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Wireless Standards and Applications:

Industrial Strategies and Government Policy

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Abstract

Wireless Standards and Applications: Industrial Strategies and Government Policy

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This paper explores the network architecture of future and the pattern of innovation tied to it. It argues that there is a struggle underway among regions and industry segments to control the value-added for the next generation of ICT architecture Five Dimensions of the unfolding space are assessed: (1) cost per bit of applications; (2) the speed of the broadband network; (3) which type of communications will dominate – voice or data, human or machine-to-machine; (4) who will be the innovation leaders; (5) how convergent will the networks of the future be. Various dimensions of policy are investigated related to innovation policy, competition policy, and international coordination. The paper compares the US fragmented innovation model, the EU model of elevating the application while commoditizing the platform, and the more interventionist models of the Northeast Asia troika of China, Korea, and Japan. The paper concludes that no single model for 4G is likely to emerge. Driven by platform battles, the US will have the least integrated broadband approach. The EU will rely on coordinated innovation a competitive EU market marked by strong lead users in the "public" sector. The northeast Asian troika will likely be depend on low-priced, high-speed networking to nurture export products while building on the special strengths of their mass consumer markets.

This paper considers the future of wireless networking and its applications.[1] It especially focuses on how the evolution of this networking system influences patterns of technological innovation. Twenty years from now will changes in the network and its uses result in a different system of technological design, production, and innovation? How might such changes have different impacts on the technological competitiveness of the major market centers of the world and among the players within each of them?

Looking backwards, the decentralized, competitive network infrastructure for long distance in the United States during the late 1980s and early 1990s enabled the particular form of innovation that is associated with the U.S. information technology revolution. This Information and Communication Technology (ICT) revolution saw a rapid rise of new specialized hardware and services entrants and the creation of architectures featuring intelligence at the edge of the network, especially the Internet. In addition, there was significant growth of software, service and dot.com providers for the supply and distribution system of the modern economy and an accompanying decline of many of the traditional electronic giants. The ICT revolution and government policies helped facilitate the emergence of the network system.[2]

With the partial exception of mobile wireless, this system of innovation and networking conferred major advantages on the U.S. economy in the technology sector until about 2001. This system of innovation also created a networking system where data exceeds voice in volume. Data traffic now heavily involves both commercial and residential users. Data prices have plummeted dramatically and voice services are moving to a "fixed price for virtually unlimited local and long distance services." The commoditizing of the traditional voice network has left most of the attractive margins to networks that feature new functionalities—notably, mobile wireless communications. The argument here is that a similar struggle over the sources of value added in the market is now unfolding.

[1] We thank Seungyoon Lee for research assistance.
[2] "Wintel" (Windows and Intel) architecture was essentially a recipe for vertical disintegration. On the growth of data networking, including the Internet see François Bar, Stephen Cohen, Peter Cowhey, Brad DeLong, Michael Kleeman, and John Zysman, "The Next-Generation Internet: Promoting Innovation and User-Experimentation" in *Tracking a Transformation: E-commerce and the Terms of Competition in Industries,* The BRIE-IGCC E-conomy Project Task Force on the Internet, eds., (Washington, DC: Brookings Institution Press, 2001). pp. 435-473.

What is the best way to think about the future of networking and innovation? Usually, people expect tomorrow to be much like today. Much of the early thinking about computer networking and office use of computing was driven by the models of telephone networks. (Remember ISDN?) More subtly, early in the introduction of technologies, the motifs of the past often are used to format the new. Look at the pictures of early long distance passenger planes—they were designed to replicate the experience of first class ship and railway transport. Nobody envisioned today's flying sardine cans.

Because it is impossible to predict the future, this paper first stipulates the dimensions of capabilities that are imaginable given technology trends and what is known about demand and what lies beyond the current networking system's capabilities. The point is to think about how government policies might influence the emerging architecture and its implications for patterns of technological innovation.[3] In contrast it assumes that the way major governments manipulate markets remains relatively constant. Policy specifics may change greatly, but the focus is on deeper patterns. The goal is to understand how government policies shape the way that the technological space is filled. The analytic tools of political economy are used to explore this question. For simplicity's sake, Part Two examines some dynamics of policy influencing all major markets. Then the focus of Part Three turns to some of the differences among three market centers—the United States, the European Union, and the Northeast Asian troika of China, Japan, and South Korea. (The three Appendices at the end of the paper supplement the discussion of these three Northeast Asian countries in greater detail.) We argue that there is a complex, global game involving opposing forces within the United States and globally over the creation of added value.

I. The Technological Space

In the mid-1980s through early 1990s some analysts recognized the full import of Moore's law for the potential of computer networking and for the economics of the

[3] Some technological breakthrough might transform this space in totally unimaginable ways. Before the full implications of the transistor became clear, forecasts about computing notoriously underestimated performance, market size, and uses. But it is encouraging that it took about twenty years for the full import of the technology to change the landscape. So, if there is something akin to transistors lurking unrecognized in the landscape today, it may not matter dramatically for this thought exercise.

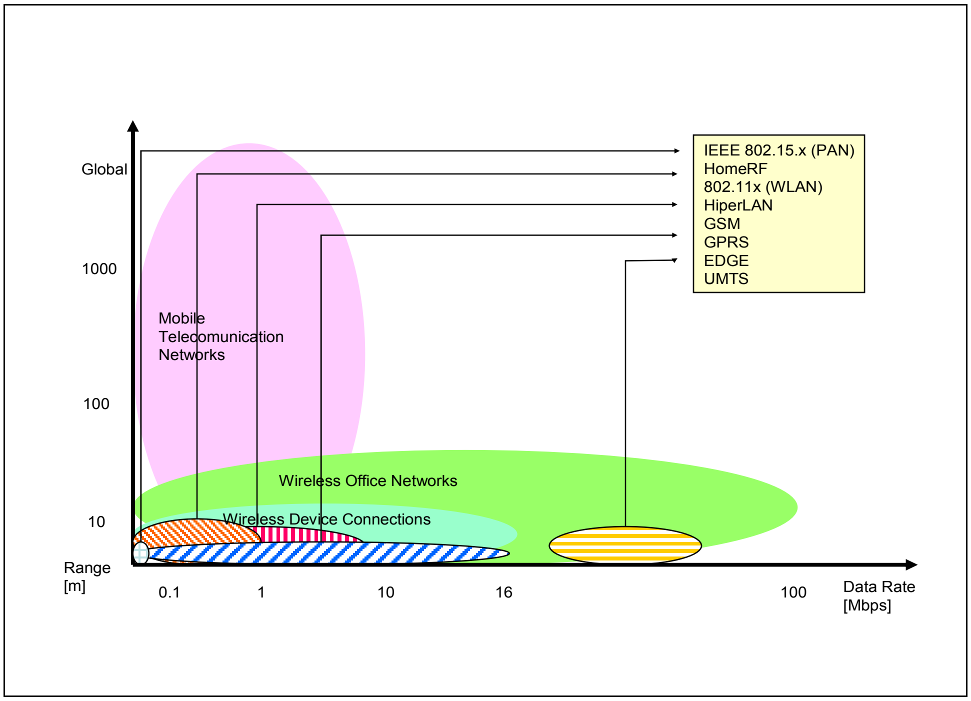
telecom equipment industry. They grasped the benefits of competition and what a digital network might mean for communications networking. The pursuit of the maximum economies of scale by monopolies was no longer acclaimed as the best path to innovation. Still, the Internet and the World Wide Web was not central to the vision of the future. The full significance of the mobile wireless communications also was not recognized.

The wireless revolution is still in its early stages. What can unlock its possibilities and progress to the next phases of the revolution? As background the paper examines two set of questions. The first six focus on key dimensions that will define emerging networks and their architectures. The second set of questions looks at policy choices facing governments and their regulators.

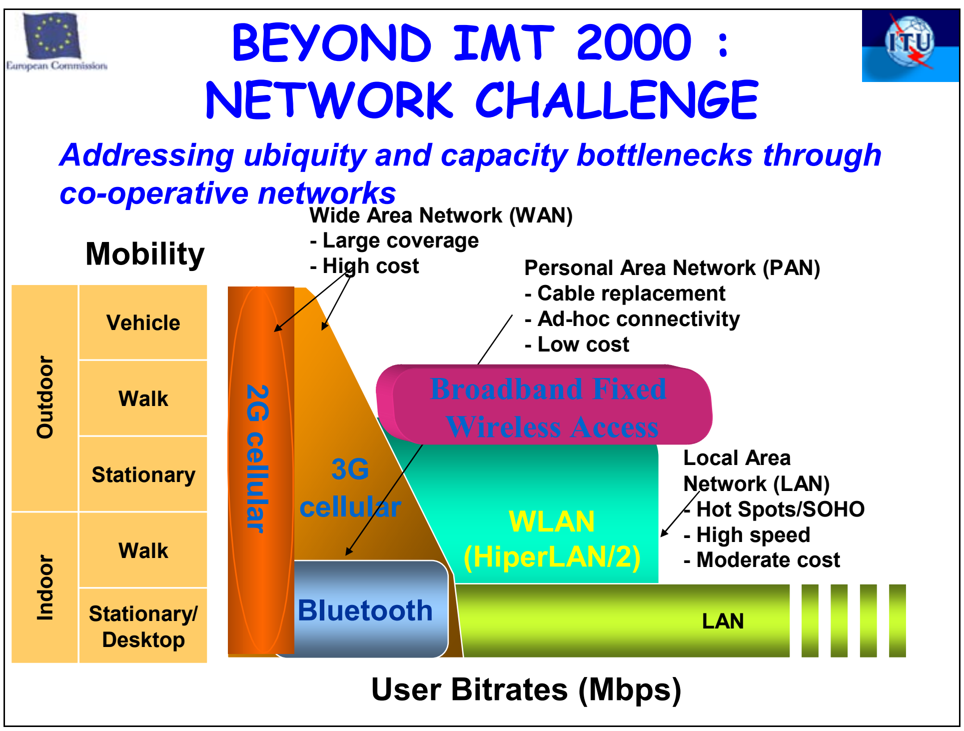
Some *key dimensions defining future network architecture* are becoming clearer. How much will it cost? How fast will it be? What is communicated to whom? Will top down planning or bottom up ad hoc leadership and innovation dominate? How seamless and convergent with the network of the future be? On the next several pages are reproduced representations of the coverage of new generation networks, their evolution, and standard's maze that must be traversed to achieve it.

1. **How much will it cost?** Obviously, the cost of networking on a cost-per-bit basis must fall, but the drops will not be uniform. It is impossible to charge the same amount per bit for movies as for text messaging. Systems need the flexibility to deliver high or low bit applications and must be flexible in providing more or less bandwidth/bits as needed. For example, household wireless networks may need to transfer bits at much higher speeds than the networks feeding the house because of audio-visual networking in the house.

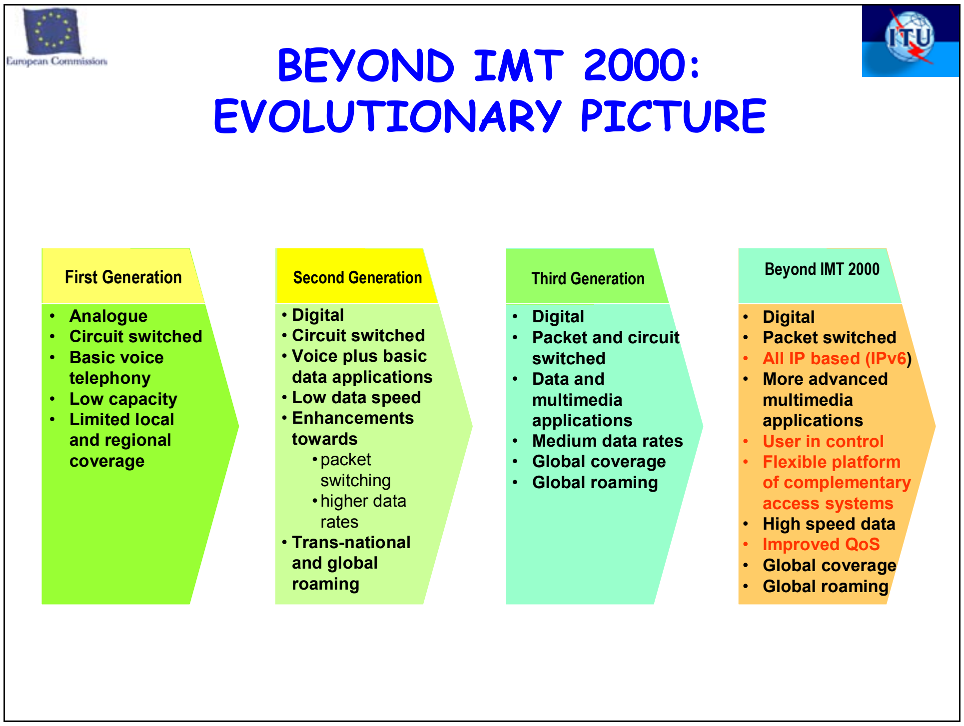
2. **How fast?** *What will be the typical speed of residential and business networks?* Former FCC Chairman Reed Hundt distinguishes between "little broadband" and "big broadband." This is as convenient a metric as any. "Big" is defined as residential speeds of 10 to 100 megabits/s and business speeds of 1 to 10 gigabits/s. Anything less is "little." However, speed is only a crude proxy for capabilities because of differences in compression and of upstream and downstream speeds. Speed does not



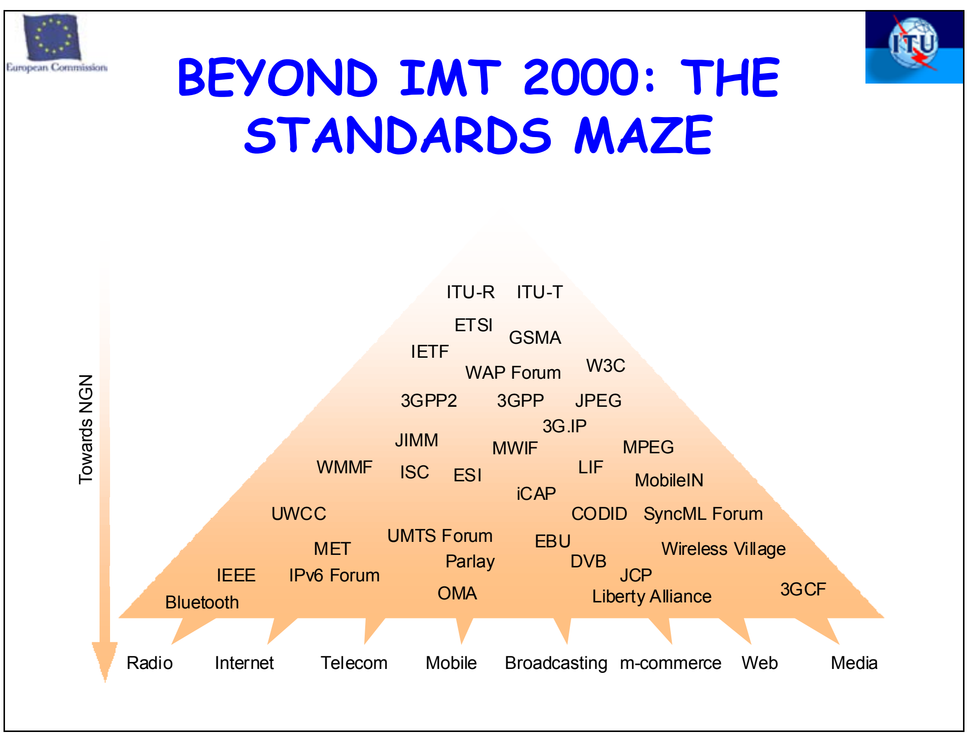
Source: Sathya Rao, Telscom
ITU-T Workshop on Next Generation Networks, Geneva, July 2003



Source: Bernard Barani, EG-DG Infso
ITU-T Workshop on Next Generation Networks, Geneva, July 2003



Source: Bernard Barani, EG-DG Infso
ITU-T Workshop on Next Generation Networks, Geneva, July 2003



Source: Bernard Barani, EG-DG Infso
ITU-T Workshop on Next Generation Networks, Geneva, July 2003

map clearly onto uses. Nonetheless, speed has become one dimension of distinguishing networks. Video is a particularly important part of this discussion about uses and speeds.

