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China and the Knowledge Economy

Seizing the 21st Century

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Foreword

China has made impressive achievements in economic growth and poverty reduction over the last quarter century. Now it faces daunting internal challenges such as ensuring employment to millions over the coming decade, continuing to maintain high growth, increasing its international competitiveness, and reducing income and regional inequalities. Compounding these challenges is the new knowledge and information revolution. To prosper in this new era, China must welcome the knowledge revolution and make effective use of knowledge in its agricultural and industrial sectors, and especially in developing its service industry. China also needs to manage the transition to an environmentally sustainable economy that better utilizes its relatively limited natural resources.

This book outlines the main challenges that China faces in its future development, and the importance of shifting from a factor-based to a knowledge-based strategy. It presents a long term strategy for China that integrates key knowledge-related policy components, improving relevant economic incentives and institutions, upgrading the education and training system, building the information infrastructure, and strengthening the innovation and research system. It concludes by suggesting concrete steps for implementing the proposed strategy.

To take advantage of this unprecedented opportunity, the book recommends that the government withdraw further from hands-on management of the economy and take on a new role—that of an architect of appropriate institutions and provider of incentives to establish a new socialist market economy based on knowledge.

China and the Knowledge Economy: Seizing the 21st Century has been developed by the World Bank Institute in collaboration with the East Asia and Pacific Region of the World Bank. These two groups have been working closely together over the past years to support East Asian countries in developing knowledge strategies and pioneering new approaches to remain competitive in the Knowledge Economy. Our hope is that this book will provide useful insights for Chinese policymakers and other countries as they embark on transforming their economies to ones based on knowledge.

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During the course of preparing this report, several missions visited five Chinese cities (Beijing, Guiyang, Shanghai, Suzhou, and Wuhan) to collect information and conduct broad consultations with Chinese officials, entrepreneurs, managers of foreign-owned enterprises, scientists, diplomats, and staff from international organizations. We are also indebted to the high level Chinese team that attended the Policy Forum on *Using Knowledge for Development,* at Wilton Park, United Kingdom, March 19–25, 2001. We would like to acknowledge the contributions made by Ma Songde, Vice Minister, Ministry of Science and Technology, Angang Hu and Lan Xue, Tsinghua University, Tian Xiaogang, Ministry of Education, and Huijiong Wang, Development Research Center of the State Council. Useful comments have also been received from Justin Lin, Peking University, Xiaoxi Li, State Council Research Office, and from Xiuyu Chen, Ministry of Information Industries.

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Contents

Appendix box

Figures

Box figure

List of tables

Appendix tables

Abbreviations

CURRENCY EQUIVALENTS

(As of June 4, 2001)
Currency Unit = RMB
$1.00 = RMB 8.2770
RMB 1.00 = $0.1208

CAMP	China Accelerated Management Program
DGT	Directorate General of Telecommunication
ETRC	Engineering Technology Research Center
FDI	Foreign direct investment
GERD	Gross Domestic Expenditure on Research and Development
GDP	Gross Domestic Product
GNP	Gross National Product
HEIs	Higher education institutions
ICRG	International Country Risk Guide
ICT	Information and communication technology
IMD	International Institute for Management Development
IT	Information technology
KBE	Knowledge-based economy
MII	Ministry of Information Industry
MNCs	Multinational corporations
MOE	Ministry of Education
MOST	Ministry of Science and Technology
NERCs	National engineering research centers
NETRC	National engineering technology research centers
NNSF	National Natural Science Foundation
OECD	Organisation for Economic Co-operation and Development
R&D	Research and development
S&T	Science and technology
SME	Small and medium-size enterprises
SOEs	State-owned enterprises
TVEs	Township and village enterprises
WBI	World Bank Institute
WHO	World Health Organization
WTO	World Trade Organization

Executive Summary

China faces daunting internal challenges compounded by the knowledge and information revolution

For a large part of the last two millennia, China was the world's largest and most advanced economy. Then it missed the Industrial Revolution and stagnated. Only after opening to the outside world in 1979 was China's economic performance again impressive. And its achievements in increasing welfare and reducing poverty are unparalleled. But China cannot sustain such progress without major changes in its development strategy, as elaborated recently in the tenth five-year plan.

China faces daunting internal challenges compounded by the knowledge and information revolution. To overcome these challenges the Chinese government must take on a new role to quickly exploit the knowledge revolution—architect of appropriate institutions and provider of incentives to promote and regulate a new socialist market economy based on knowledge.

China's strategy will have to build solid foundations for a knowledge-based economy by:

- Updating the economic and institutional regime.
- Upgrading education and learning.
- Building information infrastructure.

China must also raise the technological level of the economy by:

- Diffusing new technologies actively throughout the economy.
- Improving the research and development system.
- Exploiting global knowledge.

Facing daunting internal challenges

China faces two dramatic economic transitions: from an agricultural to an industrial and service economy—and from a command to a socialist market economy. In addition, it faces other challenges due to its large size and present growth trajectory.

Providing employment

In this decade, conservative estimates place necessary job creation within China at 90 to 100 million to take in the projected 40 to 50 million people released

from agriculture, those from state-owned enterprises and town and village enterprises, as well as the new entrants to the labor force. However, other estimates have placed required job creation much higher—anywhere from 200 to 300 million. Already, effective unemployment is about 10%, and regardless of which figures are accepted, the creation of job opportunities is on the top of policymakers' list of priorities.

Most jobs created have come from low-skill industries. But China's share in services is smaller than would be expected for a country at China's stage of development due to past policy biases toward industry and against the service sector.

China's international competitiveness is declining, so it needs to improve its productivity

Most new jobs will be in informal service employment and basic infrastructure services (construction, transport, telecommunications), retailing, tourism, and commerce. But many should also be in small, private high-value business services—such as marketing, logistics, distribution, financial, consulting, and management. And many should be in other professional services historically underdeveloped in China but critical in knowledge-based economies.

Maintaining growth and international competitiveness

China's fast growth has been possible thanks to shifts of workers and resources from low productivity agriculture to industry—and to very high rates of both domestic and foreign investment. But maintaining economic growth will be difficult with the drag of large, inefficient state-owned enterprises and a financial sector burdened with nonperforming loans.

Furthermore, according to some rankings China's international competitiveness is declining, so it needs to improve its productivity. Average worker productivity in agriculture is a mere 0.8% that in the United States; in manufacturing it's 3.6%. Ironically, as China boosts productivity it will need less labor, exacerbating unemployment, unless there is increased demand for Chinese goods and services. A critical element of China's new strategy will be to diversify its goods and services by taking advantage of new knowledge.

Reducing income and regional inequalities

China's fast growth has been concentrated in the coastal regions, those most open to international trade and receiving the most foreign direct investment. GDP growth rates in the central and western provinces have been significantly slower. Inequalities are also growing. Some people have access to capital, education, and other assets—and connections to use them to exploit business opportunities. Others still rely primarily on their own labor in subsistence agriculture or in low-productivity enterprise.

China's diversity is exceptional. It is a very large country with considerable disparities among regions, cities, and industries. The third world coexists with the first world in China's advanced regions. In the vibrant cities of the east, extremely dynamic enterprises and universities operate in high tech parks benefiting from brand new infrastructure. In nearby cities, and of course in distant western provinces, poverty is broadly spread, not only in terms of income but also in knowledge, education, and information infrastructure. Any knowledge strategy will have to take full account of such diversity.

China must shift away from resource-intensive development and move efficiently into services and knowledge-based development

Sustaining the environment

Degraded water quality has damaged agriculture, ecosystems, and fisheries—with air pollution becoming a serious threat to the economy and the people. More than 2 million deaths occur each year from air and water pollution, the result of rapid industrialization and urbanization. The depletion of China's already scant supply of forests, water stocks, and other natural resources is adding to the significant constraints on the enormous population. China must shift away from resource-intensive development and move efficiently into services and knowledge-based development.

Confronting the global knowledge revolution

Adding to the challenge of China's development is the "revolution" in the production and dissemination of knowledge. Effective use of policy and technical knowledge has always determined the process of economic development, explaining in large part the differences in countries' levels of development. Today that knowledge is even more important:

- Advances in scientific and technical knowledge make possible the information and communication technology revolution, the engineering of materials at the molecular level, and even the development of new life forms through biotechnology.
- Rapid reduction in the costs of transportation and telecommunications spur the integration of previously disparate economies through trade and other international exchanges.
- Digitization and informatization of numerous activities reduce transaction costs and increase productivity.

These trends herald a new era characterized by:

- Development of a service-based economy, with activities demanding intellectual content becoming more pervasive and decisive.
- Increased emphasis on higher education and life-long learning to make effective use of the rapidly expanding knowledge base.

- Massive investments in research and development, training, education, software, branding, marketing, logistics, and similar services.
- Intensification of competition between enterprises and nations based on new product design, marketing methods, and organizational forms.
- Continual restructuring of economies to cope with constant change.

Knowledge and information are thus becoming the key drivers of international competitiveness and the global economy, making it crucial to respond rapidly and efficiently to changes. Partly as a result of a high growth rate, but also because of the knowledge revolution, China faces a period of wrenching and continual restructuring affecting all sectors, as noted in the tenth five-year plan.

China has to open more and harness the forces shaping the global economy, leapfrogging to take advantage of rapidly evolving technologies

To compete and prosper in this new environment, China has to open more and harness the forces shaping the global economy, leapfrogging to take advantage of rapidly evolving technologies. It must welcome the knowledge revolution, which, though it presents considerable challenges, also grants significant opportunities to make China's development sustainable by:

- Improving competitiveness of existing agriculture, industry, and services—and saving jobs.
- Developing new activities, services in particular, to create new jobs and new sources of wealth.
- Facilitating the transition to a more sustainable and environmentally friendly economy that makes more effective use of China's relatively limited natural resources.

Adapting China's development strategy

China has already taken a number of measures to cope with these challenges and exploit these opportunities. Science, technology and education were put at the forefront of development policy in the mid-1990s. Investments in information infrastructure have been considerable, and a reform process is actively pursued in a myriad of fields to adapt the economy and society and prepare them to enter the World Trade Organization (WTO).

China's tenth five-year plan clearly focuses on economic development and restructuring (largely moving out of agriculture, upgrading industry, and moving into services). It emphasizes dealing with inequality and regional imbalances, sustainability, social security, and continuing market reform. Science, technology, and education are again given a prominent role for driving the change. The plan spells out China's goals, but does not detail a path to achieve them. This report offers specific policy recommendations in the context of the broader ideological and political shift needed to address the growing social, political, and economic pressures of the 21st century.

The policy recommendations are primarily addressed to the central government, but some concern provincial and local governments, which play a significant role through control of some 70% of the national budget and through influence on local enterprises, judiciary systems, schools, and other aspects of Chinese society.

Updating economic incentives and institutions

The main change will be the new role for the state. The government must move farther from controller and producer to becoming the architect of a new socialist market and knowledge-based system, a system that is more self-regulating through appropriate market-supporting institutions. The government has already been engaged in a vast array of bold structural reforms to adapt the Chinese economy. Market-supporting institutions need to be actively built in six areas that support and shape a vibrant knowledge-based economy.

The government must move farther from controller and producer to becoming the architect of a new socialist market and knowledge-based economy

- *Strengthening the legal and regulatory framework for supporting entrepreneurial capabilities.* To tap the creative and entrepreneurial capability of people, it is important to establish a clear rule of law and clear property rights that allow people to enter contracts and expect that they will be honored. This requires not just transparent and stable rules but also their fair enforcement, with no exceptions or special privileges. This also means reducing all forms of bureaucracy that impede innovation. Much further progress is needed on all these issues.
- *Promoting economic competition.* Providing stronger pressure to make effective use of knowledge for development involves reducing barriers to foreign trade, which China is addressing by joining the WTO. But it is also necessary to reduce the internal barriers to the free flow of goods and services across Chinese provinces—and establish effective competition-promoting agencies to address domestic and foreign competition.
- *Strengthening the financial system.* Finance—and the key institutions and rules that regulate it—are the "brains" of a market and knowledge-based economy, because they process information to allocate capital to its most efficient use. What does this require? Improving the risk assessment and supervision capability of banks. Developing an effective stock market with appropriate disclosure rules and safeguards against insider trading and effective governance of traded firms and financial intermediaries. Encouraging the venture capital market—to finance entrepreneurs with new ideas. And putting in place appropriate bankruptcy legislation to redeploy the productive assets of failed enterprises to new economic uses.
- *Facilitating labor market flexibility.* The rapid transition from an agricultural to an industrial economy and now to a service economy—compounded by China's eventual full accession to the WTO—creates a massive need

for mobile labor. But its labor market is severely constrained by rules restricting mobility—and by the old system that tied the health and housing benefits to enterprises.

- *Developing an effective social security system.* Reforms in the unemployment insurance and pensions systems are critical to ensure that labor is redeployed to more productive activities. It will be necessary to facilitate productive employment of the millions of workers not yet part of the formal employment system, particularly the large floating population in urban areas and the millions of underemployed in agriculture.
- *Promoting the growth of small and medium-size enterprises.* A key element of the employment promotion strategy should be promoting small and medium-size industries. Proactive measures will create a more even playing field by reducing the biases toward large state-owned industries and encouraging development of small and medium-size industries across all economic sectors. These measures include reducing the regulatory hurdles to establishing new enterprises and providing them access to finance, technical and marketing information, and business skills.

Improving education is perhaps the most critical reform for the medium and long runs

Upgrading education and learning

Higher education and greater skills are fundamental in a knowledge economy. But despite tremendous improvements, the average educational achievement in China is still low. This is perhaps the most critical reform for the medium and long runs. China is endowed with a gigantic and growing population, the raw material for a knowledge economy. But people must be educated and taught to be creative, with the ability to learn through their lives.

Centuries of Confucian tradition, decades of planned-economy regime, and emphasis on rote learning rather than creative thinking has shaped Chinese philosophies and methods of teaching. Most government support has gone to basic education, creating a very literate population. Now there is demand for well-trained, state-of-the-art, business-oriented people. This demand is being satisfied by a thriving private higher education sector, which, for ideological reasons, is not officially recognized.

Some of the major initiatives needed:

- Modernize the curriculum at all levels to provide the new basic skills that the knowledge economy demands. Beyond solid core skills in reading, writing, and arithmetic are computer and Internet skills—and the ability to think creatively to be able to adjust to constantly changing job needs and skill mixes.
- Increase the efficiency of current spending by introducing better outcome indicators.

- Integrate the private higher education system into the official system.
- Redirect the national and provincial ministries of education from primarily providing education to assuring the quality of the educational system and facilitating its proper functioning, particularly for higher education.
- Focus on equity and develop programs to ensure that talented but poor students have access to education, especially to higher education.
- Renovate the training and vocational education system to make it more responsive to local business needs and initiatives.
- Provide retraining programs for the millions of displaced workers so they can find alternative productive jobs.
- Tap the enormous potential of Internet-based education to provide the above-mentioned skills and to expand the outreach of formal education at all levels, making use of an already well-developed distance learning infrastructure.

China needs to promote greater use of information and communication technologies throughout the economy

Building information infrastructure

Dynamic telecommunications and information infrastructure is critical for leapfrogging into the knowledge economy, something the tenth five-year plan does not emphasize sufficiently. Such infrastructure reduces transaction costs, provides economies of scale, and overcomes some constraints of distance. China still lags behind most East Asian countries in telephones, computer, and Internet connections per capita.

Most of the economy has limited and poor quality access to information infrastructure. Some actions to improve the situation include:

- Promote greater competition by further opening markets dominated by China Telecom and other state-owned enterprises.
- Create an independent regulatory body.
- Open more to foreign investment as a source of capital and technical expertise for information technology services.
- Expand Internet access and promote development of domestic content on the Internet.
- Promote greater use of information and communication technologies throughout the economy, such as: giving technical support to small and medium-size enterprises; improving the efficiency of the banking system, including electronic banking, payment systems, and a national credit rating system; and delivering Internet-based education and health services.
- Promote electronic commerce—business to consumer and business to business. This will require electronic payments systems, security, electronic signatures, and a proper legal framework to settle domestic an international electronic commerce disputes.

- Promote electronic government to improve the efficiency of interaction among government ministries, efficiency of tax collection and budget management, as well as its accountability and interactions with the public.
- Promote massive training in information and communication technologies.

Diffusing technology throughout the economy

There is a need to dramatically improve dissemination and use of technology and related knowledge

Modern industrial infrastructures have been primarily concentrated in some fifty "high tech" parks established along the coast. But these are small islands in the less productive economy. There is a need to dramatically improve dissemination and use of technology and related knowledge, including greater transfer of knowledge from the most efficient producers in each sector to the least efficient. Performance disparities within industries among the different regions are daunting and contribute to severe economic and social tensions.

A better functioning market economy system is a prerequisite for efficient knowledge and technology dissemination. The most effective means of dissemination are expansion of efficient enterprise and promotion of private suppliers—of equipment, specialized inputs, and technical and managerial services for all sectors. Upgrading the economic incentive and institutional regime, as outlined above, is critical to stimulate the growth of these specialized providers and facilitate access to the capital and other resources they need to grow and thrive.

To complement this market-based technology diffusion process, the government, working in concert with local and provincial governments and through joint funding, should:

- Give higher priority and greater resources to technology dissemination schemes: engineering, research and productivity centers, renovated programs for rural industries, extension services in agriculture, and regional technical centers to support small and medium-size enterprises.
- Further support—by appropriate, decentralized funding schemes—to innovative enterprises, particularly in the small-scale sector
- Facilitate the establishment of incubators—which can support new technology-based enterprises throughout the country—and the development of regional clusters for the renewal of local economies.
- Strengthen the development and use of technical standards, a critical mechanism to stimulate the diffusion of modern technologies, but considerably neglected in China.

Strengthening the research and development system

Important and drastic reforms have been implemented over the past decade to adapt the R&D system inherited from the planned economic regime and

to reorient the research effort by launching government programs. These actions have contributed to dynamic and fruitful interactions among all actors, but problems remain. In the rush to the market the government has strongly reduced funding for government institutes and encouraged them to privatize. But it may have gone too far. Basic and precompetitive research—and areas of special social concern, such as health and environmental research—are underfunded. Moreover, government R&D programs are being designed and implemented with no involvement of the enterprise sector and other end-users. The government should:

- Increase public support for basic research and channel more public research funds to such pressing problems as promoting agriculture, protecting the environment, and exploiting China's traditional strengths.
- Reform applied and technical government R&D programs and involve enterprises in their design and implementation.
- Use technology foresights to identify areas where China should allocate its research efforts while improving the monitoring and evaluation of public spending.
- Strengthen the research capabilities at Chinese universities and better regulate their relations with the market.
- Encourage the productive sector to do more research on its own by incentives directed to smaller enterprises and improved government programs.
- Support greater collaboration among domestic researchers and with foreign researchers through expanded bilateral programs and development of information technology-based research networks.
- Promote greater awareness of the importance of intellectual property rights and encourage Chinese researchers and companies to patent more—in China and abroad—to protect their interests.

The government should increase public support for basic research, encourage the productive sector to do more research on its own, and promote greater awareness of the importance of intellectual property rights

Exploiting global knowledge

One reason for the rapid increase in global knowledge is the massive investment in global R&D. China's R&D spending is only 0.66% of the world's, so China needs to tap into the rapidly growing stock of global knowledge. Since opening to the world, China has been importing more capital goods, components, and high-technology products—and increasing foreign direct investment, technology licensing, foreign study, copying and reverse-engineering, and acquiring technical publications. The tenth five-year plan appropriately emphasizes opening even more to the outside world, but China could be even more aggressive by:

- Improving the general business climate, the rule of law, and the enforcement of intellectual property rights—all important considerations for foreign investors.

- Attracting foreign investment in areas of strategic interest to China. So far foreign investment has been concentrated in manufacturing activities, along the coast, and more than 60% has been of Chinese origin (Hong Kong, China; Macao; Singapore; and Taiwan, China). Measures need to be taken to diversify sectoral distribution and origin of foreign investment.
- Opening more to foreign investment in services. Foreign investors have tremendous expertise in finance, insurance, logistics, sourcing, marketing, distribution, customer relations, branding, training, consulting, R&D, and managing intellectual capital—and China needs to take advantage of all of this intangible knowledge.
- Being more proactive in acquiring disembodied technology through licensing and other payments instead of relying so strongly on technology embodied in capital goods.
- Developing more strategic alliances with multinational corporations, particularly before fully opening to free foreign investment inflows—to build domestic capability in critical areas.
- Undertaking more joint public and private research with foreign firms and public R&D centers and buying foreign companies and research labs to acquire foreign knowledge, as was done by Japan, the Republic of Korea, and Taiwan, China.
- Turning the Chinese brain drain into a brain gain (of the 330,000 students recently sent overseas for training, only 110,000 returned) and using the technical and managerial capacity of the overseas Chinese community by providing a very receptive domestic environment to turn their ideas and expertise into value in China.

China will have to find its own way of resolving the tensions and contradictions of moving from its past legacy

Moving to action

This report has a long list of recommendations. These include reforms that are fairly easy to implement and need no additional resources—only a change of emphasis or policy. The list also includes reforms that need financial resources, requiring budgetary priorities, as well as reforms that require major policy and political shifts. Perhaps the most difficult recommendations are the proposed change of the role of the government, the development of a dynamic private sector, and the establishment of a clear rule of law.

Such changes cannot happen overnight. They require a change of mindset that may not be consistent with past ideology and practice. And there is a delicate balance to be achieved. Moving too fast could risk social and political stability because of the adjustment costs. But moving too slowly could cause social instability because of the pressure of rising unemployment.

There is thus no readymade solution. China should look at the experiences of others and adapt them to its context. China will have to find its own way of resolving the tensions and contradictions of moving from its past legacy to respond to the new demands. Some suggestions:

• *Prioritizing and budgeting.* Though reforms in all policy planks must proceed together in a systemic way, setting priorities and sequencing reforms in each of these planks are also indispensable. This requires identifying the most pressing problems and the best solutions, with an estimate of resources needed and potential financing (including from the private sectors and foreign investors). Priority actions are suggested below (box 1). Most of these measures have low costs in the short run. They have been selected because of their leverage on job creation—the most important challenge that China faces in the short and medium terms. The proposed actions have also been selected with a view to mobilizing resources for longer-term massive investments. The measures, which mostly address improving the institutional and regulatory framework affecting the different policy planks, will help involve non-state actors in all key areas: the innovation system, information infrastructure, and education. The efficiency of the economy should then be increased, facilitating funding for more expensive longer-term investments.

• *Coordinating action.* Promoting a knowledge economy, as most successful countries have shown, requires coordinated action across multiple domains:

Though reforms in all policy planks must proceed together in a systemic way, setting priorities and sequencing reforms in each of these planks are also indispensable

BOX 1

Priority actions in moving toward the knowledge economy

- Pursue reform of the economic incentive and institutional regime through the rule of law and its enforcement, property rights, a clearer regulatory framework, stronger economic competition, and extracting political influences from business management.
- Take steps toward further reform of the education system, starting with a nationwide evaluation of students' literacy adapted to knowledge economy requirements. Establish regulations that facilitate integration of the private sector into the formal education system and exploit opportunities for a learning grid based on information and communication technologies.
- Improve the regulatory framework for the information infrastructure, with an independent regulatory agency; promote greater competition in the monopolized basic telecom market; open up more broadly to foreign investors; provide greater freedom on the Internet and expand access to it.
- Diffuse new technologies throughout the economy by strengthening technical standards and related infrastructure, supporting new businesses and other agents of technology dissemination, and multiplying local support structures of information and technical assistance.
- Reform government research and development programs to bring in the business sector, increase "core funding" to selected networks of public and university institutes, and use technology foresights to make informed choices with help from foreign and Chinese expatriate experts.
- Attract foreign investors in strategic areas, particularly service sectors; facilitate global technological alliances for Chinese enterprises; and intensify incentives for Chinese overseas to come home.
- Promote massive training of public officials to adapt the management of the economy and society to more knowledge-based development: the new party cadres and high-level civil servants, government program managers, and government officials from provincial townships.

finance, trade, industry, science, education, infrastructure. And that requires systemic action coordinated at the highest level—preferably the Premier of the State Council. Every effort should be made to foster this systemic approach—at the central, provincial, county, and municipal levels. Fast developing regions in China (and elsewhere) have clearly designed and implemented integrated programs.

- *Sharing experiences.* Given China's tremendous diversity, it already has many examples of successful knowledge strategies—such as Shanghai, Beijing, and some of the advanced coastal provinces, such as Jiangsu and Shenzhen. There should be regular forums for exchanging rich experiences across provinces or even smaller regions. Seeing what others have accomplished can motivate local governments to act.
- *Experimenting with reforms and programs.* Following a well-established Chinese practice, learning what works best under different circumstances and then expanding the successful cases is another important way to affect this transition. This should be done more aggressively by launching coherent programs to promote more effective use of knowledge in specific regions, building on their strengths.

China's leadership must not waver in driving this transition or backtrack on reforms already in place

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China is at a critical juncture in its development strategy, caught between daunting internal challenges and a demanding external environment driven by rapidly expanding knowledge. But it can seize the 21st century by making a concerted leap to a knowledge-based economy. The recommendations here should help provide the rough outlines of a strategy to overcome constraints and improve welfare. But these recommendations are just a starting point and need to be expanded and adapted to the Chinese reality by those who will implement them. Funding is another issue. The government needs to prioritize initiatives carefully and see how it can leverage its resources and those of the growing private domestic sector—as well as foreign investment and international finance.

China's leadership must not waver in driving this transition or backtrack on reforms already in place. There will be adversity along the way, but better to face it from a strong position than be overtaken. Launching a concerted and sustained effort is important. Perhaps a slogan such as "Seizing the 21st Century through Knowledge" can mobilize support for the changes required of government and civil society, forging a partnership to work toward a modern, knowledge-based China of tomorrow.

1 Catching up with the advanced countries

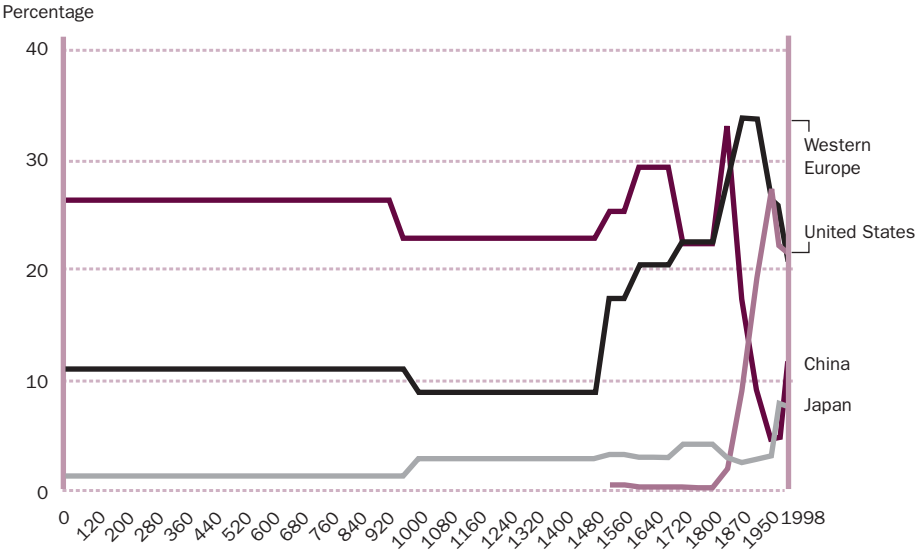
For a long part of history China was the largest and most advanced economy

For a long part of history, China was the largest and most advanced economy in the world. Over the past 2,000 years China's share of global GDP hovered around 25% until the late 1700s. In 1820 China accounted for 33% of global GDP. Then from 1820 to 1950 it suffered great internal strife and foreign exploitation. Its GDP collapsed—as it increased elsewhere. As a result China's share of global GDP fell to just 5% in 1950 (figure 1.1). China's per capita income also led the Western Europe until about the 12th century and world until the 18th century (table 1.1). Then other parts of the world caught up and roared by.

