How Revolutionary Was the Digital Revolution?

National Responses, Market Transitions, and Global Technology

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The Emerging Economies in the Digital Era

Marketplaces, Market Players, and Market Makers

Naazneen Barma

The fast-changing global digital economy presents great prospects for emerging economies. They have the opportunity to reap the dramatic gains available in the world's fastest-growing markets and the chance to participate in cutting-edge technological activities through cross-national production networks. Many assume that economically developed countries, fueled by dynamic innovation, hold an incontrovertible economic and technological lead over the poorer parts of the world. This chapter, however, challenges the view that developing countries are merely passive markets for digital products innovated in the industrialized world and directs analytical focus to the roles that emerging economies can and do play in global digital innovation. It illustrates how explosive market potential in developing countries translates into new innovative forces there, sketches out some key patterns in the roles emerging economies play in the processes of global digital innovation, and examines their innovative potential by assessing their research and development (R&D) capacity. While recognizing the significance of the digital divide between industrialized and developing countries as one of the central features of the international political economy, this chapter's approach runs against the conventional academic view that the divide is about usage or access, issues to which much attention has already been devoted.[1]

It is essential to note from the outset that the developing world comprises a large and extremely varied group, individual members of which respond in very diverse ways to the digital economy. The optimal uses of information and communication technologies (ICTs) vary widely across developing countries, as does ICT-related government policy; consider, as an exaggerated example, the need to distinguish between the state of ICT use and access in sub-Saharan

Africa versus East Asia (United Nations Development Programme [UNDP] 2000; Digital Opportunities Task Force [DOT Force] 2001; United Nations Conference on Trade and Development [UNCTAD] 2002; World Bank 2002). Yet, for the purposes of considering the production possibilities represented by the digital era for the developing world, it makes sense to focus analytic attention on those newly industrializing countries, or emerging economies, that are increasingly able to break into digital production networks. Indubitably, modes of innovation and production profiles vary within this smaller subset of the developing world. Nevertheless, these emerging economies as a group adjust to the new economy in patterns that are different from those in advanced economies (Weber and Zysman 2002). This chapter seeks, therefore, to shed light on discernible patterns at the micro—firm or market—level, as well as considering the national and international dimensions of an innovative environment.

Although advanced countries are the main purveyors of radical, breakthrough digital innovation, emerging economies are likely to find that their strength in shaping global digital markets, at least in the short and medium term, lies in a different manner of innovation. In particular, emerging economies have begun to pursue two main avenues of non-breakthrough innovation that are increasingly significant in the digital economy. The first type of non-breakthrough innovation comes in the form of improvements to specific modular applications within a digital production chain that often come from on-the-job learning-by-doing. The second form of non-breakthrough innovation that emerging economy enterprises have successfully introduced into the global economy centers around modification of the production and distribution of modular applications to meet the unique needs of their home markets.

I characterize these non-radical forms of innovation as "modular innovation." The concept builds on the insight that the prevalence of networked production in digital sectors has enabled the producers of modular applications in global production chains to become the innovative center of the digital economy.[2] The modular innovations purveyed by emerging-economy firms can and have come in improvement of the product itself as well as in organizational and marketing modifications, particularly those that take into account the characteristics of new emerging-economy consumers and commercial infrastructure. Modular innovations can hence be both product- and process-oriented. In dynamic terms, they can cumulate over time into a trajectory that matches or even surpasses the impact of innovations on the technological frontier. The global economy comprises comparative advantages that map to different sources of innovative potential. Capital-rich advanced countries have the means to finance the expensive R&D necessary for radical innovation. Newly industrializing economies can rely on their rich human

resources, track record of organizational innovation, and huge markets of increasingly sophisticated consumers to make technological advances through processes of learning-by-doing and user-driven innovation.

This chapter is organized to examine the different roles that emerging economies can and do play in the global digital economy and in ICT innovation. They are indeed marketplaces, but fast-growing ones with explosive potential; thus, rather than being passive recipients of ICTs innovated in the advanced world, they have the power to dictate the future of digital consumer products. In addition, they are increasingly relevant market players, particularly in terms of their niches in the cross-national networks of digital production and their role of producing and distributing modular applications for home market uses. Finally, and most recently, emerging economies also have great potential as market makers: they have the opportunity to shape future global digital markets as a result of their own prowess in digital innovation and the complementary resources they have to offer.

MARKETPLACES: THE NEXT 1 BILLION DIGITAL CONSUMERS

Although the digital economy continues to grow globally, poor countries represent the market potential of the future. And they are no longer simply the passive recipients of products and services innovated by and for the advanced world. They have their own very specific needs and tastes, and their buying power is sufficient across a number of different market segments to warrant the supply of customized products. Hence poor consumers are increasingly driving modular innovation in production technologies, business models, organizational management, and marketing and distributional strategies. These modular innovations are an essential type of the new value-creation patterns required in the global digital economy.

It is instructive to place the market power of the emerging economies within an international context. Global growth in ICT use has been robust over the last decade (Figure 7.1). Most strikingly, mobile cellular subscribers numbered 16 million in 1991 and shot to 1,329 million by 2003, overtaking the number of telephone landlines. While computer users have increased steadily, from 130 million in 1991 to 650 million in 2003, Internet connectivity has grown much faster, from 4.4 million users in 1991 to 665 million in 2003.