The evolution of the wired network changes the role of wireless and vice versa. Variations in regional markets already are evident. For example, Japan and Korea make higher speed paramount for policy. As a result, ADSL is much faster in major Japanese cities than in the United States because the telephone network infrastructure was thoroughly renovated after 1945. One Japanese provider of ADSL expects to achieve speeds of 10 megabits/s due to the strong network infrastructure and the use of advanced chip sets produced in the United States but not used by major U.S. carriers. Japan also has a long-standing policy of government spending to promote fiber to the home.

A key factor in thinking about speed is the capability of wireless networks over the next twenty years. Some advocates of 4G want a mobile system capable of supporting a peak speed of 100 megabits/s.[4] This would rival fiber to the home but would be considerably slower than large fiber pipes for business. Note, however, that there remains considerable controversy over the technological feasibility of this speed on a practical basis for a ubiquitous network infrastructure.

3. **What kinds of communications will dominate?** Specifically, *how rapidly and to what extent will machine-to-machine ubiquity emerge?* Data already has far surpassed voice in network traffic loads. But human-to-human or human-to-machine interaction (e.g., web accessing) still are a large part of all traffic. Yet one could imagine a future where machine-to-machine communications becomes overwhelmingly dominant with much higher network traffic loads. Optimistic forecasts estimate the current world market for equipment, software and communications services in this segment to be $34 billion with $2.5 billion going to carriers. By the optimists' forecasting the market could grow to $180 billion in 2008 with $10 billion going to carriers.[5]

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[4] Although there are differences on the time frame, the level of through put and bands for 4G, most vendors concur that 4G base-stations should be packet switched and the protocol should be IP. According to Flarion, a leading player, "4G will most likely be a framework for wireline and wireless communication, outlining a common framework for circuit-switched airlink-to-packet switched wired networks and packet-switched airlink-to-packet-switched wired networks." Renny Haraldsvik, "The Future of Broadband Communication: Two Worlds Coming Together," January 13, 2004.

[5] *Business Week*, "A Machine-to-Machine 'Internet of Things'," April 26, 2004, visited online. Don Tapscott, "The Transparent Burger," Wired, March 2004, pp. 033-034.

Radio frequency identification devices (RFIDs) and ubiquitous sensor devices for health, environment and security monitoring, or oversight of complex infrastructures are all part of the possible future. But does the growth of an ad hoc network infrastructure facilitate or hinder them? Bluetooth devices evidently interfere with some sensors, for example. Similarly, can questions regarding system integration and economies of scale (the sensor and RFID devices are still too expensive for many uses) be resolved?

4. **Who will lead and innovate?** *Will the wireless network architecture of the future be more ad hoc and less fully planned out?* 3G was the last gasp effort of largely monopolistic service markets to provide long-term, comprehensive top-down planning for the wireless architecture of the future.[6] Competition has introduced new forces that make such high levels of coordination more difficult. Competition also sped up the pace of introducing new standards and technologies. So, in the future the wireless architecture could encompass a less predictable mix of diverse mobile and fixed services ranging from personal-area networks (PANs) through wide-area and municipal networks (WANs and MANs). Users, traditional suppliers, and new suppliers (many with ties closer to the computer desktop) are struggling over who will dictate the future architecture.[7] Put differently, w*hat will be the pattern of user leadership and innovation?* Traditionally telecommunications was a network architecture where innovation came from the top down. But the rise of digital networking meant more decentralized innovation. With the Internet, users acquired greater control and often led innovation. "User-funded" innovation also may exist in wireless. 802.11 infrastructures often are bottom up in capital investment. These household and campus systems allow considerable self-financed user experimentation with speed and features.[8] The growth of specialized

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[6] 3G called for a single global plan for technology and spectrum designed: (1) to increase the capacity to handle traffic flows for any given amount of spectrum, (2) to allow mobile, high speed data transmission (from 144Kbps to 2 Mbps) able to handle at least limited motion video capabilities, and thus profitable new services; and, (3) to facilitate true global roaming of services using a single standard on common radio spectrum.

[7] John C. Tanner, "Will the Real 4G Please Stand Up?" Telecom Asia, www.telecomasia.net.

[8] This paper does not evaluate technological feasibility. But note that 801.16 MAN technology has a mobile component, like WiMax, but is primarily of interest to fixed networks. It has more of the user financed feature available than 802.10 which focuses more on mobile operators who want top speeds of several megabits per second, according to Visant Strategies. Broadband Wireless Online, ""IEE 802.20 to benefit mobile carriers, study says," November 12, 2003. The IEEE 802.20 Committee defines its mission as providing IP based data services in the band below

application networks, tied to sensors and other forms of IT, may spur more user innovation.

How diverse elements of the future wireless network intersect matters and could vary considerably. Different market regions may differ substantially in how comprehensive an effort they make to steer inter-networking. The levels of enthusiasm about 4G, and expectations about what it might imply, also vary considerably. Thus, technological progress will not halt as 3G is deployed over the next two decades. A greater variety of wireless network infrastructures is expected to exist due to the centrifugal forces just described. But policies could well influence which will be the defining key technologies that complement or supplant 3G—UWB (Ultra-Wide Band), OFDM (orthogonal frequency division multiplexing), WiMax (World Interoperability for Microwave Access), MiMo (Multiple-in, multiple-out), or something else?[9] Similarly, how much coherence will there be to the selection and deployment of technologies, and to the spectrum selected to support it? What policy and commercial arrangements will govern inter-networking of these technologies?

5. **How convergent?** *How seamless and complete will be the convergence of **services** offered by various specialized networks?* Will all networks offer essentially the same mix of services or will different networks continue to offer different mixes of services? To illustrate, today, American cable networks are carrying broadcast, little broadband, and voice while legacy voice networks are providing little broadband. Elsewhere there are proposals to create single, large pipes to provide integrated broadband infrastructure for all services. Other forms of partial convergence may come through hybrids built around mobile communications networks. For example, Ericsson

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3.5 GHz with vehicular mobility of up to 250 km/hour and speeds of peaking at over 1 megabit/s. Flarion has a mobile broadband offering using OFDM that features downlink speeds of 1 megabit/s and uplinks of around 300 to 500 kilobit/s according to its designs.

[9] Paul Otellini, President of Intel, recently observed, "I think that WiMax could be to DSL and cable what cellular was to landline (phones) not too long ago." Daniel Sorid, "Wireless Technology to Rival, Cable, DSL – Intel" Technology – Reuters, Yahoo News, September 11, 2004. On Multiple-input Multiple-output (MiMo) techniques see: ITU Radiocommunication Study Groups, Working Party 8F, "Draft New Report IYU-R M [IMT Trends] Technology Trends, Document 8/2E report, 27 October 2003, appendix 5. A typical division of the new wireless infrastructure options is set out in *The Economist*: (1) Spread spectrum wideband (ranging from WiFi to ultra-wideband); (2) Smart antennae; (3) Mesh networks; and (4) Cognitive radios. *The Economist*, "On the Same Wavelength," August 14, 2004, pp. 61-63.

Research suggests that a convergence of cellular and broadcasting networks is occurring. This becomes more likely if cell phones can use multiple bands, with some bands dedicated to broadcast.[10] The data provided in the table below indicates the extent of broadband penetration and the main delivery platform for OECD countries in late 2003.

Broadband access in OECD countries per 100 inhabitants, December 2003

	DSL	Cable Modem	Other Platforms	Total
Australia	2.2	1.3	0.1	3.5
Austria	3.5	4.2	0.01	7.7
Belgium	7.6	4.5	0.3	12.3
Canada	7.0	7.8	0.0	14.8
Czech Republic	0.1	0.3	0.0	0.5
Denmark	8.8	3.6	0.7	13.1
Finland	7.8	1.6	0.1	9.5
France	5.3	0.6	0.0	6.0
Germany	5.5	0.1	0.1	5.6
Greece	0.1	0.0	0.01	0.1
Hungary	1.1	1	0.7	2.6
Iceland	14.1	0.2	0.2	14.5
Ireland	0.6	0.1	0.1	0.8
Italy	3.7	0.0	0.4	4.1
Japan	8.1	1.9	0.7	10.7
Korea	14.4	8.4	0.4	23.2
Luxembourg	2.9	0.5	0.05	3.4
Mexico	0.2	0.1	0.001	0.3
Netherlands	5.7	5.9	0.001	11.6
New Zealand	2.3	0.1	0.2	2.6
Norway	6.4	1.5	0.1	8.0
Poland	0.4	0.4	0.03	0.8
Portugal	1.8	3.0	0.03	4.8
Slovak Republic	0.1	0.1	0.2	0.3
Spain	4.1	1.3	0.02	5.4
Sweden	6.4	2.3	2.1	10.8
Switzerland	6.6	4.8	0.0	11.4
Turkey	0.1	0.1	0.0	0.1
United Kingdom	3.1	2.3	0.03	5.4
United States	3.3	5.7	0.8	9.8
OECD	4.2	2.7	0.4	7.3

Source : OECD
www.oecd.org/sti/telecom

[10] R. Keller, R. Tonjes, and J. Huschke, "Spectrum Management for Converged Cellular Broadcasting Networks," Implications for Spectrum Management, Ericsson, 10 October 2003.

Similarly, *to what extent will **network equipment** be able to be used for multiple purposes?* In other words, what will be the asset specificity of network equipment? A principal rationale for exclusive licenses for wireless systems was the asset specificity of the investments. For example, a GSM network could only support GSM services. Although interference issues remain a reason for granting exclusive licenses, to the extent that key network assets, like base stations, can be flexibly redeployed for other uses the rationale for exclusive licenses declines.[11] Similarly, if customers can finance and deploy key parts of the infrastructure (as they did with corporate LANs and WANs in the growth of wired data networking or with WiFi) using standardized technologies, this changes the character of the network.[12]

II. The Political Economy of Government Intervention

Contrary to skeptics of government intervention in markets, government initiatives may improve market performance and social welfare. But there are reasons to doubt that any intervention will be optimal, and many may fail. The source of policy distortions, even in better policy mixes, is partly because it is technically difficult to get policies right. Poor information and implementation plague companies and governments. But governments are also inherently political. The same factors that induce market innovation also create incentives for those impacted to distort the reform of economic policies. Constituents "bid" for policy favorable to their interests. Some players are more motivated or have more resources to bid for these rights (e.g., more workers who vote). Firms facing large losses from policy changes designed to improve market efficiency are

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[11] William Lehr, "The Economic Case for Dedicated Unlicensed Spectrum below 3GHz," Issue Brief, New America Foundation, July 1, 2004. 8p.

[12] A sixth dimension deals with consequences. What does all this mean for society? We are spared from delving too deeply into this issue because Manuel Castells and his collaborators will focus on the consequences of the mobile society in a companion piece. But, in short, social connectivity is being reinvented with new networks. The behavior of Finnish and Japanese teens has been widely reported. The robust demand for 3G video downloads has surprised many. More narrowly, it now is clear from studies of those examining the massive multi-player video game phenomenon that players prefer to self-organize and work together in teams, guilds, and tribes. Massive multiplayer video games that do not allow users to innovate and morph the game usually failed. In Korea, where many players use PC Games rooms it is not unusual for dozens of players to descend on a single game room to work together on a specific initiative. We thank J.C. Herz for sharing these observations. Also see Howard Rheingold, *Smart Mobs: The Next Social Revolution* (Perseus Books, 2002).

more motivated to act politically than firms that will receive smaller diffuse benefits. This makes optimal reform difficult.[13]

In telecommunications, an entrenched coalition dominated until the mid-1980s. In each country the traditional monopoly carrier, their well-paid, unionized employees, and the equipment suppliers favored by the carrier worked together.[14] This coalition finally had to accept greater telecommunications competition because technology created the potential for large efficiency gains that could be redistributed to a new group of prominent stakeholders that advocated market reform, especially large users of the services and the computer industry.[15] Nonetheless, the old coalition created large incumbents that remain prominent in the political process of telecom policy. In time, successful new entrants also master the process.

Stories of special interest politics ignore the vital role that political leadership plays in organizing reform policies to attract new voter support.[16] However, even when political leaders advocate significant beneficial market reforms, they also skew policy by selecting changes that benefit their strongest supporters. In addition, they seek credit for difficult choices from a public that sees the issue as reasonably important, but complicated and obscure. So, political leaders frame the choice in terms of a few clear political "punch lines" to claim credit and limit the potential for critics to mobilize a successful opposing strategy. In particular, politicians emphasize visible benefits from reforms to counter complaints by losers even if this may distort reforms. For example, European leaders often justify EU initiatives on the basis of creating "good jobs" through the promotion of press-friendly technologies. It is equally important to recognize that electoral considerations can distort such pro-consumer policies as lower prices (e.g., courting the farm vote). Even generally sound policies—such as the introduction of

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[13] Mancur Olson, *The Logic of Collective Action: Public Goods and the Theory of Groups*, (Cambridge: Harvard University Press, 1971).
[14] Eli Noam, *Telecommunications in Europe* (New York: Oxford University Press, 1993).
[15] Peter F. Cowhey, "The International Telecommunications Regime: The Political Roots of High Technology Regimes," *International Organization* 44 (Spring 1990), pp. 169-99. The new alliance brought together large corporate users that constituted a large percentage of long distance traffic, equipment suppliers outside of the traditional vendors to telephone companies, and carriers that had identified potentially profitable entry strategies in the market.
[16] Gary Cox and Mathew D. McCubbins, *Legislative Leviathan,* (Berkeley: University of California Press, 1993).

effective competition—may be done with particular rules that will especially favor some subset of market participants. Or R&D policies may have a sound goal but be skewed by distributional goals.

Institutional factors further shape outcomes. Predictably, telecom regulatory institutions vary in their ability to make decisions when faced with conflicts among key stakeholders. Complex procedures may create implicit barriers that keep smaller entrants from participating in and affecting the policy process.[17] Also, in many countries the telecom regulators are subordinate in many respects to national telecom ministries. These ministries often have broader industrial policy goals. Governments create policies and rights to increase efficiency and the funds available for domestic redistribution.

The next twenty years may resemble the politics of the last twenty years in one important respect, a battle over a shift in the sources of value added in the industry. Since 1984 the long-distance industry, data transport, and traditional telecom equipment suppliers were commoditized. Simultaneously value rose in the (then) novel mobile wireless and Internet related services, and there were big winners among providers of specialized technology platforms and design companies like Cisco, Intel, and Qualcomm. Today, many electronics firms are pushing to reduce the market power, and market values, of the remaining thresholds of telecom value (i.e., wireless and certain parts of voice services) by pushing new models for Internet telephony (VoIP) and wireless infrastructure. One striking dimension of the policy push for WiFi-style technologies is the prominent advocacy role of semiconductor and Internet technology companies such as Intel and Cisco that hope to bolster demand for new electronic gear tied to these networks. Some of the new entrants in telecom equipment, for example, are pushing versions of 801.16 technologies that would be incompatible with CDMA.