Outside of China, the codification and exploitation of scientific and technical knowledge and the development of economic incentives and institutions were stimulating the creation and effective dissemination and use of knowledge.

What happened in China? It had developed some radical innovations—printing, gunpowder, shipping, calculus. But many of them more as curiosities or amusements, not for commercial exploitation.[1] In the 16th century, the age of sea exploration, China had larger and more technologically advanced ships

FIGURE 1.1
Share of world GDP in PPP by selected country or region, year 0–1998



Source: Angus Maddison, *The World Economy: A Millennial Perspective,* OECD: Paris, 2001.

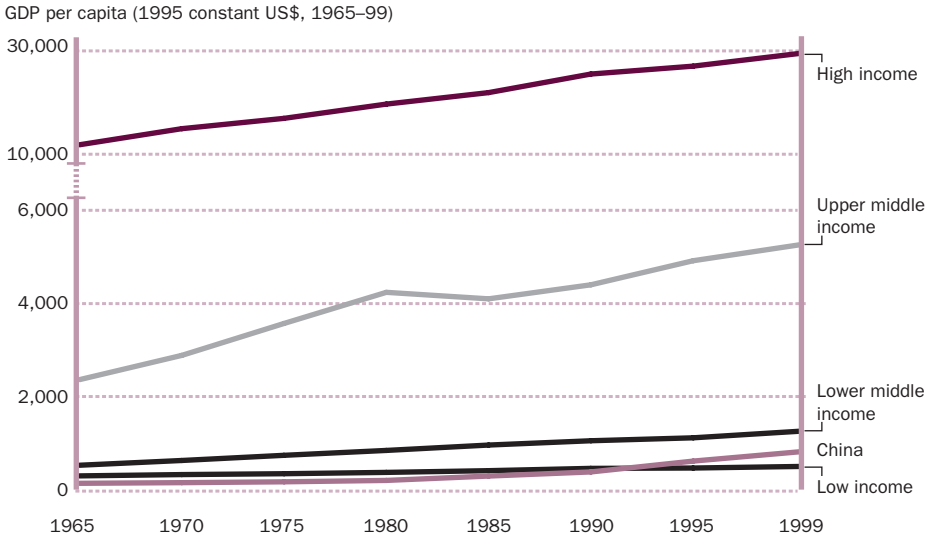
TABLE 1.1
GDP per capita by selected country or region, year 0–1998
(1990 dollars)

	0	1000	1500	1600	1700	1820	1870	1913	1950	1973	1998
China	450	450	600	600	600	600	530	552	439	839	3,117
Japan	400	425	500	520	570	669	737	1,387	1,926	11,439	20,413
Western Europe	450	400	774	894	1,024	1,232	1,974	3,473	4,594	11,534	17,921
World	444	435	565	593	615	667	867	1,510	2,114	4,104	5,709

Source: Angus Maddison, *The World Economy: A Millennial Perspective,* OECD: Paris, 2001.

China is now on a path to convergence

FIGURE 1.2
China's GDP per capita: moving to convergence



Source: World Bank staff analysis.

than the Portuguese or the Dutch. But it used them for seven voyages of global exploration to Asia and Africa—and then deactivated them. It had a well-established bureaucracy based on a meritocratic civil service. But its institutional and economic regime did not systematically exploit knowledge—causing the country to fall into stagnation. China also closed itself from most interaction with the rest of the world and did not benefit from the many advances that took place outside its borders.

Then, after reaching its nadir in the early 1950s, China began to grow faster than the world average—particularly since the late 1970s, after major reforms and opening to the world. It is now on a path to convergence (figure 1.2).

Daunting challenges ahead

Despite recent optimism, China faces daunting internal challenges (chapter 2). Chief among them: how to productively employ its labor force of 700 mil-

lion as it shifts from an agricultural to an industrial economy—and soon to a service economy. It's estimated that China will have to create 150–300 million new jobs in the coming decade. So it must maintain a high rate of GDP growth and deal with income and regional inequality—as well as serious environmental constraints.

Positioning China in the global knowledge revolution

The world is undergoing a knowledge revolution, unique in the speed and pervasiveness of change (chapter 3). The codification of our scientific understanding of nature and the rapid dissemination and exploitation of all knowledge are driving this revolution. China cannot afford to miss this. It must seize the 21st century—exploiting knowledge to regain its place in the world economy.

It must seize the 21st century—exploiting knowledge to regain its place in the world economy

Building the foundations for a knowledge economy

The effective development and exploitation of knowledge are becoming more important for economic activity, competitiveness, and growth. A key aspect of the knowledge economy is greater investment in such intangible assets as education, training, research, development, software, branding, marketing, and distribution. Indeed, in OECD countries, investment in public education, R&D, and software is already as big as that in plant and equipment.

Using knowledge for China's development

China still has much to gain by catching up with global knowledge. Its average level of technology and productivity is still far behind the world leaders in almost every area. And within its boundaries are very wide dispersions of productivity and technologies. Some firms are close to world leaders, but many are using technologies that are centuries old.

China now needs to strengthen the domestic diffusion of technology to raise its average productivity to best domestic practice and best domestic practice to best international practice. That would give a far bigger boost to its economy than investing a lot in domestic R&D.

China must continue to harness the knowledge revolution. This means tapping global knowledge through trade, technology transfer, foreign education, direct foreign investment, and access to data and knowledge on the internet. China, of course, has been doing this. But it has focused mainly on manufacturing and on hard technologies and hardware. It needs now to turn its attention to services and intangibles.

For China, seizing the 21st century to position itself for the knowledge revolution mainly means opening more to the outside world. But it also means strengthening China's ability to use knowledge more effectively across the board (box 1.1). And it means investing in education and training, in the new infrastructure for information and communication technologies, and in domestic R&D. But to get the greatest returns from these investments, it must also upgrade its economic and institutional regime—which includes changing the role of government.

Investing in education and training, in the new infrastructure for information and communication technologies, and in domestic R&D

Changing the role of government

China is moving from a command economy to a socialist market economy—in its own way, doing pragmatic things that western economists could never have imagined, such as township and village enterprises, strict controls in finance, and dual pricing structures.[2]

But the context has changed, with daunting internal challenges, tumultuous external pressures, and more international competition, all requiring speed. And speed means quick decentralized decision making, which efficient mar-

BOX 1.1

Key elements of a knowledge-based economy

All economies are knowledge-based. What is different, today, however, is that rapidly growing economies depend more on the creation, acquisition, distribution, and use of knowledge. The effective use of knowledge is becoming the most important factor for international competitiveness—and for creating wealth and improving social welfare.

This does not mean that China must simply develop high technology. It means that China must encourage its organizations and people to acquire, create, disseminate, and use knowledge more effectively for greater economic and social development.

The four pillars of a knowledge-based economy are:

- An economic and institutional regime that provides incentives for the efficient use of existing knowledge and, the creation of new knowledge and entrepreneurship.
- An educated and skilled populace that can create and use knowledge.
- A dynamic information infrastructure that can facilitate the effective communication, dissemination, and processing of information.
- An effective innovation system comprising a network of firms, research centers, universities, consultants, and other organizations that can tap into the growing stock of global knowledge, assimilate and adapt it to local needs, and create new knowledge and technology.

The economic institutional regime allows organizations and people to adjust to changing opportunities and demands in flexible and innovative ways. In a sense, it is the fundamental pillar of the knowledge-based economy, since only strong economic incentives and institutions can deploy these resources to productive uses and take advantage of a strong educational base and a highly-developed ICT and R&D infrastructure.

kets can offer. To succeed in this fast-paced environment, the government must move even more from providing most goods and services to becoming the architect of a socialist market economy.

A market economy, not developed overnight, requires institutions to support it.[3] It requires clear property rights, the enforcement of rights and rules defending contractual rights. It is up to the government to define these rights.

To take advantage of its entrepreneurial people, China needs to clearly define property rights and enforce them fairly and predictably, constraining government interference. How? Through a stronger rule of law.

The government must move even more to becoming the architect of a socialist market economy

China also needs good information flows about business opportunities, about market players and their reliability, about the quality of goods and services. Public and private institutions have to produce, collect, analyze, verify, and disseminate information among them—accounting firms, credit registries, testing, quality control, and performance-rating agencies are critical. The government can do much to help develop these institutions—and the rules and regulations to govern their behavior. It can also promote competition to spur innovation and productivity—with policies for the free exchange of goods and services, for the openness to new ideas, and for setting up institutions to promote such competition and to discipline the rule-breakers.

But the market can't do everything. When it fails, the government has to provide public goods, such as defense, the rule of law, environmental protection, basic education, some aspects of basic infrastructure, and basic research and development. But government also fails, and that makes it necessary to limit the power of the state—providing mechanisms for greater transparency, more accountability, and better governance. This report does not go into all these areas. Instead, it covers what is most relevant for getting China to make more effective use of knowledge for its economic and social development—and to prepare the way for its becoming a knowledge-based economy.

Structure of the report

Chapter 2 highlights the challenges to China's development. In the short term the critical challenge for China is to ensure as smooth and efficient a transition as possible, minimizing the unemployment that will inevitably result from the restructuring, as well as the social tensions that will follow, and maximizing the opportunities for growth and job creation. In the longer term the challenge will be to maintain high and sustainable growth that will not exhaust China's limited natural resources.

Chapter 3 summarizes key elements of what could be called a knowledge revolution. It also assesses China's progress in addressing some of the key issues

in making effective use of knowledge for development. Because China is so large and diverse, the chapter also looks at knowledge disparities across provinces, something that a knowledge-based strategy needs to take into account.

Chapter 4 highlights some of the key elements that need upgrading in the economic incentive and institutional regime to deal with the constant restructuring that is part of the knowledge economy.

In the short term the initial challenge is to minimize the unemployment that will result from the restructuring

Chapter 5 summarizes the challenges to the education system. These include not only increasing the educational attainment of the vast population, but also modernizing the curriculum so that people have the new skills demanded by the knowledge economy and can pursue lifelong learning to keep up with the continuously evolving technologies. It also proposes that China undertake a major expansion of Internet-based education.

Chapter 6 looks at what China has to do to harness the information and communications infrastructure to leverage its development. It needs to provide a competition and regulatory regime that promotes investment in the new telecommunications technologies and brings the incredible cost reductions in this sector to consumers. And it needs to provide training in the use of these new technologies and in their application.

Chapter 7 examines the important issue of diffusing technology throughout the economy to bring up the overall technological level of the country. It discusses the technological weaknesses and disparities in the country, which are enormous. It also looks at issues of markets for technology dissemination, redirecting technology-related policies, strengthening government programs for technology diffusion, stimulating innovation in enterprises, and promoting innovation sites and clusters.

Chapter 8 focuses on China's domestic R&D system. Necessary measures include reorienting top down government programs to respond more to the needs of the market, involving the enterprise sector in the decisions on research priorities, strengthening support for public good research, setting up better technology foresight mechanism to decide where to allocate the public R&D budget, and how to establish effective incentives to stimulate the productive sector to invest more in R&D.

Chapter 9 examines how China can more efficiently harness the rapidly growing stock of global knowledge by more effectively using transnational corporations—the main engine in the rapid creation and use of knowledge. It also contrasts the great extent to which China has actively acquired global knowledge embodied in capital goods, components and manufactured articles with how little it has spend acquiring disembodied knowledge in the form of patents and licensing. It also highlights the importance of greater participation in international collaborative public and private research and of tap-

ping the large overseas Chinese community, which is a strategic asset to get access to global knowledge and experience.

Finally, chapter 10 focuses on how to develop and implement a coherent strategy for China. It sets up some of the key priorities and sequencing for each of the main policy planks. It then highlights the need for coordination between different parts of the central government and between the central and provincial governments, as well as the need to develop more effective mechanisms for sharing knowledge across provinces.

NOTES

1. Joel Mokyr, *The Lever of Riches,* Oxford: Oxford University Press, 1992; David Landes, *The Wealth and Poverty of Nations,* New York: W.W. Norton, 1998, and Joseph Needham, *Science and Civilization in China,* Cambridge: Cambridge University Press, 1954.

2. See Yingyi Quian, "Goal and Process," in *Journal of Comparative Economic Systems*, no. 2, March 1999 Beijing (in Chinese), English version available at www.oyfc.org/Magazine_8_10312000/goal-and_process.htm.

3. See the forthcoming *World Development Report 2001/2002* about supporting market institutions.

PART 1 **Challenges to China's future**

Major internal challenges that China is confronted with—massive job creation, sustaining high economic growth rates, reduction of income and regional disparities, and environmental issues—are detailed in chapter 2. Chapter 3 explains the nature of the knowledge revolution and related global transformations, and positions China accordingly, notably vis-à-vis advanced countries.

2 Ensuring China's development

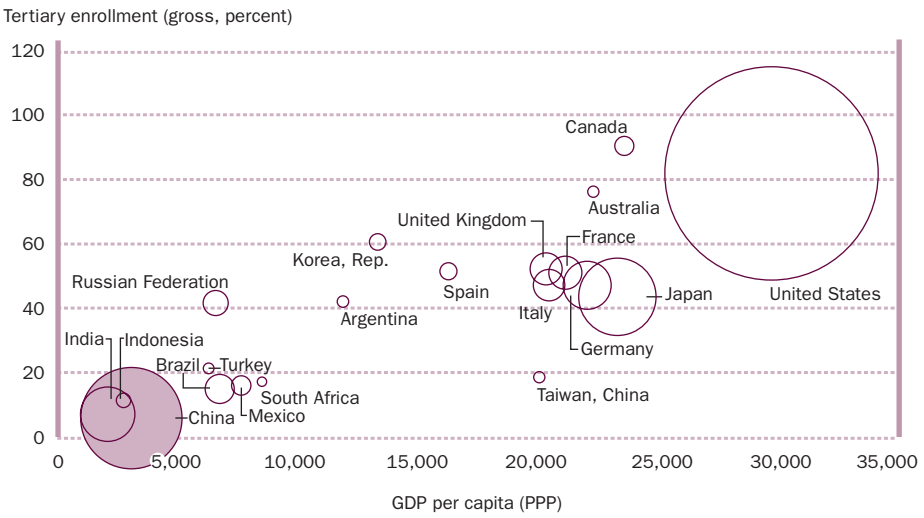
China's policy of openness triggered its extraordinary takeoff

After two decades of exceptional growth, China has become a major player in the world economy. It is now the second largest economy in GDP measured in purchasing power parity (PPP)(figure 2.1). It increased its share of world merchandise exports from 0.95% in 1980 to 3.4% in 1998 (figure 2.2). Its modernization, particularly in the coastal areas and cities, has been extraordinary. New industries have been developing, progress in the business environment has been enormous, and competitiveness and participation in the global economy have improved considerably.

China's policy of openness—allowing imports of capital flows, technologies, and management competencies—began in the late 1970s and, along with major policy reforms, triggered China's extraordinary takeoff.[1] Modernization thrives on an exceptional entrepreneurial spirit, a sense of trade, a high rate of savings and investment (more than 40% of GDP), and a thirst for education (with a literacy rate of more than 80% in 1997). Wise policies based on a gradual opening of the economy and society have been essential in promoting rapid, sustained, and socially acceptable economic growth.

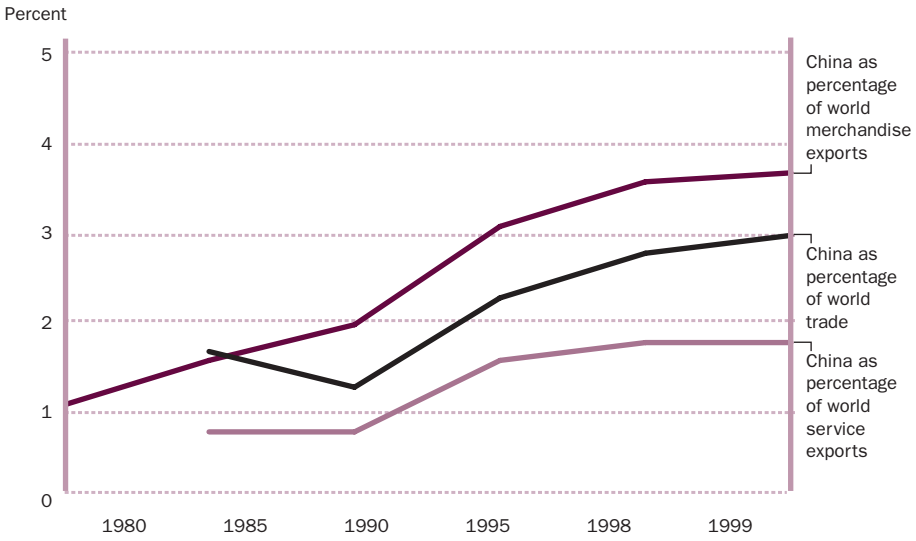
FIGURE 2.1

Comparisons of major countries by economic size and PPP, GDP per capita, and tertiary enrollment rates (1998 PPP)



Source: World Bank staff analysis.

FIGURE 2.2
China is increasing its share of world trade



Source: World Bank staff analysis.

The service sector will be a major source of employment growth

Four continuing transformations

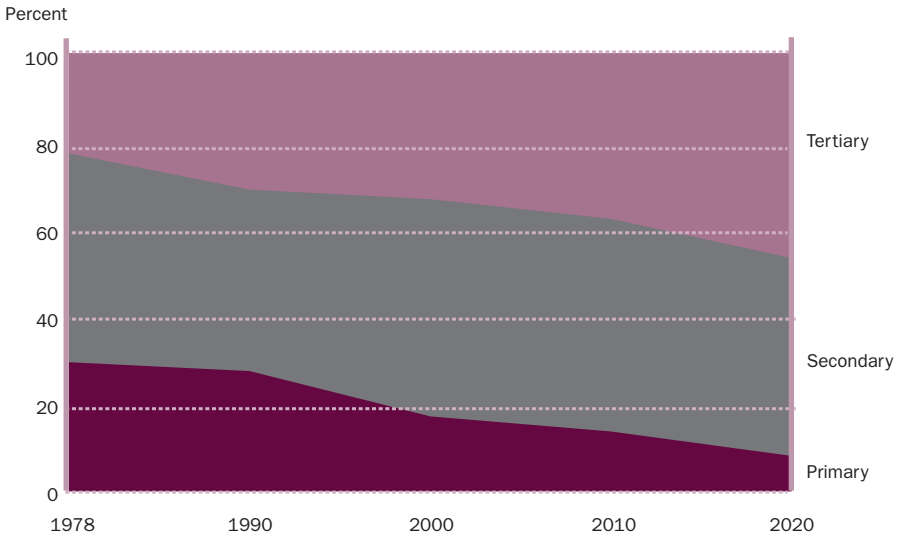
China's first transformation is from a rural agriculture–based economy to an urban-industrial economy. The share of the primary sector in employment declined from more than 70% in 1978 to about 50% in the late 1990s. Industry, which employed only 17% of the labor force in 1978, now employs almost 25% (figures 2.3 and 2.4).

The second is the transition to a service economy. The service sector is still underdeveloped compared with China's per capita income, largely because of past policy biases toward traditional industry. The service sector will be a major source of employment growth.

The third is the major restructuring to integrate into the global economy. The share of imports and exports in China's GNP increased from 16% in 1980 to 41% in 1999. This restructuring is likely to get even more wrenching with China's accession to the World Trade Organization. Agriculture and manufacturing are likely to be hit hardest. In addition, rapid creation and dissemination of knowledge makes the international environment very demanding. This presents risks and opportunities that will pressure China to embrace and exploit the dynamic global economy.

The fourth transformation is from a planned economy to a market-based regime, starting with the rural sector. Reforms have included land transfers to households and the household responsibility system, allowing farmers to sell production above their required quotas on the market. Reforms were also intro-

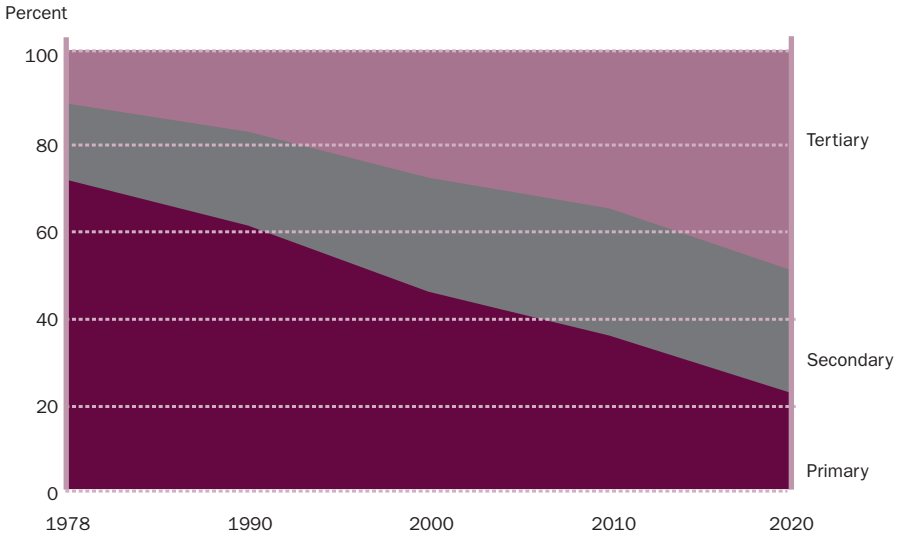
FIGURE 2.3
China's output structure, 1978–2020



Note: Figures for 2000–20 are projected based on our estimation. The primary sector excludes mining.
Source: National Bureau of Statistics, 1999.

The service sector in China is very underdeveloped for a country of its per capita income

FIGURE 2.4
China's employment structure, 1978–2020



Note: Figures for 2000–20 are projected based on our estimation. The primary sector excludes mining.
Source: National Bureau of Statistics, 1999.

duced in ownership and management of the enterprise sector, with the township and village enterprises benefiting more than state-owned enterprises from less state hands-on activity. In 1999 China formally recognized a private sector. Although these reforms have significantly improved enterprise productivity and performance, there is still a long way to go (chapter 4).

In a speech introducing China's tenth five-year plan for national economic and social development, Premier Zhu Rongji outlined China's impressive achievements during the last five-year plan (box 2.1). He also gave a very candid summary of China's problems.

Technological progress is clearly affirmed as the driving force of reform

BOX 2.1

Highlights of China's Tenth Five-Year Plan (2001–05)

The report presented by Premier Zhu Rongji at the Ninth National People's Congress on March 5, 2001 lays out an impressive program for driving China's 10th Five Year Plan. After a review of the accomplishments of the previous plan period the report lists the objectives of the new plan. Economic development is the central theme, including a need for further economic restructuring. Technological progress is clearly affirmed as the driving force of reform. Improving living standards and social development is seen as the goal and result of the policy.

The plan details actions to be taken in agriculture, industry, the Western region, science, technology, and education:

- Modernize and diversify agriculture through new technologies, pursuit of urbanization, building of infrastructure, and important changes in the tax system to reduce the burden on peasants.
- For industry, enhance traditional industries with new and advanced technologies, develop new and high tech industries, use information technology to stimulate industrialization, intensify construction of energy-related infrastructure, and accelerate the development of the service industry.
- For the western region, a coordinated approach is based on transport and other infrastructure construction, mobilizing and enriching human resources, and improving the investment climate. The east coast is seen as the gateway to the further opening on the world economy.
- In science and education, work on technological innovation and related basic research, pursue wide-ranging education policies adapted to country modernization, and form and attract talented people, including high quality public servants, enterprise managers, and scientists.

The report develops general directions for the transformation of the economy:

- Deepen reforms by addressing the expansion and regulation of the market system; the strengthening of finance, taxation, and banking; and the increased opening to the outside world in light of economic globalization and China's entry into the World Trade Organization.
- Raise living standards by improving the social security system at a faster pace, expanding employment by all possible means (including encouraging private and individual business creation), increasing low incomes, and adjusting consumption patterns.
- Implement a sustainable development strategy based on the pursuit of family planning (one child) policy, the protection of natural resources, and the improvement of ecological conservation.

The last chapter of the report offers overarching objectives for China's development: promoting further socialist civilization, improving democracy and the legal system, and strengthening national defense, aiming at a peaceful reunification with Taiwan.

In the conclusion the premier announces an immediate issuing of 150 billion yuan long-term treasury bonds; investment of the ensuing revenue in large projects under construction, notably in the Western region; and raising staff salaries in government organizations, earnings of low income urban residents, and farmers. Finally, the guiding role of the Communist Party in the modernization process is highlighted.

The principal problems are as follows: inappropriate industrial structure and noncoordinated development of local economies; low overall quality of the national economy and low competitiveness in the international market; imperfections in the socialist market economy and conspicuous systematic factors hampering the development of productive forces; a comparatively backward state of science, technology, and education and relatively weak innovative ability in science and technology; a shortage of important resources, such as water and petroleum, and the deterioration of the ecological environment in some regions; growing employment pressure, slow income increase of farmers and some urban residents, and an increasing income gap; considerable disorder in some areas of the market economy; frequent occurrences of grave accidents; serious corruption, extravagance and waste, formalism and bureacraticism; and poor public order in some localities. The causes of these problems are rather complicated, but they are not unrelated to shortcomings and errors in our work. We must pay great attention to them and take further steps to solve them.

China's economic growth has outpaced growth in employment

In this report we will highlight what we think are the main challenges and outline how a concerted strategy to make more effective use of knowledge can help to address them.

Four daunting challenges

As part of its growth trajectory China faces four internal challenges:

- Increasing employment.
- Maintaining high growth.
- Reducing regional and income inequality.
- Sustaining the environment.

The employment challenge

China's economic growth has outpaced growth in employment. According to one estimate, in the 1980s, when China's economic growth was 9.3% a year, employment growth was just 3% a year. And in the 1990s, when economic growth was about 10.4%, employment growth declined to only 1.1%. Effective unemployment is already over 10%, far above the registered unemployment level of just over 3%, and each year 12 million people leave unprofitable formal sector activities. Between 1996 and 1999 the number of urban and township workers[2] fell from 149 million to 117 million, a net reduction of 32 million or 22% (appendix 2.1).[3]

According to a World Bank study prepared as background for development of the tenth five-year plan, China's labor force will grow by 80 million people over the next decade—from 742 million in 2000 to 822 million in 2010. After accounting for continuing employment declines in agriculture, TVEs and SOEs, and retirees, it is expected that the Chinese economy needs to create about 8 to 9 million new employment opportunities annually. This contrasts with the 5.5 to 6.5 million jobs per year in the most recent five-year period, created while output was rising by about 8% a year.

A considerable number of new jobs will have to be created in the next decade—at minimum, about 100 million

However, other projections estimate the amount of new jobs to be created at a much higher level—in the range of 200 to 300 million in the next ten years, due to the potential for lay-offs of half of the population currently working in agriculture, SOEs, and TVEs.[4]

Regardless of the differences in estimates, these projections indicate that a considerable number of new jobs will have to be created in the next decade—at minimum, about 100 million (mostly in urban areas). New employment created in the high technology and advanced manufacturing sectors will not be more than 20–30 million. The main sources of new job creation will continue to be labor-intensive sectors, such as textiles (where China is projected to increase its global market share from 20 to 40%) and the service industries (including building and construction).