Yet growth in digital industries is far from even across the world. It has become almost axiomatic in ICT business strategy that the newly industrializing economies offer fast-growing and incompletely tapped markets. The thirty advanced, industrialized countries that make up the Organisation for Economic Co-operation and Development (OECD) count for less than one-fifth of the

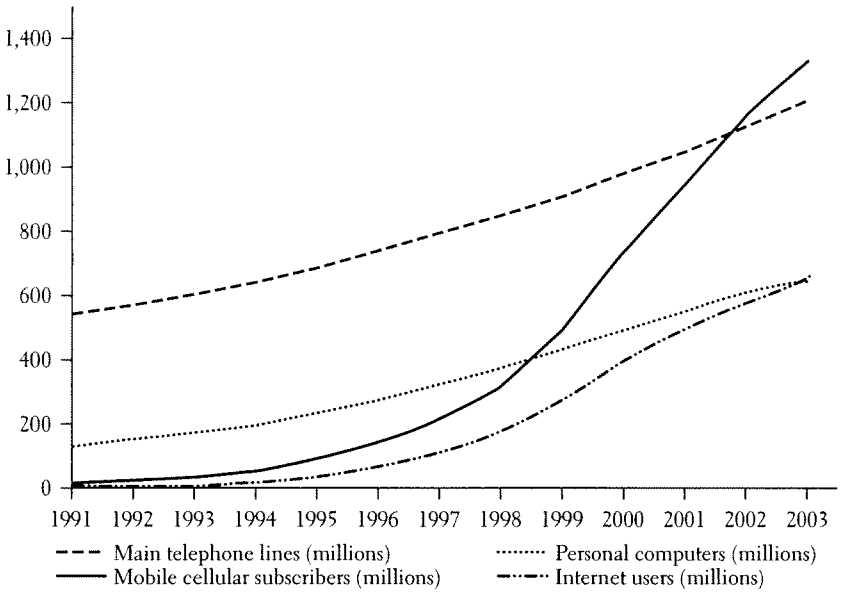

FIGURE 7.1 Global information and communications technology users (in millions)
Source: Data are from the International Telecommunications Union (ITU): World Telecommunication Indicators Database

world's population. On the other hand, China and India together make up more than one-third of the world's population, an ever-increasing share owing to population growth rates.[3] The emphasis on emerging markets comes from a pragmatic need: as the traditional markets of the digital era mature, companies must reach out to a new set of customers. During the last fifty years, about 1 billion people have come to use computers, the vast majority of them in North American, Western Europe, and Japan. Yet these markets have slowed in growth: computer industry sales in the United States are expected to increase on average only 6 percent per year for the next five years, while emerging-market demand is expected to increase at an average rate of 10 to 11 percent over the same time period (Hamm 2004). Thus, in order to continue to grow, digital industries must reach out to "the next 1 billion customers," who will come not from the industrialized world but rather from newly emerging markets. Digital-era growth opportunities for businesses in rich countries seem to be shifting inexorably to the developing world.

As Prahalad and Hart (2002) have argued convincingly, "Low-income markets present a prodigious opportunity for the world's wealthiest companies." Already tech companies are scrambling to make their mark in the emerging

economies and cash in on the next big growth wave. In 2005, annual IT-related investments are expected to grow about 15 percent to $32 billion in China and 21 percent to $8.5 billion in India (Perez 2002). Emerging markets—led by China, India, Brazil, and Russia—are expected to see ICT sales surge 11 percent per year over the next five years, to about $230 billion. These markets are very appealing to rich-country companies not just because of their sheer population size, but particularly because of the growing ranks of the middle class—a new base of consumers for digital products, estimated at 60 million in China and 200 million in India. A. T. Kearney has estimated that the number of people with equivalent to $10,000 in annual income will double to 2 billion by 2015, with 900 million of these new consumers in emerging markets (Hamm 2004). Prahalad (2005) estimates the potential profits from serving the poorest 5 billion people in the world—a group he dubs the "bottom of the pyramid"—at $13 trillion per year globally (*Economist* 2004a). He values the purchasing power parity (PPP) of a fast-growing group of emerging economies—China, India, Brazil, Mexico, Russia, Indonesia, Turkey, South Africa, and Thailand, together representing 3 billion people or 70 percent of the developing world's population—at $12.5 trillion, or 90 percent of the PPP of the developing world. This is larger than the combined PPP of Japan, Germany, France, the United Kingdom, and Italy (Prahalad 2005).

In terms of emerging markets for digital products, more specifically, China had an installed base of 250 million cellular phones at the end of 2003. China Telecom is the largest mobile cellular operator in the world in terms of usage, with an annual growth rate of cellular subscribers in the past few years of more than 60 percent (International Telecommunications Union). India had an installed base of about 30 million cellular phones, growing at 1.5 million handsets per month, with the expectation that Indians will own 100 million handsets by 2005. Brazil already has 35 to 40 million cellular phones (Prahalad 2005). Table 7.1 demonstrates that while ICT usage per capita remains much lower than in the richer countries, growth in ICT usage has been torrid over the last decade in the countries Prahalad names the emerging markets.

Digital industry giants have declared emerging markets a top priority and are pushing their products there aggressively, vying with each other for lucrative government contracts as well as for new middle-class consumers. For example, Sun Microsystems, Microsoft, and IBM have competed ferociously for deals with telecommunications and software firms in India, as well as for enormous state-by-state government contracts. IBM's revenues in Brazil recently surged past the $1 billion mark; the company plans on hiring two thousand people in Brazil and spending an additional $100 million on market development there (Hamm 2004). Microsoft famously got off on the wrong foot in

TABLE 7.1 Growth in information and communication technology use in select countries

	Telephone mainlines (per 1,000 people)		Cellular subscribers (per 1,000 people)		Internet users (per 1,000 people)		Personal computers (per 1,000 people)
	1990	2002	1990	2002	1990	2002	2003
United States	547	646	21	488	8	551.4	658.9
Japan	441	558	7	637	0.2	448.9	382.2
Finland	534	523	52	867	4	508.9	441.7
Mexico	65	147	1	255	0	98.5	82.0
Russian Federation	140	242	0	120	0	40.9	88.7
Brazil	65	223	—	201	0	82.2	74.8
Thailand	24	105	1	260	0	77.6	39.8
Turkey	121	281	1	347	0	72.8	44.6
China	6	167	—	161	0	46.0	27.6
Indonesia	6	37	—	55	0	37.7	11.9
South Africa	93	107	—	304	0	68.2	72.6
India	6	40	0	12	0	15.9	7.2
High income	420	584	13	653	3.1	445.8	
Middle income	49	168	—	176	0	59.5	
Low income	16	28	—	17	0	13.0	

Source: United Nations Development Program (UNDP) Human Development Indicators 2004; calculated from the International Telecommunications Union (ITU) World Telecommunications Database, 7th ed. Personal computer data are taken directly from ITU.