A multi-dimensional political battle is emerging over innovation and returns from the next generation of ICT. In general, the United States will continue to be more interested in trying to create big winners in innovative ICT platforms than will the

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[17] Political leaders grant authority to specialized regulators because these officials possess superior expertise and information and the discretion to act. There are many tradeoffs in regulation. For example, transparency and due process make regulatory commitments to protect private property more credible, but also alter the balance of influence among stakeholders by rewarding those with resources to participate intensively and who do not need fast decisions.

European Union. Taking their declarations literally, the Northeast Asian countries are in a race with the United States. But, they may simply be trying to steer a middle course—get better terms than Europe if the U.S. platforms dominate or remove proprietary intellectual property as the dominant source of advantage.

Within the United States there are at least two dimensions to the battle over the future. First, there are rival platform camps in both equipment and software. On telecom equipment, as just suggested, the computer electronics industry is interested in wireless infrastructures that move value from traditional telecom vendors to the computer industry. On software, there is a rivalry between, for simplicity's sake, Microsoft and IBM. The former tries to load as much value into the standardized computer platform software as possible while improving its relations with specialized applications providers. The latter is trying to move value from the computer software platform (thus its support for Linux) to customized systems integration products.[18]

The EU is especially friendly to the approach of IBM. Reducing the value of proprietary platforms and emphasizing the returns from high quality delivery of products and services based on the platform is closer to the European approach. A key part of the European strategy, induced by current market position and politics, may be to emphasize new classes of public infrastructure services incorporating innovative ICT with the lead users coming from such European public services as transport, health and water. In contrast, northeast Asia is interested in playing the platform game if they can control it. Otherwise they are content to maintain a strong emphasis on hardware and exports.

The Dimensions of Policy Choices

This section sketches out the dimensions of policy that are crucial to innovation. Although the dividing lines are messy, it is convenient to think of three major clusters of policies—innovation, competition, and international coordination. The dimensions are illuminated through a series of questions. The discussion of the three market regions will then examine how the political economy of each region influences how these policies the play out.

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[18] The other dimension is between all of the platform providers and those which do detailed applications. Platform technology providers seek to add value by absorbing separate functionalities into their platforms

1. Telecom/IT Infrastructure Innovation policy

a. Technological neutrality: Should governments be *technologically neutral?* Japan and Korea have Next Generation Network projects with major R&D funding; the United States does not. As usual, the United States has moved to policies favoring rapid, piecemeal innovation. Positions on technology neutrality influence how national innovation policy plays out. Is it stacked toward platform creation? Is it in applications? Is it in hardware?

b. Standards Setting: *How do standards policies relate to innovation?* How do standards and technology developments relate to innovations like sensor devices or mesh networks? How do existing government strategies use the standards process to try to achieve these parameters? How much should government guide future networks in providing sufficiently secure, private, reliable, and affordable billing arrangements for transactions that are being processed?

These policy issues also relate to the *process for defining and sharing intellectual property (IP) rights and the selection of standards* for global wireless networks. Traditionally, each new generation of wireless services emerged from a global collaborative planning process between carriers and equipment suppliers coordinated through the ITU and regional and national standards setting processes. The national/regional processes differ markedly in who participates and voting systems, for example. Participation in these processes, the terms of operation, and the conditions imposed on the use of IP in the standards process all shaped global technology. What will be approach to IP in the future?

c. Allocating Spectrum: *Should spectrum policy rules governing the allocation of radio spectrum for specific uses be changed? How?* All governments treated the spectrum as a “commons” that required careful licensing to avoid interference problems among rival uses. Most regulators presumed that new technology should not endanger old users even though there is a strong economic efficiency case for assuring less than perfect protection. This assured incumbents strong influence over spectrum planning. Even if there were ownership alternatives, political leaders had few incentives to explore them.[19] For carriers, rules governing the use of the licensed spectrum also created barriers to entry for other forms of wireless networks, such as non-mobile services that might substitute for some mobile service applications. For equipment vendors, the rules made it more difficult for new entrants to deploy novel technologies. Incumbent suppliers therefore played a larger role in shaping new technology markets than, for example, in the computer industry. Companies with operational experience also had informational advantages.[20] Smaller and newer companies faced steep entry barriers to participating effectively in the decision process.

In the future how much spectrum on which frequency ranges should be allocated to particular services or groups of services? How should licenses be assigned and should the resale of licenses be permitted? How much spectrum should be released for new applications? What should the mix of allocation be between licensed versus unlicensed bands? The goal is to implement good spectrum policy so that "scarcity" may be a less acute problem in the future.

d. Funding: *Who will fund new network infrastructures? How?* Most network infrastructure is built out by carriers and supporting equipment vendors. Financing is repaid from service revenues. Various subsidies come from governments, usually for the purpose of funding universal service objectives. But, competition changed the sources of funding because customer equipment was increasingly financed by users. In addition, instead of being subsidized by carriers, equipment companies often became co-financers of new entrants.

With the introduction of the Internet, a larger share of the total intelligence of the network became part of customers' investment budgets. WiFi and smart radios are a

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[19] Thomas Hazlett, "The Wireless Craze, The Unlimited Bandwidth Myth, The Spectrum Auction Faux Pas, and the Punch Line to Ronald Coase's 'Big Joke,'" Working Paper, 0101 AEI-Brookings Joint Center for Regulatory Studies, January 2001). The absence of private property rights for spectrum partly reflects high transaction costs in assigning and monitoring individual property rights in the early days of radio. It emerged from a tradition of state-building that reserved commons for government ownership. Government control also satisfied the large demands for spectrum of military and police services (about 30 percent of the spectrum) that few political leaders wanted to oppose.

[20] The arcane regulatory process is fiercely contested. Advocates debate what would constitute a threat of interference and how to reallocate different pieces of spectrum to different uses. These proceedings raise enormous informational problems for government decision-makers. The glacial process cumulatively favors incumbents. Political leaders could change the system but so far have been content to allow institutional dynamics to slow the pace of change.

logical extension of this development. But, why did WiFi emerge more successfully in the United States than in Europe or Asia? Is WiFi in North America sustainable? Moreover, are current efforts at WiFi related technologies likely to prove credible? Also, how can the numerous initiatives to move to more public funding of infrastructure, especially for high speed networks, be explained? In a return to the days of early telephone network cooperatives, there are town and regional initiatives. This is emerging both in industrial and developing countries. A variety of proposals exist for various uses of antitrust policy, tax credits or central government subsidies to fund broadband build-out.

2. Competition Policy: There are three aspects of competition policy that are particularly important for the future of ICT and the wireless infrastructure.

a. *What are appropriate competition policy priorities?* Are policies designed to ensure the survival of major competitors? Many telecom regulators are reluctant to allow carriers to fail. How are consumer and producer interests weighted? Where are the hotspots for policy oversight? For example, the OECD has argued that the Next Generation Network (NGN) will resemble computing networks more than traditional telecom network architecture. It will not be vertically integrated. The network transport infrastructure will be separate from applications; any infrastructure will be able to carry any applications. So, standards will become more important, especially at the interfaces between networks. These could be among the key spots that are crucial to creating competitive advantage.[21]

b. What will be the assignment system for spectrum licenses? The number of licenses, the method for selecting licensees, and the sequence of assignment of licenses shape market efficiency. Since the early 1980s the number of licenses slowly increased, creating more competitive markets.[22] The method of assigning licenses for spectrum

[21] OECD, Directorate for Science, Technology and Industry, Committee for Information, Computer and Communication Policy, Working Party on Telecommunications and Information Services Policy, "Next Generation Network Development in OECD," DSTI/ICCP/TISP (2004)4, Paris, 1-2 June 2004.

[22] But, since the early 1970s, the sequence and methods of licensing decisions provided substantial market rents for the original incumbents and then for their initial challengers. Often, this was done by restricting competition to two or three firms. The small pool of new entrants rapidly acquired some shared interests with the incumbents because they became prominent

most typically was the "beauty contest" where government officials weighed the merits of the competitors, their plans, and the special policy demands of the government (such as support for a particular business model or technology).

Wireless licenses traditionally contained numerous restrictions that weakened them as a form of private property rights for spectrum.[23] This had significant implications for politics and economic performance. In the United States, for example, government spectrum licenses limited the ability of spectrum owners to switch between service types (e.g., from fixed to mobile wireless), the ability of single providers to own more than limited spectrum in a given market (e.g., spectrum caps), and ownership transfer.[24] Licenses also were granted for a set number of years. These conditions could reduce market efficiency by preventing a secondary market in licenses from emerging and reducing flexibility in the services offered by a license holder. Also, stakeholders focused on manipulating government policy, not on creating market alternatives.

Asian and European governments often imposed stricter restrictions, even dictating the type of technology platform that spectrum users could employ to offer services. When these restrictions were added to differences in spectrum and the challenges of integrating systems with the existing national wired network, they effectively limited new suppliers even after the abolition of monopoly.

Although other papers explore licensing in more depth, three aspects about licensing are emphasized here. First, to what extent do licensing schemes move the system towards the creation of property rights with freedom to choose services and technologies freely and at the same time allow largely unimpeded resale rights? To what extent is this system consistent with the creation of private spectrum managers which can "sub-let" and share spectrum within large spectrum blocks? If so, what would make them consistent with competition? Second, to what extent do licenses rely on more transparent and market-based methods of assignment, such as various auction schemes. Or do they rely on beauty contests? Third, to what extent does licensing move to

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players in the regulatory process that determined future spectrum allocation and assignment policies.

[23] Owen and Rosston.

[24] Given weak property rights, commercial compromises among companies may not emerge without a credible enforceable guarantee. Political decision-making processes shape possible trade-offs.

approaches consistent with dynamic spectrum sharing, such as stipulating performance standards for smart receivers, rather than relying on a limited number of licensed carriers to reduce interference?

c. How strongly will policy favor convergence and how will converged networks be operated? There are at least two dimensions. Are governments encouraging networks to converge in the services that they deliver?[25] Korea, for example, has announced plans for a Broadband Convergence Network to provide 20 million wireline and wireless users with quality, high-speed service over the same network by 2010.[26] Should governments promote a "network platform" independent approach to regulation of services? The EU, for its part, is declaring that voice is the same service regardless of the delivery platform. In contrast, the United States is more reluctant to enact full regulatory convergence, in part because it fears that the cross-subsidy legacy of the traditional voice network could weaken the efficiency of new services. It also is significant that with broadband incumbents "continue to dominate in markets where they have been allowed to compete alongside new entrants, and this is also true for historically competitive markets such as mobile and Internet services … (E)ven in countries where telecommunications markets have been liberalized, market opening by itself has not been sufficient to bring about the development of meaningful competition."[27]

3. International Coordination: Finally, there is the challenge associated with achieving international coordination. In the wireless industry there are strong politics and policy consequences revolving around global policy-making. Global coordination influences the future. Economic theory suggests two potential gains from coordinated government intervention in global wireless markets. First, wireless depends on the use of radio spectrum that is subject to crowding and interference problems. Global spectrum coordination could reserve enough space on the same band to allow the emergence of

[25] For instance, should governments push broadcasters to move to the wired network, or open broadcast spectrum for new voice and data options? A particular target for many technology designers is the huge amount of attractive spectrum below 3GHz currently occupied by over the air broadcasting. Anything that could free this spectrum by moving video to wired networks, for example, would be highly attractive.

[26] MIC, "IT 8-3-9 Strategy," 2004, Appendix 1, p. 18

[27] ITU Internet Reports: *Birth of Broadband*, Executive Summary, (ITU, 2003), p. 5.

new global services that benefit from global economies of scale.[28] Second, coordination makes common planning of new technologies, like 3G, attractive because incumbent carriers and their equipment vendors seek favorable technology upgrades on a predictable basis.

Global network externalities and scale economies in equipment push stakeholders to look beyond their borders to arrange global coordination of technology design through standards setting processes and spectrum allocation for new services. Equipment vendors can reap large advantages if they "lock-in" customers to a more specialized technology platform.[29] However, if competitive carriers or equipment suppliers can gain from using a superior alternative technology without incurring unacceptable losses on scale economies and network externalities, then their incentives for coordination decline. Taken together, the economic realities make it unlikely that there will be large numbers of platforms, but achieving a single platform is extremely difficult. Key market centers, like North America, provide enough scale to permit selections of alternative technology standards. In short, coordination is attractive, but distributional issues are likely to lead to disagreement over which coordinated solution is best.[30] Thus, savvy players often will try to manipulate policy to their advantage in the selection of technology platforms.

The double-edged payoff from global coordination is especially challenging because the changing technological foundation of the industry attracts strong political interest. This is a political process that tries to match supply and demand. The global decision process is complex. The ITU sets wireless network standards and frequency

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[28] Consumers also may benefit from inter-operability of equipment Stanley Besen and Joseph Farrell, "The Role of the ITU in Standardization, Pre-eminence, Impotence or Rubber Stamp?" Rand Corporation, 1991. Joseph Farrell and Paul Klemperer, "Coordination and Lock-In: Competition with Switching Costs and Network Effects," in *Handbook of Industrial Organization*, Vol. 3. Also see Carl Shapiro and Hal Varian, *Information Rules*, (Cambridge: Harvard Business School Press, 1999), pp. 237-253. Also see: Bruce Owen and Gregory Rosston, "Spectrum Allocation and the Internet," December 2001, SIEPER Discussion Paper 01-09.)

[29] Once a carrier installs a supplier's network equipment, it is locked in and is unlikely to switch equipment vendors. Global carriers prefer suppliers with global support capabilities, so this limits entry for both network and handset equipment. Based on interviews with European and Asian suppliers, November 2002 and December 2002

[30] This discussion is based on: Peter F. Cowhey, Jonathan D. Aronson, and John E. Richards, "The Peculiar Evolution of 3G Wireless Networks: Institutional Logic, Politics, and Property Rights," forthcoming in Ernest Wilson and William Drake (eds.) *Governing Global Electronic Networks* (Cambridge, MIT Press, 2005).

allocations in a process that is formally organized around, and fed by, leadership from the major regional standards and spectrum bodies. Many international institutions, such as the ITU, have a large membership and require unanimity in decision-making. Although political and economic pressure may induce reluctant parties to compromise, the system is subject to vetoes. Thus, international institutions often deadlock if they do not settle on the lowest common denominator for a decision. These weaknesses shape stakeholder strategies.

Standardization dynamics for 3G, for example, reflected the then prevailing system of limited competition.[31] However, during the 3G process, the consensus driven system at the ITU broke down as the range of corporate stakeholders expanded and their interests diverged. The result was temporary stalemate and unexpected compromises that produced a "suite" of 3G standards.

The 3G story represents a collision of institutions and new market realities. 3G deadlocked, in part, because its core technology (CDMA) was subject to a strong set of key patents by one firm, Qualcomm, which had developed a business model more like the computer industry than traditional telecoms. Qualcomm was not much interested in being in the manufacturing and distribution business, except for chip sets. It wanted to enable key suppliers to use its technologies and then to charge royalties for the IP. Other new suppliers have studied the Qualcomm model and now attempt to duplicate its basic approach.[32] This strategy will influence how standards get set and which ones triumph in the marketplace. For example, orthogonal frequency division multiplexing (OFDM) is a prominent technology in 4G discussions.[33] But one major innovator, Flarion, has a model

[31] At the start of the 3G process, IP stakeholders still were mainly incumbents with close ties to service providers and governments. In sharp contrast to the computing industry, their business models reflected their monopoly roots. The traditional equipment firms typically cross-licensed their intellectual property rights for TDMA 2G systems on a cost-free basis while developing major new standards within the ITU system. Everybody needed the IP so, rather than quibble about the precise distribution of payments, the top tier of suppliers benefited by using low or zero cost licensing to grow the market. They competed on economies of scale, marketing and systems engineering for large carriers. More recently, to reinforce cross-licensing of an agreed standard among suppliers, large regional bodies only embraced a standard if there was agreement to license the relevant IP to every IP holder under the standard.