Increasing employment in the service sector from 190 million jobs to more than 270 million will be challenging. This increase would amount to matching the entire increase in employment that has taken place in developed countries since 1980. Most of these new jobs will be in informal service employment and basic infrastructure services (construction, transport, telecommunications), tourism, retailing, and commerce. But many also should be created in small private high-value business services (such as marketing, logistics, distribution, financial, consulting, management) and in other professional services. Historically underdeveloped in China, those industries are critical elements of knowledge-based economies.

In the past five years China has had exceptional success in several new industries, particularly high technology and science parks. China has also been successful in modernizing and restructuring the economic base of coastal cities, such as Shanghai. But these successes should be seen in the broader context of the overall economy. High-technology centers remain small active islands in the immense, decaying sea of Chinese industry. In the late 1990s employment in the 53 designated high-technology parks (mostly in the coastal areas) had reached only 2.2 million people, even though several parks have enjoyed rapid and sustained growth (annual growth in sales of 50%).

Accounting for about 10% of industrial production and 55% of China's computer-related products, the parks have concentrated almost half of their activi-

ties on electronic products and telecommunications equipment. Foreign enterprises of non-Chinese origin are responsible for more than 62% of the parks' exports (those from Hong Kong, Macao, and Taiwan, China add another 14%). The contribution of such high-technology parks to employment, output, and exports will grow significantly. But the technology diffusion beyond the parks has been limited, as seen in the persistent and increasing gap in labor productivity, which is two times higher in the parks than in the larger industrial sector. Moreover, several parks have not reached the critical mass of activities to ensure self-generated growth, perhaps explaining the government's recent decision to concentrate its support on just five parks in Beijing, Shanghai, Xi'an, Shenyang, and Yanglin.

Electronics and telecommunications industries, despite considerable efforts to develop them, do not generate many new jobs. These industries' share reached 8.1% of the manufacturing labor force in 1998, up from 7.3% in 1994 (table 2.1). By contrast, the strongly labor-intensive light industries employed more than 30% of the labor force in 1998. Growing steadily, the traditional basic industries—such as metal products, chemicals, and machinery, which have not received priority attention from the authorities—contained about 56% of the labor force that year.

The bulk of the labor force is still in agriculture, traditional low and medium technology industries, and low skill services

The bulk of the labor force is still in agriculture, traditional low and medium technology industries, and low skill services. Mediocre performance in these sectors shows up in poor productivity rates and a surprising decline in the share of services in overall GDP, despite rising prices.[5] Indeed, much of the economy has not yet benefited from the diffusion of new technologies and related management practices. Moreover, income disparities have grown throughout the economy, even though overall GDP per capita has increased considerably.

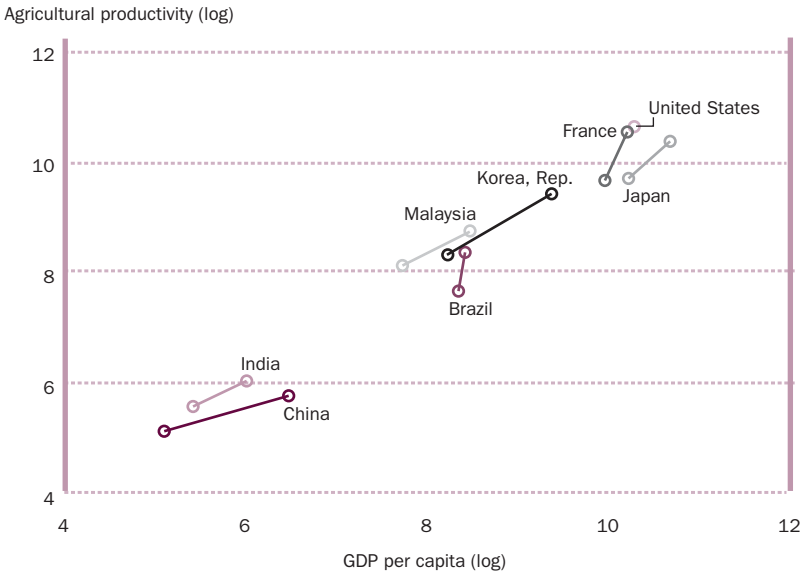
Comparisons of China's labor productivity with industrial economies and other developing economies show that China is lagging and needs to make significant progress in all sectors (figure 2.5). Agricultural productivity per worker in China is 75% of that in India (a poorer country) and only 0.8% of that in France

TABLE 2.1
Number and share of workers in manufacturing industries, selected years

	1994		1996		1998	
Category	Number of workers (thousands)	Share (percent)	Number of workers (thousands)	Share (percent)	Number of workers (thousands)	Share (percent)
Manufacturing industry[a]	54,320	100	52,930	100	37,690	100
Light industry	18,060	33.25	17,280	32.65	11,650	30.91
Chemical products	7,960	14.65	8,140	15.38	6,220	16.5
Metal products	10,440	19.22	10,260	19.38	7,430	19.71
Machinery	10,810	19.9	10,560	19.95	7,510	19.93
Electronics and telecommunications	3,960	7.29	3,990	7.54	3,040	8.07
Miscellaneous	3,610	6.65	2,110	3.99	1,390	3.69

a. Includes only state-owned industrial enterprises and nonstate enterprises with annual sales greater than 5 million yuan.
Note: Industries were grouped by World Bank staff according to six categories: light industry, chemical products, metal products, machinery and transport equipment, electronic and telecommunications equipment, and miscellaneous.
Source: National Bureau of Statistics, 1999.

FIGURE 2.5
Agriculture productivity versus GDP per capita for China and other countries, 1979–81 compared with 1996–98 (value added per worker in 1995 U.S. dollars)



Note: Data should be interpreted cautiously because international productivity comparisons are fraught with problems, including inconsistent data sources and definitions and biases caused by currency devaluations or appreciations.
Source: World Bank staff analysis.

Agricultural productivity per worker in China is 75% of that in India and only 0.8% of that in France or the United States

TABLE 2.2
Cereal yields, selected countries
(Kilograms per hectare)

Year	China	United States	France	Japan	India	Republic of Korea	Malaysia	Brazil
1976–81	3,027	4,151	4,700	5,252	1,324	4,986	2,828	1,496
1998–2000	4,879	5,794	7,272	5,971	2,293	6,400	2,826	2,660

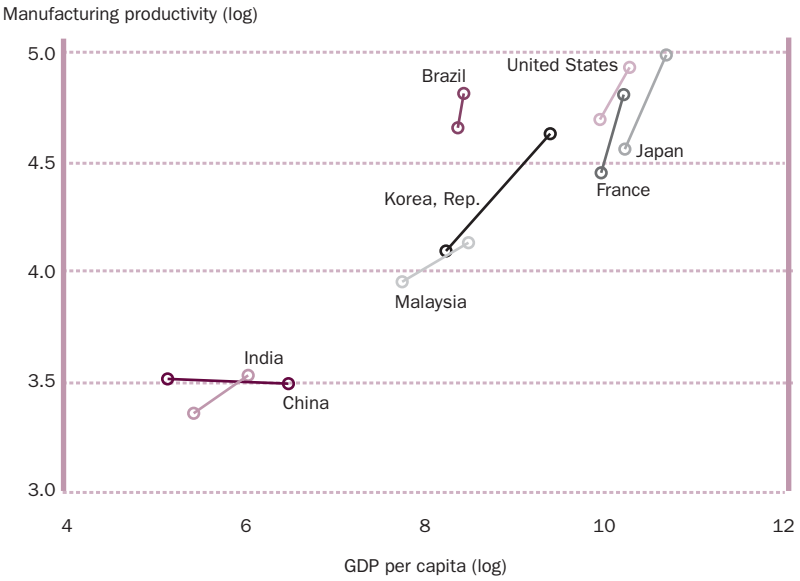
Source: World Bank, *World Development Indicators 2001,* Washington, D.C., 2001, pp. 136–39.

or the United States. But cereal yields per hectare in China are not far from U.S. yields and are much higher than those in Brazil, Malaysia, and India (table 2.2). These statistics suggest that the productivity problem in Chinese agriculture is one of surplus labor and land tenancy—the household responsibility system segments the land, making it unsuitable for large machine-based production—rather than technical inefficiency. Manufacturing labor productivity is 92% that in India and less than 5% that in Brazil, France, Japan, and the United States (figure 2.6).

After significantly accelerating in the first part of the 1990s, labor productivity growth slowed in all sectors of the Chinese economy (figure 2.7). Labor productivity is considerably lower in agriculture, services, and construction than in industry, implying excess labor and low capital outside industry.

The productivity gaps between China and international competitors are daunting considering the implications of China's accession to the World Trade

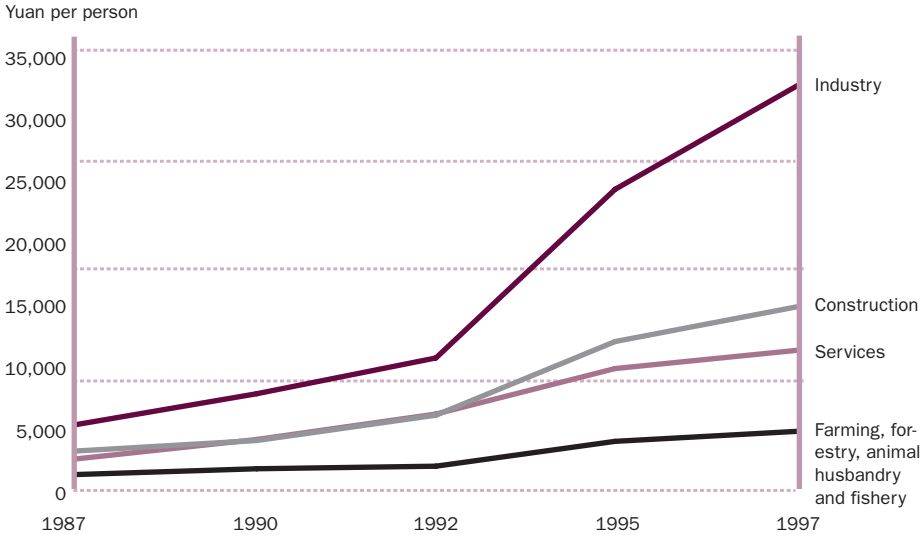
FIGURE 2.6
Manufacturing productivity versus GDP per capita, 1980–84 compared with 1995–99
(average nominal U.S. dollars)



Note: Data should be interpreted cautiously because international productivity comparisons are fraught with problems, including include inconsistent data sources and definitions and biases caused by currency devaluations or appreciations.
Source: World Bank staff analysis.

Manufacturing labor productivity is 92% of that in India and less than 5% that in Brazil, France, Japan, and the United States

FIGURE 2.7
China's labor productivity, 1987–97



Source: E.C. Hwa, *China: Service Sector Development and Competitiveness,* World Bank: Washington, D.C., 2001, and World Bank staff calculations.

Organization. Although liberalization will be gradual with time for adjustment (box 2.2), the Chinese economy will be subjected to strong competitive pressures, forcing it to restructure according to its international comparative advantages.

BOX 2.2

Accession to the World Trade Organization entails important changes

To prepare to join the World Trade Organization China recently agreed to a set of trade reforms that will have far-reaching effects on domestic capital and product markets:

- Eliminating the import quota by 2006.
- Eliminating import tariffs on computers, semiconductors, and related products by 2005.
- Reducing the import tariff on agricultural products from 22% to 17.5%.
- Reducing the import tariff on industrial products from 24% to 9.4%.
- Reducing the import tariff on vehicles from 100% to 25% by 2006.
- Reducing the import tariff on vehicle parts by 10%.
- Allowing up to 50% foreign ownership of telecommunications and insurance.
- Allowing importers to own domestic distribution networks.
- Allowing full market access for foreign banks within five years of accession (foreign banks will be able to conduct local currency business with Chinese enterprises two years after accession).

The country is hindered by a large and inefficient state-owned enterprise sector and a financial sector burdened with non-performing loans

Sustainability of high growth

The second major challenge for China is to sustain its high growth rate—one of the world's most impressive and long running. Between 1965 and 1999 GNP growth averaged 8.1% a year. Over this period only three economies—with less than 3 million people each—grew faster: Botswana, 10.6% (a diamond exporter); Oman, 9.5% (an oil exporter); and Singapore, 8.3 %. But after GDP growth peaked at nearly 14% in 1995, growth slowed to 7.1% in 1999. Though the East Asian crisis caused part of the 1998 slowdown, a large portion of it was China specific. The country is hindered by a large and inefficient state-owned enterprise sector and a financial sector burdened with non-performing loans (most from the state-owned enterprises).

The high growth rate in the two decades since China's opening can be attributed to increases in capital and total factor productivity (TFP).[6] Future growth is expected to be 6 to 6.5 %, with lower contributions from all labor and capital, and unchanged growth rates of TFP. Although there are many projections of future growth, an alternative study of the decomposition of economic growth rates between 1979 and 1998 attributes 3.8% of the 9.7% growth to capital, 1.1% to labor, 1.1% to education, and 3.6% to TFP. The same study estimates growth for 1999–2020 at 7%, only 3% of which will be from capital, 0.3% from labor, 1.6% from human capital, and 2.1% from TFP. In both periods the main source of TFP growth is factor reallocation.

Increasing the contribution of TFP will require better policies for allocating capital, an efficient and market-oriented financial sector that can effectively

intermediate China's high savings into more productive investment, larger investments in education, and more effective use of improved technologies. Boosting TFP will become even more important as a result of the one-child policy: the labor force will stop growing and the dependency ratio will increase, reducing savings and draining resources to care for an aging population.

As for international competitiveness, China has had a tremendous increase in its exports and in the structure of those exports, which has shifted toward more knowledge-intensive goods. The share of manufactured products increased from 37% of merchandise exports in 1985 to 87% in 1999, and within manufactured goods the composition shifted toward capital goods and transport equipment, which are usually more knowledge intensive than light manufactures (table 2.3).

China has had a tremendous increase in exports

China's main export products remain labor-intensive light manufactures (table 2.4). But it is beginning to make inroads in some higher technology goods such as automated data processing equipment and telecommunications equipment. High and medium technology goods make up 17% of its manufactured exports. Nevertheless, most assessments of the implications of China's entry into the World Trade Organization suggest that China will benefit primarily from the expansion of labor-intensive industries such as textiles and garments, in which its global market share is expected to increase significantly.[7]

TABLE 2.3
China's export structure by main categories
(Percent)

Year	Total value (millions of dollars)	All food items	Agricultural raw materials	Fuels	Ores and metals	Total manufactured goods	Manufactured goods: Chemical products	Manufactured goods: Other manufactured goods	Manufactured goods: Machinery and transport equipment
1985	25,632	16.7	6.2	25.9	2.6	36.3	5.0	28.5	2.8
1990	62,091	12.7	3.5	8.4	2.1	71.4	6.0	47.9	17.4
1995	148,780	8.2	1.8	3.6	2.1	83.9	6.0	56.9	21.0
1998	183,809	6.6	1.1	2.8	2.0	87.3	5.6	54.4	27.3

Source: UNCTAD, *Handbook of Statistics,* Geneva, 2000.

TABLE 2.4
China's top 10 export commodities, 1997–98

Commodity	Value (thousands)	As percentage of country total	As percentage of world
All commodities	183,300,366	100	3.5
Toys and sporting goods	8,228,785	4.49	24.49
Footwear	8,102,152	4.42	22.97
Outer garments knit nonelastic	6,683,356	3.65	16.69
Women's outerwear nonknit	6,599,427	3.6	16.12
Automatic data processing equipment	6,214,197	3.39	3.87
Men's outerwear nonknit	5,980,146	3.26	19.02
Telecommunications equipment, parts, access	5,941,329	3.24	4.32
Undergarments knitted	4,920,840	2.68	17.25
Articles of plastic nonelastic	3,780,707	2.06	6.97
Travel goods and handbags	3,292,128	1.8	31.03

Source: UNCTAD, *World Investment Report 2000,* Geneva, 2000.

And China faces a much more competitive external environment; according to some rankings it is falling behind in international competitiveness (table 2.5). For example, the Institute for Management Development's World Competitiveness Yearbook ranked China number 33 in 2001, down from 21 in 1998. The World Economic Forum Global Competitiveness Report also shows a decline in China's international competitiveness, from 42nd in 1998 to 44th in 2000.

China's rapid economic growth has been concentrated in the coastal regions

Growing income and regional inequality

The third challenge is to address the growing inequality in incomes and regional development. China's rapid economic growth has been concentrated in the coastal regions, which have opened up the most to international trade and foreign direct investment, resulting in a growing gap between urban and rural areas and between the coastal, central, and western provinces.

Between 1987 and 1998 GDP growth in the coastal provinces averaged 3 percentage points more than growth in the central regions and nearly 4 percentage points more than growth in the western regions.[8] These figures suggest that the government needs to strengthen its "Going West" strategies for helping the western regions to develop. Beyond addressing regional inequality, policies are needed to raise western rural incomes. The poor are primarily rural: in the eastern regions urban incomes are twice as high as rural incomes; in the western regions they are more than three times as high (table 2.6).

In addition, household income inequality has increased between the 1980s and the 1990s based on nationwide estimates made by the National Bureau of Statistics. The Gini coefficient rose from 0.282 in 1991 to 0.388 in 1995. An

TABLE 2.5
China's overall competitiveness

Index	1998	1999	2000	2001
Overall Performance (IMD)	21	29	30	33
Current Competitiveness Index (WEF)	42	49	44	

Note: Rankings compiled based on surveys sent to key government officials and enterprise managers in the countries. The samples are not statistically robust random samples so they should be interpreted as indicative of how an important segment of the business community ranks a country's competitiveness, not an absolute measure.
Source: World Economic Forum, *Global Competitiveness Report,* Geneva, 2000; International Institute for Management Development, *The World Competitiveness Yearbook,* Lausanne, 2001.

TABLE 2.6
China's regional income disparities, 1998
(Current U.S. dollars)

	Eastern	Central	Western
Urban disposable income	790	546	591
Rural net income	353	244	188

Source: World Bank staff analysis.

TABLE 2.7
Trends in household income inequality, China versus other regions

	1980s	1990s
China	28.8 (1985)	38.8 (1995)
High-income countries	33.2	33.8
Latin America	35.0	31.8
South Asia	49.5	49.3
Sub-Saharan Africa	43.5	47.0

Source: World Bank, "China's Medium Term Transition Issues," China Department, Washington, D.C., 1999.

alternative estimate relying on internationally standardized measures of income showed that the Gini coefficient rose from 0.382 in 1988 to 0.452 in 1995 (table 2.7). It is also likely that the situation in China has worsened in recent years—in both urban and rural areas. Urban areas have seen rising earnings dispersion combined with massive layoffs from public enterprises and reductions in welfare payments, plus a large inflow of migrants into the cities. In rural areas, depressed prices for some agricultural products have reduced incomes.

China's environment has deteriorated since 1978 as a result of rapid industrialization and urbanization

Environmental constraints

The fourth challenge is ensuring the sustainability of the environment. China's environment has deteriorated since 1978 as a result of rapid industrialization and urbanization. Degraded water supplies have damaged agriculture, ecosystems, and fisheries. Acid rain from burning fossil fuels is hurting forests and crops. Industrial pollution is a serious problem—as is indoor air pollution, with most households still burning coal and wood for cooking and heating. Over the past decade urban air pollution has risen with the increase in trucks and automobiles in major cities. Together air and water pollution damages have been estimated at $54 billion a year—8% of China's GDP in 1995. Deaths from air and water pollution were estimated at 2 million a year in 1990.[9] China's resource base (arable land, forests, wilderness, water) is small relative to its population, and if China does not address these problems, resource depletion could restrain economic growth. China must shift from a resource-intensive development pattern to a sustainable development plan (table 2.8 and box 2.3).

The need for a new economic development strategy

A high growth rate, internal challenges, and dramatic advances in creation and dissemination of knowledge (see chapter 3) will contribute to a period of wrenching and continuous restructuring that will affect all of China's sectors—agriculture, industry, and services, as aptly noted in the tenth five-year plan. To compete and prosper in this new environment, China must continue to open and harness the forces shaping the global economy. China must catch

TABLE 2.8
Natural resources per capita—how China compares with the world

	Arable land per capita (hectares)	Forests per capita (square kilometers per 1,000 people)	Freshwater resources per capita (cubic meters)
Low income	0.18	3.65	6,205
India	0.17	0.64	1,913
Lower-middle income	0.21	6.67	7,585
China	0.10	1.30	2,257
Upper-middle income	0.29	13.70	16,744
Brazil	0.51	31.70	32,256
High income	0.41	8.91	..
United States	0.65	8.13	8,906
European Monetary Union	0.21	3.06	3,769
Japan	0.04	1.90	3.397
World	0.24	6.46	8,241

Source: World Bank, *World Development Indicators 2001,* Washington, D.C., 2001.

China must continue to open and harness the forces shaping the global economy

TABLE 2.9
Responding to the challenges with a knowledge-based strategy

Challenge	Knowledge implication
Maintaining growth	Go from factor intensive to knowledge intensive by increasing productivity across the board (knowing that a productivity increase may exacerbate employment problems). Improve the financial system to efficiently allocate capital, increase labor mobility, develop social safety nets, improve rule of law, improve domestic competitiveness, harness information communication technology infrastructure, and exploit global knowledge (chapters 4, 6, and 9)
Providing employment	Knowledge will make industries more competitive, protect existing jobs, and develop employment opportunities in the production of new goods and services. Most important will be developing the service sector. Promoting growth of the dynamic private sector is also critical, especially growth of small and medium-size enterprises (chapters 4, 7 and others).
Addressing income and regional inequality	Address income inequality by developing more effective tax and transfer system (chapter 4). For regional inequality invest in physical infrastructure and knowledge infrastructure (chapters 5 and 6). Investing heavily in education and technological diffusion mechanisms will help meet the needs of poor areas (chapter 7). Migration out of areas where physical conditions make it difficult to develop productive livelihoods should be considered.
Ensuring environmental sustainability	Better policy knowledge is needed to cost the use of environmental resources (chapter 4). Technical knowledge is needed to create environmentally friendly technologies. Productive knowledge is needed to start activities that do not deplete the environment. Much can be obtained from abroad, but the domestic system should be improved, too (chapters 7 and 8).

the West's knowledge, even pushing beyond to develop new, ground breaking technologies.

A key element of the new strategy will be a shift in emphasis away from factor-based growth toward knowledge-based growth. Making more effective use of existing and new knowledge for development will allow China to respond to the many challenges it faces (table 2.9).

In the short term the critical challenge for China is to ensure as smooth and efficient a transition as possible, minimizing the unemployment that

BOX 2.3

Balancing growth and environmental sustainability

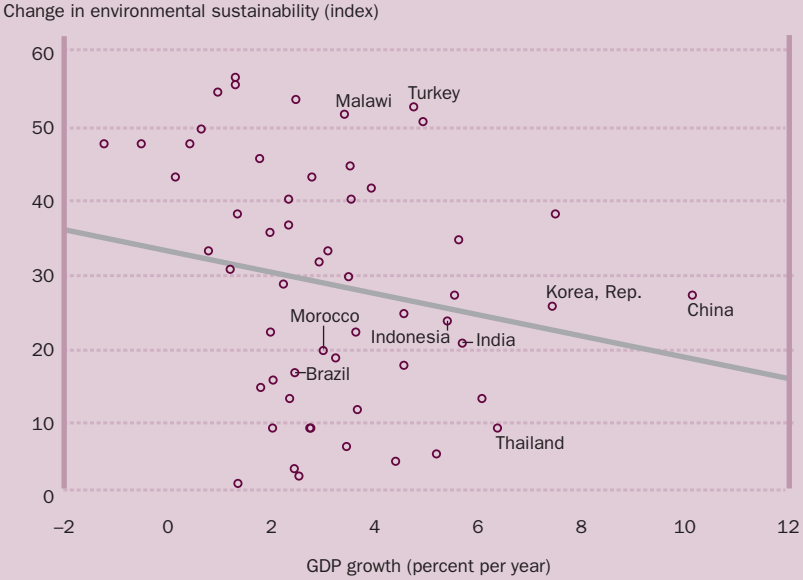
Faster growth generally leads to more rapid environmental degradation, so China is doing well considering its high growth rate (see figure 2.8). But much remains to be done to prevent rapid growth from destroying the environment. A major study on China's sustainable development by the United Nations University noted the following concerns:

- Although China has made considerable progress in energy efficiency, compared to international standards energy intensity is high. For every $1,000 of GDP output China needs almost four times as much energy as the U.S.
- China will be one of the major sources of greenhouse gas emissions—its share could exceed 25% of the world's by the middle of the next century. Without control measures China's carbon dioxide emissions will increase roughly threefold between 1990 and 2050. China would then surpass the United States as the largest greenhouse gas–emitting country.
- Recycling efforts are low. The national integrated use of mineral resources is about four times less than that in the United States and five times less than that in Japan.
- The average water recycling and reuse rate is 50% in China, 70–80% in developed countries.
- In 1996, 78% of the rivers flowing through cities carried undrinkable water, while 50% of the underground water in cities was polluted.
- Desertification affects some 400 million people. Northern lands account for 80% of China's desertification, almost all attributable to human activities (over-cultivation and grazing, urban construction, unreasonable use of water resources).

Source: United Nations University/Institute for Advanced Studies, *China's Sustainable Development Framework,* Tokyo, 1999.

BOX FIGURE 2.1

Change in environmental sustainability and growth of income, 1981–98



Note: The sustainability index was constructed so that a higher score represents more reduction in carbon dioxide emissions, more increases in forest cover, and more reductions in water pollution. Correlation is –0.27 (significance 0.05) for 56 countries.
Source: Thomas and others, *The Quality of Growth,* World Bank: Washington, D.C., 2001.

The challenge will be to maintain high and sustainable growth that will not exhaust China's limited natural resources

restructuring will cause and the social tensions that will follow and maximizing the opportunities for growth and job creation. In the longer term the challenge will be to maintain high and sustainable growth that will not exhaust China's limited natural resources.

NOTES

1. The impact of foreign direct investment on the economy has been considerable. As of 1999 foreign direct investment had reached $306 billion of cumulative inflows. In 1998 it accounted for 9% of the total fixed asset investment, 19% of the total value added, 44% of total export, and 14% of the national income. It should be noted, however, that 94% of the FDI has come in the 1990s; thus, the role of FDI in China is best seen as one that deepens and sustains growth rather than one that initiates growth or augments savings.

2. The formal sector's state-owned and collectively owned enterprises, plus joint stock and shareholding companies and foreign funded enterprises but excluding township and village enterprises.

3. This consisted of a drop of 39.2 million in state-owned and urban collectives and an increase of 8.4 million in the emerging formal private sector (joint stock and shareholding companies and foreign-funded enterprises). At the same time there was an increase of 11.4 million in private and self-employed informal employment.

4. See 1999 Chinese Academy of Social Science report by Feng Nanrui. Note also that the next Five-Year Plan estimates that 40 million rural laborers will have to find jobs outside of the agriculture sector.

5. See Hwa 2000 for data and an analysis of the underdevelopment of the service sector in China.

6. Total factor productivity is a methodology for decomposing growth in value-added into the contribution of growth in capital and labor inputs, and a residual (total factor productivity) that is attributed to technical change. The results of the decomposition depend on the type of production function assumed and the degree of adjustments made to the quality of inputs (for example, average education of labor) or the quality and rate of use of capital.