China: although it owns the desktop market there, it earns little money because 97 percent of its software is illegally copied. Every time Microsoft pressures the government to crack down on piracy, however, the state makes a move to support Linux, the open-source operating system rival to Windows.[4] Yet Microsoft is pouring $750 million into China over the next three years to help develop a software industry infrastructure, on top of the $1 billion it spends there annually in running its business. Sun Microsystems has countered by signing a deal with the Chinese government to supply its Linux desktop operating system and office program to as many as a million personal computers (Leander 2004).

What makes the emerging economies crucial in terms of innovation, however, is not just their sheer market volume potential. In developing countries, the world's wealthiest companies find consumers with unique needs and varied tastes. These middle-class emerging-economy consumers may have lower incomes, but there is sufficient buying power across the huge numbers of people

in these growing market segments to drive demand for products that are customized to their needs and tastes. These submarkets are thus significant enough to drive modular innovation, particularly in specific digital applications and in organizational form, to respond to the existing commercial infrastructure. The innovative challenge lies in tailoring new products to these consumers and taking advantage of their uniqueness. As an example, emerging-market consumers are younger and less loyal to brandsthan their Western counterparts. Brown and Hagel (2005) report that these new demographics and consumer patterns are forcing companies to rethink the manner in which they design and deliver their products, and a growing number of established digital vendors acknowledge that returning to the drawing board is the only option in the emerging markets. Furthermore, advanced-country companies are increasingly recognizing that if they are not competing in the growing emerging markets, they are not developing the capabilities they need to remain viable back home. Providing goods and services for poor consumers forces companies to innovate in ways that promote long-term success.

Prahalad points out that "if we stop thinking of the poor as victims or as a burden and start recognizing them as resilient and creative entrepreneurs and value-conscious consumers, a whole new world of opportunity will open up" (2005, 1). As he further argues, and as rich country companies have learned the hard way, firms cannot profitably serve emerging market consumers with the products designed for advanced-country consumers. Rather, Prahalad argues, they will need to thoroughly reengineer products in order to reflect the different customer needs and production and distribution economics at the bottom of the pyramid: the demand for small unit packages that can be paid for with poor consumers' limited cash in hand, and the necessity of a cost structure that can produce goods and services in high volume to compensate for the low margin per unit (Prahalad and Hart 2002; Prahalad 2005). (Note that lower prices in emerging markets will likely put pressure on prices worldwide, which may reduce ICT industry growth rates and profit margins [Hamm 2004]). In short, emerging markets are not implicitly stuck relying on commoditized, hand-me-down innovation from the developed world (Weber and Barma 2003). They have their own lead users who pull technology development toward applications that specifically fit their indigenous needs and demands.

In addition, selling to the world's poor requires investment in market development and, in some cases, the creation of a commercial infrastructure that can unlock the latent purchasing power in emerging markets (Prahalad and Hart 2002). For example, recognizing the enormous business and development opportunities in emerging economies, Hewlett Packard has articulated its "e-inclusion" initiative, which focuses on providing technology, products,

and services appropriate for the world's poor. Intel has a team of ethnographers traveling the world to provide input into designing or redesigning products to fit different cultures and demographic groups. This, in turn, leads rich companies to develop innovative new strategies for allying with other stakeholders on the ground in the developing world — nongovernmental organizations, international financial institutions, and governments — as well as catering to local stakeholders and conditions and undertaking locally tailored research and development. Following this logic, IBM has developed a $12 microprocessor and simple network computer that it supplies to Chinese companies that then sell computers and Internet access services in rural parts of the country; Hewlett Packard has agreed to install Poland's new computerized driver's licensing system using a pay-as-you-go scheme (Hamm 2004). These are some of the ways poor consumers can and will drive modular innovation in production technologies, business models, organizational management, and marketing and distributional strategies.

MARKET PLAYERS: A NEW ECOLOGY OF COMPETITION IN THE EMERGING ECONOMIES AND THE WORLD

The demand of poor consumers for customized, low-cost products and services has created a new ecology of competition and innovation in emerging markets. The industrialized world's most successful companies are finding tough competition on the unfamiliar terrain of emerging markets in the form of home-grown companies who know their local markets intimately and have grown up supplying to them. Furthermore, these enterprises have been able to leverage their home market advantages into larger inroads into worldwide markets. Yet a number of questions arise in examining emerging-economy firms as market players. Are they actually competing directly with advanced-country companies in their home markets, or are they targeting different market segments? Are rich-country companies adequately addressing the evolving needs of lower-income middle-class consumers in developing countries, or are domestic companies successfully catering to their home markets in a vacuum of competition from overseas? From a survey of the anecdotal evidence available, it appears that emerging-economy companies are competing quite directly with their overseas competitors, and that the former appear to have the edge on the latter in successfully gauging what their consumers want and need. At the same time, however, examining where emerging-economy companies have been successful demonstrates that they may have specific skill sets that make their forms of competitiveness distinctive given the structures of the global digital economy.

First, emerging-economy enterprises seem to be competing successfully in their home markets and making inroads into global markets on the basis of cheaper pricing structures and lower production costs. In China, for example, the new networking company Huawei can charge 50 percent less for gear than Cisco. It has captured a 16 percent home market share in routers, second only to Cisco, and is starting to make inroads into global networking gear markets from Russia to Brazil, already ranking second worldwide in broadband networking gear. Domestic service companies in India provide stiff opposition to foreign challengers. I-Flex Solutions, an Indian company which provides banking and software services, has built the world's top-selling software suite for managing consumer, corporate, Internet, and investment banking needs; its revenues grew 26 percent in one financial quarter in 2004, in a slow-growth worldwide enterprise software industry.