[32] Cowhey, Aronson, and Richards in Wilson and Drake.

[33] According to the OFDM Forum, a single, compatible OFDM standard would allow for the implementation of "cost-effective, high-speed wireless networks on a variety of devices. OFDM is a cornerstone technology for the next generation of high-speed wireless data products and

that appears too close to Qualcomm's for the taste of some, including Korea. So, other variants employing other business models also are being investigated.

Similar complexities will shape the effort to coordinate spectrum allocation for future wireless systems. Global processes at the ITU predictably reinforce national arrangements.[34] Every two years a World Radio-communication Conference (WRC) makes decisions on new spectrum allocations and other policies to avoid interference among spectrum uses. The WRC uses a one country, one vote system to approve changes in global spectrum allocations and service rules, but in practice votes are rare. It is a consensus system that is prone to deadlock. However, compromises sometimes emerge because government and commercial interests want some certainty about spectrum plans.[35] The easiest changes involve less change in the existing spectrum plan. This can produce differences among the major ITU regions over spectrum allocation plans. Today, UHF spectrum for RFID is not uniform. Europe and the US are on different bands (868 and 915 MHz, respectively).Japan did not permit use of the band until recently and then promptly chose yet a third spectrum location, 960 MHz. China may adopt yet another band (or adopt the EU band)[36] Unique choices may reflect prior differences or simply the desire to shelter local producers.

In summary, the technological space for the future wireless infrastructure is both malleable and unknown. Some dimensions of the technological space are known as are some ways in which it might vary. Other technological dimensions are subject to great controversy. Politics and policy will influence the precise dimensions and it is predictable that even good policies will be distorted by the process of political coalition building. Thus, there is no guarantee of a single global outcome for the network infrastructure. Moreover, even within broad classes of technological outcomes there

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services for both corporate and consumer use." OFDM Forum, http://www.ofdm-forum.com/index.asp?ID=92, visited August 31, 2004.

[34]The objective of the ITU's Radio Regulations is "an interference-free operation of the maximum number of radio stations in those parts of the radio frequency spectrum where harmful interference may occur." As regulations that supplement the treaty governing the ITU, the regulations have the "force of an international treaty. Heather Hudson, *Global Connections* (New York: Van Nostrand, 1997), p.406.

[35] Member governments have committed to work within ITU allocations. So, national bargaining positions must take these ITU dynamics into account.

[36] Based on http//www.RJIDjournal.com, "FAQs". Visited August 26, 2004. Tom Holland, "Shopping-Cart Spy Chips," Far Eastern Economic Review, September 9, 2004, pp. 36-39.

could be different patterns of innovation tied to the infrastructure and different areas of competitive strength and weakness. The next step is to assess how the political economic dynamics in each of the three major market regions could influence infrastructure and innovation patterns.

III. Differences among the Major World Market Centers

Three major market centers—the United States, the EU, and Northeast Asia (Korea, China and Japan)—constitute over 80 percent of world demand in most telecom/IT markets. Their decisions have major impact on the markets' R&D paths, economics, and politics. They will be examined one-by-one. But, as a base it may be helpful to provide basic information about broadband penetration at this point.

The United States: Fragmented Innovation

The United States combines a fragmented industrial structure in the communications and electronics industries with federalism and a system of divided government powers among the branches of government.[37] Its national electoral system rewards parties for championing programmatic innovations for household political support, but the structure of authority makes it difficult to undertake major initiatives without rather widely dispersed benefits to build large coalitions of support.

This profile has some strong consequences for a country with a continental-sized market. The United States always had less monopoly in telecom services and equipment supply and a more fragmented IT industry than other countries. The U.S. system makes it politically difficult to define an industrial or competition policy that effectively funnels benefits to one or even a handful of companies. Historically, protection of consumer welfare through price and product competition also had a much higher priority in U.S. policy than in most countries.[38] Further, on the American political stage, large corporate

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[37] This includes a national legislature that emphasizes federalism in the Senate where every state has equal representation.
[38] See Peter Cowhey and Mathew McCubbins (eds.) *Structure and Policy in Japan and the United States* (New York, Cambridge University Press, 1995) on why the U.S. electoral system rewards politicians advocating consumer welfare issues like pricing.

users quickly organize and offer arguments about household welfare and the competitive position of smaller suppliers to bolster their political punch.

Even when U.S. industrial structures consolidated in some capital intensive segments of more mature sectors, such as the auto industry, supply chains often remain fragmented. These dynamics make it difficult for the U.S. Government to pick corporate or technology standard champions. Policies usually need to result in geographically diverse winners. This creates the "technology pork barrel."[39] The same political factors impeding any industrial policies that pick winners also narrowly favor policies conducive to new market entrants. In addition, the United States has a huge national consumption market with relatively sophisticated and decentralized capital markets that facilitate entry by targeting selected market niches.

This political economic logic explains why the United States was the first to introduce competition in the wired network. Initially, competition in data networking served both large corporate users and the many, geographically diverse firms in the computer equipment industry which challenged Western Electric, the AT&T equipment arm. The introduction of telecom competition was, in effect, a government decision to favor the computer industry over the traditional telecom establishment. The subsequent move to long distance competition gave visible price and service benefits to middle-class households and business users, but cross-subsidies from long distance service to monopoly local services still shielded local prices. The control of local pricing and universal service policies remained federal in structure. When the 1996 Telecom Act permitted local competition, it compensated local incumbents with entry into long distance. Elaborate cross-subsidies remained for household local services. While competition for local phone services faltered in all areas except for larger business service, there was a huge boom in data networking that created numerous opportunities for new equipment suppliers. Massive entry into backbone fiber networks caused the pricing structure for long distance voice and data service to collapse. The emergence of

[39] Linda Cohen and Roger Noll, *The Technology Pork Barrel,* (Washington, DC: The Brookings Institution, 1991).

one fixed price for bundled local and long-distance service on wireless networks further hastened this transition.[40]

Regulatory policies coaxed cable television companies into competitive household data networking (and now VoIP). The cable companies are also digitizing their systems so that they will be able to offer HDTV and hundreds of channels. At the same time, incumbent local exchange carriers (ILECs) slowly got into ADSL (asymmetric digital subscriber line). Policies produced highly favorable network costs for Internet Service Providers (ISPs) and their customers. As a result, even today, Internet penetration in the United States remains among the highest in the world. But, the United States has fallen behind Korea and Japan in high-speed Internet access. Compared to Japan and Korea the United States has a lower percentage of households with "little broadband" and typical U.S. data speeds are lower.

Together, these forces have produced a situation where the United States has low prices for fiber backbone traffic and several national fiber networks along with numerous fiber networks in the major metropolitan business centers. The biggest problem in "big band" connectivity is service for households and small and medium-sized enterprises. Here, the implosion of the competitive local exchange carriers (CLECs) and the uneven implementation (due to judicial battles) of the FCC rules on local loop unbundling has produced what is essentially a duopoly between cable and ADSL provided by ILECs. Although cable was the early leader, today these two approaches are starting to move towards parity in market position. Prices are considerably higher than in Japan and Korea. The question is will "big broadband" develop there.

Despite fiber upgrades in parts of the Bell networks serving residential and commercial neighborhoods, there is little prospect of extensive fiber networking for these customers. This has led many to advocate a variety of policy changes. These range from the Bell proposals to change interconnection rules substantially to increase their returns on investment to ideas proposed by liberal think tanks to redirect funds going to provide universal service (and for other purposes), into "prizes" for the network in each region

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[40] Gerald W. Brock, *The Second Information Revolution* (Cambridge, MA: Harvard University Press, 2003), pp. 219-285 provides a concise summary of U.S. telecom regulatory developments between 1985 and 2002.

that agrees to build out big broadband.[41] The problem with all of these ideas is that to be carried out *decisively* the U.S. Government would have to pick clear winners and allow many active players to be clear losers.

The stalemate on wired networking may make wireless policy especially critical for high speed infrastructure, but U.S. wireless policies also bear the stamp of politics. The complexities of divided government and federalism make it difficult to reverse policies that have broad geographic support. If the benefits are spread across the country, for example to television stations, it usually takes an equally broad-based coalition to support a new policy and to make appropriate side payments to the old beneficiaries. This situation emerged during the spectrum allocation process. The spectrum below 3GHz is especially favorable for power efficient transmission involving many users. Yet, much of this spectrum is tied up by broadcast activities where utilization of the spectrum is either light (as in UHF broadcasting) or arguably better achieved by switching to wired delivery of programming. Yet, given the ubiquitous business base of local broadcasters, it is difficult to reallocate their spectrum without their consent. Similar problems have plagued other spectrum changes.

The United States released less spectrum for 2G (PCS) systems than Europe because of the difficulties of getting political support for the wholesale clearing of adjacent spectrum.[42] One way to clear out some spectrum was to authorize the FCC to stage auctions. Both parties highly prized the revenues from auctions as they wrestled with the politics of balancing the federal budget. So, this provided an incentive to support spectrum reallocation.[43] Even then, the new licensees for 2G bore the responsibility of buying out or moving the incumbents to new spectrum.

At the same time, the FCC designed an auction conducive to creating a competitive service market with four to six carriers in every region. This competition produced for U.S. consumers the lowest prices anywhere. The auction scheme also was vetted carefully with major North American manufacturers, especially Motorola, Lucent and Nortel. From this emerged the conviction that a technology neutral standard would

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[41] The FCC has already exempted the RBOC fiber "last mile" from interconnection rules. See Reed Hundt, New America Foundation proposal.

[42] William Lehr, New America Foundation.

[43] Incumbents on licensed spectrum had to be compensated by auction winners.

be the best way to balance their diverse interests. Fragmentation in standards resulted, but so did innovation, especially CDMA deployment. Government neutrality complemented an industry standard setting process that is one company, one vote. The key organization, the IEEE, requires a 75 percent vote in favor a new standard. This can lead to multiple standards in a common general framework or paralysis in some cases, as is currently the case with the 802.15.3a standard for OFDM.[44] This leads to many standards on critical technologies adopted less officially by marketplace leadership.

Another important principle in the auctions that grew out of the diversity of players was neutrality about service applications. Although cloaked in the language of public policy analysis, this simply meant that the FCC would allow the service mix (and technology) of the carriers to evolve freely between voice and data. This occurred because, on the one hand, the spectrum would be more valuable if more flexible (and thus yield higher auction prices) and, on the other hand, there was no significant political support to segment the 2G and 3G markets. This later made the transition to 3G easier in the United States because incumbents could simply upgrade their existing networks rather than switch to new spectrum as was required in the European Union.

The same politics created the experimental unlicensed spectrum bands in 1985 (at 2.4 GHz and 5.8 GHz). Then seen as junk bands with little use, it was politically attractive to create the unlicensed bands as an opportunity for entrepreneurial activities. It took an industry group until 1997 to agree upon the 802.11 standards for low power, short-range systems capable of high data speeds. Then, an ad hoc group of a few intensely interested manufacturers formed to certify true inter-operability among systems. This label became WiFi. Subsequently this led to further innovations such as 802.11g using OFDM that promises 54 megabits/s at 2.4 GHz.[45] This success also became the inspiration for the FCC Spectrum Taskforce whose investigations inspired much of the interest in the expanded use of unlicensed bands employing a commons model of shared non-exclusive use, underlay networks (using technologies like UWB) on licensed bands, and private spectrum managers on large blocks of spectrum.

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[44] Suzanne Deffree, "UWB stretches further," Electronic News, September 16, 2004, visited online. *The Economist*, "Untangling Ultrawideband," September 18, 2004, pp. 40-41.
[45] *The Economist*, "A Brief History of Wi-Fi," June 11, 2004, pp. 26-27. The coalition of firms was Lucent (now Agere), Symbol, Intersil, Cisco (then AeroNet), Nokia, and 3Com.

The growth of WiFi and its successors (such as WiMax for longer-distance transmission) opens the way to wireless having strong elements of the Internet experience (and its favorable politics) in the United States. Users have been prominent in developing the applications and infrastructure on these networks, including their financing. New business models for build-out, such as schemes for setting up urban WiMax networks using street light poles, emerge just as in the Internet. (Also note that the Internet did not exclude business possibilities for older carriers which could carve out roles in traditional services, high end data transmission, and integrated networking solutions for customers.)[46]

There is a larger lesson for U.S. innovation and network deployment. Just as with the introduction of competition and policies geared to favor innovative computer networking, the U.S. government resolves the tensions about innovation less with plans than with competitive free for alls fuelled around new prizes. Planning requires a politics of setting complex long-term bargains about precise wins and losses among many players. Opening up new markets under competitive rules with some assured compensation for losers is much easier to accomplish. Moreover, the diversity of the U.S. market environment and the minimal role of government in standards setting allows for rapid movement to markets of specialized new platforms, like WiFi. When the large industry effort to set standards proved inconclusive, a smaller sub-coalition emerged.

Today spectrum policy features technology and service neutrality plus resale. Spectrum reform is one way of allowing more winners. The FCC spectrum policy task force was an intellectually ambitious analysis. But, politically, it also served as a free for all bargaining exercise that identified areas of potential mutual advantages among diverse players and beneficial horse-trading opportunities created by technological innovation. The FCC is opening up the white space in the UHF television bands for low-power systems, for example. Resale of licenses, real technology neutrality, and flexible use of spectrum for services further reinforces this bargaining because they provide new entrants with more options (e.g., many standards and technologies) and allow incumbents

[46] Craig McCaw, for example, has been buying existing fixed wireless licenses of defunct carriers and converts them to Wi-Max carriers at a capital cost of $10,000 to cover a seven to ten mile area. Andrew Park with Steve Rosenbush, "Craig McCaw's Secret Plan," *Business Week*, May 17, 2004 Visited on www.freepress.net/press, May 20, 2004.

who might lose from innovation to monetize the benefits from their existing licenses by changing their service mix or selling their licenses. There is a price at which incumbents will sell.[47]

The EU: Commoditizing the Platform and Elevating the Applications

For the most part, the 1990s were difficult for the European ICT industry in world markets. There was one notable exception—wireless mobile communications fuelled by the compulsory GSM standard for the EU market. GSM was a huge political victory for advocates of a stronger European Union. As the European Union looks to the next twenty years, a key political question is what can take the place of this ageing success as an export champion? Further, how can the EU achieve the modernization of its economic processes through the use of ICT?

Policy in the European Union has complicated political roots. Policy begins at the national level because the EU remains more of a confederation of states than a sovereign entity. But the EU is more than the sum of its parts because the members have agreed by treaty to give the European Commission supremacy on some issues. This grew out of a common agreement among the core states that they could only succeed through the creation of a common internal market with strong independent competition policy powers (originally to cope with national monopolies), foreign trade policy, money (through the EMU), and now the main economic infrastructure services (as testified by the growing powers over telecoms and transport, including aviation). The origins of a strong EU mean that trade and export policies are far more central to its politics than those same issues are in the United States.

One other key feature of European policy is the more structured, less flexible European labor market. Although there are significant differences among national policies, American-style disruption of employment in industrial and service markets is generally not as easily accepted in Europe. Moreover, there are significant problems posed by employment benefits and guarantees that make it difficult for small firms in

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[47] For example to gain greater flexibility, regulators might offer that TV stations could hold on to their spectrum but use it for other purposes or sell it

technology industries to gear up flexibly.[48] This also makes it challenging to have policies based on "winner-take-all" prizes in new technologies.

The EU also must hold down disruption for individual countries, especially key countries, and therefore works diligently to proceed with mutual consent. Major countries still hold at least a quasi-veto power even when the Commission is strong. Moreover, large states alone cannot push through major initiatives because of the expanded number of members and complicated voting formulas. Thus, there is significant wrangling over how to distribute benefits geographically in politically salient ways.