7. See Deepak Bhattasali and Masahiro Kawai, "Implications of China's Accession to the World Trade Organization," World Bank, Beijing, 2001.

8. According to official statistics the balance among the three main regions of China—coastal, central, and western—has not changed significantly during the past 20 years in population, employment, and output. Why? Though growth of the coastal cities has attracted workers from the central and western regions, this labor force has not been officially registered as living in the coastal provinces. These laborers benefit only from temporary stay permits and constitute what is recognized as a large floating population. The resources they gain probably continue to be registered in their provinces of origin, which partly fits the reality, because these workers send part of their resources to families in their home bases. Nevertheless the rapidly growing coastal area has generated much more wealth per inhabitant than other areas.

9. See World Bank 1997a, *China 2020: Clear Water, Blue Skies,* Washington, D.C.

APPENDIX TABLE 2.1

Changes in the urban employment structure, 1990–99

			Traditional formal sector				Emerging formal sector		Informal sectors			
Year	Total employed	Total number of staff and workers	Subtotal	State-owned units	Urban collectives	Percentage of workers in total employment	Subtotal	Percentage of workers in total employment	Subtotal	Private	Self-employed	Percentage in total employment
1990	166.16	181.15	138.95	103.46	35.49	83.6	1.64	1.0	6.71			4.0
1991	169.77	186.80	142.92	106.64	36.28	84.2	2.16	1.3	7.60	0.68	6.92	4.5
1992	172.41	189.69	145.10	108.89	36.21	84.2	2.82	1.6	8.38	0.98	7.40	4.9
1993	175.89	188.22	143.13	109.20	33.93	81.4	5.36	3.0	11.16	1.86	9.30	6.3
1994	184.13	188.69	141.01	108.90	32.11	76.6	7.47	4.1	15.57	3.32	12.25	8.5
1995	190.93	149.08	140.31	109.55	30.76	73.5	8.77	4.6	20.45	4.85	15.60	10.7
1996	198.15	148.45	139.03	109.49	29.54	70.2	9.42	4.8	23.29	6.20	17.09	11.8
1997	202.07	146.69	135.83	107.66	28.17	67.2	10.86	5.4	26.69	7.50	19.19	13.2
1998	206.78	123.37	107.09	88.09	19.00	51.8	16.28	7.9	32.32	9.73	22.59	15.6
1999	210.14	117.73	99.98	83.36	16.52	47.5	17.85	8.5	34.67	10.53	24.14	16.5

Source: Angang Hu, "China's Employment Problem: Analysis and Solutions," *World Economy and China* 9(1), 2001.

3 Positioning China in the global knowledge revolution

Compounding the challenges to China's development are the advancements in production and dissemination of knowledge. Consider the revolution's new language: the new economy, the knowledge-based economy, the ICT revolution, the information society, the knowledge society. After outlining the revolution's implications, this chapter benchmarks China's situation as a starting point for a more detailed analysis in later chapters. It also examines the inequalities in the knowledge across China's provinces.

A major new element on the international front is the speed of change in producing and disseminating knowledge

The knowledge revolution and global competition

A major new element on the international front is the speed of change in producing and disseminating knowledge—possible because of greater scientific understanding and rapid advances in information and communications technologies (ICTs). Advances in scientific understanding and the codification of knowledge permit engineering new materials at the molecular level and even engineering life forms through biotechnology.

Rapid advances in information technologies speed the processing and transmission of information, which in turn speed scientific advances. Over the last quarter century, the cost of one megahertz of processing power has fallen from $7,500 to 20 cents—and the cost of sending one trillion bits of data, from $150,000 to 10 cents. The lower computing costs amplify brain power in the same way that the technologies of the industrial revolution amplified muscle power. This added power increases computation and simulation capacity, speeding up research. Low-cost electronic networking among researchers in different locations is also speeding up research and generating many more new technologies. All these advances transform business and social interactions.[1]

Dynamic networks and new styles of organizations and management create new forms of competition. Wealth is no longer created just by natural resources or production, but by the way products and services are designed and delivered to the market. The power of ideas and brand names—and the harnessing of knowledge and information to leverage them—are driving the world economy. Keeping up requires investments in such intangibles as R&D, software, education, training, marketing, distribution, organization, and networks.

This knowledge revolution mirrors past periods of rapid change—those brought by the printing press in the 1500s, the harnessing of steam in the 1800s, the development and expansion of electricity in the early 1900s, and the automobile industry in the 1900s. What is special today is the pervasiveness of change in almost all technologies, not just ICTs, and the fact that they are affecting the organization of productive and social activities.[2]

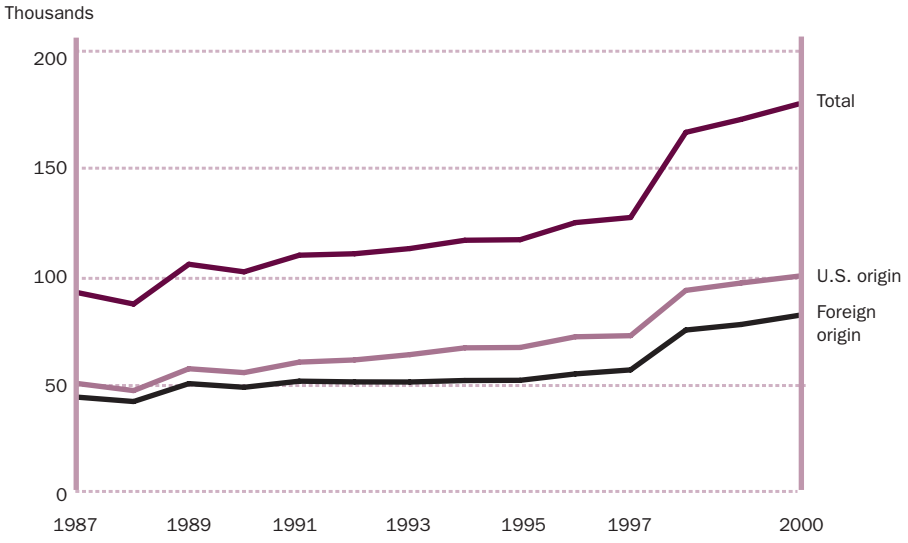
One indicator of the acceleration in the creation of knowledge is the number of new patents each year. In the United States the annual number of patents doubled from about 80,000 at the end of the 1980s to nearly 180,000 by the end of the 1990s (figure 3.1). Part of this increase is due to the greater importance of protecting intellectual property—a sign of the awareness of what knowledge means for wealth creation.

The rapid spread of knowledge is creating a more competitive and interdependent world

The rapid development and spread of knowledge is creating a more competitive and interdependent world. The share of world trade (exports and imports) in world GDP—an indicator of globalization and competition in the global economy—rose from 28% in 1970 to 52% in 1999 (table 3.1).[3] Beyond trade is the greater interdependence through foreign direct investment, international sourcing of production inputs, and interfirm alliances for R&D and technology licensing. Accelerating this process are the greater availability of ICTs, the deregulation of financial and product markets, and the liberalization of trade, investment, and capital movements. Greater international competition, in turn, spurs firms to create new products and more efficient production processes.

In industries with low or medium technology, an increase in technical knowledge and associated organizational changes provide an edge in productivity

FIGURE 3.1
Protection of intellectual property on the rise: patents granted by the U.S. Patent Office



Source: U.S. Patent Office.

TABLE 3.1
Increased share of trade in global GDP
Share of trade (imports plus exports of goods and services) in GDP

	1970	1999
Low income	28	52
India	8	27
Lower-middle income	19	59
China	4	41
Upper-middle income	30	52
Brazil	14	22
High income	29	43
World	28	52

Source: Calculated from World Bank, *World Development Indicators 2001,* Washington, D.C., 2001, table 1.5.

Such services as transportation, distribution, finance, insurance, health, and education are becoming more intensive in knowledge and information

and enable product differentiation, significantly shaping competitiveness and value added. Even such traditional industries as textiles, cement, and steel are using new technical knowledge and information systems to improve the design and quality of products and production processes—and the efficiency of marketing and distribution. In agriculture, too, greater understanding of plant reproduction and growth, advances in genetic engineering, and better techniques for harvesting, storage, transportation, and distribution are changing the value and competitiveness of different types of plant and animal products. And such services as transportation, distribution, finance, insurance, health, and education are becoming more sophisticated, more intensive in knowledge and information.

Effective use of high technology throughout the economy is equally important as its creation, especially for improving and upgrading products and services.

The growing importance of knowledge

The discussion of the "new economy" in the press draws attention to the belief that advances in ICTs have significantly changed the economic system and increased productivity. These advances significantly reduce transaction costs and improve the efficiency of economic activity.[4] Some take this to mean the end of the business cycle and the beginning of a new era of unprecedented productivity growth. (But the recent slowdown of the U.S. economy, the leader in this wave, suggests otherwise.)

The OECD uses the term "knowledge economy" to draw attention to the importance of knowledge in all economic activities. The definitions have been evolving from focusing just on manufacturing industries that make intensive use of technology to including services that are also heavily knowledge based. The knowledge economy now accounts on average for roughly half of nongovernment economic activity in the OECD (table 3.2).

China's knowledge economy is not as developed as that of the OECD countries

TABLE 3.2
Value-added of knowledge-based industries, OECD countries

	Total	High-technology industries	Medium-technology industries	Communication services	Finance, insurance and other business services	Community, social and personal services[a]
EU 1994	47.7	2.5	7.7	2.0	20.2	15.3
Japan 1996	52.1	3.7	8.6	2.0	19.1	18.6
UK 1995	51.4	3.3	7.2	3.2	28.3	9.4
United States 1997	56.1	3.1	6.1	2.9	31.6	12.3
OECD 1993	49.9	9.9[b]		2.1	23.7	14.1
China 1997	29.7	4.7	6.0	5.0	8.0	6.0

Note: This is based on an OECD classification.
a. Many community and personal services are not that knowledge-intensive, so this category overstates the knowledge economy, particularly in the rough estimates for China.
b. For the OECD average, this includes medium technology industries, and is the average for 22 OECD countries.
Source: For OECD countries, OECD, *Science, Technology and Industry Outlook: 2000 Edition,* Paris, 2000, annex table 2, p. 220. For China, author estimates from China Statistical Bureau, *China Statistical Yearbook,* Beijing: China Statistics Press, 1999.

TABLE 3.3
Employment is low in China's knowledge-intensive services

Sector	Employment (percentage of total) 1990	1995	1998
Transport, storage, post, and telecom	2	3	3
Wholesale, retailing, and hospitality	4	6	7
Finance and insurance	0.3	0.4	0.4
Real estate	0.1	0.1	0.1
Social services	1	1	1
Health care, sports, and social welfare	1	1	1
Education, culture, and entertainment	2	2	2
Scientific research and polytechnical services	0.3	0.3	0.3
Government and social organizations	2	2	2
Service total	13	15	16

Source: China Statistical Bureau, *China Statistical Yearbook,* Beijing: China Statistics Press, 1999.

This statistic makes it clear that the knowledge economy is largely about services. High- and medium-technology industries account for only about a fifth of what the OECD defines as knowledge-based industries. The balance are services, and if government services were added, the share of services would be even higher.

It is not surprising that China's knowledge economy is not as developed as that of the OECD countries since it is at an earlier stage of development. More telling is that it is not growing as fast as might be expected. Data for the services most related to the knowledge economy (table 3.3) show that employment is very low and that it has not grown much over the last decade. The share of employment in China's high-tech industries as share of total industrial employment stayed at 32% between 1994 and 1998, even as industrial employment fell by 28%, the result of industrial restructuring and the closing of some unviable state-owned enterprises (appendix table 3.2).

BOX 3.1
Country knowledge strategies

United Kingdom: Building the Knowledge-driven Economy
(http://www.dti.gov.uk/comp/competitive/)
The UK's Department of Trade and Industry charts a new strategy to boost competitiveness and prosperity and build a high value economy through stressing science and entrepreneurship, collaborating across companies, and exposing the economy to competition.

Finland: Quality of Life, Knowledge, and Competitiveness
(http://www.sitra.fi/tietoyhteiskunta/english/st51/eng206b.htm)
To make the best use of the opportunities in the information society, Finland has a vision and strategy to be a forerunner in building an information society based on humane and sustainable development.

Canada: The Knowledge-Based Economy
(http://strategis.ic.gc.ca/SSG/it04360e.html)
Providing a general introduction to the "knowledge revolution" and the changes that it is expected to have on the Canadian economy, the paper begins with some general ideas on what the knowledge economy is all about and moves on to discuss what Canada could do to be better equipped for a more active role in the shift to a knowledge-based economy.

Scotland: Towards the Knowledge Economy
(http://www.scotland.gov.uk/library/documents-w9/knec-00.htm)
This official report on Scotland and the knowledge economy, delivered by the Knowledge Economy Task Force of the Scottish Office, provides a detailed overview of the economic and industrial climate in Scotland.

Malaysia: Building Knowledge Societies
(http://www.nitc.mimos.my/resources/index.html)
Aimed at a better understanding of the various challenges of the information age, this website addresses access, empowerment, and governance in six areas: politics, the economy, society, learning, environment, and technology.

New Zealand: The Knowledge Economy
(http://www.med.govt.nz/pbt/infotech/knowledge_economy/)
This report provides general background on what the knowledge economy is all about and how various economies are faring. It concentrates on key issues and on what New Zealand needs to do to successfully find the way forward.

Various countries have developed—or are starting to develop—strategies to take advantage of the potential of new technologies

Various countries have developed—or are starting to develop—strategies to take advantage of the potential of new technologies (box 3.1). The importance put on knowledge for international competitiveness can also be seen by the addition of numerous technology-related variables to international assessments of the competitiveness of countries.[5]

Even within firms there is emphasis on managing intellectual capital, with knowledge management now seen as fundamental to competitive advantage (box 3.2). This has spawned a growing consultancy practice, including work to develop new accounting systems to measure the intellectual capital of firms.

BOX 3.2
Knowledge management within firms

With knowledge as the key to survival, companies need to systematically manage what they know. Knowledge management has thus become important for IBM, Microsoft, AT&T, Ernst & Young, and KPMG. Larry Prusak, executive director of IBM's Institute for Knowledge Management, says, "All of life and business is a game of odds. Just as human resources policies increase the odds of employee retention, and good customer service increases the odds toward repeat business, knowledge management is about increasing the odds toward knowledge being transferred, utilized and [contributing to] innovation."

A 1997 report from the Ernst & Young Center for Business Innovation and Business Intelligence revealed that 94% of 431 organizations surveyed in Europe and the United States have executives who believe that "it would be possible, through more deliberate management, to leverage the knowledge existing in [their organizations] to a higher degree." Although adopting effective knowledge management practices depends on how knowledge-intensive an organization is, there is agreement on where to get started: understand the corporate culture, evaluate knowledge, process it, and act on it.

Multinational companies are establishing more strategic alliances to collaborate on technological assets

What's going on worldwide? Global trends in knowledge

More R&D

In most OECD countries, spending on R&D has risen faster than GDP, though there have been year-to-year fluctuations (table 3.4). More important, there has been a shift in the composition of R&D. After 1990 and the end of the Cold War, the share for defense R&D declined for some of the largest R&D spenders—notably the United States, United Kingdom, and France. But the share for civilian research rose, to more than 90%. In the OECD the number of researchers grew faster than the labor force.

Of global R&D, 86% is in high-income countries (table 3.5), with 37% of global R&D centered in the United States. Multinational companies, now doing R&D in countries other than their home countries, are establishing more strategic alliances—even mergers and acquisitions—to collaborate on technology and acquire technological assets. Also on the rise: international collaborations in patenting and technical publications. In the OECD, the share of foreign coinventors rose from 5% in the mid-1980s to 9% eight years later. And the share of scientific publications with foreign coauthors more than doubled for many OECD countries, to an average of 26% for 1995–97.[6]

Even large countries rely on knowledge from abroad, evident from royalty and licensing payments to other countries and from the technology they import in capital goods and components. One study found that the R&D implicit in imports was as high or higher than domestic R&D.[7]

TABLE 3.4
Gross domestic expenditures on R&D as a % of GDP

	1981	1985	1990	1995	1999
OECD	2.0	2.3	2.4	2.1	2.2[a]
United States	2.4	2.9	2.8	2.6	2.8
Japan	2.3	2.8	3.0	2.8	3.0[a]
EU	1.7	1.9	2.0	1.8	1.8[a]

a. 1998.
Source: OECD, *Science, Technology and Industry Outlook: 2000 Edition,* Paris, 2000, annex table 8, p. 226.

TABLE 3.5
R&D effort in selected countries, by income level

	R&D spending as a percent of GNI (1987–97)	Share of world total (percent)
World	2.2	100
Low income	0.5	0.7
India	0.7	0.4
Lower-middle income	0.6	2.2
China	0.7	0.7
Upper-middle income	1.2	5.0
Brazil	0.8	0.8
High income	2.4	85.5
United States	2.6	36.7
European Monetary Union	2.2	21.4
Japan	2.8	20.0

Source: World Bank, *World Development Indicators 2001,* Washington, D.C., 2001, table 5.11.

Foreign investment is driven mainly by the desire to exploit knowledge assets on a global scale

An important implication is that all countries need to focus on how to obtain knowledge produced outside their borders. Indeed, there has been a shift over the last two decades from an almost exclusive focus on generating knowledge to a broader focus on disseminating knowledge, especially knowledge acquired from abroad.

More foreign investment

Foreign investment, one of the key agents of globalization, is driven mainly by the desire to exploit knowledge assets on a global scale—technology, management, access to markets, and access to such special inputs as finance, labor, and natural resources. Knowledge does not depreciate with use, so once it is developed there is a strong incentive to exploit it over the largest scale possible.

Foreign investment inflows increased 15 times between 1982 and 1999. And its share in world gross fixed capital formation, from 2.6% to 14.3%. Other increases were equally stunning: exports of foreign affiliates from 31% of world exports to 46%; sales of foreign affiliates, $13.6 trillion in 1999, from 23% of world GDP to 45%. The value added of these sales in 1999: $3 trillion, roughly 10% of world GDP (appendix table 3.1).

In 1997 the estimated value added of home and overseas production by transnational corporations was $8 trillion, more than 27% of world GDP![8]

Transnational corporations are estimated to account for two-thirds of international trade, with roughly half that between parents and affiliates or among affiliates.[9] They are also estimated to do 75–80% of global R&D.[10]

More investment and trade in intangibles

Transnational corporations account for two-thirds of international trade and 75–80% of global R&D

Investment in intangibles has been skyrocketing. OECD public investment in education, in R&D, and software, is almost the same as that in machinery and equipment, almost half of total investments in GDP (table 3.6). But this is clearly an underestimate. It does not include private investment in education, public and private investments in training, or investments in design, marketing, advertising, brand development, engineering, publishing, and the arts.

With intangibles now more important for economic activity and international competitiveness, there has been more trade in intellectual property. Globally, trade in intellectual property as measured by royalty and license fees reported in international trade, increased from just over $10 billion in the early 1980s to more than $60 billion by the end of the 1990s (figure 3.2).

Country data on trade in royalties and licensing show the large gap between high-income and developing countries. The high-income countries receive almost 98% of all royalty and licensing payments, with low and medium income countries paying out an amount disproportionate to what they receive (table 3.7).

A big part of the payments for royalties and fees involves intrafirm payments between transnational corporations and their affiliates—as much as 75–80% of the receipts for payments for royalty and licensing fees in Germany, Japan, and the United States.

More importance for education and training

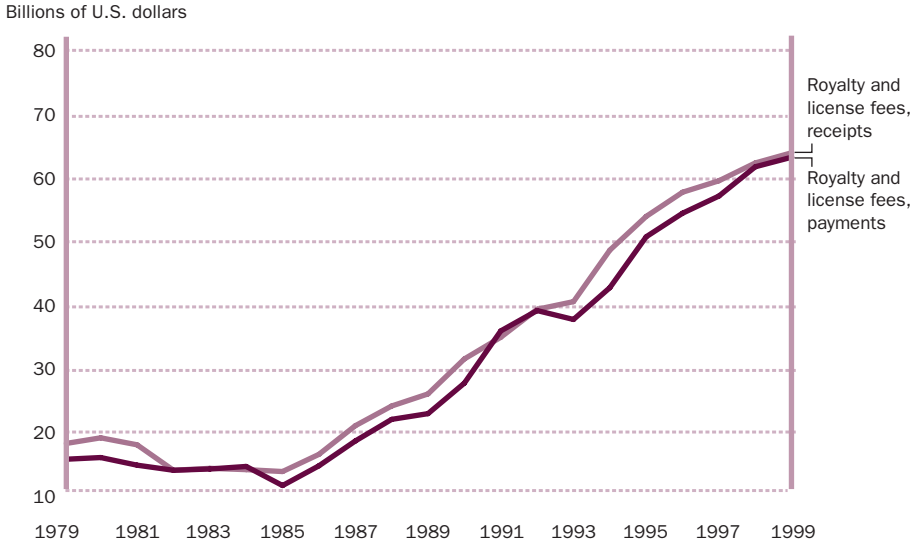
In OECD countries the proportion of adults with at least a secondary education has risen from 44% to 72% and that for those with some tertiary education

TABLE 3.6
Intangibles overtaking the tangibles

	Investment in tangibles and intangibles as a % of GDP (1999)					
	Investment as % of GDP	Of which: investment in machinery and equipment	Investment in intangibles	Of which: Public spending on education	R&D	Software
OECD	22.4	8.6	7.9	4.6	2.1	1.2
United States	21.3	11.0	8.4	4.6	2.3	1.5
EC	21.1	8.6	8.0	5.1	1.8	1.1
Japan	28.8		6.6	3.0	2.7	0.9
UK	19.4	10.9	8.5	5.1	1.8	1.5

Source: For OECD countries, OECD, *Science, Technology and Industry Outlook: 2000 Edition,* Paris, 2000, annex table 1, p. 219.

FIGURE 3.2
Worldwide payments of royalty and license fees, 1979–99



Note: The nominal values were converted to 1995 values by the U.S. GDP deflator.
Source: World Bank staff analysis.

The high income countries receive almost 98% of all royalty and licensing payments

TABLE 3.7
Payments and receipts of royalty and license fees, selected regions and countries, 1999
(Millions of U.S. dollars)

	Receipts	Percent	Payments	Percent
Low income	41	0.1	370	0.6
India	23	0.0	315	0.5
Lower-middle income	434	0.6	2,461	3.6
China	75	0.1	792	1.2
Upper-middle income	966	1.5	6,221	9.5
Brazil	133	0.2	1,283	2.0
High income	66,201	97.8	57,786	86.2
United States	36,467	55.5	13,275	20.3
European Monetary Union	10,379	14.1	22,880	32.8
Japan	8,190	12.5	9,855	15.1
Other	11,165	15.8	11,836	18.0
Total	67,691	100.0	66,837	100.0

Source: Calculated from World Bank, *World Development Indicators 2001*, Washington, D.C., 2001, table 5.11.

has doubled, from 22% to 44% over the last generation (table 3.8). And the absolute gap between developed and developing countries has increased. According to UNESCO the number of students enrolled in postsecondary institutions worldwide increased from 28 million in 1970 to 88 million in 1997. But the gap between developing countries and developed countries widened from 21 to 45 million, even though the population of developing countries is larger and growing faster.

To cope with rapid technical change and provide workers with skills to use the new technologies, the developed countries have increased average labor skill through extensive continuing education both in universi-

TABLE 3.8
Distribution of population age 25–64 by level of educational attainment
(1998)

	Primary and secondary		Postsecondary	
	Below upper secondary	Upper secondary	Study of at least 2 years focusing on practical skills	Study of at least 3 years theoretical education
OECD[a]	38	44	8	14
United States	14	52	8	27
EU[a]	46	57	10	12
Japan	20	50	13	18
UK	19	57	8	15

a. Simple average for the group of countries. For the OECD this leads to a total of 104%, for the EU 125%.
Source: OECD, *Science, Technology and Industry Outlook: 2000 Edition,* Paris, 2000, annex table 7, p. 225.

The fast pace of change may widen the knowledge gap creating a "knowledge divide"

ties and in firms. But developing countries, including China, haven't. Its educational attainments are still low, and the workforce needs massive retraining (chapter 5).

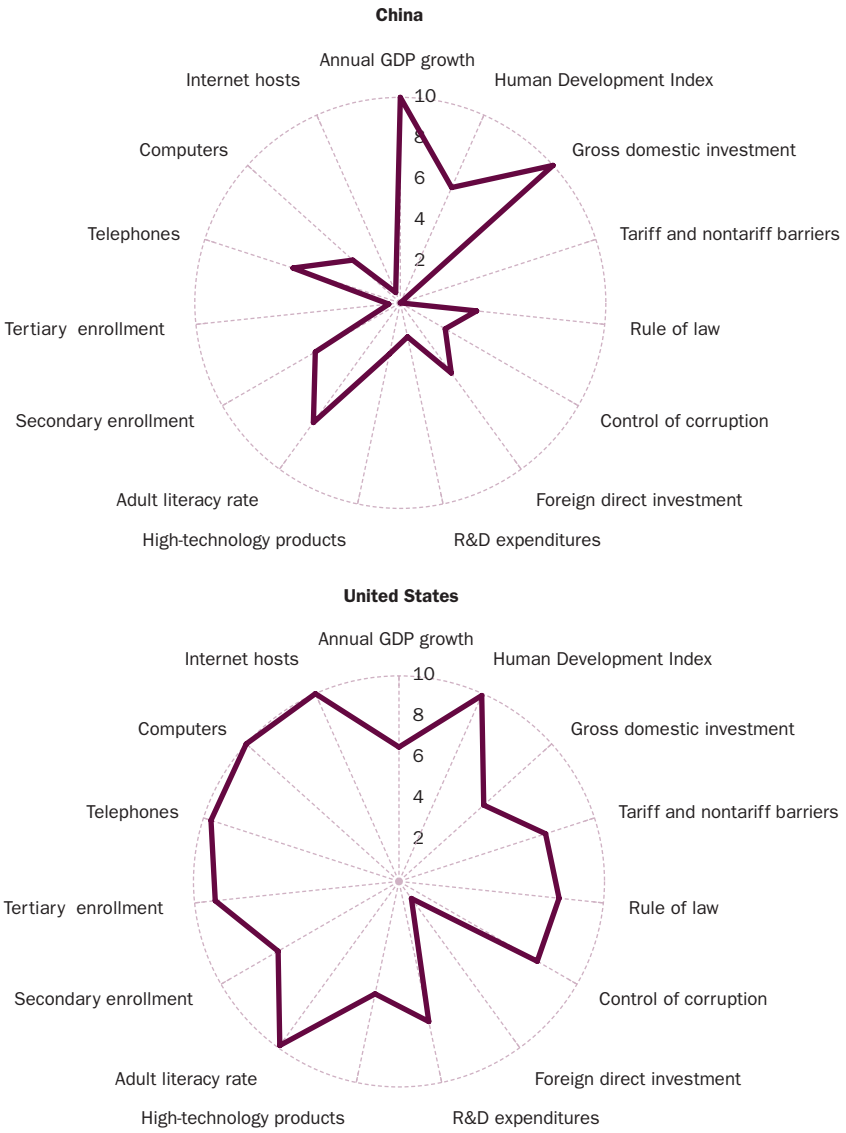
Assessing China's situation

The globalization of trade, finance, and information makes it easier to narrow knowledge gaps across countries. But the fast pace of change may widen the knowledge gap creating a "knowledge divide." If the gap widens, capital and other resources might flow to countries with stronger knowledge bases, adding to the inequality.