Second, it appears that closeness to market allows emerging-economy enterprises to capitalize on the demands and increasing purchasing power of their home market consumers. The South Korean companies Samsung Group and LG have taken advantage of the advent of the wireless age in East Asia to make their move away from the personal computer-centric era, which has been dominated by U.S. companies. While 30 million computers are expected to sell in Asia in 2004, this figure is dwarfed by the 200 million Internet-enabled cellular phones expected to sell there. Samsung and LG are taking advantage of their cellular phone lines rather than their personal computer lines; in the past four years they have risen to become the third and sixth largest mobile phone makers in the world. TCL Mobile is one of the top two Chinese mobile handset makers, and its solid position in the largest cellular market in the world has given it an edge in other developing markets in Africa, Asia, and the former Soviet Union.[5]

For digital industry powerhouses, these different forms of competition in newly industrializing economies means that they will likely have to invest substantial sums of money to succeed in emerging markets. In addition, they will have to dramatically alter the very business strategies that made them so successful in the advanced world. Dell, for example, introduced a consumer PC in China, the SmartPC, which was different from anything it had sold before: "It came preconfigured rather than built to order, and it was manufactured not by Dell but by Taiwanese companies. At less than $600, the SmartPC has helped Dell become the top foreign supplier in China. Its share of the PC market there rose from less than 1 percent in 1998 to 7.4 percent today" (Hamm 2004). Yet two local Chinese companies, Lenovo Group and Founder Electronics, both rank ahead of Dell and other foreign hardware suppliers and remain the top PC sellers, with market shares of 25.7 percent and 11.3 percent

respectively. They have an advantage in reaching Chinese customers through vast retailing operations; when Dell set up retailing kiosks for the SmartPC and other products, it faced competitors selling stripped-down PCs for about $360 and had to withdraw from the consumer market. IBM recognized Lenovo's potential when it sold its PC business to the Chinese PC maker in December 2004. The move signaled a recognition by IBM that its future in China depends on close partnership with a local market leader. The deal offers the Chinese the chance to tap into overseas management and technological expertise, reflecting "the rising global aspirations of corporate China" (Lohr 2004).

Emerging-economy companies have increasingly been able to beat out rich-country competitors on their home turf with intimate local knowledge and low-cost, low-margin products. At the same time, some domestic firms are finding their strengths lie in niches in cross-national production networks as they take advantage of the constantly shifting determinants of competitiveness in the global economy.[6] This is the strategy that East Asian manufacturing firms used with great success in the 1980s as the East Asian Tigers became the original newly industrializing economies (NIEs) of the postwar era. South Korea, Taiwan, Hong Kong, and Singapore pursued economic growth strategies that differed in important ways, but all were successful in responding to the major shifts that continue to determine competitiveness in the world economy today. Lall (1999) identifies these successful competitiveness adaptations as a new pattern of competition marked by knowledge- and technology-based advantages rather than on factor endowments; the emergence of new, less hierarchical organizational structures where firms are embedded in dense technological and productive networks; and the restructuring of old industries, driven by radical technological change.

What all the East Asian Tigers succeeded in doing was moving away from a reliance on low labor costs and hence from static sources of comparative or cost advantage by moving up the technological ladder and the economic-value chain. They diversified into complex technologies, not just adopting more capital-intensive technology but also moving into more advanced technological functions within activities. For example, they moved from being key nodes for simple assembly in cross-national electronics manufacturing networks to manufacturing their own goods with local content, and finally into design, innovation, and product development (Lall 1999). The challenge is structurally the same for economies hoping to make their mark in the digital era today: how to move from static advantages to dynamic innovation.

India has emerged as an important player in global digital markets as a result of its huge reserve of well-trained software engineers and one of the largest

pools of engineering and scientific manpower in the world. India's IT successes have come through "body-shopping," whereby programmers are sent abroad on a contract basis,[7] and its large and growing business process outsourcing industry. But the longer-term innovative potential of both these activities is questionable. Some have argued that young Indian engineers benefit immensely through body shopping, learning technological, business, and organizational management skills abroad. In turn, they represent an important source of knowledge and technical transfer back to India. Yet India's software industry has competed internationally on the basis of low-cost skilled professionals, which becomes less viable as the growing demand for programmers increases their salaries, decreasing their advantage in shaping future markets. Moreover, increased human capital in the form of returned body-shoppers may yield very little in terms of innovation if there are no domestic outlets for the skills with which the programmers return. In business process outsourcing, as competition from other parts of the world heats up, leading companies in India are fighting to win higher-value-added activities to continue to compete in and innovate for global digital markets.[8] In this sense, the future of innovation in emerging economies lies exactly where it did in the past: moving away from a static comparative advantage in cheap labor and toward building dynamic comparative advantage higher up the value chain.

Borrus and Cohen (1998) discuss more specifically the structural changes in the competitive dynamics in the global digital industry in the past decade. First, the ICT industry has been increasingly characterized by the growth of networked production, where a growing number of core functions are contracted out, including production and final assembly itself. This phenomenon encapsulates the increasing modularization of digital production. It has commodified a growing range of advanced intermediary products, disaggregated the organizational form of the major, integrated producers (beginning with U.S. firms), and shifted the geography of production toward emerging economies, particularly centering many cross-national production networks in Asia. Second, the ICT industry has seen a shift in power from integrated producers to major users such as banks, insurance companies, and automobile manufacturers. These consumers have increasingly pushed the changes in ICT policy, such as telecommunications deregulation and a demand for interoperability of standards and no proprietary standards and systems. In addition, these major users have pushed the development of new applications that have become large new markets in data communications, including corporate private networks and intranets, for example. These new networked applications have increasingly driven the personal computer industry and propelled growth for hardware and software companies. Borrus and Cohen suggest that

emerging economies should focus on the markets for these applications in seeking to develop competitive domestic ICT industries. Third, there is new competition to set market standards in the ICT industry, which has shifted value-added, and hence power, in the production chain from integrated producers to holders of a standard located anywhere in the production chain. This means that new ICT markets are increasingly characterized by rivalry to set de facto market standards. Although U.S. companies have dominated this rivalry, it provides emerging-economy enterprises with remarkable opportunities in global ICT markets.

