, the advent of MOOCs is challenging the notion that traditional brick and mortar universities are the only models. 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 (Frank 2012). Not only are these opportunities, they will become the imperatives of the future.

Asia is taking pole positions in some key frontier technology areas, such as semiconductors and solar photovoltaic. 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 or 31.8%, 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 carry a great deal of potential to be game-changers for Asia in that they can challenge the linear path of progress and enable countries to jump technology cycles. Conducive policies and appropriate incentives are required for countries to take advantage of these trends, yet they hold great promise.

Some Questions for Discussion

6

National Strategy for KBE

- Is there a need for a national strategic blueprint or action plan for KBEs in Asia? How useful is a separate government agency, in the mold of the Republic of Korea's newly established ministry?
- How can priorities for KBEs be established for countries at low and middle income levels? Is there any sequencing that is right?
- Can developing countries make a leap directly from an agricultural economy to knowledge economies without an adequate industrial base? Is this a new development model? Can it provide enough employment? What is necessary to make it work?

Role of Government and KBE

- How can Asian countries resolve the paradox of the role of the state in the KBE? There is clearly a role for the government in leading and coordinating KBEs—for example, supporting innovation and enforcing intellectual property rights, building ICT infrastructure, promoting inclusive and sustainable growth—but excessive government intervention can stifle entrepreneurship, innovation, and growth.
- What can be done to reduce the endemic problem of corruption and poor governance that undermine the business environment and constrain dynamic entrepreneurship which are fundamental for the KBE?

Innovation and KBE

- Should developing countries go for home-grown innovations at the frontier or concentrate on adapting existing technologies at low cost? Or both? How should developing countries make sense of important game-changing trends in technology and business innovations?

ICT and KBE

- In ICT, should developing countries invest in most advanced versions such as cloud computing and wireless broadband rather than promote older technologies?

Education and Training and KBE

- Should DMCs aim for a few elite world-class standard educational institutions or should they adopt less expensive options such as MOOCs in expanding tertiary education? Or both?

KBE and technological leapfrogging

- What other opportunities are there for technological leapfrogging for developing countries? Can they get in early into some areas of the biotech and nano-tech revolutions? How can developing countries in Asia leverage their strengths in offshore services sector, mobile telephony and frugal innovation to accelerate inclusive growth?
- Can Asia aspire to its own versions of Silicon Valley? What is necessary to transform existing high-tech clusters such as those in Beijing, Shanghai, Bangalore, Gurgaon, Hyderabad, Cyberjava, Daedeok, Hsinchu, Singapore, and Tsukuba into truly global hotbeds of innovation?

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Asia: The Road to Becoming a Knowledge Economy
Game of Catch-up or Game Changers?

This paper provides initial insights from an ongoing ADB study "Asia's Knowledge Economies: Next Policy Agenda". It assesses the current state of knowledge-based economies (KBEs) in a number of developing Asian countries compared to selected advanced countries in Asia and elsewhere. It identifies gaps that developing Asia must fill to catch up with advanced countries. At the same time, it also highlights game-changing trends that put developing Asia in an advantageous position to move faster toward the global knowledge frontier.

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