With regard to ICT, these politics mean that the Commission must build support from states while using its selective agenda setting power, like competition policy, as a stick. A typical formula is four-fold. First, advance the argument that a common internal market requires stronger competition policy to break the tradition of state-guided markets. This is not just a matter of keeping competition honest within the European Union. It is about making the EU home market into a sufficiently efficient environment to create global economies of scale to take on non-EU competitors.[49] Second, argue that seizing the full benefits of a common internal market requires dealing with common market failures (a classic rationale for R&D funding) and perfection of the infrastructure that facilitates trade and commerce. This leads to examination of everything from common payments systems for electronic commerce to common smart highway systems to make the road infrastructure work better. Third, building on the second step, emphasize how ICT will build common infrastructure and applications for societal benefits. Emphasize the quality of life (Europe is greener than the United States and Asia) and, especially, voice support for small- and medium-sized enterprises (which generate jobs). Fourth, assert that international economic negotiations regarding matters vital to the internal market require Commission guidance. As a result, the Commission seeks to expand its power through, for example, the coordination of positions on matters

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[48] There also are benefits from the policies. Labor policies may maintain skills for specialized regional needs and restrain wages. Peter Hall and David Soskice (eds.), *Varieties of Capitalism* (Oxford: Oxford University Press, 2001).

[49] Wayne Sandholz and John Zysman, "Recasting the European Bargain?" *World Politics*, 42:1 (October 1989), pp. 1-30.

such as spectrum allocation and standards setting in global forums such as the ITU.[50] Aside from the technical or economic merits of any particular policy this political formula emphasizes the importance of a common European approach to tackling the world market.

The EU market for ICT is much more competitive now than in the mid-1980s. Telecom monopolies are dead as a matter of law and seriously dented in the wireline marketplace in many countries, especially in long distance, data, and wireless. Much rationalized equipment giants along with a modest array of innovative start-ups operate on a more business-like basis than in the protected days of old. In the wireless markets they are formidable.

In Europe, like the United States, there is no overriding goal to implement broadband. Although members vary considerably, the EU still lags in broadband compared to NE Asia and the United States. The EU is promoting broadband, but "big" broadband is not an overriding priority. In addition to EU structural funds for regional development, many regional and national governments are considering public subsidies for little broadband in rural areas.[51]

Wireless policy is in transition. Standard setting for telecoms in the EU is more transparent than ten years ago and it is largely centralized around an EU process. But, it remains complex. Even on equipment certification for new terminals like WiMax systems, EU power take precedence when there is a harmonized standard, but national power has the lead when there is not. On spectrum there is even more decentralization. To achieve quicker deployment the EU made a political bargain making a single band for GSM compulsory. But most spectrum policy is still under the control of the individual states and there is heated, ongoing debate over how much power to cede to the Commission. In addition, spectrum policy is quite restrictive in most countries.[52] Thus,

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[50] F. Greco (European Commission), Radio Spectrum Policy in the European Union, Presentation to European Utility Telecom Conference, 17 November 2003.

[51] PublicTechnology.net, "Scotland offers contract to extend broadband to rural and remote areas," posted August 9, 2004. Some of the large European countries, like France, have become more aggressive in boosting competition in DSL. *The Economist*, "The broader art of deregulation," August 21, 2004, p. 53.

[52] The most notable exception is the United Kingdom which in the past five years has become one of the most sophisticated and flexible in the world. Martin Cave, chairman, *Review of Radio*

the EU was slower initially than the United States to deploy WiFi because of various national spectrum restrictions on the 2.4 GHz band and the 5 GHz band.

Trying to establish EU control and a common approach requires considerable haggling. It is tempting to create uniform compulsory standards and spectrum policy that suit the needs of some dominant coalition of producers and states.[53] Balancing interests by simply letting the market decide as much as is technically possible is politically unattractive because the distributional results are much less predictable. This appears in many pan-European interest group positions. The major European commercial players, operating through the UMTS Forum, put their highest priority on getting "extended system capacity and higher (than current IMT-2000) bit rates…but [this] will require new spectrum."[54]

Consensus building with reduction of risk for states and major companies makes it much more difficult to agree in Europe on how to liberalize spectrum policy than in the United States. The EU has been slower in three ways. The EU market was slower to introduce unlicensed bands and to award licenses that are service and technology neutral. (Even today, for example, Sweden is a European outlier because it allows its 450 MHz band to be used flexibly, including for cellular services.) In addition, the EU was slower to allow a secondary market in spectrum license trading. This deprives license holders of an incentive to sell the license to others who could use the spectrum more productively.

The EU Commission recognizes that these rigidities may hinder the introduction of innovative technologies and services. So, it is considering an expansion of the number of unlicensed bands and the creation of a secondary market in licenses.[55] The same concerns may lead to another type of centralized decision—creating large unlicensed

Spectrum Management, reported to the Chancellor of the Exchequer and the Secretary of State for Trade and Industry in February 2002.

[53] Neil Gandal, David Salant, and Leonard Waverman, "Standards in Wireless Telephone Networks," (NERA and CEPR Working Paper, 1 March 2003).

[54] UMTS Forum Response, to the RSPG Consultation on WRC 2007, 19/5/2004, p. 2. This document raised concerns about Northeast Asian work on the next generation of systems.

[55] Radio Spectrum Policy Group, "Public consultation on secondary trading of rights to use radio spectrum," Consultation documents, http://rspg.groups.ue.int/consultation/consultation_secondarytrading/index_en.htm, visited August 14, 2004. Amit Nagpal, "Spectrum trading, liberalization and innovation," Analysys.com. Visited August 14, 2004. Nagpat summarizes the research done for the EU Commission by his firm and notes that EU has fallen behind in WiFi, and may lag in WiMax and Flarion's Flash OFDM technology.

bands that are subject to elaborate technical standards (to control interference) rather than simply allowing technology and service neutral licenses. There may be efficiency costs attached to this approach.[56] But, the real point is that the EU political economy makes such approaches attractive and they could follow from the coordinated European positions on matters such as 3G spectrum.[57]

The standards process in Europe differs from the United States in important respects. It is more difficult to get revolutionary jumps in technology in Europe simply because incumbents know that the standards system precludes unwanted initiatives by new entrants. The main telecom standards organization, ETSI, operates on a weighted voting system that is determined by the European revenues of its members. (Many standards do not fall under ETSI, but European-wide telecom standards do.) While discouraging innovative proposals by upstarts, this system has the advantage of including most European firms in the process. It can come to a binding decision to unify market standards more easily than the United States. This may lead to real advantages in areas where some standard can bring large gains even if not optimal.[58] To fortify their claim, Europeans note that the EU approach to standardizing radio frequency identification (RFID) recently displaced North American leadership on the standard. In contrast, the EU moved slowly into WiFi and the effort to promote an EU standard, HyperLAN2, has not gone swimmingly because it is late to market.

One other factor may influence the European path to innovation. During the late 1990s Europeans became more comfortable with open source as a path to greater technology independence. Linux, which exemplified open source software, had its roots in a European technological community frustrated by Microsoft's control of one layer of the IT system. The open source experience could reinforce the preferences of the EU

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[56] Thomas W. Hazlett, "Trends," The Milken Institute Review, 4th Quarter, 2003, pp. 9-15

[57] For example, the EU will argue vigorously for the 2500-2690 spectrum band being reserved for terrestrial 3G at the next WRC. ETNO Expert Contribution in response to the Consultation to develop an RSPG (Radio Spectrum Policy Group), Opinion on World Radiocommunication Conference 2007," May 2004.

[58] See Peter Grindley, David Salant, and Leonard Waverman, "Standard Wars: The Use of Standard Setting as a Means of Facilitating Cartels Third Generation Wireless Telecommunications Standard Setting," mimeo, 1999. On European-wide practices see Walter Mattli, and Tim Buthe, "Setting International Standards: Technological Rationality or Primacy of Power?" *World Politics* 56:1 (October 2003), pp. 1-42.

equipment giants to compete on price, quality, and marketing acumen. They are used to working with high-end public users. They are suspicious of being penalized by expensive indispensable platforms for technology.[59] The EU Commission Information Society DG envisions a convergence of all IP networks. To achieve this goal would require the convergence of wireless networks providing service faster than 3G over diversified access platforms in a seamless manner, the prominent use of ultra-wide band technologies (UWB), and software defined radio (SDR), with distributed computing and databases.[60] Recent Commission documents call for a major R&D effort at a European level and a program for creating global standards and platforms for innovative high-speed mobile broadband services.[61]

The smaller European companies and countries often look to specialized engineering products and customized solutions in processes as one of their particular strengths. Further, the consensual European standards system may reinforce this advantage. Thus, a future European ICT mix might emphasize a new set of leading edge users, especially parts of the public infrastructure (including health). This approach might de-emphasize creating advantages on network/IT platforms and give great attention to pioneering standardized supporting systems, such as for micro-payments and protocols for service capabilities featuring deployment of components like RFID systems.

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[59] See the Siemens response to the Consultation in the context of the development of an RSPG Opinion on the priorities and objectives for the Community in the World Radiocommunication Conference 2007," 28 April 2004, "…Europe should not drop its principle of harmonization and interoperability principle that has been successfully applied for the second generation of telecommunication systems (GSM). The fashionable term of "technology neutrality" has nothing in common with standard neutrality….In this sense "Technology neutrality" contradicts potentially the European objective of market harmonization…The European telecom industry faces the strong competition from Asia. The Asian administrations have a homogenous policy by supporting the research and development of so called 4G telecommunications systems and by simultaneously requiring of the adequate spectrum where their 4G systems could be placed." Also see UMTS Forum Response to the Consultation in the context of the development of an RSPG Opinion on the priorities and objectives for the Community in the World Radiocommunication Conference 2007," 19 May 2004.

[60] See presentation of Ruprecht Niepold of the Commission to 11th CEPT Conference, Nice, 22-24 October 2003.

[61] Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee, and the Committee of the Regions, "Mobile Broadband Services," 30 June 2004. The same document endorses a common EU position at the next WRC on next generation services and more coordination of spectrum management models so as to ensure a single market for goods and services. It also suggests Commission guidance for M-payment systems regulated by members.

Intelligent transportation systems ranging from highways through railroads illustrate the possibilities. The German government has undertaken an ambitious piece of industrial policy to benefit Daimler-Chrysler and Deutsche Telekom through the creation of an integrated platform for collecting road tolls electronically that will also service fleet management and navigation. The EU is discussing the possible harmonization of new electronic toll systems.[62] More generally, European public infrastructure operations are much admired in developing markets and could be strong lead users both as a source of innovation and as prestige customers to build a global reputation.

The Northeast Asia triangle: Japan, China and Korea

Although it does an injustice to Japan, China and Korea, for the sake of simplicity we emphasize some common features that emerged out of the region's political and economic experience. (The appendices to this paper lay out the position of each country in detail.) Japan was the model for this troika because it was the first to democratize and the first to create a modern technological economy with a strong export emphasis. Korea modeled much of its rise to an industrial power on the Japanese precedent. China repeatedly experimented with industrial policy for its industrial and especially its technology sector.[63] There is still a strong interest in support of export platforms in manufacturing in all three countries. Certainly, compared to the United States, but even compared to the EU, there is much stronger acceptance of central coordination attempts by government in these countries.

These surface similarities may make it seem that Japan, Korea, and China are poised to resurrect old style, industrial planning on the classic Japanese planning model. That is not the case; the world has changed. A central lesson drawn by Japanese leadership about the setback of the 1990s was that insufficient competition deadened the promotion of innovation at home. Both Korea and Japan embraced managed network competition, including the unbundling of the local wired loop, to force more rapid build-out of broadband. But competition remains managed in the sense that governments do

[62] *The Economist*, "The Road Tolls for Thee," June 12, 2004, pp. 30-32; "Road Rage," January 24, 2004, pp.56-57 for a description and discussion of the teething problems with the system.
[63] Nina Hachigian and Lily Wu, *The Information Revolution in Asia* (Santa Monica, CA: RAND, 2003).

not hesitate to try to manipulate pricing, the number of competitors, and spectrum licensing to maintain the welfare of carriers and their suppliers.

These arrangements are complicated by the rise of consumer politics in Japan and Korea where changes in electoral systems and the emergence of more vigorous party competition has increased the weight given to the interests of urban consumers. China also is betting that prosperity is a substitute for rapid democratization, so consumers also have more weight than in authoritarian systems of the past. Another lesson learned from the experience of the United States in the 1990s was that low prices for communications services drove innovation, including faster adoption of the Internet and e-commerce. So, consumer policy fits into a certain style of industrial policy emphasizing more competition and better price performance. As a consequence, consumer politics is one of many challenges fearing countries that want to steer technology markets. Efforts at official guidance inevitably face in-fighting within governments over whose plans and what terms to adopt. Globalization also makes the situation more problematic. Consider, for example, the consequences as countries begin to rely more on world financial markets and less on government aid or carefully guided national banks. In China the government is trying in to guide telecom carriers' technology approaches. But all of the major Chinese carriers are, or soon will be, listed on global stock exchanges. That imposes restraints on Chinese government dicta. WTO commitments on ICT also constrain, but do not eliminate, government steering of markets

How have government policies impacted on the network of the future and the pattern of innovation tied to it? Asia is far more concerned with the speed of delivery than either the United States or the EU. Japan and Korea and, to a lesser degree, China strive to achieve "big broadband" quickly. This policy emphasis supports key equipment manufacturers and boosts new user applications, like video gaming. Specifically, in the spring of 2004 these three countries announced plans to collaborate on a common 4G standard that will feature 100 megabit/s service and will feature 100 megabit/s service that will allow high resolution video.[64] The target date is 2010. (In contrast, 3G will have a maximum speed of 1 to 2 megabits/s.) The architecture will also feature I.P.v.6,

[64] The 100 megabit/s goal is a maximum rate and probably could only be obtained with limited mobility (e.g., walking across campus, not on a train).

the Internet addressing system that increases the sophistication of identifying specialized terminals on the network and, significantly, provides Asian exporters with a better chance to seize advantage from Cisco which dominates IPv4. [65]

The governments have numerous tools to pursue this goal. All three run spectrum policies that allow extensive government management of market entrants, uses, and technologies. Licensing more closely resembles beauty contests than auctions, for example. Licenses usually specify which technologies to use. Governments also play a large role in defining standards. In Korea, for example, standard setting is led by TTA (Telecommunications Technology Association). The NGMC (Next Generation Mobile Communication) forum was established under the leadership of MIC for research on 4G standard setting in Korea. Samsung Electronics is in charge of system and technological issues and SK Telecom was assigned responsibility for service and market issues.[66] The R&D policies are tied to specific export and market goals. The Chinese effort on 4G is led by the Communications Research Lab in cooperation with the Chinese Academy of Telecommunications Research, the Beijing University of Post and Telecommunications, and Chinese carriers. China is keenly interested in 4G as a possible way to create intellectual property for export manufacturing under Chinese leadership.[67] Korea has this same goal.

Of course, diplomatic handshakes do not make technological realities. It still must be demonstrated that the engineering and economics of 4G technology with these performance characteristics is workable. Even if it is, there is the small matter of turning a principle (let's have 4G soon) into a particular market entry. Here interests may diverge. Good intent must confront different market positions.

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[65] Robert Cole in John Zysman (forthcoming).