The implication of structural shifts in global digital production for emerging economies can be tied to the micro-political economy of innovation. Developing countries are not doomed to a lifetime of technological catch-up through the "stages of growth" of a single trajectory of industrialization and modernization (Rostow 1962). This chapter instead supports a perspective that is better able to account for and elaborate different trajectories of digital innovation in the developing world. The appropriate micro-institutional political economy model is captured in the "varieties of capitalism" approach, which emphasizes the importance of the set of relationships the firm is embedded within and the characteristics of those relationships.[9] A varieties of capitalism perspective yields the insight that there are indeed different mechanisms at work, at the firm level, in responding to various production and innovation challenges. In terms of innovation for the global digital economy, in particular, we see a wide array of experiments being carried out in the market place. Successful innovations in modular applications and user-driven product modifications come from these varieties of experimentation in emerging economies.

MARKET MAKERS: INNOVATIVE POTENTIAL IN THE EMERGING ECONOMIES

It is worthwhile at this point to take a step back and consider again the different dimensions of innovation. The concept is conventionally associated with breakthrough or radical invention, financed by expensive research and development operations. Yet in emerging economies these characteristics are rarely found. This does not mean, however, that there is no innovation occurring in the developing world. Lall (1993) points out that the view of technological innovation as major breakthroughs, where a technological lead emerges from a completely new production or process, is misleading. Rather, the correct scope of technological activity is much wider, including what are characterized here as modular innovations. These are sometimes considered incremental improvements;

nonetheless, they account for the larger share of production increases even in the advanced, industrialized world. This form of innovation in the developing world includes gaining "technological mastery" over imported technologies; that is, it includes learning the tacit elements of foreign technologies and building the ability to modify technology for domestic applications, for example, through imitation and reverse engineering. The modular innovations in the global digital economy that have been discussed in this chapter represent this type of non-frontier technological innovation.

There is much to be learned about the processes of and potential for digital innovation in emerging economies today by examining the industrial-technological innovation paths followed by the original NIEs of East Asia. As Kim and Nelson (2000) point out, reverse engineering and imitation were the basis of the creative innovation that propelled the rapid industrialization of the East Asian NIEs in the 1960s and 1970s. Hobday (2000, 158) concurs that emerging and advanced countries have qualitatively different paths of innovation:

> The innovation paths of the NIEs make an interesting comparison with Western innovation models, which stress new product development, dominant designs, and R&D. . . . In contrast with normal Western models, the NIEs began with mature, standardized manufacturing processes and gradually moved to more advanced stages of technology. . . . Typically, firms graduated from mature to early stages of the product life cycle, from standard to experimental manufacturing processes, and from incremental production changes to R&D. In this sense, the NIEs progressed "backward" along the normal stages of the product life cycle.

The R&D efforts of latecomer South Korean electronics firms in the high-growth 1970s and 1980s, for example, were mostly applied, targeted at improving manufacturing technology and, to a lesser extent, developing new designs (Hobday 1995). Lall states, even more forcefully, "The process of technological change in developing countries is one of acquiring and improving on technological capabilities rather than of innovating at frontiers of knowledge" (2000, 13). The assimilation and adaptation of a given technology can involve just as much technological effort in developing countries as more radical innovation, and often requires formal R&D. It is this gaining of technological mastery, which often comes from on-the-job learning-by-doing and the production of modular applications that cater to users in home markets, that explains most innovation in and much of the dynamic comparative advantage of emerging economies.

The overall competitiveness of companies in terms of the scope for innovation in turn depends on a host of different factors. These can be thought of as constituting a national innovation system, the supporting resources and

TABLE 7.2 R&D potential

	Tertiary students in science, math, and engin. (% of tert. students)	Patents granted to residents (per million people)	Receipts of royalties and license fees (US$ per person)	Research and Development (R&D) expenditures (as % of GDP)	Researchers in R&D (per million people)	High-technology exports (% of merch. exports)	
	1994–1997[a]	2000	2002	1996–2002[a]	1990–2001[a]	1990	2002
United States	—	298	151.7	2.8	4,099	33	32
Japan	23	884	81.8	3.1	5,321	24	24
Finland	37	5	107.5	3.4	7,110	8	24
Mexico	31	1	0.5	0.4	225	8	21
Russian Fed.	49	99	1.0	1.2	3,494	—	13
Brazil	23	0	0.6	1.1	323	7	19
Thailand	21	3	0.1	0.1	74	21	31
Turkey	22	—	0.0	0.6	306	1	2
China	53	5	0.1	1.1	584	—	23
Indonesia	28	0	—	—	130	1	16
South Africa	18	0	1.0	—	992	—	5
India	25	0	—	—	157	2	5
High Income	—	350	82.9	2.6	3,449	18	23
Middle Income	—	5	0.5	0.7	751	—	9
Low Income	—	—	—	—	—	—	9

[a] Data refer to the most recent year available during the period specified.

Source: UNDP Human Development Indicators Calculated from: World Intellectual Property Organization (WIPO) 2004 Intellectual Property Statistics; UNESCO 1999 Statistical Yearbook; United Nations 2003 World Population Prospects 1950–2050; and World Bank 2004 World Development Indicators.

policies that increase national absorptive capacity for technological innovation (Mowery and Oxley 1995).[10] The core characteristics of a national innovation system are public agencies that support or perform R&D; universities, which perform both research and training; firms that invest in R&D and application of new technologies; public programs intended to support technological adoption; and laws and regulations defining intellectual property rights (IPRs). For the purposes of examining the innovative potential of a group of emerging economies, I focus on (1) the level of human capacity; (2) research and development activity and funding, both public and private; and (3) the enforcement of IPRs.

A few key emerging economies are gaining on core advanced-country innovators in terms of the elements for the research and development essential to innovation. Table 7.2 illustrates several of the core arguments of this chapter.

High-tech exports provide a measure of international competitiveness, and the figures in the last column show that the developing countries in question have indeed emerged on the global scene in the past decade. Patenting activity and royalty and licensing receipts are dramatically lower in the emerging economies than in the advanced countries represented. Thus, advanced countries are indeed the major purveyors of radical, breakthrough digital innovation. Yet these figures represent only the types of breakthrough innovation that developing countries rarely engage in. Emerging economies are instead likely to find that their strength in shaping global digital markets, at least in the short and medium term, lies in the modular innovation associated with improvements to specific applications through on-the-job learning-by-doing and user-driven product modifications. Emerging economies are indeed equipped with the resources necessary for these types of innovation. The comparative figures shown in Table 7.2 on tertiary science, math, and engineering students and R&D expenditures and researchers are far more encouraging in indicating the modular innovative potential of the emerging economies.