There is also the danger of widening knowledge gaps within countries. OECD countries worry that the rapid advances in knowledge may hurt unskilled workers and add to unemployment. There is evidence that technology and technology-related organizational change are widening wage disparities between skilled and unskilled workers, impacts likely to be felt even more in developing countries. The main causes of these issues are that access to education and ICT infrastructure is far more differentiated and formal safety nets are less prevalent. Rural areas and the poor run the risk of being left out of the knowledge-based economy.

Therefore China must position itself to take advantage of the potential of the knowledge revolution—and reduce the risks of social upheaval. To assist China with this task, the World Bank Institute has developed a framework outlining the main elements that need to be addressed. This section develops the framework (box 2.1) and makes a preliminary assessment of China's situation using a benchmarking tool developed by the World Bank Institute (appendix table 3.2).[11] To illustrate China's shortcomings, its basic scorecard is compared with that of the United States, perhaps the leading knowledge-based economy (figure 3.3).[12] More detailed analysis follows in chapters 4–9.

FIGURE 3.3
Knowledge scorecards for China and the United States



Source: Knowledge for Development, World Bank Institute.

China must position itself to take advantage of the potential of the knowledge revolution—and reduce the risks of social upheaval

Updated economic incentives and institutions

A flexible society and economy, able to cope with constant change is necessary to realize the full potential of the knowledge revolution. To achieve this goal, economic incentives and institutions must promote the constant redeployment of resources from less efficient to more efficient uses, requiring good macroeconomic, competition and regulatory policies. The financial system (including venture capital) has to allocate resources to promising new oppor-

tunities and redeploy assets from failed enterprises to more promising ones. Conditions have to be conducive to entrepreneurship, risk-taking, and the expansion of small enterprises. Science and industry have to exchange information. Labor markets have to be flexible enough to enable the redeployment of labor. And social safety nets have to facilitate the constant relocation and retraining of people for new jobs, and help those hurt by restructuring.

The ways people obtain relevant knowledge, and the incentives for them to gather, provide and use it, are also affected by the institutional structure of a society. These interactions involve relationships between legal rules and procedures, social conventions, and organizations such as firms, government, nongovernmental organizations, and markets. Equally important are the institutions that govern the rules and procedures in a society, which in turn determine how decisions are made and actions taken. A key feature is the quality of government, because its integrity and effectiveness determine the basic rules of a society. Another important element is the extent to which the legal system supports basic rules and property rights. For example, the creation and dissemination of knowledge are strongly affected by the degree to which intellectual property is valued and its rights protected and enforced.

Many areas in the economic and institutional regime need to be considerably improved

The ICT revolution also has implications for governance systems. Globalization and the move to a global innovation system intensifies pressure for international harmonization in the treatment of intellectual property protection, competition policy, and taxation. At the same time, greater democratization, transparency, accountability, and decentralization in government—in part facilitated by the ICT revolution—raise new challenges in responding to local needs in a global environment.

On the basic scorecard China has had a very impressive economic performance. It has also reached a high level of human development for a country at its per capita income. But its rapid growth has been the result primarily of very high investment rates. The economy is still relatively protected from international competition, indicated by its low score on tariff and nontariff barriers (though that will change with accession to the WTO). Moreover, there are significant barriers to competition across provinces in China because of internal regulatory and other intraprovincial nontariff barriers. This lack of competitive pressure and fragmentation of the market gives rise to great dispersions in productivity and efficiency across firms (chapter 7). In addition, China scores poorly in the indicators for the rule of law and control of corruption. Many areas of its economic and institutional regime need to be considerably improved (chapter 4).

Skilled and creative human resources for the knowledge economy

Skilled, adaptable people are crucial in taking advantage of the potential offered by the explosion of new knowledge and accelerating technical change. Ensur-

ing that expenditures on education are allocated efficiently and that the entire population has the knowledge and skills necessary to participate in the knowledge-based economy, requires particular attention—education is the basis for creating, acquiring, adapting, disseminating, sharing, and using knowledge.

Basic education increases peoples' capacity to learn and to use information. But this is just the beginning. It is also necessary to have technical secondary-level education—as well as higher education in engineering and scientific areas—to monitor technological trends, assess what is relevant for the firm or the economy, and use the new technologies. The production of new knowledge and its adaptation to a particular economic setting is generally associated with higher-level teaching and research. In industrial economies, university research accounts for a large share of domestic R&D. In China, however, universities still carry out little basic research.

Continuous learning and openness to new ideas are critical for a knowledge-based economy

Opportunities for life-long learning are also essential. Creating a culture of continuous learning and openness to new ideas is critical for a knowledge-based economy. This should not be limited to learning on the job, but should be expanded to foster learning at home and at school through structured continuing education courses, self-learning on the Internet, or computer-assisted instruction.

On the basic scorecard, China does fairly well on adult illiteracy for its per capita income. But it does less well on secondary enrollment rates, and even more poorly on tertiary enrollment rates—a major concern because higher education is important for making effective use of knowledge. China also has to considerably expand and modernize its education system and reform the ministry of education in order to provide an efficient incentive structure, both for educators as well as the students themselves (chapter 5).

A dynamic information infrastructure

The rapid advances in ICTs affect how manufacturers, service providers, and governments are organized—and how they perform. Greater access to ICTs is affecting how people work, learn, play, and communicate. As knowledge becomes a more important element of competitiveness, the use of ICTs is reducing transaction costs and barriers of time and space. They are also allowing the mass production of customized goods and services, substituting for limited factors of production. Indeed, they are the backbone of the knowledge-based economy. To support Internet-based economic activities, countries need to ensure competitive pricing of Internet services and provide an appropriate legal infrastructure to deal with online transactions.

On the basic scorecard, China still has a long way to go in fully developing and exploiting its information infrastructure. This is critical because China

can leapfrog in development by harnessing the new infrastructure (chapter 6). The national information infrastructure consists of telecommunications networks, strategic information systems, the policy and legal frameworks affecting their deployment, as well as the skilled human resources needed to develop and use the ICT infrastructure.

Effective use of the information infrastructure is equally important to capture the benefits of the knowledge revolution. It is also important to assess the knowledge and skills required to design, implement and use the new ICTs, requiring researchers and technicians across a spectrum of information technologies, a workforce that can use the new production technologies, and a general population that can use technology effectively. Addressing these needs will require developing education and training policies, institutions and programs to prepare the appropriate human resources. While the government does not need to provide any of these services, it can play a key coordination role in identifying needs and weaknesses, ensuring that the necessary skills are developed and setting in motion the mechanisms to achieve these goals. But there are also many policy areas in which the government will have to do more (chapter 6).

Effective use of the information infrastructure is equally important to capture the benefits of the knowledge revolution

An effective innovation system

An innovation system consists of the network of institutions, rules and procedures that affect how a country acquires, creates, disseminates, and uses knowledge (box 3.3). Today, the bulk of technical knowledge is produced in the developed countries: 86% of R&D and 86% of patenting and the production of scientific and technical papers. The disparity in the production of technical knowledge per capita between developed and developing countries is even

BOX 3.3
The national innovation system

There is no single accepted definition of a national innovation system; what is important is the web of interaction or the system as a whole. The concept of national innovation systems rests on the premise that understanding the linkages among the actors in innovation is key to improving a country's technological performance.

Innovation and technical progress are the result of a complex set of relationships among actors producing, disseminating, acquiring and applying various kinds of knowledge. Performance depends on how these actors relate to each other as elements of a collective system of knowledge acquisition, creation, and use. These actors are primarily private enterprises, universities, and public research institutes—and the people in them. The linkages can take the form of joint research, personnel exchanges, cross-patenting, technology licensing, equipment purchases, and a variety of other channels.

Source: Adapted from OECD, *Science, Technology and Industry Outlook: 1997 Edition,* Paris, 1997.

greater than the disparity of income. Fortunately, developing countries do not have to reinvent the wheel: there are many ways for them to tap into and use the knowledge created in developed countries. So, a key element of a developing country's innovation strategy is to find the best ways to tap into the growing global knowledge base and to decide where and how to deploy its domestic R&D capability.

To create and adapt knowledge requires universities, public and private research centers, and policy think tanks. Non-government organizations and the government are also part of the innovation system to the extent that they also produce new knowledge. Institutions central to the dissemination of knowledge include agricultural and industrial extension services, engineering consulting firms, economic and management consulting firms, and government research institutes.

China does poorly in its domestic R&D and in the technological intensity of its exports

The mere existence of these organizations, however, is not enough. More important is how effective they are in creating, adapting and disseminating knowledge to the people, firms, government, and other organizations, that then put it to use. That is why networking is critical. The intensity of networks—and the incentives for acquiring, creating, and sharing knowledge—are also influenced by economic incentives, such as policies for imports of foreign technology through technology licensing, direct foreign investment, foreign collaboration—and for the protection of intellectual property.

On the basic scorecard, China is average in its use of direct foreign investment as a way of obtaining global knowledge. But it does poorly in its domestic R&D and in the technological intensity of its exports. Chapter 7 assesses the technological level of the Chinese economy and the dissemination of technology, whether produced domestically or acquired from abroad.

Chapter 8 analyzes China's domestic R&D effort, and chapter 9 details how China exploits global knowledge.

Knowledge disparities across China

China is huge, with large and diverse provinces. The largest of them have more than 100 million inhabitants, more populous than even the largest European countries. But they differ greatly in natural and human resource endowments and in economic performance and welfare indicators. Parts of such prosperous areas as Beijing, Shanghai, and Tianjin are very much like first-world countries. Parts of the poorest provinces appear to be several centuries behind in their technology and living standards.

It was not possible to obtain the same data at the province level as was used for the cross-country scorecards, but regional comparisons of knowledge indicators[13] can still be made. The 31 Chinese provinces, including the four

TABLE 3.9
Vast differences in knowledge across Chinese provinces
Regional rankings based on a comprehensive knowledge development indicator (1998)

	Eastern Region	Middle Region	Western Region
High (I>= 150)	Beijing (606.1) Shanghai (529.0) Tianjin (283.7) Guangdong (212.7) Fujian (156.5) Jiangsu (154.6)		
Above average (150>I>= 100)	Hai'nan (127.6) Liaoning (126.7) Zhejiang (122.7)		
Below average (100>I>=75)		Jilin (99.5) Hubei (92.2)	Shaann'xi (88.1)
	Shandong (82.1) Hebei (75.7)	Heilongjiang (84.6)	
Low (I<75)		Hu'nan (69.7) Shanxi (64.3) Henan (63.7) Jiangxi (61.0) An'hui (57.7) Inner Mongolia (56.6)	Xinjiang (65.9) Chongqing (63.7) Gansu (58.3) Ningxia (54.7)
	Guangxi (50.9)		Sichuan (51.5) Yun'nan (48.8) Qinghai (44.2) Guizhou (38.3) Tibet (32.0)

Source: Hu Angang and Yizhi Xiong, *China's Regional Gaps in Knowledge Development: Characteristics, Causes, and Countermeasures,* Tsinghua University, 2000, p. 12.

autonomous municipalities, are characterized by indicators of R&D inputs (expenditure and personnel), R&D outputs (publication and patents), FDI (to gauge foreign inputs), education (primary, secondary, and tertiary enrolments), and information (newspaper subscriptions, telephone users, and Internet users).

The differences are daunting (table 3.9). It appears that Beijing and Shanghai, the most knowledge-intensive areas in China, have knowledge intensities 6.1 and 5.3 times the national average, respectively. Overall the coastal region has a much higher knowledge level than the Central and Western regions. Guizhou province reaches only 32% of the national average. Provinces with a low knowledge intensity tend to have rich natural resource endowments. This advantage, together with isolation and a closed outlook, may have driven them away from modern development policies.

The knowledge gap between the less developed and most developed regions appears to be larger than the economic gap in GDP per capita (table 3.10). Differences are also considerable in total factor productivity growth. The main issue is the lack of knowledge infrastructure (in a broad sense), reducing the efficiency of investment. In the western provinces, the growth in capital investment per capita over 1978–95 has been higher than growth in GDP per capita, reaching levels comparable to those in two eastern provinces.

TABLE 3.10
Growth of GDP per capita and its sources in seven Chinese provinces
(1978–95)

Growth rate	Shaanxi	Gansu	Quinghai	Ningxia	Xinjiang	Guangdong	Fujian	National total
GDP per capita	8.0	7.0	5.1	6.5	9.0	12.2	12.1	8.3
Capital per capita	8.3	5.7	10.2	10.5	13.3	12.3	10.3	9.1
Total factor productivity	4.7	4.7	1.0	2.3	3.7	7.3	8.0	4.7

Source: Angang Hu, Presentation at the World Bank Policy Forum China, India, Brazil, March 2001.

NOTES

1. The knowledge and ICT revolution involve significant reallocation of jobs across industries and changes in the skill and occupational composition of the workforce. OECD countries are having to make significant investments in training and retraining to help workers make use of the new technologies and perform new functions. In OECD countries the investments in just a subset of these intangibles (R&D, public education, and software) are already almost as high as investments in plant and equipment (about 10% of GDP).

2. For a good overview of some of the current trends and how they compare to prior revolutions, although it is limited to just the ICT technologies, see the special section in *The Economist,* September 23, 2000 titled "The New Economy: Untangling e-conomics."

3. The direct role of technology in this process is reflected in the changing patterns of international trade. Between 1976 and 1996, the share of high- and medium-technology products increased from 33% to 54% of total goods traded. On the other hand, the share of other primary commodities fell from 34% to just 13 percent, while that of resource-based products remained constant. These trends have major implications for developing countries, which are primarily exporters of primary commodities. Not only the share, but also the prices of their exports have been falling over the last five decades.

4. OECD, *A New Economy? The Changing Role of Innovation and Information Technology in Growth,* OECD: Paris, 2000.

5. See its prominent role in the annual *Global Competitiveness Report* produced by the World Economic Forum, and in the *World Competitiveness Yearbook,* produced by the IMD Management School in Switzerland.

6. OECD, *Science, Technology and Industry Outlook: 2000 Edition,* Paris, 2000.

7. OECD, *Science, Technology and Industry Outlook: 1998 Edition,* Paris, 1998.

8. UNCTAD, *World Investment Report 2000,* Geneva, 2000, p. 3.

9. UNCTAD, *World Investment Report 2000,* Geneva, 2000, p. 17, citing UNCTAD, *World Investment Report 1996,* Geneva, 1996.

10. UNCTAD, *World Investment Report 2000,* Geneva, 2000, p. 17, citing UNCTAD, *World Investment Report 1995,* Geneva, 1995.

11. The indexes have been scaled from 0 to 10 (the highest value). A higher value should be interpreted as positive. Country rankings are determined by the raw score on the 10 intervals. A country does not need to get a 10 on the variables, because there are some tradeoffs among some of them.

12. The benchmarking tool allows comparisons of China with any of the other countries on the full range of 61 variables. Presented here is the basic scorecard of 15 variables, representing some of the key factors in each element of the framework.

13. Hu Angang and Yizhi Xiong, *China's Regional Gaps in Knowledge Development: Characteristics, Causes, and Countermeasures,* Tsinghua University, 2000.

APPENDIX TABLE 3.1
Foreign direct investment in the global economy
Billions of dollars

	1982	1990	1999
FDI inflows	58	209	865
FDI outflows	37	245	800
FDI inward stock	594	1,761	4,772
FDI outward stock	567	1,716	4,759
Cross border M&A	..	151	720
Sales of foreign affiliates	2,462	5,505	13,564*
Gross product of foreign affiliates	565	1,419	3,045*
Total assets of foreign affiliates	1,886	5,706	17,680*
Exports of foreign affiliates	637	1,165	3,167*
Employment of foreign affiliates (in 1000s)	17,433	23,605	40,536*
Global GDP at factor cost	10,611	21,473	30,061*
Gross fixed capital formation	2,231	4,686	6,058*
Royalties and fees receipts	9	27	65*
Exports of goods and nonfactor services	2,041	4,173	6,892*

* Estimates for this year made by UNCTAD staff.
Source: UNCTAD, *World Investment Report 2000,* table 1.1, p. 4.

APPENDIX TABLE 3.2
Employment in China's high-tech industries

	1994 (1,000 people)	Percent of total industrial employment	1996 (1,000 people)	Percent of total industrial employment	1998 (1,000 people)	Percent of total industrial employment
Total industrial employment	65,800	100	64,500	100	47,530	100
Raw chemical materials and chemical products	4,050	6	4,070	6	3,040	6
Medical and pharmaceutical products	970	1.5	1,020	2	860	1.8
Chemical fiber	450	0.7	490	0.8	400	0.8
Ordinary machinery	4,420	7	4,220	7	2,750	6
Special purpose equipment	2,940	4	2,800	4	1,970	4
Transport equipment	3,450	5	3,540	5	2,790	6
Electric equipment and machinery	2,330	4	2,360	4	1,700	4
Electronic and telecom	1,630	2	1,630	3	1,340	3
Instruments, meters, cultural, and clerical machinery	900	1.4	820	1.3	530	1.1
Subtotal	21,110	32	20,950	32	15,380	32

Source: China Statistical Bureau, *China Statistical Yearbook,* Beijing: China Statistics Press, 1999.

APPENDIX BOX 3.1

The knowledge assessment tool

The knowledge assessment looks at 61 structural and qualitative variables to benchmark how an economy compares with its neighbors, competitors, or countries it wishes to emulate. It helps to identify the problems and opportunities a country faces, and where it may need to focus policy attention or future investments. The comparisons cover 75 countries, including most of the developed OECD economies and about 40 developing economies. The 61 variables are proxies for the four pillars of a knowledge-based economy (box 3.1). In addition, the methodology includes several variables that track overall economic performance, to show how well an economy uses knowledge for economic and social development. (An interactive Internet-based exercise, to facilitate comparisons of countries, is available at http://www1.worldbank.org/gdln/kam.htm.)

The "standard" 15-variable scorecard looks at:

Performance indicators

1. Average annual GDP growth 1990–98 (%) (*World Development Indicators 2000*).
2. Human development index 1998 (*Human Development Report 2000*).

Economic incentives

3. Gross domestic investment as a % of GDP (annual average growth, 1990–98) (SIMA database 2000).
4. Tariff and nontariff barriers (Heritage Foundation 2000).

Institutional regime

5. Rule of law (World Bank Institute 1999).
6. Control of corruption (World Bank Institute 1999).

Human resources

7. Adult literacy rate (percentage of those 15 and older) 1998 (*Human Development Report 2000*).
8. Secondary enrollment 1997 (*World Development Indicators 2000*).
9. Tertiary enrollment 1997 (*World Development Indicators 2000*).

Innovation system

10. FDI as percentage of GDP 1990–98 (SIMA database 2000).
11. Total expenditure for R&D as a percentage of GNP 1987–97 (*World Development Indicators 2000*).
12. High technology products as a percentage of manufactured exports 1998 (*World Development Indicators 2000*).

Information infrastructure

13. Telephones per 1,000 persons, 1998 (telephone mainlines and mobile phones) (*World Development Indicators 2000*).
14. Computers per 1,000 persons, 1998 (*World Development Indicators 2000*).
15. Internet hosts per 10,000 persons, July 1999 (*World Development Indicators 2000*).

PART 2 **Building the foundations of the knowledge economy**

These foundations consist of three elements:

- An improved economic incentive and institutional regime, requiring actions, among other areas, in the legal, regulatory, and competition framework, and the labor and financial markets; these are outlined in chapter 4.
- A well educated population, equipped with skills needed to cope efficiently with the challenges and opportunities of the knowledge revolution; new efforts and reforms required for the adaptation of the Chinese education system; discussed in chapter 5.
- A massive investment in information and telecommunications infrastructure, key infrastructure of the knowledge economy and information society; further measures to be taken by China are detailed in chapter 6.

4 Updating economic incentives and institutions

China's incentives and institutions, despite considerable progress over the last two decades, still constrain the economy

Economic incentives and institutions set the context for an economy that has to continually restructure in response to the rapidly changing challenges and opportunities of the knowledge revolution. China's incentives and institutions, despite considerable progress over the last two decades, still constrain the economy in taking full advantage of rapid advances in global knowledge and such knowledge-related assets as education, information infrastructure, and domestic R&D. They also constrain the absorption of the millions of workers being displaced by the wrenching restructuring under way as part of China's rapid transformation—and cause inefficient allocation of capital.

Most of the problems with institutions stem from three causes:

- The state and its various agents want to control most economic activities.
- The legal framework lacks clarity, especially for private property rights.
- The institutions supportive of the market economy are underdeveloped.

These causes are legacies of the command economy. But they are also remnants of centuries-old Chinese traditions—and of Chinese conceptions of the state and society. Interpersonal relationships (guanxi), combined with the strong Chinese bureaucracy, encourage the allocation of resources based on privilege and familiarity rather than viability and productivity, which in turn causes inefficiencies in business and innovation.

A theme of this chapter is establishing more transparent policy administration, program development, and funding allocation mechanisms. A broad and deep cleansing of government agencies and business practices is essential to provide proper incentives. Policy measures can evolve to produce a knowledge-based economy with a distinctly Chinese flavor, as demonstrated by Hong Kong (SAR), Singapore, and Taiwan, China. Each of them has adapted to international norms—enabling more extensive participation in the global economy, while remaining uniquely Chinese.

The main challenge will be to transform the Chinese state. The government can no longer control all economic activity. Going forward, transparency will be essential. Knowledge and information are now more generally available, and there is more awareness of injustice and inefficiency, increasing the demand for accountability. Given the need to cope with the fast-paced knowledge revolution, the government should decentralize decisions to those who

have the best feel for needs and opportunities and can react quickly. Reducing its direct influence on the economy, the government should guide the market to promote a self-regulating, knowledge-based, socialist market system through clear rule of law, an effective regulatory regime, an effective government, and other elements of good governance (box 4.1).

Most changes involve improving the investment climate[1] for both large and small businesses. Promoting private enterprises is necessary for China to absorb its large workforce. In addition, the government should strengthen social safety nets and the markets for labor and finance.

The government should guide the market to promote a self-regulating, knowledge-based, socialist market system

Some of key elements of this new role of the state include:

- Promoting a more formal rule of law, with fair, transparent, and stable rules but also consistent, reliable enforcement mechanisms, with no exceptions or special privileges.
- Strengthening regulatory frameworks by constructing key institutions to support the market and address market failures, including: agencies for consumer protection and to guard against anti-competitive practices; internationally acceptable quality standards and administrative guidelines; and independent, supervisory and regulatory authorities.
- Strengthening support for the private sector, especially through removal of barriers to private development and foreign participation in services, where policy biases, inattention, and excessive regulation have constrained growth.
- Reforming inefficient state-owned enterprises in manufacturing and heavy industry—and opening such services as power, transportation, telecommunications, and finance to competition from the private sector.
- Implementing appropriate social safety nets.
- Facilitating the flexibility of the labor market.
- Strengthening the financial sector—increasing the autonomy of Chinese banks, permitting them to allocate capital more efficiently by instituting risk-based, rather than policy-based lending practices, and further developing the stock and insurance markets.
- Ensuring equal access to economic opportunities for all members of society, especially groups that have been often discriminated against even in developed economies, such as women, minorities, and the undereducated and underemployed.

Establishing a more formal and transparent rule of law

The legal system in China is extraordinarily complex, often unclear, and sometimes even contradictory. This uncertainty seems to result principally from the many uncoordinated legal initiatives of the different levels of government—central, provincial, and local—and the various government ministries, each

BOX 4.1

Governance matters: How ineffective policy administration hampers growth

While anecdotal examples of how poor government effects economic growth and development are plentiful, the number of studies that actually attempt to quantify these results are quite scarce. However, the World Bank Institute's Governance, Regulation, and Finance division has developed six clusters of governance indicators:

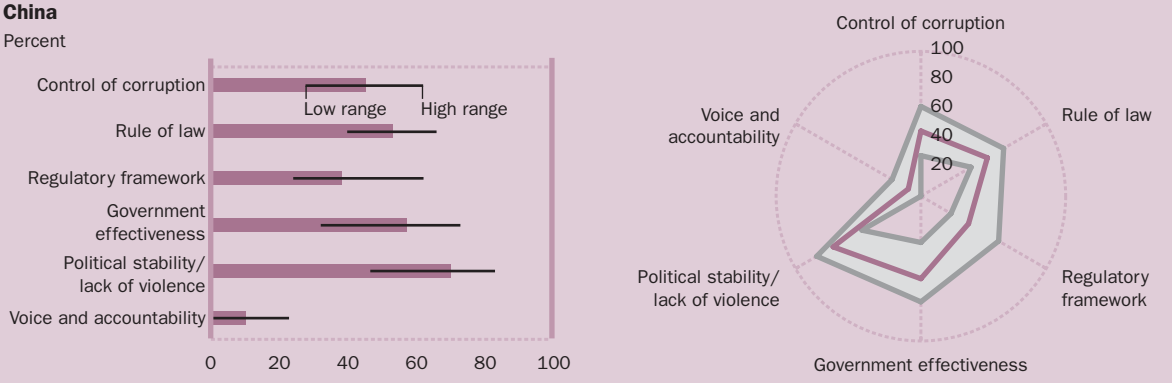
- Rule of Law—evaluates the levels of crime, consistency and fairness of the judicial system, and the effectiveness and enforceability of the law.
- Regulatory Burden—the degree to which the government controls rather than guides with its polices.
- Government Effectiveness—the quality of government services, and the quality and independence of the bureaucracy, and the credibility of the government's commitment to stated policies.
- Graft—the level of corruption in an economy.
- Voice and Accountability—the political process, civil liberties, and political rights, including media rights.
- Political Instability and Violence—the risk that the government in power could be overthrown by methods outside the normal process of transferring power.

These clusters of indicators—for 155 to 173 countries, depending on data available for the indicator—were regressed against per capita GDP, infant mortality, and literacy, to determine what, if any, effect each had on development. The results are staggering. For any of the six clusters, a one-standard-deviation increase leads to a two-and-a-half to four-fold increase in per capita income, a similar decline in infant mortality, and anywhere from a 15 to 25% increase in literacy.

Curiously, the results held for large changes in an aggregate, and not for small specific changes, suggesting that small steps in any of the areas will have little effect on overall development, but that large overhauls in any of them would significantly increase a country's living standards.

BOX FIGURE 4.1

China



In both charts, higher values imply better governance ratings, so China fares reasonably well in most areas except voice and accountability, suggesting significant potential for exploiting positive change.

Source: Daniel Kaufmann, Aart Kraay, and Pablo Zoido-Lobatón, "Governance Matters," Policy Research Working Paper 2196, World Bank, Washington, D.C., 1999.

with specific responsibilities and administrative territories. A complicated grid has developed, leading to an accumulation of legal and bureaucratic regulations—and clandestine laws to test their effectiveness. Additional problems include corruption, weak enforcement mechanisms, inadequately trained (and underpaid) judges, and long consensus efforts to unite administrative players with contradictory interests. This penalizes entrepreneurs, particularly those not plugged into power networks and foreigners unfamiliar with the legal and administrative climate.

The National People's Congress recently passed a National Legislation Law to define the hierarchy of laws and regulations. It should also establish an independent commission to audit the aspects of the legal system most detrimental to innovative projects (on the basis of complaints) and then use its power as supreme arbitrator to address the deficiencies exposed.

Moreover, several important legal pillars of a market economy are still lacking. Property rights are still undefined in many areas. Unclear rules for the ownership of state enterprises impede their restructuring. Competition and antimonopoly laws are incomplete. Many laws affecting the financial sector, such as bankruptcy and the regulation of financial institutions, are also ineffective. So are laws to provide adequate social safety nets, consumer protection, and environmental regulations.