[66] "Research and forums on 4G standards," *Digital Times*, August 25, 2004, (available at http://www.dt.co.kr/view20.html?gisaid=2004082502010856600003, in Korean)

[67] China also is pushing into IPv6 (Internet Protocol version 6) because it opens many new addresses and will have many standards to implement in equipment that opens up patents for Chinese firms. IPv6 is seen as a key to 4G. Huwawei and ZTE are the most aggressive firms on creating IPv6 routers. Harbour Networks and Tsinghua Bitway are also in the game. See for example, NE Asia Online, "Japan, China, Korea to Jointly Develop 4G Cell Phone Technology," April 15, 2004, http://neasia.nikkeibp.com/wcs/leaf?CID=onair/asabt/news/299929 visited August 15, 2004**.**

Korea is strong in consumer terminals, computing and chips and high-end components (like LCD screens). It is not a leader in network equipment, especially in export markets. Korea also has the smallest domestic market of the three. Its success in telecom came from making a bet on a CDMA standard that succeeded in the U.S. market. Innovation in production and deployment in Korea gave it a head start on commercial production based on the U.S. standard, but the bet would have failed if the U.S. market had not propelled its economies of scale. The question for Korea is if a "home grown" standard or genuine solidarity among Asian markets could replace a reliance on the United States. There is also the complication of its position on intellectual property. For example, so far Korea has been cool towards any form of OFDM that is controlled by a non-Korean firm that plans to charge for use of its IP, such as Flarion. Instead Korea is intrigued by WiMax (a form of OFDM) which is being pushed by Intel because Intel has promised not to collect IP royalties. To prepare for these possibilities Korea has announced that it plans to set aside spectrum for WiMax.[68]

Japan's position has weakened substantially in the export market for telecom network equipment. It shares leadership in most segments in the chip industry, but has slipped and now trails in some areas. It remains strong in high-end components and many phases of consumer equipment, but it has lost substantial ground on mobile handsets. Its position was damaged after it failed to conform to global standards for telecom/IT networking in the 1990s, so Japan is now more careful about its positioning for the coming decade. Even though Japan is courting the Chinese by signing the proclamations on 4G, it shows less enthusiasm for this initiative. Japan already has made significant bets on W-CDMA and CDMA2000 that could suffer from a failed 4G push.

China has an unevenly developed network infrastructure. Thus, many of the goals for the next generation of networking may amplify both advantages and weaknesses (depending on your position) of not building on a well-developed set of capabilities. Put differently, Japan and Korea possess sophisticated network infrastructures even without dramatic changes. Change in those countries will play off of their strong bases. China has no comparable base, so China's strategic situation is different. China's network

[68] Korea also ended up in a trade dispute over its effort to create a national mandatory standard for wireless Internet browsers (WISPI). As of the summer of 2004, it had temporarily retreated.

infrastructure is incomplete; it has a relatively weak software industry; and its equipment industry still operates at the lower end of the value chain despite some notable advances since 2000. China has done well on consumer terminals and is entering the router market and some other network equipment segments. Its key advantages are the enormous size of its market and its willingness to use that market as a bargaining lever with foreign technology firms. It also benefits from its supply of skilled and inexpensive human capital. But, playing at the edge of the technological frontier poses strategic issues that are difficult to resolve even with vast experience. Those issues are complicated in China by a rapidly shifting set of domestic political economic interests as the market and its politics shift rapidly.

Assuming progress on coordination within the troika, there is still the large issue of global coordination. The spectrum and standards processes globally make it difficult to preempt these decisions. For all the size of the troika's market, the combined U.S. and EU market still dominates. Moreover, Japanese and Korean firms count on success in exporting to those markets. So, unless the troika can reach a general agreement with one of those two market centers, it is difficult to plot a course that would result in their emerging as the recognized leader. Thus it is still necessary to place bets on whether the U.S. or EU models of infrastructure and innovation are more likely to succeed. Only courageous or foolish policy-makers would bet decisively on this question.

Even if the push for 4G does not yield a master plan, it still could significantly change the technology space of the future. Technology markets are subject to "tipping" where small early advantages can sometimes change expectations sufficiently.[69] Simply put, the political glitz of the project might also tilt the technological field toward a larger component for a variety of new fixed wireless networks. (More specifics on each country help to clarify the situation. These are supplied in Appendices A, B, and C.)

The troika resembles a wild card in poker, a potent but undefined force in the strategy of the global game. Neither Korea nor Japan can confidently push ahead on its own. But neither can count on capturing China. China, for all of its power derived from its gigantic market and low cost human capital, is still an incipient force in advanced

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[69] On the general topic of tipping see Malcolm Gladwell, *The Tipping Point: How Little Things Can Make a Big Difference* (New York: Little, Brown, 2000).

technology. It may make an independent mark as a supplier, but it is likely to be highly selective at this stage. So, the real question is whether the interaction of the troika with either the United States or the EU will forge a genuine surprise in the next generation of infrastructure and its associated pattern of innovation.

IV. Preliminary Conclusions about Paths and Innovation

A multi-dimensional political battle is emerging over innovation and returns from the next generation of ICT. In general, the United States will continue to be focused more than the EU on creating big winners in innovative ICT platforms. Northeast Asia may play a two-sided strategy as it tries to balance the U.S. and the EU strategies.

The U.S. approach still is oriented toward platforms because the U.S. system is good at strategies that quickly bring innovations to market deployment. The less regulated and more fractionated market environment in the United States makes coordination around broad technology approaches difficult. At the same time, America's fragmented innovation system is backed by flexible labor markets, often with strong regional concentrations of skills, and reinforcing university innovation systems. Capital markets facilitate this approach. U.S. politics and policy further strengthen it. For example, reforms in spectrum policy fit the U.S. pattern of policy innovation by allowing prizes for new winners and compensation to losers. Thus, spectrum policy innovations all have the political logic of trying to define spectrum space for new potential winners while allowing easier resale of spectrum to pay off incumbents which lose. Standards setting policies are basically permissive. They do not attempt to steer the market. Similarly, competition policies produce keen pressure for cost reduction, as witnessed by the early U.S. movement towards a single flat price for all mobile services.

A national policy to create big broadband or achieve convergence is unlikely. More likely is something like an inexpensive, flat price packaging of voice and data for ubiquitous little broadband with both wired and wireless options.[70] Many specialized big broadband overlay and underlay systems will supplement this architecture. Some of

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[70] Ubiquitous wireless delivery of little broadband will likely discipline the pricing of wired networks.

these specialized networks will produce major platform winners. But specialization of networking in a competitive environment makes full convergence unlikely.

This U.S. market mix creates at least a two dimensional battle over the future. There are rival platform camps in both telecom equipment and services and in regard to IT software. On telecom, the computer electronics industry is focused on wireless infrastructures that move value from traditional telecom equipment vendors and carriers to the computer industry and new service suppliers. As technology options proliferate, there will be a strong contest over which business model for providing services is viable. Resale of spectrum and service neutrality means that there is ample opportunity for new service models even on licensed bands. But, of course, the question is whether the models and technologies are viable?

As stated earlier, software rivalry that resemble old battles between Microsof5t and IBM. Microsoft and its allies want to load as much value as possible into the standardized software platform while maintaining good relations with specialized applications providers. IBM and its allies want to place most of the value in customized systems integration products, not in the software platform. Thus it supports Linux against Windows. Both camps seek to score breakthroughs in a fragmented user community of large commercial, consumer, and research clients. This means that the origin and mix of traffic (e.g., the deployment of sensors) will be uneven. Specialized networking architectures will respond appropriately. One large uncertainty could be how massive government spending is on security systems featuring ICT.

The EU favors IBM's approach. Reducing the value of proprietary platforms, while emphasizing the returns from high quality delivery of products and services based on the platform, meshes more closely with the strengths of European suppliers. Although the European environment is more strongly market driven than twenty years ago, the political process favors policies that try to reduce the risks of market disruptions (whether for major national suppliers or labor). This leads policy to seek coordination on innovation, which tends to limit the magnitude of downside risks while, if done properly, opening up gains from scale and standardization. Further, the effort to perfect the internal European market reinforces this propensity. It is difficult to imagine an EU policy mix that tilted strongly, even implicitly, against the major telecom carriers.

As a result, policy and politics may tilt Europe towards incremental upgrades of current network platforms. There will be ample big broadband at competitive prices for large business and research centers. There will be widespread deployment of little broadband. Convergence in policies overseeing services delivered over different platforms (e.g., VoIP or audio-visual) may be strong, while network convergence itself may be weak. Alternative wireless infrastructures may be more tightly integrated into the platforms of established carriers because spectrum allocation and assignment will remain more restrictive than in the US. Most innovatively, there may be a new approach to defining the key lead users. A key part of the European strategy, induced by current market position and politics, may be to emphasize new classes of public infrastructure services incorporating innovative ICT with the lead users coming from such European public services as transport, health, and water.

In contrast to the EU, northeast Asia is interested in playing the platform game if the countries can control it. Taking their declarations literally, the Northeast Asian countries are in a race with the United States. High growth rates in demand, especially in China, make this seem attractive. But, they may simply be trying to steer a middle course—get better terms than Europe if the U.S. platforms dominate or remove proprietary intellectual property as the dominant source of advantage. After all, while the northeast Asian market is formidable in aggregate, it is not a single market in the U.S. or EU sense. Nor is there strong coordination of policy interventions among the three countries. This is a strategic disadvantage for efforts to steer the market.

Thus, a default position, consistent with their political economies, is to use the development of network architecture primarily to fuel successful equipment exporting strategies. In the new synthesis of consumer and producer politics in these countries low priced, high speed networking is the preferred environment for nurturing export products. Competition helps to speed the rollout of new network services, but governments continually intervene to steer the mix of players and direction of technologies. One unique source of advantage may be that the massive, non-European language market of the region will produce unique lead user applications. The Korean and Japanese strategies of ubiquitous big broadband could reinforce this specialized advantage. Thus, it could be mass consumer markets and small and medium sized enterprises that especially leverage their strengths.

How do the regional stories add up to a global picture? A popular song of our youth went, “There's something happening here. What it is ain't exactly clear …”[71] Engineers disagree about the future of the infrastructure, but they don’t easily embrace fuzziness. Our message is simpler. There is uncertainty about the engineering of the future infrastructure. The experience of the past ten years should make us cautious about forecasting winning new business models. But a deeper uncertainty is the way in which policy and politics may shape the future of the network architecture and related innovation system. Almost certainly, twenty years from now analysts will continue to be struck by global variations in architecture and innovation patterns.

[71] Buffalo Springfield., “For What It’s Worth,” Stephen Stills, 1966.

Appendix A
Japan

The economic setbacks of the 1990s helped provoke the beginning of political reform in Japan. These political changes will influence the shape of economic policy reform. Japan has a parliamentary government where the power of the executive and the Diet are one, because the Prime Minister is selected by Parliament. The strong Japanese state firmly maintains power over telecom and technology policy. There is no federalist model akin to that of the United States. It is easier for the concentrated Japanese government to make decisions than it is in the United States. This was especially true during the long postwar one party dominance by the LDP. Industrial policy was straight forward because the electoral system emphasized political competition through personal service for voters, not fights over policy. Politicians briskly traded their support for large industrial groups in exchange for startlingly large campaign contributions that they used to woo voters.[72]

Electoral reforms in the mid-1990s slowly shifted the incentives in favor of policy debates among candidates and increased the power of urban voters, both of which made pro-consumer policies more desirable. After reflecting on the downturn of the high tech sector in 1990s, those advocating the continuation of industrial policies grew convinced that their policies needed to be more pro-market. Thus competition was embraced more in Japan and there was considerable effort to stimulate technology clusters of small and medium-sized entrepreneurial firms to match the American successes of the 1990s. Nonetheless, a system of reciprocal consent under which powerful firms forge enduring alliances with politicians and bureaucrats remains in place.[73] However, today even large firms are growing more wary of accepting coordination.

The result of these changes has been a mixture of old and new Japanese telecom policies. In the 1980s NTT coordinated the research programs and industrial investments

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[72] On the logic of the voting system and the consequences of centralized authority under one party rule see Cowhey and McCubbins. The LDP delegated much of the authority over decision-making to the career bureaucracies who had assimilated the political demands of the LDP while promoting higher growth. .

[73] Mark Tilton, "Neoliberal Capitalism in the Information Age: Japan and the Politics of the Telecommunications Reform," Japan Policy Research Institute Working Paper No. 98, February 2004.

of its suppliers through massive planning and subsidies in the procurement system. But the losing bets by NTT--including reliance on ATM switching rather than Internet approaches and idiosyncratic standards for wireless--hurt Japanese firms in the 1990s. Japan also lagged on e-commerce because Japanese households moved more slowly to adopt the Internet because of high prices for connectivity. So, there is now more emphasis on competition to drive down prices to stimulate consumer innovation both because of the U.S. example and because of the rising appeal of consumer politics. As in the United States, long distance services are becoming a commodity with KDD-I and Japan Telecom providing competition to NTT (which still dominates local services). After moving much more slowly than the United States on wired network unbundling, Japan moved strongly to force unbundling by NTT for ADSL in order to spur a race for build-out of ADSL, especially led by Softbank and (later) e-Access.[74] The resulting increase in competitive players throughout the Japanese market is shown below.

[74] Interconnection rates for voice services remained higher than for ADSL. In 2004 Softbank purchased Japan Telecom to extend its marketing to commercial customers. Todd Zaun, "2 Deals Could Reshape Telecom Business in Japan," *New York Times*, May 28, 2004, p. W1. As elsewhere the dominant incumbent, NTT, is trying to reverse the unbundling rules. *Nihon Keizai Shumbun*, "KDDI Chief Onodera Warns of NTT Monopoly's Return," NikkeiNet Interactive, June 16, 2004. Mark Tilton, JPRI..

Telecom Industries in Japan

	Wireline provider			Wireless provider		Broadband Internet	Wireless Equipment Manufacturer (domestic)
	Local	Long-distance	International	CDMA	3G		
1	NTT	NTT	NTT	NTT Docomo	NTT Docomo (FOMA)	NTT Docomo	NEC
2	KDDI	KDDI	KDDI	KDDI	-	Softbank	Panasonic
3	Japan Telecom	QT Net, IDC, Etc.	Japan Telecomm	J-Phone	-	E-access	Sharp
4	TTNet, QTNet, Etc.	−	IDC	Tu-Ka	-	Acca Networks	Mitsubishi Electric
5	-	-	MCI Japan	-	-	Etc.	Sanyo
	-	-	−	-	-	-	Sony Ericsson, Toshiba, Fujitsu, Etc.

Source: Recreated based on data from MPHPT, White paper 2004

The new strategy led to dramatic changes in wired networking. The January 2001 "e-Japan Strategy" set a target of 40 million households with access to broadband by 2005. Of these, 10 million were to be accessible to (but not actually using) big broadband. By June 2002, 57 million households had access to broadband of which 14 million households had access through fiber. Between the end of 1999 to end of 2002 the Internet penetration rate jumped from 21.4 to 54.5 percent.[75] As a result of local loop unbundling triggering fierce competition, Japan is heading toward 16 megabits/s service at low prices (about two-thirds below the prices for fiber optic broadband). Japanese

[75] MPHPT reports 11.2 million DSL subscribers. 2.58 cable modem, and 1.14 ftth subscribers at the end of 2003. About one-third of Japanese Internet users rely on broadband and almost half of the households with the Internet rely on broadband. MPHPT, *White Paper*, 2004, p.6.

broadband consumer prices are the lowest in the world, just below what is charged in Korea.[76] At same time, NTT fixed voice traffic fell by about 20 percent. This is primarily due to the explosion of use of the mobile networks, but VoIP also is growing rapidly in a broadband environment.[77]

Competition in wireless grew, including competition using different technology platforms, as DoCoMo (NTT), KDDI, and Vodafone emerged as the big three. It was a significant change that the government allowed the control of one major competitor by a leading foreign carrier. DoCoMo showed unusual agility in its launch of "i-mode," the first of the successful SMS systems. 3G systems also grew rapidly. At the end of 20003 Japan had 81.22 million mobile phone subscribers, of which 16.69 million had 3G service.[78] The surprise was that KDDI's dominated as a result of its use of a CDMA 2000 platform that had fewer roll out glitches. In contrast to 3G, hot spot deployment was slow; at the end of 2003 there were only about 5,300 public hot spots.[79]

Japan has had the most command and control oriented system for spectrum allocation and licensing of the industrial countries. Licensing was done through "beauty contests" held by MPHPT and the uses and technologies deployed on the licensed spectrum were subject to extensive formal rules and informal administrative jawboning. Wireless LANs were subject to restrictive rules to assure non-interference. In response to the growth of new wireless technologies MPHPT has lightened its rules on low power LANs and is considering a new approach to spectrum policy, including possible extensive reallocations of spectrum. But the economic design of these rules remains vague.[80] This is not surprising since these rules could significantly reduce ministerial discretion over market entry and business models even further. Therefore, many market participants and the Ministry will be cautious about this prospect.