In assessing a country's research and development activity, however, it is not just the quantity that matters. The sector in which R&D is performed and whether it is linked to specific consumer demands or product development are also significant. Mowery and Oxley point out that public sector R&D investments have expanded to complement increases in private sector R&D, but, citing Thailand and Argentina as examples, they add: "Efforts in developing countries to build up public sector R&D programs in the absence of demand from the private sector often fail to produce results" (1995, 84). In Latin America, for example, the model of national councils of science and technology "underestimated the relationship between market and technology, and the importance of the management of innovation at the enterprise level" (Correa 1995, 833). Table 7.3 breaks down R&D performance between the productive sector and higher education, and the source of R&D financing between the private and public sector. The figures demonstrate that the countries we conventionally identify as important innovators—i.e., the advanced countries and the East Asian NIEs—perform and finance more of their R&D in the private sector than in the public sector. The slower-growth emerging economies, however, such as those in South Asia and Latin America, tend to rely more on government financing of R&D and conduct less R&D in the private sector than in the public sector.

Emerging-economy governments often favor basic research facilities that are oriented toward frontier technologies. Instead, it is important to link public labs with private funding in order to reorient the research agenda and activities such that public R&D has good linkages with private firms. For example,

TABLE 7.3 Sector and source of R&D performance

	Sector of R&D performance (%)		Source of R&D financing (% distribution)	
	Productive sector	Higher education	Productive enterprises	Government
Industrialized market economics (a)	53.7	22.9	53.5	38.0
Developing economics (b)	13.7	22.2	10.5	55.0
Sub-Saharan Africa (except S. Africa)	0.0	38.7	0.6	60.9
North Africa	N/A	N/A	N/A	N/A
Latin America and Caribbean	18.2	23.4	9.0	78.0
Asia (except Japan)	32.1	25.8	33.9	57.9
NIEs (c)	50.1	36.6	51.2	45.8
New NIEs (d)	27.7	15.0	38.7	46.5
South Asia (e)	13.3	10.5	7.7	91.8
Middle East	9.7	45.9	11.0	51.0
China	31.9	13.7	N/A	N/A
European transition countries (f)	35.7	21.4	37.3	47.8
World	36.6	24.4	34.5	53.2

Notes: (a) United States, Canada, Western Europe, Japan, Australia, and New Zealand; (b) Including Middle East oil states, Turkey, Israel, South Africa, and formerly socialist economies in Asia; (c) Hong Kong, Korea, Singapore, Taiwan; (d) Indonesia, Malaysia, Thailand, Philippines; (e) India, Pakistan, Bangladesh, Nepal; (f) including Russian Federation

Source: Lall and Pietrobelli, 2002 42. Calculated from UNESCO 1997.

business R&D only accounts for 13 percent of the total in India; the rest is conducted by the public sector and universities, where it may not be relevant to economic applications (Dedrick and Kraemer 1993). In an effort to combat this effect, the government has established "science cities" around prominent research institutions to create centers for high-technology industrial development through stronger ties between research and industry. Mowery and Oxley (1995) argue that the optimal sequence for public investment in research and development is initially to target technical schools and universities that emphasize training, rather than to encourage basic research. This basic frontier-technology research in public laboratories seems to hold promise for economic returns only at a later stage of economic development.

This logic holds at the micro or firm level as well. Hobday (1995) concurs that the key to competitiveness for latecomer firms runs contrary to theories which stress R&D or place R&D at the beginning of the innovation process. Rather than radical innovation, behind-the-frontier innovation through imitation and reverse engineering was essential in allowing catch-up development. He debunks conventional wisdom: "East Asian latecomers did not

leapfrog from one vintage of technology to another. On the contrary, the evidence shows that firms engaged in a painstaking and cumulative process of technological learning: a hard slog rather than a leapfrog" (1985, 1188). He also emphasizes the importance of home-market consumer-driven innovation in analyzing the success of latecomer electronics firms in East Asia. He points out that latecomer firms located in developing countries have two major disadvantages in terms of innovation: they are dislocated from the main international sources of technology and R&D, and they are dislocated from leading-edge markets and demanding users. In order to succeed, therefore, the latecomer firm must devise ways to overcome market barriers to entry and then forge the user-producer linkages that stimulate technological advance. With growing and increasingly sophisticated domestic consumer bases, emerging-economy enterprises may find that catering to their home market will further propel them onto global markets. These arguments reinforce this chapter's claim that experimental innovation in modular applications and user-driven product modifications is central in shaping economic success in emerging economies.

A closer examination of patenting data allows further analysis of whether emerging economies have built indigenous technological and entrepreneurial capabilities. Mahmood and Singh (2003) find that the original East Asian NIEs — Taiwan, South Korea, Hong Kong, and Singapore — have much higher U.S. patenting activity than other emerging economies, which they attribute to different sources of innovation in each country. Though it is important to bear in mind that patenting activity reflects bursts of innovation rather than modular innovation, Mahmood and Singh's data nonetheless demonstrate significant growth in innovative capability across the emerging economies over time (see Table 7.4).