Clarifying the law and enforcing it are of utmost importance

The highest Chinese institutions, such as the National People's Congress and the State Council, should initiate appropriate policy measures to address these barriers. Needed are adjustments to laws, auditing or hearing procedures for preparing those adjustments, and providing the financial and human resources to implement laws and regulations.

Clarifying and enforcing the law are of utmost importance. These mechanisms require informed and diligent prosecutors, well-established courts, cataloging of and adherence to precedents from prior decisions, and imposing stiff penalties. China has traditionally paid little attention to the rule of law in the western sense. The predictable and equitable application of the law has not been fully integrated into Chinese practice. Some areas for further development:

- Creating transparent, stable, and predictable legislative processes.
- Enhancing public understanding of the law.
- Improving access to legal advice to protect the rights and obligations of parties to economic transactions
- Solidifying public confidence in the fairness of dispute resolution mechanisms
- Ensuring that the government, as well as individual enterprises, is accountable to the law.

Intellectual property rights

Special attention also needs to be paid to the development of appropriate incentives for knowledge creation, valuation, and protection. Urgent action is needed on widely spread copying practices, which are problematic not only for foreign enterprises, but also for an increasing number of domestic ones, notably the new technology-based firms. A series of laws were recently passed to update the intellectual property rights regime in China to place it on par with those of industrial countries.[2] However, serious problems of enforcement remain, requiring

multi-pronged actions that include education and awareness campaigns, recruitment and training of appropriate human resources, streamlining of the judicial and administrative procedures, and strengthening of penalties. Intellectual property rights issues in certain sectors, such as pharmaceuticals, where there are major areas of friction with foreign companies, should receive the greatest attention. The counterfeiting practices that plague not only foreign investors,[3] but also many domestic producers, should be energetically combated with vigilant monitoring and penalties. Chinese authorities are well aware of most of these issues and stronger enforcement actions are being taken on trademarks and copyrights; however, enforcement on patent legislation is lagging behind. This area will need to be strengthened, particularly as China moves to more sophisticated technologies and upgrades its own technology development and patenting mechanisms.

However, China should also participate in the global discussion addressing the evolving international agreements on intellectual property rights. Many new and complex issues, particularly in biogenetics and software, with important implications for China are being opened as the technological base evolves. China should actively represent its interests in the formulation of these agreements. It can also play an important leadership role in representing the interests of other developing countries in this complex area.

The conditions of economic competition in China are still poor

Strengthening competition and regulatory frameworks

Establishing effective regulation is a complex, arduous, and never-ending task. Even in the most advanced countries, continual tweaking ensures that the economic system encourages competition and equality, yet discourages rent-seeking and fraudulent activity. But guiding economic participants to interact effectively through capable regulation still is much less demanding than controlling all economic activity through exchanges forced by government.

Trade

One key to creating stronger incentives to make effective use of knowledge for development is fostering more competition in the economy. The conditions of economic competition in China are still poor—still strongly affected by monopolies, opaque procurement policies, protected markets, and interprovincial barriers to trade. Rent seeking and inefficient management of public funds put a drag on GDP that ranges anywhere from 5.1% to 7.2% a year.[4] Competitive pressure is the best incentive for improving management, encouraging innovation, and spurring economic growth. China's admission into the WTO will help promote these changes, by placing great pressure to restructure activities and profit from China's international comparative advantages.

But even more reform is needed, and the government is establishing appropriate rules and standards in underadministered sectors, while taking action to deregulate sectors in which it has too much control.

Another area requiring attention is the array of administrative and other obstacles to the free flow of goods and services among Chinese provinces. By joining the WTO China is going to reap even greater gains from international specialization. But many tariff and nontariff barriers to internal trade defeat the potential of China's large internal market for realizing economies of scale and scope. Taking advantage of a large market at home is a big part of the reason the United States was so well positioned to expand to international markets. It is also the main force driving the European Union and many other regional trading arrangements. The Chinese government should remove internal trade barriers to take full advantage of its large market.

The Chinese government should remove internal trade barriers to take full advantage of its large market

Competition and regulations

Market-supporting institutions, such as fair trade and anti-monopoly commissions, should also be strengthened to maintain discipline among large domestic monopolists, as well as the multinationals that will be entering many sectors. Both have the potential to abuse superior technologies, creating insurmountable first mover advantages and monopoly power in such sectors as telecommunications, finance, distribution, and marketing. Small and medium enterprises and independent new start-ups, perhaps the most significant prospective vehicles for growth in China, are particularly vulnerable to predatory behavior. Administrative, industrial,[5] financial, and geographic restrictions hinder their development—restrictions that need to be gradually eliminated.

In addition, the government has to put in place appropriate regulations to deal with safety, standards, and environmental regulation. In the environmental area it also needs to strengthen market mechanisms to internalize some of the costs of using the environment (box 4.2).

Information collection and dissemination

More generally, the government has to promote better collection and dissemination of information. This should start with improving the collection of statistics on socioeconomic activities, which can be used to track economic performance as well as social development. It should also include stronger requirements for the disclosure of financial information by firms and organizations (including government) to promote greater transparency and accountability. Finally, it should also include the promotion of spe-

BOX 4.2

Incentives and regulations to improve sustainability

The Chinese government has established regulations for environmental protection and invested considerable resources in protecting air and water. And the economic reforms have reduced China's energy intensity at an impressive pace. But China now has to go beyond the command and control measures of the past. It needs to harness the market to work for the environment, not against it.

This means pricing energy and water resources to reflect their scarcity. It also means expanding the use of taxes on pollution. Environmental taxes on coal and gasoline and pollutants would use the market to clean the environment. Pricing energy correctly would create incentives for firms to invest in more efficient technology and abatement. Firms would use cleaner technologies and invest to bring even cleaner technologies to the market.

China must also pursue investments with the highest environmental benefits for future generations. For example, public investment in natural gas to replace home use coal, in research and development for cleaner technologies, in wastewater treatment, and in public transit systems to reduce the pollution from an automobile-based urban transport system.

China needs, in addition, to increase its administrative capabilities for the environment. This includes better integration of policies and implementation of reforms across different functional areas as well as between the federal, provincial, and local level. And it needs stronger environmental education—to increase citizen awareness of environmental issues. Combined with better environmental monitoring and provision of information on polluters, increased education can lead to greater pressure by people on the worst polluters, as has been found in many countries.

Note: For more on environmental polices in China see Todd M. Johnston, Feng Liu, and Richard Newfarmer, *Clear Water, Blue Skies,* China 2020 Series, Washington D.C., World Bank, 2000.

cialized institutions to analyze and disseminate information, such as credit-rating agencies; testing and quality control, and product evaluation agencies.

Taxation

Tax collection in China is also underdeveloped

Tax collection in China is also underdeveloped. The tax revenue of the central and provincial governments is just 14% of GNP, less than half the average for OECD countries. The government is forced to finance a large part of its spending through off-budget funds, including those from the banks. Under the command economy, China had a very simple taxation system for enterprises and individuals. But with the transition to a socialist market economy, the tax system has become more complex. Authorities at all levels have far too much latitude to manipulate the tax code. To promote economic activity, they have established many tax incentives to try to attract firms, stimulate innovation, and promote other economic activity. The result: inconsistent, inefficient tax collection, contributing to the government's deepening financial difficulties.

Improving tax collection would also be important to fund government programs to improve social safety nets and social spending to deal with problems of equity and inequality across provinces.

The central authorities, possibly the National People's Congress Financial and Legal Commission, should establish a precise list of useful incentives that foster the promotion of a knowledge-based economy without being a drag on revenues, potentially establishing some order in the muddled array of arrangements that currently exist. Establishing functional incentives that promote innovation will be more beneficial than those that endorse specific sectors or industries. Specific recommendations include providing rebates for researchers or overseas Chinese who create enterprises (chapter 9), and supporting the development of nonprofit organizations—essential for technical training and knowledge diffusion.

Although people in China are remarkably resourceful, they have had difficulty establishing themselves as visible private entrepreneurs

Expanding the private sector

China's growth has been based on first restructuring agriculture and then moving people out of agriculture and into industry, including SOEs, TVEs, and foreign enterprises. China is now in the middle of a dramatic transformation from a command economy to a socialist market economy. The number of workers in state-owned enterprises plunged from 112 million in 1995 to 86 in 1999, and those in collective urban enterprises from 32 million to 17, for declines of 23% and 46% in just four years (table 4.1). Meanwhile the number in the private enterprises—broadly defined to include enterprises fully registered as private plus some sort of shareholding companies—rose from 13 million to 32 million, and the self-employed from 46 million to 62 million. The private sector (private plus self-employed) shot up from 59 million to 94 million employees (59%) in just four years!

This recent transformation has set the stage for unleashing one of China's greatest assets—the tremendous entrepreneurial capability of its people. Although people in China are remarkably resourceful, they have had difficulty establishing themselves as visible private entrepreneurs. But despite the unclear legal and regulatory environments,[6] entrepreneurs have found ingenious informal ways of overcoming bureaucratic hurdles in order to survive. Informality has allowed private enterprises to respond flexibly to changing policies and regulations and react nimbly to new market opportunities, while diversifying risk and avoiding excessive taxation, regulation, and competition.

Informality, however, has its limits, especially for firms growing in size and complexity. Employment in private enterprises, more narrowly defined, was only 17 million at the end of 1999—only 1.5 million of 8 million enterprises, with sales of 720 billion yuan, or slightly less than 10% of China's 7.7 trillion yuan

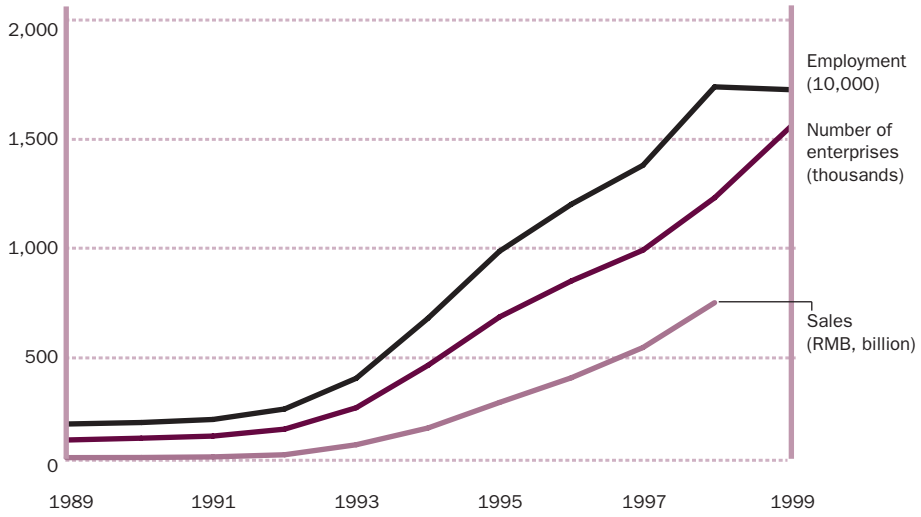
economy in 1998 (figure 4.1). Large, mature companies are often unfocused with limited management capacity and have difficulty in attracting funding and technical skills.

At the 15th Party Congress held in September 1997, the private sector was recognized in a constitutional amendment. The amendment provides greater assurance of a better policy environment for private firms. It should also encourage more formalization of enterprises, creating conditions that would increase the capacity of domestic firms to withstand the foreign competition from joining the WTO. But these actions are not enough. Clarifying the current functional definitions, including the distinction between public and private enterprises, and determining the governance structures and incentive regimes that pertain to each are essential to establish greater transparency and to reward effort fairly.

The next major step will be explicitly recognizing private property

The next major step will be explicitly recognizing private property. The current lack of clarity and fear of possible appropriation by the state are still

FIGURE 4.1
The private sector, developing in China



Source: International Finance Corporation Beijing office.

TABLE 4.1
Structure of employment, by type of ownership in China
(1980–99, in millions of workers)

	Total	Urban	State-owned	Collective	Private[a]	Foreign	Self-employed	Rural	TVE	Private	Self-employed
1980	423.6	105.3	80.2	24.3	0.4	..	0.8	318.4	30.0	..	..
1985	498.7	128.1	89.9	33.2	0.5	..	4.5	370.7	69.8	..	..
1990	693.1	166.2	103.5	35.5	1.5	0.7	5.7	472.3	92.7	1.1	14.9
1995	679.5	190.9	112.6	31.5	8.6	5.1	15.6	488.5	128.6	4.7	30.5
1999	705.9	210.1	85.7	17.1	22.7	6.1	24.1	495.7	127.0	9.7	38.3

Note: In 1995 and 1999, an important amount of "floating" employees in urban areas was not registered in any official category.
a. Under this heading are companies classified as private enterprises, plus those classified as joint-owned units, limited shareholding corporations, limited liability corporations, and shareholding corporations. The last two categories actually appear only from 1998 on.
Source: Calculated from Chinese Statistics Bureau, *China Statistical Yearbook,* Beijing: China Statistics Press, 2000, table 5-4.

disincentives for Chinese people to fully apply themselves, expand their businesses, and innovate—thus hampering economic growth. While this action might seem inconsistent with socialist theory, it seems compatible with the "one country, two systems" arrangement in Hong Kong and Macao.

Promoting small and medium enterprises

China does not yet have a well-developed service sector, so the potential for growth is huge

In addition to establishing a legal basis for private property, the government should undertake proactive strategies to help the development of small and medium-size enterprises in all sectors, from agriculture to services:

- Drastically reducing the many regulatory hurdles for establishing and operating new private enterprises.
- Ensuring that small and medium-size enterprises have access to bank credit.
- Promoting informal lending schemes to small start-up businesses, such as group lending and special micro-venture schemes.
- Providing small and medium enterprises access to market and technical information.
- Developing formal and informal basic business and accounting skill training aimed at small and medium enterprises.
- Strengthening university and continuing education offerings relating to business and entrepreneurial skills.
- Drawing on extensive global experience on small and medium enterprise support programs, adapting the most relevant to the Chinese context (box 4.3 and table 4.2).

The Chinese government should encourage private enterprise within service industries. Due to past policy biases, China does not yet have a well-developed service sector, so the potential for growth is huge in such industries as financial and insurance services, management and technical consulting, call centers, law, sales, marketing, advertising, public relations, accounting, computer programming, travel, and tourism. Service industries are knowledge and labor-intensive, and therefore are particularly necessary for the transition to a knowledge based society. Productivity gains made in service sector industries not only benefit the service industries themselves, but benefits also trickle down through other sectors, including manufacturing and agriculture, leading to huge productivity and efficiency gains in all segments of the economy.

Reforming the state-owned enterprises

Still employing almost 90 million people and accounting for more than 60% of government revenues, SOEs play a major role in the Chinese economy, and

BOX 4.3

Government support for smaller enterprises

Small and medium-size enterprises account for significant economic activity in all high-income countries. In the EU they make up 93% of firms, with nearly two-thirds of employment (more than 70 million people). In the United States, more than 50% of private employees are employed by SMEs, and they account for 78% of employment in nonprimary industry in Japan. This is especially true of the service sector, where SMEs are particularly prevalent.

In order to promote these types of enterprises, governments of advanced countries enact policies and programs that promote entrepreneurial activity. Most OECD countries have specific agencies responsive for promoting small business. Agencies such as the Small Business Administration in the U.S., the Small and Medium Business Administration in South Korea, and the Small Business Service in the United Kingdom provide assistance and support for people trying to start a small business. However, there are often many regulatory hurdles that small business founders must contend with to gain access to the incentive programs and benefits provided by the government, which potentially discourages would-be entrepreneurs. Best practice in this area are "one-stop shops" for SME information and program benefits, such as One Stop Capital Shops in the U.S., and the UK's Direct Access Government online resource.

Lack of finance availability is a major impediment to small business growth. Governments often facilitate venture capital and other methods of financing in order to spur growth of small firms. In addition, many governments provide fiscal incentives, such as grants or tax breaks, to provide financial incentives for small enterprise growth. A particularly effective form of growth for SMEs is through exports. Therefore, many countries have also targeted SMEs with export credit programs and/or assisted them with accessing foreign markets.

Innovation is also an important part of small business development. Best-practice governments provide grants for R&D to small enterprise, as well as providing technological support through diffusion programs designed to promote the flow of expertise throughout the economy. In addition, ICT technologies are providing significant opportunities for cost cutting and to widen their market penetration through B2B and B2C ecommerce, providing opportunities for SMEs to serve very small market niches that might otherwise be impractical and unprofitable.

The government should undertake proactive strategies to help the development of small and medium-size enterprises

TABLE 4.2

Best practice in SME promotion

Regulatory reform	Funding and promotion	Innovation and technology	Market access
• US—One Stop Capital Shops • UK (regional), Direct Access Government • Portugal—Centres for Company Formalities • South Korea—Small and Medium Business Association • Norway—Action Plan for Small Enterprises • Turkey—Small and Medium Industrial Development Organization	• UK—Enterprise Investment Scheme, Venture Capital Trusts • Netherlands—SME Credit Guarantee Scheme • US—Small Business Investment Companies, NASDAQ • Denmark—VaekstFonden Loan Programme	• US—Small Business Innovation Research programme • South Korea—Enterprise Information Incubator Project • Canada—Industrial Research Assistance Program • Sweden—Foundation for Technology.Transfer • Ireland—Small Business Operational Programme	• Spain—100 Policy for SMEs • Turkey—Export Credit Programme • US—Export Express • Mexico—Export Guidance System • Australia—Export Access Program • Netherlands—New Businesses in Foreign Markets

Source: OECD, *SME Outlook 2000,* Paris, 2000.

their transformation is the most challenging industrial policy problem faced by any government in the world. A majority of these enterprises are experiencing difficulties and will be forced to lay off large numbers of employees to survive. The proposed reforms are not that the state should get out of the production entirely, but that it should get out of sectors that are not strategic, or those in which it does not have a comparative advantage. In some sectors SOEs are demonstrating fairly competitive capabilities, allowing them to successfully enter difficult world markets. These successful ventures could stay in state hands as long as they do not receive special financial or regulatory treatment, or garner other unfair advantages over non-state owned competitors.

A concerted effort should facilitate the spinoff or creation of small enterprises from bankrupt and other state enterprises

To make the SOEs more efficient and productive, a three-pronged approach is recommended:

- First, a reform of the corporate governance structure is necessary. As long as the government appoints the top managers, the SOEs will only respond to their bosses within the government instead of reacting to the needs of the market, leading to corruption, rent-seeking, and resistance to change, risk, and innovation. SOEs should be given more autonomy with elected managers and independent boards of directors, while government representatives, whatever their level, should be separated from business decisions.
- Second, social services should be unbundled. SOEs are burdened by obligations to provide housing, kindergarten, pension plans, and other social service functions. This unbundling will require the rapid establishment of a social security system as well as other safety nets.
- Third, asset ownership should be resolved. Assets now belong to the state and can therefore not be freely used, sold, or transformed by enterprise management. As long as this remains unresolved, the climate for innovation and increased competitiveness in SOEs will remain poor.

A concerted effort should facilitate the spinoff or creation of small private enterprises from bankrupt and other state enterprises. For both, the issue of the ownership of state assets is critical. For bankrupt state enterprises it is important to have efficient ways to redeploy their assets to productive use. For existing enterprises it is important to have them shed noncore activities and to contract out services that private firms can provide more efficiently. This can help absorb the labor—and support the development and growth of an efficient service sector.

Strengthening social safety nets

Current and potential future unemployment make appropriate social safety nets essential for stability in China. Establishing these nets will remove the bur-

den of providing financial support to SOEs for unnecessary employees and allow SOE managers to hire the proper staff to innovate in products and processes. This should accelerate sale of the SOEs to foreign bidders.

One big concern in reforming SOEs is that the resulting high unemployment could cause social and political instability. People affected by the reforms need financial support in the short term. But this support should not be a limited welfare system that just hands out money. An incentive-based unemployment system, linked to achievements such as re-education, is strongly recommended.

Other social safety nets are needed as well, such as low-income housing, health systems, pension and disability funds, and other transferable benefit packages. The transition to a fully funded system will take significant effort and financial resources. It will also require detailed analysis and coordination with policies in other policies, such as the strengthening of financial markets.

Current and potential future unemployment make appropriate social safety nets essential for stability in China

Enhancing labor's flexibility

Dealing with a larger labor force, including the millions being displaced from the agriculture and informal industry, requires a more flexible labor market. But China's labor market is constrained. Rules restricting mobility, such as "hukou" laws—the system that limits considerably health, housing, school, and other benefits for those who migrate from one province to another (particularly workers with low qualifications) considerably worsens unemployment. Unless the restrictions are eased, there will be large regional pockets of socially destabilizing unemployment.

The large "floating population" without residency permits in urban areas may range from 90 to 150 million people, or 13% to 21% of the labor force. These people, unable to find official jobs without proper hukou, settle for unsavory employment in the black market as janitors, low-paid factory workers, nannies, and construction workers. The wages in these less-than-prestigious positions are hardly enough to support one person, so informal workers are often separated from their families for long periods. The restrictions on labor mobility widen the income disparity between the coastal provinces and the rest of China—and inflate the numbers entering illegal professions, such as prostitution, drug dealing, and smuggling.

While labor cannot be immediately allowed to be freely mobile, the rising unemployment and displaced labor must be addressed. One possible solution is to partially dismantle the hukou system, keeping some of its benefits attached to geography (such as retraining), but allowing others, including the ability to be employed and health care, to float with the population. By increasing the mobility of labor, this would ease unemployment and preempt some migration into larger cities. It would also increase the quality of life for

those in these low-skilled, unpleasant occupations, and reduce the number seeking a socially undesirable living.

Beyond these actions, the government also needs a labor-using development policy, with three elements:

- Investing in public infrastructure, such as feeder roads, water supplies, and other basic social infrastructure, especially in the western provinces.
- Developing cities and towns creating construction that will absorb excess labor. But it is also important to consider the sources of livelihood for those cities once built—their productive base, and how knowledge can provide economic livelihood.
- Strongly promoting services, removing regulatory and other policy constraints, and using knowledge to diversify the range of services that China can provide.

China is fortunate to have one of the highest savings rates in the world, but the allocation of these savings leaves much to be desired

Strengthening the financial sector

The financial system—and the key institutions and rules that regulate it— are the "brains" of a knowledge-based and market economy, processing information to allocate capital to the most efficient projects. China is fortunate to have one of the highest savings and investment rates in the world—more than 40% of GDP. But the allocation of these savings leaves much to be desired.

As in most developing countries, China's financial system is dominated by the banking sector, which is more than three times larger than the stock market. China has rapidly expanded its banking sector over the last decade, and in 1999 banks provided credit equal to 130% of GDP, almost the average for high-income economies (table 4.3).

In the past the bulk of lending went to the SOEs, with the rest distributed as policy loans, targeted at specific sectors. But many distressed SOEs have begun to stop payment on their loans, creating a high level of nonperforming loans in the banking system, estimated at $270 billion, or roughly 30% of GDP, with $133 billion of those loans (roughly 14% of GDP) recently transferred to four specialized asset management corporations similar to the Resolution Trust Corporation in the United States.

A few years ago the government separated policy loans from the rest of the banking system by creating three special policy banks. The government has also been doing a lot to strengthen the four national commercial banks, which account for roughly 60% of the banking sector. Improvements include setting up stricter and more transparent loan classification schemes, better accounting and supervision procedures, and a more independent auditing system. But new nonperforming loans are reappearing as more loans to state owned enterprises go bad, and the policy banks extend credit for projects not

financially viable. The basic problem is that the government still uses the banking system to subsidize ailing enterprises and to pursue special policies, both of which lead to additional non-performing loans and greater strain on the banking system.

These forced loans constrain the emerging private sector's access to sufficient credit from the formal banking system, as banks are allocating all of their capital to projects which are less productive than some private sector projects. Therefore, most of the financing for the private sector comes from re-invested earnings and informal financing, which limit the speed with which it can expand and provide productive employment.

Government still uses the banking system to subsidize ailing enterprises and to pursue special policies

In addition the Chinese stock, insurance and bond markets are underdeveloped. These other components of the financial system need to be improved. The stock market has actually been developing very quickly (table 4.4). At the end of 1999, the Chinese stock market comprised 1,086 listed companies, and total market capitalization was US$400 billion, about 41% of China's GDP, and by the end of 2000 market capitalization was about US$550 billion.

A new, NASDAQ-like venture stock market was to be opened in 2000, but plans were aborted as a result of the burst of the dot.com bubble worldwide. Meanwhile, a venture capital industry is taking shape, notably around the technology parks, nurtured in particular by the experience of overseas Chinese attracted by lucrative incentives. The development of a strong venture capital market is an important instrument to finance new high technology firms. Even in developed countries, it is nearly impossible for new start-ups to access finance from banks since they usually do not have a track record or tangible collateral for their borrowing. Venture capital, which takes an equity stake in the companies and usually also helps them develop business plans and gets involved

TABLE 4.3
The banking sector—China and the rest of the world

	Domestic credit from the banking sector (% of GDP)		Liquid liabilities (% of GDP)	
	1990	1999	1990	1999
Low income	45	43	37	44
India	52	50	43	52
Lower-middle Income	66	84	64	87
China	90	131	79	148
Upper-middle income	64	58	35	48
Brazil	90	52	26	32
High income	137	148	98	80
United States	111	164	66	62
European Monetary Union	97	116		...
Japan	267	144	188	126
World	124	126	86	78

Note: Liquid liabilities include bank deposits, of generally less than one year, plus currency. The ratio of liquid liabilities to GDP measures the size of these readily available forms of money that savers can mobilize quickly to buy goods or services without incurring direct financial costs.
Source: World Bank, *World Development Indicators 2001,* Washington, D.C., 2001, table 5.4.

The development of a strong venture capital market is an important instrument to finance new high technology firms

TABLE 4.4
Stock market development—China compared with the rest of the world

	Market capitalization (% of GDP)		Value traded (% of GDP)		Listed domestic companies	
	1990	1999	1990	1999	1990	1999
Low income	9.8	31.7	4.7	19.6	3,446	8,332
India	12.2	41.3	6.9	27.3	2,435	5,937
Lower- middle income	5.9	31.0	..	22.8	1,833	11,420
China	0.5	33.4	0.2	38.1	14	1,086
Upper- middle income	22.3	49.8	8.5	37.2	3,081	5,119
Brazil	3.5	30.3	1.2	11.6	581	459
High income	55.3	138.7	31.8	120.9	17,064	24,741
United States	53.2	181.8	30.6	202.9	6,599	7,651
European Monetary Union	22.0	84.0	7.3	71.0	2,485	3,880
Japan	98.2	104.6	54.0	42.5	2,071	2,470
World	50.7	119.0	28.5	102.6	25,424	49,612

Note: Financial market development is closely related to an economies overall development. In less developed economies, banks tend to dominate the financial system. As countries develop specialized financial intermediaries and equity markets develop. The indicators presented in this table measure the growth in the size of the equity market (market capitalization relative to GDP, and number of listed companies), as well as liquidity (value traded relative to GDP). Comparability across countries is limited by conceptual and statistical weaknesses such as inaccurate reporting and different accounting standards.
Source: World Bank, *World Development Indicators 2001,* Washington, D.C., 2001, table 5.3.