For all of the growth of competition, the tradition of setting ambitious goals for technology and industrial policy has not disappeared. Japan's long-term goal is to have ubiquitous networks that are both broadband and mobile. In other words, they can be

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[76] MPHPT, 2004 *White Paper*, p. 7
[77] ITU, "Promoting Broadband: The Case of Japan," pp. 6-16 and 36.
[78] MPHPT, 2004 *White Paper*, p.7.
[79] MPHPT, 2004 *White Paper*, p. 9.
[80] MPHPT, 2004 *White Paper*, p. 58.

accessed from anywhere and are "always-on." They will be "multi-modal networks, that is, users can freely cross the boundaries between fixed and mobile networks, wired and wires, communication and broadcasting, and between terrestrial and satellite transmission. … The effectiveness of ubiquitous networks as the basis of a new social system will be enhanced further by linking RFIDS, sensors, webcams and other devices which enable machine-to-machine (M-to-M) communication via the Internet protocols."[81] Japan's agreements on 4G, noted earlier, will be important in implementing this vision. Just as significantly, Japan has set a goal of fiber to the home (FTTH). It views stable high-density resolution video as requiring FTTH in the long-term. So, the goal is to accelerate to 100 percent national fiber coverage shortly after 2005.[82] Despite plans for these big broadband pipes, convergence has a special twist in Japan because of the ministry's long-standing commitment to digital broadcast systems as a way to boost industry (including household appliances and high quality imagery). They are scheduled to be deployed fully by 2011.[83] Given the influence of over-the-air broadcasters this means that convergence in Japan has a large role for satellite and broadcast television and the spectrum that they use.

Another strong point of Japan, and the mobile data usage of Japanese youth (where the i-mode took off), the government expects other innovative uses. A recent inter-ministerial document on broadband in Asia set three goals for new applications. The first is to increase information flows within Asia to levels comparable to those between the United States and the EU. The second is to digitize major cultural assets in

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[81] ITU, "Promoting Broadband: The Case of Japan," p. 38. The 2004 MPHPT *White Paper*, p. 56 also calls for gigabit speed wireless LANs for indoor use to transfer 3-d and ultra high definition images plus large information streams.

[82] That said the number of actual subscribers in February 2003 was only .27 million for big broadband and 8.6 million for little broadband, far short of turning access into subscription. There are typical problems involving rural service that are inducing government build-out programs. There are government subsidized loans and tax credits for fiber, but the dollars spent are still small. Government policy is especially targeting the 37.7 percent of Japanese households in apartment buildings, of which half live in two cities. (The U.S. number is 26.9 percent). ITU Workshop on Promoting Broadband, "Promoting Broadband: The Case of Japan," ITU, April 2003, pp. 31-36.

[83] MPHPT, 2004 *White Paper*, pp. 9, 11.

Asia. The third is to create a practical machine translation system for major Asian languages.[84]

[84] MPHPT and other ministries, "Asia Broadband Program," March 28, 2003, unofficial translation . www.soumu.go.jp/joho_tsusin/eng/Releases/Telecommunications. Visited June 17, 2004.

Appendix B

Korea

In 1960 telephone penetration in Korea was only 0.36 per 100 inhabitants, one tenth of the world average at the time. Korean penetration reached the world average in 1981 and by 2002 was three times more than the world average. Korea advanced from just 1 internet user per 100 in 1995 to overtake the average internet penetration in industrial countries by 1999. Today, Korea leads the world in broadband penetration.[85] Korea was the first country to roll out 3G and garnered a huge status boost as an IT leader within the OECD as well as an economic boost from its success. What is going on?

Starting with international long distance in the early 1990s the Korea systematically liberalized, privatized, and introduced competitors to its historical monopolist, Korea Telecom (KT). Under pressure from external events, "Korean telecommunications reforms have been initiated and led by the state despite the relatively well developed private sector."[86] Starting with a Ministerial reorganization in December 1994 this effort was led by the Ministry of Information and Communication (formerly the Ministry of Post and Telecommunications) which at the direction of the Blue House was ceded the lead by the Ministry of International Trade and Industry (MITI).[87] MIC has consistently directed the reform process, listening to major corporate and other interests, but for the most part acting with great autonomy. Their discretion was, if anything increased, by the economic downturn that followed the East Asian financial crisis.

Recent figures place indicate that ICT accounts for 14.9 percent of Korean GDP, a figure higher than in the United States. Telecom equipment accounts for a large share of the total ICT market. The rise of Samsung and LG is particular striking. The success of CDMA industrial policy was a winning gamble to influence policy. The payoff was that from 2002 to 2003 exports of Korean telecom equipment jumped by 37.9 percent to 18.4 billion. Wireless telecom equipment, was the big winner, accounting for $15.4

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[85] ITU, "Broadband Korea Internet Case Study," 2003, p. 1.
[86] Sung Gul Hong, "The political economy of the Korean telecommunications reform," Telecommunications Policy, 22:8 (1998), p, 697.
[87] Ibid., pp. 702-703.

billion of the telecom equipment surplus in 2003 with Korean shares of both CDMA and GSM phones rising rapidly.[88]

The link between service and equipment goals exists because the major mobile service providers in Korea are major *chaebols* (LG, SK and KT) which dominate a large portion of wireline, wireless, and equipment market. At the end of 2003 SK Corp., for example, was the single largest shareholder in SK Telecom with a 21.47 percent stake. All three service providers also are connected to manufacturing affiliates as well: SK Teletech with SK Telecom, KTFT with KTF, and LG Electronics with LG Telecom.

The relationship between the government and the *chaebols* also is unusually close. Standard setting is led by TTA (Telecommunications Technology Association) in Korea. The NGMC (Next Generation Mobile Communication) forum has been established under the leadership of MIC for research on 4G standard setting in Korea. Samsung Electronics is in charge of system and technological issues and SK Telecom is in charge of service and market issues.[89] Moreover, at the top, for example, Chin Daeje, the current Minister at MIC was previously the President and CEO Digital Media Network Business at Samsung Electronics. His predecessor, former Minister Lee Sang-chul, was appointed after chairing Korea Telecom.[90] This close relationship allows the government to continue its traditional practice of interventionist reform, forcing private firms to embrace specific tasks and setting deadlines for their completion.

The rise of a more electoral political basis led to more emphasis on consumers and to continuing industrial policy. In addition, the East Asian financial crisis of late 1997 hit Korea hard and spurred a change in domestic economic policy direction in the summer of 1998 towards economic expansion through monetary and fiscal expansion. The government also initiated a major restructuring and reform of the financial, corporate, and public sectors as well as the labor market. In the wake of the crisis, the embarrassed and weakened *chaebols* were less resistant to government changes in policy direction that forced them to compete. The corporate sector, including ICT, radically reduced their debt-to-equity ratios and greatly increased their equity capital positions. To

[88] MIC, 2003 With Paper, appendix 3, p. 81.
[89] "Research and forums on 4G standards," *Digital Times*, August 25, 2004, (available at http://www.dt.co.kr/view20.html?gisaid=2004082502010856600003, in Korean)
[90] MIC, (http://www.mic.go.kr/intro_min_profile.jsp).

survive the crisis they also sold off assets to foreigners, sought foreign capital, and strengthened their domestic and international strategic alliances. Competition led to revival, so it became easier to embrace new ways instead of clinging to old ones.

Today, there is network competition in the Korean market, but regulators also actively worry about welfare of carriers. The local loop was unbundled to advantage a new entrant, Hanaro Telecom, as it began to compete for local business with Korea Telecom (KT). Wireline domestic long-distance service is provided by four competing carriers and international long-distance services is provided by five competing firms. Number portability was introduced in October 2003.

In Korea the mobile phone has become a social and interpersonal networking tool, especially among the young. Handsets are fashion item that is reshaping the urban lifestyle. Nomadic lifestyles, enabled by mobility, have created a new kind of person, "homo telephonicus."[91] This was largely a result of a huge winning gamble by Korea which chose CDMA as its vehicle for export leadership. To build the market they chose it as the initial Korean standard, even though this required them to pay substantial IP royalties to Qualcomm. They then built the market by subsidizing handsets via carriers.[92] The Korea Broadband study for the ITU puts the total size of subsidies for handsets at $4 billion from 1996 to mid-1999. The handset subsidy was instituted at a moment when Korea was pushing urgently to reduce its trade imbalance to meet its obligations under the IMF bailout program. By jump starting Korean handset manufacturers, the government hoped to reduce its trade deficit.[93] It abolished the mandatory subscription period in April 1999 and then banned subsidies altogether in June 2000. This improved the position of mobile carriers at the expensive of the handset manufacturers.[94] More recently, in the first half of 2003, Korea approved collapsing its five mobile carriers into three. In this consolidation of IMT-2000 (W-CDMA) carriers Shinsegi Telecom was

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[91] Kim Shin-Dong, "The Emergence of Homo Telephonicus: Cultural Conditions for the Diffusion of Mobile Phone Technology," 2001.

[92] Han-joo Kim, Sang-kyu Byun, and Myeong-cheol Park, "Mobile handset subsidy policy in Korea: historical analysis and evaluation," *Telecommunications Policy*, 28:1, February 2004, pp. 23-42. ITU, Korea Internet study and see Stephan Haggard, *The Political Economy of the Asian Financial Crisis* (Washington, DC: Institute of International Economics, August 2000).

[93] Han-joo Kim, Sang-kyu Byun, and Myeong-cheol Park.

[94] The ban on subsidies allowed Korea's mobile industry to blame the prices they charged for handsets at home on the MIC. ITU, "Broadband Korea Internet Case Study," 2003, p. 21.

merged into SK Telecom and Hansol M Com PCS was merged into KT Freetel, which was renamed KTF. So as shown below by 2004 the same three companies—SK Telecom, KTF, and LG Telecom—competed in offering wireless services both in the CDMA and the IMT-2000 (3G) arena. As of June 2003 these three mobile companies offered 203 different rate structures from which customers could choose—discounts based on calling habit was in reach even if the system was overly complicated and confusing.

Telecom Industries in Korea

-	**Wireline provider**			**Wireless provider**		**Broadband Internet**	**Wireless Equipment Manufacturer (domestic)**
	Local	**Long-distance**	**International**	**CDMA**	**IMT-2000 (3G)**		
1	KT	KT	KT	SK Telecom	SK Telecom (june)	KT	Samsung Electronics
2	Hanaro Telecom	Dacom	Dacom	KTF	KTF (fimm)	Hanaro Telecom	LG Electronics
3	-	Onse Telecom	Onse Telecom	LG Telecom	LG Telecom	Thrunet Cable	Pantech & Curitell
4	-	Hanaro Telecom	Hanaro Telecom	-	-	Onse Telecom	SK Teletech
5	-	-	SK Telink	-	-	Dacom	KTFT
	-	-	-	-	-	Dreamline Etc.	Appeal Telecom Maxon Telecom Etc.

Source : Recreated based on data from KISDI, “Facilities-based telecommunications service,” 2004; Digital Times; INews24

Korea’s broadband penetration is the highest in the world. The average revenue per user of broadband users is greater by a factor of seven than for narrowband users.[95]

[95] ITU, Birth of Broadband, Executive Summary, p.6.

Its goal is 50 percent penetration on 1 megabit/s broadband by 2005 followed soon by 20 mbps for 84 percent of households. Speed for public institutions in big broadband range. To reinforce its momentum, in 2004 the Ministry of Information and Communication (MIC) announced its "IT 839 strategy" to prepare for the network of future. The plan launches eight service projects, three infrastructure initiatives, and proposes nine new growth engines for the future. The objective is to sustain Korea's leadership in broadband innovation at home and establish Korea as the key hub for IT in East Asia.[96]

The chart below identifies the projects, indicates the goals for 2004, and the mid and long-term goals. To illustrate the process, take one example. Korea has been investing in the portable Internet service WiBro (Wireless Broadband) that will provide high-speed Internet access anywhere anytime, while stationary or on the move as the starting point for the next generation mobile technology. MIC seeks to upgrade subscriber networks and achieve universal access to broadband internet at transmission speeds of at least 1Mb/s shortly and to upgrade the Korean infrastructure so that subscribers can access the internet from PDAs and other mobile devices shortly thereafter.[97] MIC is going through the initial step of selecting standards and licensing carriers and hopes to launch the service in 2006. MIC announced in July 2004 that standard of WiBro will follow IEEE 802.16 specifications, including Intel's WiMax (World Interoperability for Microwave Access) technology and the domestic standard HPI (High speed Portable Internet) jointly invented by Samsung, ETRI, KT, SK Telecom, etc.[98] The Government has said that OFDM by Flarion or ArrayComm technologies offering IEEE 802.20 may be excluded due to technological issues.[99] However, it is an open secret that the Government dislikes their IP model.

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[96] MIC, "Broadband IT Korea Vision 2007," 2004, p. 96.
[97] MIC, "e-Korea Vision 2006," 2003, p. 60, 62.
[98] "Wi-Bro to follow domestic standards," *The Korea Economic Daily*, July 29, 2004 (available at http://news.naver.com/news/read.php?mode=LSD&office_id=015&article_id=0000730348&section_id=105&menu_id=105, in Korean); "Business license for portable Internet to be granted on February 2005", *MIC news*, July 29, 2004 (available at http://mic.news.go.kr/warp/webapp/news/list?section_id=p_sec_3, in Korean)
[99] See "Korean 802.16e Now Global Standard?" Dailywireless.org, March 22, 2004 (available at http://www.dailywireless.org/modules.php?name=News&file=article&sid=2263) for more details.