Interestingly, the sources of innovation differ quite dramatically across the countries that Mahmood and Singh (2003) analyze. The relative contribution to innovation by multinational corporation (MNC) subsidiaries is highest in Singapore and India, minimal in Taiwan and South Korea, and in between for Hong Kong and China. Business groups contributed more than 80 percent of patenting from South Korea in the 1990s, compared with less than 4 percent in Taiwan. Individual inventors' importance is declining across all countries over time, but they still hold 59 percent of recent patents in Taiwan. Thus there is evidence to support the proposition that a country's industrial policy and profile shapes its innovative fabric. The predominant sector of innovation is business groups in South Korea versus other domestic firms or organizations in Taiwan; this maps to the well-documented difference in industrial profile between the two countries, with *chaebol*, conglomerates of many companies

TABLE 7.4 U.S. patents granted to emerging economies

Recipient countries	1970–1974	1975–1979	1980–1984	1985–1989	1990–1994	1995–1999
Newly industrialized economies						
Taiwan (ROC)	1	176	397	1,772	5,271	12,366
South Korea	24	43	91	424	2,890	11,366
Hong Kong.	59	75	113	177	279	570
Singapore	21	9	20	47	148	499
Emerging Asian economies						
India	83	67	40	64	126	316
China	61	2	7	129	239	332
Indonesia	19	5	5	10	26	18
Malaysia	2	13	6	13	43	89
Thailand	4	3	7	11	15	56
Emerging Latin American economies						
Mexico	243	246	191	202	189	257
Brazil	86	100	110	156	260	353
Argentina	126	113	100	82	109	183
Chile	22	20	12	18	21	44
Venezuela	36	35	50	103	121	145

Source: Table 2 in Mahmood and Singh 2003, 1034. Data are from U.S. Patent Office.

clustered around a parent company, dominant in South Korea while small and medium enterprises are dominant in Taiwan. Further reflective of industrial profiles, the predominant sector of innovation is foreign MNCs or organizations in Singapore and a combination of domestic firms or organizations and foreign MNCs or organizations in Hong Kong, India, and China. The figures further demonstrate that research institutes appear to play an important role in all countries. In China and India, however, private sector R&D is not yet fully developed, as evidenced by a disproportionately high number of government-affiliated organizations among the top fifty patent holders.

It would be impossible to discuss the potential for digital innovation in emerging economies without considering in some way the relationship of intellectual property rights to innovation. Lax IPR enforcement in developing countries permits the learning-by-doing modular innovation that emerging economies have used in making their mark in global markets, namely imitation and reverse engineering. This has been true most recently with the East Asian Tigers, but, as Maskus and Reichman point out, "few now-developed economies underwent significant technological learning and industrial

transformation without the benefit of weak intellectual property protection" (2004, 290). They cite Japan as an example: from the 1950s through the 1980s, Japan pursued an industrial property regime that favored incremental innovation and technology adaptation and diffusion. On the other hand, stricter IPRs may facilitate technology transfer to developing countries, as well as the local diffusion of that technology. Thus, stronger IPRs, since they promote local frontier-technology innovation, are most likely beneficial for leading newly industrializing countries that are launching serious R&D activity.

On balance, Lall (2003) argues that the effects of IPRs vary according to countries' levels of industrial, technological, and economic development, with the need for and benefits from stronger IPRs rising with income and technological sophistication.[11] As the World Bank points out: "Interests in encouraging low-cost imitation dominate policy until countries move into a middle-income-range with domestic innovative and absorptive capabilities. . . . Least-developed countries devote virtually no resources to innovation and have little intellectual property to protect" (2001, 131–132). Thus there is an inverted U-shaped relationship between the strength of IPRs and income levels: IPR intensity first falls with rising incomes as countries allow slack IPRs to build local capabilities through adaptive innovation, then rises as countries begin to engage in more innovative effort. Lall (2003) concludes that the income per capita threshold at which innovative activity begins is fairly high: $7,750 in 1985 dollars.[12] Innovative capacity is the constraint here—if a country has little indigenous innovative capability, IPR strengthening cannot stimulate domestic innovation, and stronger IPRs have no stimulating effect on incremental innovation through absorptive and adaptive technological activity.

IPR enforcement also affects where emerging economies may position themselves in cross-national production networks. Global production networks have made it possible for countries to move up the ladder of technological complexity and value-added without necessarily building a local technology base. Lall (2003) argues that this is the case with many of the East Asian countries: although the global electronics production network encompasses only a few developing countries, almost all situated in Asia, few of these countries have strong domestic technology bases in electronics. The emergence of integrated cross-national production systems does not necessarily force emerging economies to better enforce IPRs: "Most TNC [trans-national corporation] assembly activity in the past has gone to countries that have isolated export-processing zones from the rest of the economy without having changed the IPR regime." In the longer term, however, stricter IPR enforcement may

be beneficial for countries hoping to locate themselves in cross-national production networks:

> IPRs in developing host countries may be growing in importance as, with technical progress, more complex technologies have to be deployed by high-tech systems even at the assembly level, raising the cost of technological leakages. Moreover, when competing host countries offer stronger IPRs it may be an essential prerequisite for all aspirants to offer similar protection. Countries that have high-tech assembly operations may need to strengthen IPRs to induce TNCs to move into more advanced functions like R&D and design. At the highest end of TNC activity, where developing countries compete directly with advanced industrial countries, the IPR regime would have to match the strongest in the developing world (Lall 2003, 1673).

Countries with stronger IPRs may indeed be able to attract those transnational corporations with higher-technology activity to be offshored. Yet, because integrated systems remain highly concentrated geographically, these considerations may not apply. Thus the optimal level of IPR enforcement varies by country, according to the specific income level, sectoral composition of economic activity, and production profile.

The global intellectual property regime, embodied in the World Trade Organization's Agreement on Trade-Related Aspects of Intellectual Property Rights (the TRIPS agreement), necessarily affects the prospects for technology transfer and innovation in developing countries. Maskus and Reichman (2004) point out that the global regime could, very simply, reduce the scope for emerging-economy enterprises to break into global digital markets by compounding technological backwardness and inhibiting innovation. This danger is heightened by the process of world market regulation in knowledge goods, which is driven by the lobbying of powerful private interests in advanced countries rather than by a global consensus on the public-good dimensions of knowledge. Product imitation and reverse engineering, along with temporary migration of students, scientists, managers, and technicians, are important non-market forms of international technology transfer. International IP standards can make the task of reverse engineering by honest means and the transfer of technology through people more costly, even impossible.