BOX 4.4
Critical issues for developing venture capital in China

Improving access to private equity and venture capital. These are at an early stage of development in China. Offshore venture capital appears to be more important as a source of capital for start-up companies than domestic venture capital. Recognizing the importance of private equity markets for the development of the high technology sector, the government has increased efforts at stimulating the development of these markets. A RMB 1 billion venture fund has been established by the Bank of China recently, and work has started on venture capital and investment fund legislation. A comprehensive legal framework defining the legal-organizational structures, which can be used to establish private equity funds, known in China as "industrial investment funds," is required. Other related issues are the contractual structure to protect both investors and companies, the need for trustees to protect investors against adverse actions of the fund manager, and tax treatment to avoid double taxation. Appropriate amendments would also be required in company law, contract law, trust law, and taxation policy. Also, the state presently plays the role of sponsor, investor, and fund manager. The investment industry in general would benefit considerably from the state's changing its role from patron of companies in which it invests to protector of efficient competitive markets.

Improving access to public equity. The company law discriminates against the listing of private firms by requiring both a three-year record of profitability and an RMB 50 million market capitalization as conditions for listing.

Broadening and strengthening the range of exit mechanisms available to investors. With the opening of the secondary boards and official pronouncements of transparency in the listing approval process, non-state companies can expect more equal access to listing, countering the favoritism traditionally shown to SOEs on the main boards in Shanghai and Shenzhen. Under existing conditions, the lack of viable exit is the greatest risk to investors who continue to eye the possibility of listing firms in Hong Kong or elsewhere offshore. The current quota system for entering the stock market has given priority to state enterprises. This has resulted in inefficient use of financial capital and less chance for more efficient private firms to get investment funds through stock markets. It is recommended that state and non-state enterprises have equal access to finance or stock markets on terms that vary only with market-related characteristics of their investment according to central or provincial government criteria.

with their management, is the appropriate vehicle for financing such high risk new businesses. In China several issues still need to be addressed to help promote the development of a robust venture capital industry (box 4.4).

In summary, in today's competitive global environment, China must develop a much larger and more efficient financial market. Some of the specific actions include:

- Reducing the use of the banking system to finance special policy programs or to bail out failing enterprises. These should be financed as direct fiscal outlays of the treasury in order to have greater transparency on government expenditures and to avoid contaminating and constraining the banking system.
- Strengthening supervision of the banking system, accounting practices, and loan classifications
- Training bank managers and loans officers more thoroughly in project analysis and portfolio management so that they can allocate credit to the projects with the best returns, and monitor the performance of their loan portfolios.
- Using foreign financial institutions to provide innovative new products and better management practices.
- Developing an effective stock market with appropriate disclosure rules and safeguards against insider trading as well as effective governance of the traded firms and the financial intermediaries.
- Developing the venture capital market, critical to finance entrepreneurs with new ideas who do not have tangible collateral required by bankers.
- Implementing appropriate bankruptcy legislation and procedures to be able to re-deploy the productive assets of failed enterprises to new economic uses
- Developing an effective insurance market to help companies and individuals deal with risk.

China must develop a much larger and more efficient financial market

More fundamentally, China needs a substantially overhauled system offering a broader array of products and services to a wider range of customer segments, particularly those in the private sector. The government so far has been more focused on the providers of the financial services than on the users, which is not surprising as it is virtually the only provider of such services. However, the government should be playing a different role. Rather than providing all the services itself, it should be establishing the infrastructure (laws, information, incentive focused regulation and supervision) necessary to allow a competitive, innovative, and prudently managed financial sector to develop. Besides the problems of conflict of interest between its role as main provider and that of developer, facilitator and guarantor, an additional problem is the lack of accountability for financial sector reform and development within the government itself. Therefore, the government needs to rethink the way it approaches financial sector development, creating an overarching infrastructure to drive a comprehensive reform program.

NOTES

1. The investment climate also includes macroeconomic stability and openness as well as the quality of infrastructure such as power, transportation, and telecommunications. But from the perspective of the knowledge economy this chapter will not deal with the key role of government in promoting an appropriate macro environment, or of basic infrastructure (except telecommunications, critical for the knowledge economy).

2. The law on employee inventors is particularly progressive. It gives employees a fairly substantial financial reward for their inventions, either when enterprises exploit them or when the employees establish their own firms to commercialize their inventions. These incentives have been neglected in Western countries, despite having played a decisive role in building the competitive strengths of a number of industrialized nations, notably Germany between the two world wars.

3. Foreign investors have constituted a coalition against counterfeiting (CAC), grouping major firms from Europe, North America, and Asia. The coalition has listed the many cases and problems encountered in the current situation and has transmitted detailed complaints to the Chinese government.

4. According to "Corruption and Anti-Corruption Strategies in China," a study by Angang Hu, Center for China Study, Chinese Academy of Sciences, Tsinghua University, for the Carnegie Endowment for International Peace, 2001.

5. As a result of vague criteria for official review, administrators have great discretion. For example, the partnership law gives officers the power to evaluate whether the relationship fits the "fairness and equity" criteria. The wholly individual owned enterprise law requires enterprise owners to prove their business ability to the officers. Successful registration partially depends on the judgment of the officers. For restrictions to entry, the central government stipulates that access to certain industries be restricted; as a result, private firms face restrictions on license for 15 types of businesses. These include such industries as copper, steel, polyethylene products, aviation, power, automobile manufacturing, financial services, and radio and audio products.

6. There are not even very clear statistics on the size of the private sector, because of the bias until very recently against even acknowledging the private sector.

5 Investing in China's human capital

Effective education is the foundation of a knowledge-based economy. Economic growth and social progress are historically strongly correlated with development of human capital. Child mortality falls as mothers learn. Agricultural productivity improves with farmers' education. GDP per capita increases with female education. But in the new economy, students need to master more than the basic subjects of reading, writing, and arithmetic. They also need behavioral skills, such as thinking critically, communicating effectively, and working in teams. Creativity, risk-taking, entrepreneurship, and computer skills have also become vital. And most important is the flexibility to apply knowledge to new and unusual problems.

China's competitive edge will be determined by its people's ability to create, acquire, share, and use knowledge effectively

In countries at all levels of income there is a mismatch between the skills of secondary school graduates and the needs of employers (table 5.1). Educational achievement must now be gauged by students' abilities to take a difficult situation and apply knowledge-based skills to work toward a solution. And because these skills will change continually, the Chinese government must create an environment that encourages lifelong learning so that people can constantly upgrade their skills to adapt themselves to the demands of the knowledge economy.

As China moves to a knowledge-based economy, its competitive edge will be determined by its people's ability to create, acquire, share, and use knowledge effectively. The government must continue its efforts to transform its education system into one that is content-rich, comprehensive, and flexible. Even

TABLE 5.1
Differences between traditional and new teaching strategies and workplaces

Traditional arrangements		New arrangements	
Teaching strategy	**Workplace**	**Teaching strategy**	**Workplace**
Teachers as experts convey knowledge to passive learners	Passive order-taking in a hierarchical work organisation; heavy supervision to control workers	Under teacher guidance, students assume responsibility for learning, in the process developing knowing-how-to learn skills	Workers are expected to take responsibility for identifying and solving problems and for adapting to change by learning
Emphasis on facts and on getting the right answers	Emphasis on limited responses to limited problems and on getting a task done	Focus on alternative ways to frame issues and problems	Workers deal with non-routine problems that have to be analyzed and solved
What is to be learned is stripped of meaningful context	Focus on the specific task independent of organisational context or business strategy	Ideas, principles, and facts are introduced, used, and understood in meaningful context	Workers are expected to make decisions that require understanding the broader context of their work and their company's priorities

Source: Sue Berryman, "Hidden Challenges to Education Systems in Transition Economies," Europe and Central Asia Region, Human Development Sector, World Bank, 2000.

the most advanced countries are struggling to match the skills of graduates to the needs of employers.

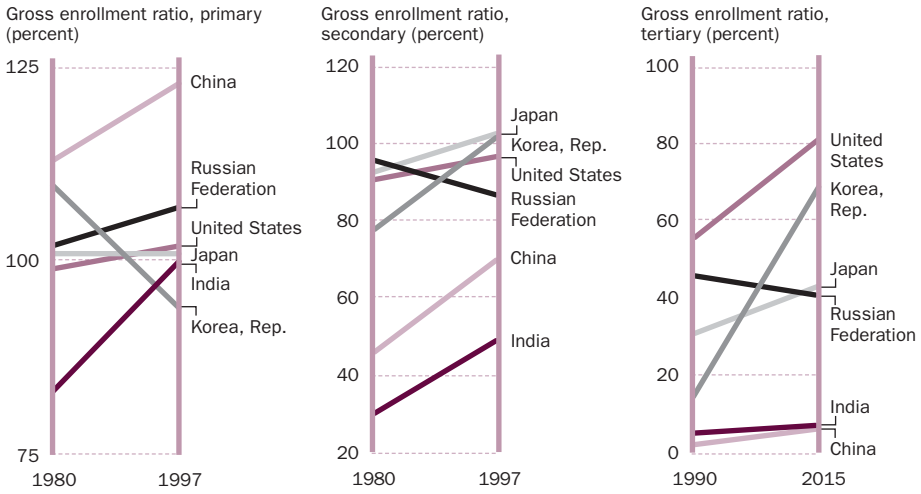
China has the opportunity to reassess its education priorities and close the gap with the world's highly developed economies. But this will take significant effort—upgrading and expanding curricula, improving support, evaluation, and standards for teachers, and increasing equity, quality, and access. There is also the massive challenge of creating jobs and providing retraining for today's unemployed and tomorrow's. The government has to address governance and control of the education system. It also needs to fund these efforts, as providing education is expensive.

Thanks to China's compulsory basic education program, literacy has improved dramatically

Strategic goals and issues

Thanks to China's compulsory basic education program, literacy has improved dramatically—to more than 75%. China's gross enrollment ratio in primary education increased from 113% in 1980 to 123% in 1997 (figure 5.1). In secondary education, it has made impressive progress and increased it share from 46% to 70% during the same period. In tertiary education, it increased its enrollment ratio from 2% to 6%, lower than that of other Asian countries such as Korea, which had a rapid expansion in tertiary enrollments (from 15% to 68%) and developed countries, such as Japan or the US (who increased their share from 31% to 43% and 56% to 81% respectively, during the same period). But this figure of 6% needs to be seen in perspective, because China has been increasing its tertiary enrollments at a remarkable rate since the early 1990s. The government estimates, however, that the ter-

FIGURE 5.1
Enrollment ratios, selected countries



Source: World Bank staff analysis.

tiary enrollment ratio increased to 11% in 2000 and has set a target of 15% for 2005 (box 5.1).[1]

But even with these staggering successes, significant issues remain to be tackled.[2] A National Education Working Conference, in Beijing in June 1999, led to the following general recommendations:

- Achieving efficiency gains should be the first step in increasing the funds available for teaching and learning. But even so, it is unlikely that there will be enough funds in the system to meet China's needs. So, while efforts to improve efficiency should persist, a substantial increase in government spending is also needed.
- Greater investment in education is needed, especially in China's poorest regions. Annual spending on education amounted to about 2.5% of GDP in 1997, considerably less than the outlays of developed countries and other countries in the region (table 5.2).[3]
- Given the lack of resources for the public system, a dynamic private sector is responding to the demand for basic and higher education and for retraining. The growth of private institutions has considerable benefits, but it also aggravates regional inequalities in access to education and in its quality. So, it is essential for the government to ensure that regional disparities are addressed.
- The curriculum needs reforming and upgrading at all levels to increase the emphasis on problem solving and practical skills. In higher education, students need to be able to enroll in a wider range of subjects to prepare themselves

TABLE 5.2
Education expenditure as a share of GDP, selected countries
(2000)

Country	Percent
Japan	3.6
Korea	4.4
Germany	4.5
United Kingdom	4.6
United States	5.2

Note: The data refer to direct public expenditure for education institutions.
Source: OECD, *Education at a Glance: OECD Indicators,* Paris, 2000.

BOX 5.1
Basic facts on China's education system

In 1998 there were 243 million students in China in just over 890,000 education institutions. Of primary-age children, 99% were in school. Enrollment ratios were 88% at the junior secondary level, 35% at the senior secondary level, and 8% at the tertiary level.

Government spending on education stood at 2.49% of GDP in 1997, about the same as in 1980, a low proportion compared with that in OECD countries and other countries in the region (and ranking 98th in the world). About 87% of expenditures were funded by local governments (provincial, county, municipal). About 37% of the government spending went to secondary education, 34% to primary, 18% to tertiary, and the rest to other types of education.

Expenditure per student increases with the level of education. In 1996 it was 6.5% of per capita GDP at the primary level, 15% at the secondary level, and 65.9% at the tertiary level.

According to official figures, China had 42,000 private education institutions in 1998. Those at the preschool level (85%) and the primary school level (8%) taught 6.5 million students. An estimated 4 million students study at privately funded tertiary institutions, not formally recognized by the Ministry of Education.

Source: Norman LaRoque and Veronica Jacobsen, "Minban: A Market and Regulatory Survey of Private Education in China," World Bank, Washington, D.C., 2000.

for the broad requirements of the knowledge economy. And the vocational and training system curriculum should put more emphasis on general competencies that promote adaptability and lifelong learning, and less on job-specific skills. Rather than provide or finance lifelong learning opportunities, the state might ensure that lifelong learning opportunities are facilitated, learning achievements recognized, and artificial barriers to adult participation removed.

- The quality of education needs to be better gauged. The focus now is on inputs to education (funding and student-teacher ratios) and outputs (basic literacy rates and test scores). It should be on achievement—applying knowledge to solve problems. Two possible frameworks for such evaluation are the OECD's International Adult Functional Literacy Survey, which tests students' problem-solving ability, and the Program for International Student Assessment, which tests the ability to function in the knowledge economy, independent of country curricula. China could adapt and broadly apply these instruments to assess and compare regional achievements (box 5.2).

The vocational and training system curriculum should put more emphasis on general competencies that promote adaptability and lifelong learning

BOX 5.2

Measuring educational achievements

Gauging educational achievement has been changing dramatically in recent years. Old measures, such as literacy rates and scores on standardized tests, are being updated with new, comprehensive testing methods that test not only the ability to perform in narrowly defined academic assessments—but also an individual's ability to solve problems that one might encounter in everyday life and to apply knowledge to new and unusual situations. The OECD has been at the forefront of such efforts, developing two such testing systems in recent years: the International Adult Literacy Survey (IALS) and the Programme for International Student Assessment (PISA).

The IALS defines literacy as "the ability to understand and employ printed information in daily activities, at home, at work, and in the community—to achieve one's goals, and to develop one's knowledge and potential." The three domains of literacy skills, each scored on a five-level scale include:

- Prose literacy—functional command of common texts.
- Document literacy—understanding and using data in contexts such as maps, tables, forms, and charts.
- Quantitative literacy—manipulating numbers in circumstances that might be encountered in occupational or private life.

The PISA also tests the knowledge and skills that individuals will need to function as an adult, assessing proficiency in three major areas:

- Reading literacy—functional command of common texts.
- Mathematical literacy—abilities in using mathematics and developing skills in everyday situations that affect not only that individual, but others as well.
- Scientific literacy—identifying evidence and drawing, evaluating, and communicating conclusions.

The IALS also emphasizes general skills such as communication, adaptability, flexibility, problem-solving, and the use of information technologies. Broadly adaptable, it could be used to assess the strengths and weaknesses of any country's education system.

Source: OECD, *Measuring Student Knowledge and Skills: A New Framework for Assessment,* Paris, 1999 and *Literacy in the Information Age: Final Report of the IALS,* Paris, 2000.

• Governance of the system needs to improve. Too many people are trying to control its direction. Responsibilities should be transferred from line ministries and their state-owned enterprises to the Ministry of Education, with the ministry taking the lead on national issues. Governing responsibilities should be removed from any tier below the county level, with provincial or municipal authorities shouldering the brunt of the responsibility for planning, budgeting, and executing a strategic plan for providing education.

Adapting basic education

The Chinese government has traditionally given a high priority to primary and junior secondary education, aiming for universal access. More than 60% of education spending goes to this segment, extremely large when compared with other countries. Often having a higher return than that for higher levels, this investment has been largely responsible for increasing literacy to more than 75%.

Fighting inequality

Maintaining strong principles of equality is important for social justice and for the efficiency of the economy

Maintaining strong principles of equality is important for social justice and for the efficiency of the economy.[4] But inequality is increasing both among provinces and within provinces (among counties).[5] Governments in poor areas lack resources for investments, a gap widened by private resources in more affluent regions. Tertiary students come increasingly from urban families because even the best rural education is not of sufficient quality, and only urban parents can afford the high-quality senior secondary schools. Gender inequalities also appear to be increasing.

Widening the knowledge divide risks undermining long-term economic development. To alleviate this risk, the central and provincial governments should substantially increase funding for compulsory education in the poorer counties. The government could also explore targeted subsidies and vouchers for low-income families, which have proved successful in a number of developing countries.

It has been suggested that China expand compulsory education from 9 years to 12. This would equip people for the more demanding intellectual requirements of the knowledge economy. It would also reduce labor market tensions by keeping many of the country's youth in schools for three additional years. But it would add to the financial burden on government. And it could widen inequalities, depending on the capabilities of local governments to provide educational resources. Even so, the government should carefully consider it. Whether or not this happens, it will be important to raise the overall quality of education and to ensure that students have achieved the ability to apply their knowledge, as well as mastered the accumulation of knowledge in specific areas.

In parallel, there is a need to adapt curricula to emphasize contemporary Chinese culture and to increase the flexibility, creativity, and autonomy of China's youth. New methods of training, new learning materials (books), and more well-trained teachers are needed. Evaluation procedures should be upgraded to include criteria focusing on education outputs, and to supplement current input measures such as enrollment ratios and students per teacher.

Although public schools currently lack the resources and flexibility to adjust to the needs of the rapidly changing economy and society, private schools—with greater resources and autonomy—have a competitive edge in developing new curricula and teaching methods.[6] Only 3% of primary and secondary students attend private institutions, but this share is increasing. Private schools tend to benefit only those who can afford the prohibitively high tuition, again exacerbating inequalities.

The qualifications from vocational schools are too narrow due mainly to the numerous, overdetailed specifications from the planned economy

Retooling vocational education

Vocational schools make up a large part of China's secondary education system,[7] with a much larger share of students (60%) than in OECD countries (40% at most). The World Bank finds the current target ratio of vocational to general secondary schools of 50 to 50 to be too high. It recommends reducing the ratio considerably, increasing the number of students taking the route to further education through general senior secondary school.

The emphasis on vocational education has its origins in the planned economy, which required a massive workforce with skills for the production system of a low-income developing economy. But the qualifications from vocational schools are too narrow—due mainly to the numerous, overdetailed specifications from the planned economy. The economy needs skills in information technology, software, management, and services. More generally it needs core skills that people can transfer across occupations and industry, including entrepreneurism, language, social, teamwork, and other fundamental skills. Reducing and broadening currently narrow classifications would allow vocational schools to focus on those skills, reducing overspecialty in education.

The traditional vocational system thus needs to be downsized, with a new training infrastructure developed to emphasize these core skills, offering more flexibility for placements in enterprises, along with other forms of dual education.[8] Change, slow until recently,[9] is gaining speed, with a more active policy put in place by the 1999 decision for curricular reform and regrouping management responsibilities. Whether these changes will be implemented at the local level and as a concrete part of the Chinese education system remains to be seen.

Expanding higher education

In higher education, the government deserves plaudits for encouraging the mergers of small, single discipline institutions to broaden the education of students and lower the unit costs. The system should continue to broaden the education offered in tertiary institutions, facilitate student mobility, and open the system to change.

With the limited resources for public higher education, the authorities have a very selective recruitment process, creating intense competition for these seats. But in 1999 they decided to increase the intake of students by 50% a year for three years, primarily in technical institutions rather than the top 100 academic universities. Tuition fees, boosted significantly, now account for at least 30% of the financing for higher education— high for any country, especially for a socialist one.

The system should continue to broaden the education offered in tertiary institutions, facilitate student mobility, and open itself to change

China's enrollment ratio in public higher education in 2000, at about 11%—still low by international standards—needs to be raised.[10] Immediate actions include:

- Integrating the rapidly growing private segment into the formal education system.
- Shifting education authorities from a role as education providers to a role as quality assurors, giving greater autonomy to institutions of higher education.
- Emphasizing "soft" skills, such as management, and those needed in the growing service sector.

Integrating private institutions into the formal education system

In addition to China's public higher education system[11] and an independent military higher education system, there is a large, almost informal private system of higher education (table 5.3).

Estimates of the size and growth of the private education system vary, but all suggest a rapidly developing private sector beginning in the early 1980s. Some estimate that 4 million students are currently studying at privately funded tertiary institutions. According to official 1998 estimates, there were about 1,274 private tertiary institutions. Of these, 37 are authorized to confer degrees, 157 can grant joint diplomas (probably in partnership with public universities), and 1,080 prepare students for the national exams.

These institutions, usually located in provincial urban areas, are independent, nonprofit entities that derive revenues from tuition and boarding fees (where relevant). They offer a limited range of professional and practical courses and programs (for example, English, accounting, and international finance) and

TABLE 5.3
China's higher education system, 1998

Form of higher education	Number of institutions	Enrollment (number of students)
Regular higher education		
Under central and local government	1,022	3,607,649
Run by state-owned enterprises	7[a]	11,521
Run by nonstate sectors	10[a]	19,518
Adult higher education		
Under central and local government	962	2,822,171
Run by state-owned enterprises	224[a]	129,466
Run by nonstate sectors	42[a]	26,172
Military higher education	n.a.	169,000
Self-study for the higher education qualification examination	n.a.	11,254,135
Total	2,267	18,133,632

n.a. Not available.
a. Data refer to 1997.
Source: Xue Lan and Y. Zhang, "Higher Education and the Role of University in the Knowledge Economy," background paper, World Bank, Washington, D.C., 2000.

The government should create a friendly environment for institutions and individuals interested in establishing private universities

attract second-chance students unable to get into public universities.[12] Because of the limited access to institutions of higher education, self-study for the state-administered higher education qualification examination has become an alternative. More than 11 million learners were registered to take the exam in 1998, many enrolled in informal private tertiary institutions (see table 5.2).

Private institutions help to meet the enormous pent-up demand for higher education, and China should encourage their integration into the formal system. In addition, students' willingness to pay for private education offers a way to obtain more resources for higher education. A recently prepared law on integrating the private sector into the formal system should be passed and put into effect as soon as possible.

The government should also create a friendly environment for institutions and individuals interested in establishing private universities by:

- Establishing transparent standards and regulations and methods of ongoing monitoring and quality assurance.
- Introducing a more neutral policy environment that treats the private and public sectors equally in funding and regulation.
- Reducing jurisdictional overlaps to ensure policy consistency as well as alleviating bureaucratic and institutional difficulties in establishing universities.
- Financially rewarding private institutions of good quality, while pushing others to improve or close.

As a consequence of current structure and quality of China's higher education, a large proportion of students go abroad. Data from 50 major countries indicate that in 1995–96 some 121,000 Chinese postgraduate students were enrolled in their institutions.[13] If these students pay on average $5,000 a year for tuition and board,[14] that spending amounts to about $600 million a year.

Extracting this global knowledge is most certainly useful and should be encouraged, provided it is appropriately utilized (chapter 9). China would be well served to further develop top-notch and high quality teaching universities domestically—both public and private—to educate its students, reduce the need to finance education abroad, and even attract more foreign students to China.

Focusing on quality and deregulating the system

To transform the higher education system, the Ministry of Education and the provincial education authorities should shift their role dramatically—from tightly regulating the formal system to assuring the quality and equity of the overall system. The government should also raise the quality of all higher education institutions to develop skilled, creative people. Investing in leading universities to help them become world class will be beneficial, but this strategy should be complemented by actions to raise quality and reduce variance throughout the education system.

The higher education authorities should shift from tightly regulating the formal system to assuring the quality and equity of the overall system

China's higher education institutions have limited autonomy in managerial, financial, and pedagogical matters. They lack choice in determining academic offerings, the number of students they can admit, and the tuition they can charge. In addition, faculty salaries, set according to a national standard, are often lower than the market would bear. This causes inefficiency and mismanagement. The government should consider giving the institutions more autonomy in setting curricula, developing academic programs, admitting students, charging tuition, using funds, and staffing. In addition, the government should clarify the roles and powers of the Ministry of Education, other central government ministries, as well as the provincial and municipal governments toward these institutions.[15]

Developing soft skills for China's growing service sector

China faces tremendous pressures to accelerate the restructuring of its economy, especially as it enters the World Trade Organization. As it does so, it needs to pay special attention to finance, law, accounting, design, marketing, education, technology, and consulting. It must develop not only the "hard," technical skills in which the Chinese excel (in science, engineering, and other areas), but also "soft" skills, including management, human resource development, foreign language fluency, and the ability to work in teams. The new knowledge-based production system requires people to shift their attention from individual competition to teamwork.[16] These soft skills have been underdeveloped because of the traditional emphasis on mastering the hard skills. Developing them requires a dramatic change in mindset.

BOX 5.3
Motorola's training program in China

With facilities and training staff at Motorola University in Beijing, the Tianjin Learning Center, and a training office in Shanghai, Motorola has the largest education program of any foreign enterprise in China. Motorola invests 3% of payroll in training each year in the belief that the best workforce is local, competitive, and knowledgeable. The students at Motorola University include Motorola employees, joint-venture partners, suppliers, distributors, customers, and Chinese government officials. Courses fall into four categories: management, quality, technology, and sales and marketing.

Motorola's policy is to employ local management at each of its facilities in China. To this end, Motorola University has designed the China Accelerated Management Program, to condense years of management experience into an intensive 10-month program. So far, 155 students have participated in the program.

Motorola also provides special training to state-owned enterprises. Since 1998 its Center for Enterprise Excellence has trained 1,200 people from more than 300 enterprises in 22 provinces and autonomous regions. This strengthens the capacity of the enterprises, and develops a broad supplier base for Motorola.

Source: Motorola Beijing brochure, 2000.

Worldclass business schools offering master of business administration degrees should continue to be promoted

In addition, managers in China will need more training and exposure to best practices in management, both at home and internationally. The economic transformation has forced Chinese higher education institutions to develop a range of management training programs. But more needs to be done. Worldclass business schools offering master of business administration degrees in such disciplines as marketing, finance, accounting, human resource management, and operations management should continue to be promoted. And the use of foreign enterprises as means of acquiring cutting-edge skills, practices, and knowledge should continue to be endorsed (box 5.3).

Building a technology-based national learning framework

As the world's most populous country, China faces special needs and demands in education, including lifelong learning. It is attempting to meet some of these needs through distance education. Use of advanced information technologies is already leading to substantial changes in the Chinese education system. Innovative methods are being developed and used to deliver basic education, in-service training for primary and secondary school teachers, and training in communications and agriculture including cable television, satellite television (both broadcast and two-way, interactive modes), Internet-based cyberschools, and online training (using computer-based, virtual classroom environments).

At the end of 1999 there were 8.9 million Internet users in China, 21% of them students. And over the past 20 years more than 2 million Chinese have graduated from radio and television universities.[17] The new technologies give

rural and poor regions access to the modern distance education network at a very low cost. Greater use of these technologies would expand access for all people in China, helping to increase regional equity in education.

The Ministry of Education is formulating an agenda to expand distance education from 6 universities to 32, and eventually to 84. The system will rely on multimedia technology and interactive learning combined with independent study. The main obstacle is developing content. Programs broadcast on distance learning networks cannot be directly transposed from traditional courses in schools and universities, and therefore significant resources need to be harnessed to adapt these curricula.