IT 8-3-9 Strategy: Plan for 2004 & Mid-to-Long Term Goal

	Name of Project	Plan for 2004	Mid-to-Long Term Goal
Services	WiBro Service	Standardization, Establish licensing framework	Service launch ('06)
	DMB Service	License broadcasting station, Service launch	Interactive service ('06)
	Home Network Service	Provide the service to 500,000 homes (VOD/Electronics control)	10 million home network service houses ('07)
	Telematics Service	Establish information center, Pilot project launch	10 million service users ('07)
	RFID based Service	Allocate frequencies, Develop core technologies	Tiniest & cheapest RFID ('07)
	W-CDMA Service	Allow subsidies, Support tech. Development	Nationwide networks across cities ('06)
	Terrestrial Digital TV	End standard dispute, Expand coverage	Nationwide networks ('05)
	Internet Telephony (VoIP)	Establish service framework, Allocate numbers	4 million service users ('06)
Infra-structures	Broadband Convergence Network (BcN)	Develop tech., Establish network for R&D use	20 million users ('10)
	Ubiquitous Sensor Network (USN)	Establish framework, Pilot project launch	Realize u-life ('10)
	Next-Generation Internet Protocol (IPv6)	Support pilot project, Develop equipment	Switch over to all IPv6 ('10)
New Growth Engines	Next-Generation Mobile Communications	Develop portable Internet prototype	Develop 4G mobile communication prototype ('07)
	Digital TV	Develop terrestrial DMB transmitter-receiver	Telecom & broadcasting convergent service server/ devices ('07)
	Home Network	Develop wired & wireless convergent home server	Telecom & broadcasting & games convergent home server ('07)
	IT SoC	Develop multimedia chipset for mobile phones	Develop into one of the three major countries in IT SoC ('07)
	Next-Generation PC	Introduce watch-type PC	Wearable PC ('07)

Embedded S/W	Build embedded S/W in 100 kinds of products	Develop into the second largest producer in embedded S/W ('07)
Digital Contents	Develop multi-platform game engines	One of the three major open source S/W producers ('07)
Telematics	Establish test-bed for tech. Verification	In-vehicle mobile office ('07)
Intelligent Service Robot	Develop humanoid that recognize its master	Global presence ('07)

Source: Ministry of Information and Communication Republic of Korea (2004). IT 8-3-9 Strategy . http://www.mic.go.kr/eng/res/res_pub_it839.jsp

The Korean government has also announced plans to reallocate the 2.3-gigahertz spectrum to a new portable broadband Internet system and has informed the U.S. Government that it will only permit one technology standard to be used for this service. At the insistence of the United States, the Korean government provided a written justification for its one-technology preference in January 2004. The United States and its private sector have found serious flaws in Korea's justification, some of which call into question Korea's adherence to its bilateral and WO commitments."[100]

As broadband progresses, wireline is losing ground to wireless. Local telephony revenues have been dropping sharply and MIC forecasts hat they will be lower in 2007 than they were in 2000. So the focus is turning to wireless. In December 2000 the MIC awarded two licenses for W-CDMA services, one to SK Telecom's SK IMT and one to Korea Telecom's KT IMT. A third license for cdma2000 was awarded to Hanaro Telecom. But when Hanaro Telecom, the sole bidder for the cdma2000 failed to meet minimum requirements, MIC pushed forward and decided to hold another auction to attract new bidders. It then granted a license to LG Telecom for cdma2000 1xEV-DV. The government simply was unwilling to allow the providers only to offer the European-favored W-CDMA approach. They also demanded that that new networks needed to be interoperable with the one that already existed. Since it was more difficult to develop dual-mode terminals to support W-CDMA and CDMA, this pushed more focus among the W-CDMA providers to take the cdma2000 1x market seriously. The result has been

[100] USTR Foreign Trade Barriers, pp. 317-318

the fastest deployment of 3G anywhere. The W-CDMA status remains in flux. It has been pushed on two or three carriers by government policy, but it is not being implemented rapidly by the carriers.[101] However, as MIC allowed the adoption of cdma2000 1x EV-DO service for all three providers, SK Telecom and KTF have been focusing on the expansion of existing EV-DO rather than W-CDMA which has had technical problems and a higher risk due to the cost of requiring a larger-scale network upgrade.[102] The goal for mobile wireless is 2 mbps which government claims is best achieved by W-CDMA. The government has pushed plans to make Korea a leader in creating 3G experience in Asia. It also has given major support for NGN that is defined as allowing seamless high speed convergence of fixed and mobile on IPv6 architecture. To this end, it is working with China and Japan to support open source software and 4G. In addition, Government R&D is especially on software defined radio and OFDM. Emphasis is placed on Korean IP or patent pooling among all suppliers with no IP fee being paid. This approach is meant to help Korea get its equipment to market rapidly, at low cost, and excellent design. (Leading Korean manufacturers are investing heavily to achieve "cool" designs that will attract users.)

[101] For W-CDMA service, SK IMT by SK Telecom and KT Icom by KT were selected, and for cdma2000 1x EV-DV service, LG Telecom was selected. *Digital Times*, October 29, 2003. KTF provided a trial service for W-CDMA (*G-Cube*) in September and October 2003, which has revealed problematic issues in handset and service qualities.

[102] *Digital Times* (October 29, 2003). KTF provided a trial service for W-CDMA (*G-Cube*) in September and October 2003, which has revealed problematic issues in handset and service qualities. H.-Y. Park and S. G. Chang, Mobile Network Evolution toward IMT-2000 in Korea: A Techno-economic Analysis. *Telecommunications Policy*, 28(2), 2004. 177-196.

Appendix C

China

In recent years China's transformation of its communication and information infrastructure was extraordinary. But China is still a largely unfinished piece of work. China is the world's largest cell phone market and the world's [X] computer market, but it still lags most global benchmarks for connectivity. Its talented and comparatively inexpensive technical cadre is impressive, but the country still trails on R&D spending and little new IP is produced.

China introduced competition in telecom, but a study by the National Bureau of Asian Research emphasizes the influence of the Japanese and Korean models on Chinese strategy. The NBR report characterizes Beijing's policy as "neo-techno-nationalism" that uses the leverage of its fast-growing market to create advantage and export possibilities. Despite large absolute gains China seeks greater relative gains vis-à-vis international technology leaders. But as NBR acknowledges, globalization tempered this model, especially after China joined the WTO.[103]

China's flirtation with industrial policies is not guided by a tightly focused strategy. Its leadership recognizes that market competition has rejuvenated the economy and it has a vested interest in perfecting the market. The Communist Party made an enormous gamble that the practical benefits, and legitimacy, conferred by rapid economic growth could sustain it in power. In addition, the political leaders are eager for major, visible successes in glamorous global markets to trumpet to its people. Yet, the political capacity for such a policy mix is imperfect.

China is not democratic, but politics still matter. The Chinese government is organized by the Communist Party, but rests on a system of political bargaining and promotion with elements of federalism because fiscal policy is decentralized and provincial officials vie for influence.[104] The politics are intense and a competitive pork

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[103] Richard P. Suttmeier and Yao Xiankgul, «China's Post-WTO Technology Policy: Standards, Software, and the Changing Nature of Techno-Nationalism » National Bureau of Asian Research Special Report No 7, May 2004.

[104] Susan Shirk, *The Political Logic of Economic Reform in China* (University of California Press, 1993) and Gabriella R. Montinola, Barry R. Weingast and Yingyi Qian "Federalism, Chinese Style: The Political Basis for Economic Success in China" *World Politics* 48 (1) (October, 1995):50-81.

barrel model often applies. As in other countries, local leaders compete for foreign direct investment in technology production and national leaders seek to share research and production over a wider geographic region.

China is subject to technology strategies that are distorted by attempts to frame benefits in ways that allow leaders to take credit for the benefits. To do so, leaders concentrate on choices that yield concrete gains that are easy to publicize. These incentives for governments are important for China's ICT strategy because government plays a larger role in total R&D and technology innovation decisions than in countries like the United States.[105] An astute study of the Chinese software industry notes that the Chinese government strategy reads like a textbook of the "credit taking" syndrome.[106] China prefers hardware over software, and consequently has weakened the development of the Chinese software industry, especially for domestic uses. The failure to enforce intellectual property rights is effectively a transfer of rents from software to hardware exporters whose growth is trumpeted in the *People's Daily*.

The political side of ICT policy also is evident in China's effort to balance globalization and political control. Policies on Internet Cafés are indicative–in 2004 the government announced that it would bring all Internet cafes under the umbrella of a dozen groups, each of which can be more effectively watched and regulated.

Politics and inter-ministerial struggles shaped the initial policy of telecoms privatization and competition. China partly privatized its traditional monopolist, China, Telecom, and then introduced wired competition through Unicom, a new entrant backed, and partly owned, by powerful ministries (especially the army). The struggle over competition policy to guide the struggle of Unicom reflected ministerial rivalries. When introducing competition in local services the government divided up territory between China Telecom and Netcom. (Netcom was awarded Beijing and ten of the poorer Northern provinces in addition to a license to build a broadband net.) China is still working on a general interconnection model between carriers. On wired they are looking at long-run incremental cost. The more significant decision for competition was the

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[105]OECD Science, Technology and Industry Scoreboard 2003

[106]Mingzhi Li, and Ming Gao, 2003, Strategies for developing China's software industry, *Information Technologies and International Development*, Vol. 1, issue 1, pp. 61-74

choice to retain a discretionary spectrum allocation and licensing system that leaves huge power with the ministry.

The more significant decision for competition was the choice to retain a discretionary spectrum allocation and licensing system that leaves huge power with the ministry. The Ministry was determined to minimize the chance of economic embarrassment with political consequences. It therefore introduced a duopoly in mobile wireless by spinning off China Mobile from China Telecom and giving a wireless license to Unicom. The Chinese Ministry of Information Industry (MII) then intervened in pricing management by declaring that Unicom could offer a discount off of the China Mobile rate because it was a new entrant. (More recently, MII declared that interconnection between mobile carriers will be at a flat rate that is identical for all carriers.) The current array of ICT players is indicated in the table that follows.

Telecom Industries in China

	Wireline provider			**Wireless provider**		**Broadband Internet**	**Wireless equipment Manufacturer (domestic)**
	Local telephone	**Long-distance telephone**	**International telephone**	**CDMA**	**IMT-2000 (3G)**		
1	China Telecom	China Telecom	China Telecom	China Mobile	License not issued yet	China Telecom	Motorola
2	China Netcom	China Unicom	China Unicom	China Unicom	-	China Netcom	Bird
3	China Railcom	China Netcom	China Netcom	-	-	China Railcom	TCL Mobile
4	China Unicom	China Railcom	-	-	-	-	Nokia
5		-	-	-	-	-	Konka
	-	-	-	-	-	-	Amosonic, Soutec, Samsung, Etc.

Source : Recreated based on data from China MII (Ministry of Information Industry) report; Chinese Academy of Telecommunications Research

The Ministry treats these deci   sions as more than an exercise in competition policy. It also wants to preserve the value of state ownership stakes in the carriers and make the companies successful on global equity markets. This mixed set of interests within the government means that MII has the paradoxical characteristic of seeming to be powerful and at times totally ineffectual as its orders are defied by carriers protected by other parts of the government.

The government was heavily involved in technical standards and technology choices. This jawboning was a response both to external trade pressures and to the desire to promote Chinese technology. Thus, China Mobile and Unicom use GSM on their older networks, while Unicom's newer premium network features CDMA technology. This choice occurred partly because Unicom management saw CDMA as a better business opportunity to pursue high-end customers and partly because the Chinese Government, after much political discussion, decided that the Ministry could not deny Unicom's choice without appearing to be discriminating against U.S. technology.

As the wireless market boomed, the wired network carriers sought a share but could not get licenses. The solution was to pursue the Japanese systems for limited mobility wireless (PHS). MII opposed this PHS rollout by China Telecom and Netcom, but the carriers defied the order and now have 50 million subscribers. Given the cheaper infrastructure for low mobility, they can offer discounts that undercut the mobile carriers.[107] This pressures margins on the mobile carriers just when China wants them to launch 3G.

The arrival of 3G has shown much the same mix of attempted industrial policy, in-fighting, and prolonged decision-making. MII promised that it would issue four 3G licenses. The plan was to grant licenses to the incumbents plus one license to China Telecom and one for either China Satcom or a foreign operator. The MII make the licensing decisions; there are no auctions. Technology choices are tied to licensing. MII expects China Telecom to use TD-SCDMA, a Chinese backed standard (discussed below) and China Mobile to employ W-CDMA, the variant pushed by Europe. China Unicom would employ CDMA2000. This scheme faces issues because China Mobile estimates the cost of rolling out a 3G network at $7 billion. SASAC, the holding

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[107] *The Economist*, "Disconnected," August, 28, 2004, p. 59,

company for state share holding, is worried about the return on their investment in the mobile carriers if they are pushed to adopt TD-SCDMA because TD-SCDMA has no commercial track record. As a result of these pressures MII is now discussing consolidation of all Chinese carriers with China Mobile acquiring Netcom and China Telecom getting Unicom.[108] Thus, China lags on 3G roll out but, for reasons discussed shortly, is actively proclaiming its desire for 4G.

More generally, the 3G issue is a window into the way in which China is trying to blend market forces, R&D, and industrial policy to advance its high tech future in ICT. The Government has especially relied on four policy tools in addition to subsidies for high tech industrial parks and government R&D. First, like many countries China uses proactive government procurement policies to encourage technologies that it desires. The experiments on procurement favoring Linux over Windows are an example. Second, China leverages its huge market by using a mixture of tools to force foreign suppliers in China to deploy manufacturing (and research) of advanced technology in China and then promoting exports from China. For example, ZTE, now exports CDMA equipment to ten countries because foreign firms know that helping it with exports is important.[109] But China often is divided on which strategy to promote. Third, the Government uses an array of tools to bargain on behalf of Chinese firms over their terms for licensing foreign IP. For example, one reason why MII delayed 3G licensing was to get better IP fee terms for Chinese manufacturers.[110] Finally, imposing proprietary technology standards for China are a visible way of trying to organize the market.

Private initiatives and public private partnerships in standard setting are growing ever more complex in China. China would like to set some key standards for Chinese and foreign firms operating in China, but often competing standards move up through the bureaucracy and China tends to embrace both domestic standards rather than to choose. "There is too little coordination between development goals set by China's industry-based ministries and the Ministry of Science and Technology. … Oftentimes, their goals are at odds given the fact that some ministries (including the Ministry of Information

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[108] This is occurring just as Netcom is seeking an equity share in PCCW's wired network in Hong Kong. *The Economist*, August, 28, 2004, p. 59.
[109] An example is 1.9 GHz system for CDMA WLL in Algeria. *Telecom Insider*, September 2003.
[110] *Telecom Insider*, September 2003.

Industry) still have a financial stake in the industries they oversee."[111] Chinese standards have been less efficient than international standards, but so far Chinese standards have not been embraced anywhere outside of China.

Elements of industrial policy often get blended with claims concerning national security. The most prominent case involved WAPI (WLAN Authentication and Privacy Infrastructure) encryption technology. The Government directed foreign firms to work with Chinese competitors and perhaps reveal IP secrets to facilitate WAPI. Eventually, firms like Cisco successfully argued, with vigorous help from Washington, that this was a violation of national treatment to products imported into China. In April 2004, China delayed implementation indefinitely.

The same pattern emerged in 3G. Siemens lost the debate over the specification of the 3G standard in the EU and brought its preferred (but rejected) standard to China in an attempt to salvage value from its effort. After working with Chinese research institutes on its refinement (whereby the Chinese researchers created their own IP), China decided to proclaim TD-SCDMA as "made in China" and took it to the ITU for approval as a 3G standard. Some Chinese advocates argued that TD-SCDMA could build economies of scale in China and then compete on export markets. Given the China first deployment, Chinese manufacturers would have early learning on the production and deployment systems.

The case of TD-SCDMA shows why China is interested in 4G. It is unlikely that TD-SCDMA could avoid the standard licensing fees paid on all forms of CDMA, the core technology. It is also late to the 3G deployment market. In contrast, China's enthusiasm for 4G is partly because there are no established global standards for 4G. Thus, China can try to use its market size to manipulate the market without running into complications over violating WTO rules by substituting national for global standards or violating intellectual property holdings of foreign firms.

So, China scores low on broadband wired speed. It is interventionist on technology choice. It is reluctant to allow radical spectrum reform. It has a policy geared to support export manufacturing and to get deployment to all. 4G is less about speed and

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[111] Kathleen Walsh, Foreign High-Tech R&D in China: Risks, Rewards, and Implications for US-China Relations, Stimson Center, 2003. http://www.stimson.org/techtransfer/pdf/FinalReport/pdf

more about market opportunity. The ability to achieve policy coherence is limited, but 4G remains an attractive market with clout**.** One further complication for innovation in China is the effort to retain political oversight over the use of information networks. While restrictions on freedom of expression can sometimes drive specialized forms of great art, it is harder to know its consequences for commercial innovation that tries to leverage learning from the experiences and experiments of users.