In this way, Maskus and Reichman (argue that private capture of the global process for IP regulatory-standard-setting "undermines the ability of governments in developing countries to devise and promote their own national systems of innovation" (2004, 304). They urge developing country governments to integrate international IP standards into their own national innovation systems in order to maximize the benefits. Emerging economies could, for example, become the promoters of a transnational innovation system in which

properly balanced IPRs were not an end in themselves but rather the means of generating innovation in a healthy competitive environment; they could preserve the ability to reverse engineer routine innovations by honest means and foster exchange between innovators at work on common technologies.

The idea of national systems of innovation has been central to the logic of this section. It has become quite clear that there are country-specific drivers of technological activity and innovation; that is, technological specialization and modular innovation are heavily dependent on the resources embodied in national systems of innovation. In addition, there is wide variation across countries in the productive and innovative roles played by different economic stakeholders such as multinational corporations, business groups, small and medium enterprises, research institutions, and the public sector. Nevertheless, in examining the innovative potential of emerging economies as a group, a few broad patterns have also emerged: the centrality of experimental modular innovation in emerging economies as they attempt to close the digital production divide, the significance of having some proportion of R&D funded and conducted by the private sector, and the dual relationship of intellectual property rights to innovation.

CONCLUSION

This chapter has examined the different roles that emerging economies can and do play in the global digital economy and ICT innovation. They are fast growing and hence vitally important marketplaces, with their increasingly sophisticated users just beginning to exercise their power in dictating the future of digital consumer products. Emerging-economy enterprises are also ever more relevant market players, having leveraged their success in home markets into inroads in global markets through a number of distinctive competitive advantages. Finally, emerging economies also have great potential as market makers: they have the opportunity to make new and different marks on the future global digital economy with their distinct national innovation systems and advantages.

Although advanced countries are the main purveyors of radical, breakthrough digital innovation, emerging economies will continue to find that their strength lies in the experimental modular innovation that is achieved through improvements in specific applications driven by on-the-job learning-by-doing and user-driven product modifications. Modular innovation in the emerging economies adapts product characteristics, business processes, and the commercial infrastructure to yield dynamic digital innovation that is, at this point in time, fueled to a great degree by the growing consumer base of

the developing world. At the same time, the changing structures of the global digital economy provide unique and varied opportunities for emerging economy enterprises to leverage their innovative potential.

The future of digital innovation promises to continue to hold varieties of experimentation. One particular area to watch for new advances is the nexus forged between local business ecosystems in emerging markets and the broader cross-national networks that are the bedrock of the global digital economy. Understanding the trajectories of modular innovation in emerging economies will continue to be central to an analysis of the role that these countries can and will play in the global digital economy. Although different forms of modular innovation in emerging economies may not necessarily pose a direct challenge to currently dominant digital producers, they do have the potential to alter the structure of future global digital markets. Thus, in terms of both their market power and their production and innovation possibilities, emerging economies are positioned to increase their presence in the digital era.

NOTES

1. The international "digital divide" can be conceived of as the gap between developed and developing countries in terms of information and communication technology (ICT) implementation, access, and usage rates (Bridges.org; T. Dunning 2003). Conventional wisdom, as represented by development organizations (DOT Force 2001; UNDP 2000; UNCTAD 2002; World Bank 2002) and the scholarly literature (Kraemer and Dedrick 1994; Yue and Lin 2002; Braga, Daly, and Sareen 2003), tells us that ICT may have tremendous implications for economic development. The most Pollyannaish of such views are techno-determinist, treating ICTs as a silver bullet for slaying developing-country woes. In such formulations, emerging economies can "leapfrog" along developmental paths aided by the potential wealth of a growing information technology sector and its beneficial spillover effects. A gloomier mindset has begun to emerge, however, as numerous attempts to enact IT-driven development strategies have stalled in implementation. This view emphasizes the fact that the digital divide between industrialized and developing countries is growing, further miring the latter in poverty as IT-driven productivity continues to spur economic growth in the former. In this sense, "fairly sophisticated information technology capabilities should be thought of now as prerequisite to effective interaction with the world economy" (Weber and Barma 2003, 17).

2. Borrus and Cohen (1998) argue that the growth of networked production and thereby the commodification of a growing range of advanced intermediary products is a major structural change in the competitive dynamics of digital industry.

3. Population data are from the U.S. Census Bureau (mid-2004 statistics) and the OECD (2003 statistics).

4. As the newly industrializing countries continue to modernize, their governments are becoming increasingly important information and communications technology

customers. For example, in India, over half of all ICT purchases are made by the public sector which is required to use indigenous sources when available. Since government is such a large consumer in proportion to private interests in many emerging economies, government purchasing decisions may tip a market toward one particular form of a product over another. See Weber and Barma 2003 for an extended discussion on the role of governments in the use of open-source and free software (OSFS) in the developing world, including a discussion of the multiple motivations surrounding the adoption and use of OSFS applications in the developing world and a catalog of such initiatives. Also see Weber 2004 and Weber and Barma 2003 for a definition of OSFS and a discussion of the economics and political implications of OSFS solutions.

5. Examples of specific emerging-economy companies in this section are from Hamm 2004.

6. Borrus and Zysman (1997b) identified the importance of cross-national production networks in the digital era, as the production organizational counterpart to "Wintelism," or the struggle over de facto product standards throughout the value chain.

7. In the 1990s, 70 percent of India's software export revenues came from body-shopping.

8. Although China's IT industry is much less organized and of patchier quality than India's, this may change in the near future, because China already churns out more IT engineers than India. Russian and Eastern European engineers are as well trained and cost about the same as their Indian counterparts. Data on the offshoring of IT services are from the *Economist* (2004b).

9. See, for example, Hall and Soskice 2001. The varieties-of-capitalism approach ties the multiple networks of micro relationships around the firm to the macro political economy and vice versa.

10. Mowery and Oxley (1995) distill the considerable literature on national innovation systems.

11. See Lall 2003 for an excellent discussion of technological differences among countries. He has developed sophisticated country classifications of domestic innovation and national technological activity based on R&D financed by public enterprises and the number of patents taken out in the United States, which he then maps against an index of competitive industrial performance.

12. Maskus and Reichman (2004) agree on the threshold effects of per capita income on IPRs.