A wholesale change in focus and mindset is needed to meet the requirements of an efficient distance learning system. Integrating the curriculum and offerings of the various distance education providers requires a coordinated and networked national education and training system, or a "learning network," to connect all providers. The network should be open to everyone in China and provide a range of education services, from basic to higher education, as well as training for all walks of life. The government must also ensure that the information infrastructure (Internet, bandwidth, adequate telecommunications infrastructure) enables people to get the content relevant to their needs. China may want to study the United Kingdom's development of an integrated system for delivering distance education and training (box 5.4)—and Australia's community-based "learning cities" system.

A wholesale change in focus and mindset is needed to meet requirements of an efficient distance learning system

Establishing large retraining programs

Structural adjustment and retrenchment by state-owned enterprises will give rise to an urgent need for large nationwide labor retraining programs for the massive number of displaced and laid-off workers.[18] Current programs, although substantial, have had limited success. Of the 12 million laid-off workers at the end of 1997, only 26% had found new work.[19] Roughly 60% were still searching for work, and the remaining 14% were engaged sporadically in casual labor or had retired or otherwise withdrawn from the labor force.[20]

China needs a national strategy and policy framework for training and retraining to deal with:

- The extreme fragmentation and lack of coordination among education, labor, and industry in the provision and financing of training.
- The mismatch between skills supplied and those demanded by the market.
- The absence of policies for deregulating private provision and undertaking quality assurance.

BOX 5.4

The United Kingdom's National Grid for Learning

The National Grid for Learning (http://www.ngfl.gov.uk/) is the national focal point for Internet learning in the United Kingdom. This collection of resources was brought together by the U.K. government to help raise standards in education and to support lifelong learning. It is both an architecture of educationally valuable content on the Internet and a program for developing the means to access that content in schools, libraries, colleges, universities, workplaces, homes, and elsewhere. Its structured content provides links to information, advice, and learning resources. The main aim of the grid is to help all types of learners, whatever their age. It also features the Virtual Teachers Centre (http://vtc.ngfl.gov.uk/index.html), which brings together news, information, and resources for teachers in the areas of curriculum subjects, school management, and professional development. Teachers throughout the country can interact with one another through mailing lists and electronic conferences.

In education and lifelong learning services, the grid will provide all institutions and agencies delivering and promoting learning with new opportunities to offer better services. These will be closely tailored to the needs of all learners, collectively and individually. Particularly important is the development of content for community grids for learning and linking education, library, health, leisure, and other services at the local, metropolitan, or regional level. The grid's Lifelong Learning website (http://www.lifelonglearning.co.uk/) is designed to encourage, promote, and develop lifelong learning in the United Kingdom. It contains news, government reports, and information on aspects of lifelong learning, including career development loans, individual learning accounts, and a free learning and career information telephone service.

The University for Industry initiative (http://www.ufiltd.co.uk/), a new kind of public-private partnership, aims to boost the competitiveness of business and the employability of individuals. Working with businesses and education and training providers, it will use modern technologies to make learning available at times and places that suit the learner: at home, in the workplace, and through a national network of learning centers. The initiative has launched the learndirect website (http://www.learndirect.co.uk) and the learndirect program, which provides basic skills and information and services to dislocated workers and mothers entering the workforce. The 251 learndirect centers deliver more than 200 online courses. The website also has a web-based career package, with profiles of more than 700 jobs.

Source: Various websites (http://www.ngfl.gov.uk/; http://vtc.ngfl.gov.uk/index.html; http://www.lifelonglearning.co.uk/; (http://www.ufiltd.co.uk/).

Retraining programs need to be tailored to the job opportunities and to the ages and backgrounds of the workers to be retrained

Retraining programs need to be tailored to the job opportunities and to the ages and backgrounds of the workers to be retrained. For example, training needs for agricultural workers with little education will differ substantially from those for industrial workers with a strong secondary education. Only a flexible retraining system can quickly adapt to new skill demands generated by changing markets and technologies and deliver cost-effective training. But structuring this customized retraining will be extremely complex. Further analytical work will be required to develop a system appropriate to China while also applying and adapting best practices from abroad.[21]

Economic restructuring in Shanghai and the restructuring of state-owned enterprises led to the shedding of 500,000 textile workers. After massive train-

ing at the district level, sponsored by the municipal government, it took less than five years to absorb 80% of the laid-off workers into such services as commerce, real estate, tourism, and information technology consulting. This experience clearly has application to other regions in China.

Local employment service centers, where workers could receive job search assistance and retraining, could also help in redeploying the unemployed. These centers could continually analyze data on imminent and future layoffs—and on existing and planned job openings—to forecast the employment needs of the knowledge economy. And the Internet could be used to create online job databases (similar to www.Monster.com and www.Alx.org) where people search for positions and apply for jobs.

The government should also find ways of retraining laid-off workers in areas of high future job growth, especially in information and communications technology. One way might be to tap, for a fee, the training capabilities of service industries. The government should also provide training, materials, and access to microcredit and support services for new business start-ups. The training should address basic business skills, such as accounting, market assessment, business plan development, business registration, and the filing of taxes. Banks, business associations, municipal agencies, and reemployment and retraining institutions should be brought together to coordinate support for laid-off workers. And because most job creation occurs in small and medium-size enterprises, the government should provide business support services, finance, technical assistance, and other targeted programs.

The government should find ways of retraining laid-off workers in areas of high future job growth

NOTES

1. According to the *World Development Indicators 2000,* tertiary enrollment in China was 6% in 1997. But Chinese authorities estimate that enrollments increased from 3.7% in 1993 to 11% in 2000 (figures quoted by Tian Xiaogang, Deputy Director General, Ministry of Education, China at the Policy Forum on Using Knowledge for Development, March 19–24, 2001, Wilton Park, U.K.).

2. Many of which the World Bank detailed in "Strategic Goals for Chinese Education in the 21st Century," World Bank, 1999.

3. We understand that the government aims to raise the proportion of GDP spent on education as a whole to 4% from the current level of 2.5%.

4. See Ramon Lopez, Vinod Thomas, and Yan Wang, "Addressing the Education Puzzle: The Distribution of Education and Economic Reforms," Policy Research Working Paper 2031, World Bank, Washington, D.C., 1998.

5. See Shaikh I. Hossain, "Making Education in China Equitable and Efficient," Policy Research Working Paper 1824, World Bank, Washington, D.C., 1997, and World Bank, "Strategic Goals for Chinese Education in the 21st Century," op. cit.

6. See Norman LaRocque and Veronica Jacobsen, "Minban: A Market and Regulatory Survey of Private Education in China," World Bank, Washington, D.C., 2000.

7. Vocational schools are part of the Senior Secondary School System. They include secondary specialist or technical schools (STS), skilled worker school (SWS), and secondary vocational schools (SVS). Vocational education is also provided to adults. In the mid-1990s, about 50 million adults—of 60 million undergoing vocational education—were enrolled in SVS and STS schools.

8. Most state-owned enterprises operate Enterprise Training Centers to meet their own training needs.

9. See "Reform of Vocational Education and Training in China," China Country Study, 19774, World Bank, October 1998.

10. Tertiary enrollment ratios in 1997 were 81% for the United States, 68% for Korea, 43% for Japan, 39% for Singapore, 28% for Hong Kong (China), and only 6% for China. See World Bank, *World Development Indicators 2000.*

11. This system consists of the radio and television universities; schools for workers, peasants, and cadres; pedagogical colleges; independent correspondence colleges; and evening or correspondence courses run by regular higher education institutions.

12. The public provision of education has significant implications for the private education market. The lack of funds for public education that has driven the reform of the sector and the encouragement of private provision affects private education directly and indirectly through the college entrance system. Public universities' lack of resources creates a system of excess demand in which places are rationed by the college entrance examination system and in which senior secondary schools are focused on preparing their students for this crucial examination. The result is that a market exists for the private provision of tertiary education for second-chance students who did not get into public universities, and for secondary students who are unable to get into key public schools (Norman LaRocque and Veronica Jacobsen, "Minban," op. cit.).

13. While most either have grants from overseas universities or are financed for a single year with the expectation that they will find their own subsequent funding. This figure of $5,000 per year is on the low side when compared to the expenses at U.S. universities, but is taken here to be an indicative figure.

14. UNESCO, *Statistical Yearbook 1998,* Paris, 1998, pp. 3–409.

15. Despite the Law on Higher Education of 1998, the autonomy of universities remains circumscribed, with much control still being vested in the Ministry of Education and other government authorities. If universities and other tertiary institutions are to play their part in addressing national and provincial needs, real autonomy at the local level—and its essential counterpart, accountability—will provide the flexibility to respond to emerging needs. (OECD, "Current Issues in Chinese Higher Education," Paris, 2001).

16. See Peter F. Drucker, "Knowledge-Worker Productivity: The Biggest Challenge," *California Management Review* 41(2): 79–94.

17. World Bank, "Distance Education in China: Current Status, National Policy, and Development Strategies," background paper, Washington, D.C.

18. Employment service centers have been set up under municipal labor administrations and also directly under large enterprises and enterprise groups to absorb most of the laid-off SOE employees for up to three years. During this time, these centers will provide counseling, job search assistance, and some retraining, channel the payment of social benefits, and permit individuals continued access to social services. But retraining services vary widely in quality, extent, and targeting of job opportunities.

19. This may have been because there were no jobs, not because they were trained with inappropriate skills.

20. The downsizing of SOEs and TVEs means that there will need to be a finer balance between training and job creation, as well as on other aspects of downsizing, such as the provision of social safety nets, pensions, health insurance, etc. for those who have lost their jobs (see chapter 4 for a discussion of these issues).

21. In 1998 the Bank agreed to a request from China to reallocate project funds to finance retraining through the Vocational Training Fund (VTF). The experience has been successful, with high re-employment rates when the programs respond to changing labor market demands.

6 Building the information infrastructure

The government is committed to building the telecommunications networks and strategic information systems that enable widespread access to information and communication

China's ability to realize the potential of the knowledge economy will depend on having a dynamic and efficient information infrastructure—the telecommunications networks and strategic information systems that enable widespread access to information and communication. Countries benefit from explicit strategies to deploy their information infrastructures, remove constraints to efficient use, and empower the private sector to invest and provide services. The government of China is committed to building the information infrastructure and connecting all citizens.

Information and communications technologies (ICTs) are likely to have a large impact on China's markets, services, earnings opportunities, educational possibilities, government administration and provision of social services. To the extent that complementary macroeconomic, financial, and educational policies are put in place, ICTs would contribute substantially to trade, investment,[1] and growth. ICTs help firms, farms, and entrepreneurs reduce costs,[2] increase market coverage, and achieve economies of scale. Small manufacturers of traditional handicrafts can use ICT to market and distribute their goods worldwide. Businesses use ICTs to create job opportunities and then move up the value chain.[3]

Overview of China's ICT market

China's fixed-line and mobile phone networks, with 140 million and 85 million connected customers respectively, are the world's second largest (after the United States) and the paging network (47 million users in 1999) is the world's largest. Relative to population size, however, China's fixed and mobile telecommunications networks are about average among low and middle-income countries and lag far behind other East Asian economies (table 6.1).

The Ministry of Information Industry in China expects the ICT industry in China to grow by more than 20% a year over the next five years and the telecommunications market alone to double its current size in five years. The information infrastructure has grown more than three times as fast as the total economy. Compared with some other countries in the East Asia and Pacific region, China has the highest growth rate of fixed main telephone

TABLE 6.1
ICT penetration, selected countries and regions

Countries	2000 Mainline per 100	2000 Mobile per 100	2000 PCs per 1,000	2000 Internet hosts per 10,000	Compounded annual growth (percent), 1995–98 Mainline	Mobile	PC	Internet hosts
China	11.1	6.5	1.5	0.5	29	87.3	46	140
India	3.2	0.3	0.4	0.3	19.4	149.8	31	128
Indonesia	3.1	1.7	0.9	1.2	16.9	71.7	32	174
Japan	65.3	52.6	31.5	365.6	1.1	59.2	19	93
South Korea	46.3	56.6	19.0	84.1	1.6	104.4	22	75
Malaysia	19.9	21.3	9.4	29.3	6.0	29.8	N/A	N/A
Philippines	3.9	8.2	1.9	2.5	21.7	47.8	27	118
Singapore	48.4	68.3	48.3	437.5	5.5	52.9	22	112
Taiwan, China	56.8	80.3	22.4	492.3	6.8	82.9	29	86
All low/middle income countries	7.9	32	16.8	7.2	N/A	N/A	N/A	N/A

Note: The figures in this table are not the latest, but they offer the comparison of these selected countries for all four performance variables in the same time frame.
Source: International Telecommunications Union, *World Telecommunication Development Report 1999,* Geneva, 1999 and *Telecommunications Indicators* [http://www.itu.int/ti/industryoverview/index.htm].

lines and PCs per 100 inhabitants, 29% and 46% respectively, from 1995 to 1998. China's mobile phones per capita grew at 88% a year over the same period.

Internet connectivity has been growing especially fast, albeit from a very low base.[4] According to the China Internet Network Information Center, there were 22.5 million Internet users in China in January 2001, quintupling from a year and a half earlier. This makes China the leading Internet market in Asia, excluding Japan. In addition, according to Total Telecom, there are around 520 Internet Service Providers (ISPs) and 600 Internet Content Providers (ICPs) in China.

Foreign investment in China's telecommunications market is mostly in manufacturing equipment to supply the operating companies. There are about 170 foreign joint ventures producing a wide range of equipment. The world's five largest switching equipment manufacturers have large production facilities in China. Alcatel, for example, has invested about $420 million in 21 ventures. Among wireless equipment suppliers, Motorola has invested over $1 billion in its China operations. Ericsson, Motorola, and Nokia mobile phones are prevalent throughout China. As foreign manufacturers previously excluded from supplying telecommunications network equipment attempt to gain market share, some analysts expect price wars across most market segments.

Foreign investment in telecommunications operating companies is banned. Some exceptions include Internet services and joint ventures with Unicom, but these have not been particularly profitable. Surveys typically quote 20–30% of foreign joint ventures to be profitable, with average returns on equity of just 3%. Companies that invested in Unicom's network infrastructure failed to generate an attractive return on investment. Consumer services, priced well

below international comparators (for example, Shanghai offers the lowest cellular airtime charges in the world), also have very low margins.[5] Poor earnings, nonetheless, have not deterred new investors. In 1999 foreign companies collectively invested some $175 million in Internet enterprises, most of them small. Some mid-range players are spending $5–$10 million each developing Internet portal sites. At the upper end of the scale, a consortium of investors led by computers is injecting some $60 million in Sohu.com, a Yahoo!-style portal.

The Internet backbone is the prime target of new investments in 2001. China's four major fixed-line carriers—China Telecom, China Unicom, Jitong and China Netcom[6]—announced plans to spend more than $1 billion on Internet-related infrastructure alone. The Internet zeal in China is spurring demand for fiber-optic cables, high capacity switches, routers and other equipment. Nortel Network—the no. 2 network equipment maker—plans to produce 10G optical systems, the fastest currently on the market in China. In the past 18 months, Nortel installed four 10G optical networks, three for China Telecom and one for China Unicom. By next year, probably 30% of China optical-transmission market will be 10G. China Netcom—jointly owned by China Academy of Sciences, the Ministry of Railways, the Shanghai Municipal Government and the State Administration of Radio, Film and Television—is raising $300 million equity financing to invest in a fiber-optic network backbone, CNCnet, connecting 17 major cities and providing OC-48 access and 40 Gbps transmission capacity.

The telecom legal and regulatory environment has not kept up with the major changes in the telecommunications sector

Regulating China's ICTs

Upgrading China's ICT legislation

The telecom legal and regulatory environment has not kept up with the major changes in ICT sectors since the current telecommunications law was enacted in 1987. This has created uncertainty for new entrants and investors. Telecommunications regulation has been based on fragmented administrative decrees dealing mainly with technical standards and service tariffs. The overall framework for increasing competition has lacked transparency and inhibited entry of new players and the quick development and adoption of advanced technologies.[7, 8]

As a step towards modernizing the regulatory regime, the government outlined new telecommunications regulations in September 2000 (box 6.1). These mainly refer to the telecommunications market (licensing, interconnection, tariffs), services, construction (telecommunications facilities, network access), and telecom security. Detailed implementing rules are being drafted by the Ministry

BOX 6.1
China Telecommunications Regulation—September 2000

The new telecom regulation, approved by the State Council on 20 September 2000, has 81 articles, which define basic services and value-added services, to be fast, accurate, safe, convenient, and affordable. Licenses for all basic services and value-added services that cover more than two provinces will be issued by the State Council. Basic services have government-set (or guided) prices and market-based prices—while value-added services use market-based prices or government-guided prices. The responsibilities, including universal access obligations, are detailed in the regulation for service providers. Restricting users to select other providers, using unreasonable cross subsidies, or charging below-cost prices to drive out competition are considered illegal.

Telecom infrastructure (facility construction and network access) will still be planned and highly regulated by the central and local governments.

No organization or individual will be permitted to engage in creating, duplicating, and disseminating content that conflicts with constitutional principles, harms national security, interests, and unity, damages religion policy, promotes superstition, destructs social discipline and stability, or impairs lawful rights of any other individual. Penalties for violating the articles on telecom security are quantified in the last chapter of the regulation.

Competition can dramatically improve the quality of service and lower the cost of provision

of Information Industry. This new regime will be tried out for one or two years before a new law is drafted, giving the government opportunity to make changes as may be needed to reflect increasing convergence among traditionally separate technologies, lines of business, and companies. Attempting to meet the WTO Basic Telecommunications Agreement under the guidance of fragmented regulations could, however, lead to confusion. A timely national law with an overarching set of regulations, procedures, and enforcement mechanisms is urgently needed.

Increasing competition in ICT sectors

The importance of privatization and competition to create a modern information infrastructure is now widely accepted. Evidence from Latin America shows that privatized open markets achieve basic line rollouts about three times faster than countries with a state monopoly and two times faster than those with private monopolies. Countries with private provision also realize higher employment in the telecoms sector.[9]

Competition can dramatically improve the quality of service and lower the cost of provision. In competitive markets, the average price of a call from a Global System for Mobile Communications (GSM) handset is 40–50% lower than in markets with a single provider.[10] And a recent study of Internet access pricing found that countries with the least liberal markets had access charges 700% higher than countries with the most liberal.

State-owned China Telecom has so far maintained its monopoly in the fixed-line market, and it remains the dominant player in the Internet market (table

6.2). For mobile services, China Mobile and its state-designated competitor, China Unicom, are a duopoly, respectively controlling 70% and 30% of the market. The paging market is competitive, with more than 2,000 operators, but China Unicom, which took over the pager operation of China Telecom, still dominates.

In 1999 the Ministry of Information Industry attempted some liberalization. First, it allowed China NetCom to enter the telecom market. NetCom, owned by three other ministries, operates data transmission and Internet services. Second, China Unicom gained the right to operate CDMA, long distance and data communications networks nationwide. And it got China Telecom's paging operations and the Ministry of Railway's telecom assets. Third, China Telecom was broken into four separate companies focusing on fixed-line, mobile, paging, and satellite services.

Chinese telecom markets still have to be liberalized and deregulated

Today the Chinese telecom markets still have to be liberalized and deregulated. According to the ITU, telecom, basic telephony, domestic long distance, and international long distance still lack competition. Although the mobile market is more competitive, it has great room for further liberalization (table 6.3).

TABLE 6.2
Market structure of telecoms sectors in China

Market segment	Market structure
Local calls	Duopoly: China Telecom, China Unicom
Long-distance calls	Limited competition: China Telecom, China Unicom, China Mobile
International calls	Monopoly: China Telecom
Mobile (GSM)	Duopoly: China Mobile (70%), Chine Unicom (30%)
Data communications	Limited competition : China Telecom, China Unicom, Jitong, China Netcom
Radio paging	Competition: More than 2,000 operators, China Unicom dominant
Satellite services	Competition

Source: World Bank analysis.

TABLE 6.3
Competitive environment in telecoms segments, selected countries and regions

Country	Basic telephony	Domestic long distance	International	Mobile	VADs
Australia	C	C	C	C	C
Brazil	PC	PC	PC	PC	C
China	PC	PC	M	C	C
France	C	C	C	PC	C
Germany	C	C	C	PC	C
Hong Kong	C	N/A	C	C	C
India	C	M	M	C	PC
Japan	C	C	C	C	C
Malaysia	C	C	C	C	C
Singapore	M	N/A	M	C	C
South Korea	C	C	C	C	C
Spain	C	C	C	PC	C
Taiwan	M	M	M	C	C
United Kingdom	C	C	C	C	C
United States	C	C	C	C	C

M: Monopoly; C: Competition; PC: Partial Competition.
Source: The Yankee Group, *Wireless/Mobile Asia-Pacific Report,* Vol. 1, No. 1, 2000; ITU, *World Telecommunication Development Report 2000,* Geneva, 2000.

The need for an independent regulator is urgent

The Ministry of Information Industry, responsible for overseeing telecoms, has a close relationship with the dominant incumbents, China Telecom and China Unicom. This collaboration has helped China reach its telecom development targets and growth rates. But several service providers have interests or stakes in each other—the State Secrets Bureau, the Ministry of Public Security, the Railway Telecoms Group, and the State Administration for Industry and Commerce, all belong to the state—creating conflicts of interest in the market environment. This problem is demonstrated by the close relationship between the two dominant operators and the Ministry of Information Industry, which protects China Telecom in all regulatory decisions.

The need for an independent regulator is urgent. The old regulations are based on the idea that broadcasting, computing, and telecommunications are commercially distinct—and thus should fall under separate regulatory regimes. But the borders dividing them are disappearing. The convergence of telecommunications and broadcasting—and the convergence of services and markets—call for a convergence of institutions, or at least coordination of mandates.

With the national information infrastructure and the already complicated relationships among regulators and players, China will soon face the regulatory questions of convergence and the struggles for power. The challenge is to determine how to regulate continually evolving technologies, what the regulator should do in a converged sector, and how best to encourage technological innovation.

China may soon need to decide whether to develop a separate regulatory model for new activities (see box 6.2 for the US and Canadian approaches), to coexist with existing regulation, or to leapfrog to a new regulatory model to cover the full range of existing and new services.[11]

Some key issues in telecom infrastructure relate to the interconnection rules and the tariff structure. The rule on interconnection is limited to physical interconnection and fixed tariffs not based on cost. The Ministry of Information Industry does not require network elements to be "sufficiently unbundled" so that new entrants pay only for the incremental cost of network components, not for facilities they do not use. This service aggregation[12] prevents new entrants from providing resale services, precluding most would-be competitors because they cannot afford the sunk costs of building their own networks, raising the entry barriers for potential competitors.

This bundling also makes cost-based interconnection tariffs impossible to implement, with both fixed line and mobile tariffs set by the Ministry of Information Industry. The distortion in relative prices makes rebalanc-

ing tariffs a necessary prelude to competition. Otherwise competitive operators could just target and exploit the high-price segment to make large profits, leaving cross-subsidies to the low-price segment unsustainable in the long run.

The current price structure (table 6.4), with a high installation fee and low monthly fee and local call charges, will have adverse consequences. With a larger and larger customer base in the major cities, installation fee will be a decreasingly important income source for local operators. Yet the low monthly fees and low local call charges will barely cover operating costs for Chinese telecoms' local operating companies. Competition from Voice over Internet Protocol (VoIP) services would also increase the pressure to drop the price of international calls. China Telecom needs to continue its tariff rebalancing effort to better prepare for the introduction of competition in basic services.

China Telecom needs to continue its tariff rebalancing effort to prepare for the introduction of competition in basic services

BOX 6.2
Telecom regulation: The U.S. and Canadian experiences

Although convergence has emerged only in recent years as a major issue in the communication industry, the United States established in 1934 a single regulatory authority for all communications services. The Federal Communications Commission oversees regulatory functions for all domestic and international telecommunications, cable television, radio and television broadcasting, amateur radio, equipment type approvals, and spectrum management. Licensing basic cable television services is the responsibility of individual states.

In Canada, the Radio-television and Telecommunications Commission regulates telecommunications carriers, broadcasters including cable, radio, pay television, multipoint distribution systems, subscription television, and pay audio. It numbers plan, approves tariffs, establishes interconnection rates, arbitrates disputes, monitors service quality, licenses international operators and cable television, and regulates the Internet.

Source: ITU, *World Telecommunication Development Report 1999,* Geneva, 1999.

TABLE 6.4
Telecom tariff structure, selected countries and regions
(U.S.$)

	Telephone tariff			Cellular tariffs			
	Connection	Monthly subscription	Local call	Connection	Monthly subscription	Peak per minute	Off peak
China 1998	226	1.9	0.01	60	6.04	0.05	0.05
China 1999	60–125	<2.0	0.026	60–180	6.02	N/A	N/A
Lower-middle income	133	4.8	0.05	90	20.99	0.25	0.18
High income	112	11.6	0.13	49	23.04	0.30	0.17
United States	44	19.9	0.09	...	25.0	0.39	0.39
World	109	6.9	0.09	86	21.4	0.27	0.18

Source: ITU, *World Telecommunication Development Report 1999,* Geneva, 1999.

PRIVATE AND FOREIGN INVESTMENTS

The size and potential of the Chinese telecom market naturally attracts foreign investors. But the lack of a clear policy for investment prolongs negotiation, increases the risk for long-term partnership, and slows the sector's development. The Chinese-Chinese-foreign (CCF) fiasco serves is a well-publicized reminder.[13]

The size and potential of the Chinese telecom market naturally attracts foreign investors

The agreement on the conditions for WTO membership recommends big changes in telecommunications (table 6.5).[14] Opening China's telecom market is widely applauded as a step in the right direction. The WTO agreement heralds benefits for Chinese telecom players. First, in the near term, the WTO will provide an external framework for reform, which in the mid- to long term will permit sustainable foreign investment in the sector. Second, it will facilitate access to foreign capital markets and fuel the next phase of competitive expansion in telecom services, to come from private enterprise and private capital.

The Basic Telecommunications Agreement requires WTO members to erect pro-competitive regulatory institutions in six areas: competitive safeguards, interconnection, universal service, public availability of licensing criteria, regulatory independence, and allocation and use of scarce resources. But the Agreement's terms and conditions are rather vague, so China may interpret the requirements in its own way—to reflect the nationalistic and protectionist sentiments of Chinese regulators and companies.[15] For example, the broad terms and conditions of the Agreement fail to offer effective guidelines on how to achieve universal service.

Overall, the value of China joining the WTO, specifically committing to a market liberalization timetable and adopting the regulatory principles, is likely

TABLE 6.5
WTO requirements and timetable for foreign investment in telecoms

Sector	Phase	Permitted percentage of foreign investment	Date	Geographic limit
Value-added and paging services[a]	I	30	Upon accession	Beijing, Shanghai, Guangzhou
	II	49	One year after	Extended to 14 other cities[b]
	III	50	After 3 years	Nationwide
Mobile voice and data services	0	0	Upon accession	N/A
	I	25	One year after	Beijing, Shanghai, Guangzhou
	II	35	After 3 years	Extended to 14 other cities
	III	49	After 5 years	Nationwide
Fixed service (including long-distance)	0	0	Upon accession	N/A
	I	25	After 3 years	Beijing, Shanghai, Guangzhou
	II	35	After 5 years	Extended to 14 other cities
	III	49	After 6 years	Nationwide

a. This category includes electronic mail, voice mail, online information and database retrieval, electronic data interchange, enhanced value-added fax services, code and protocol conversion, data processing, and paging services.
b. The cities are: Chengdu, Chongqing, Daliann, Fuzhou, Hangzhou, Nanjing, Ningbo, Qingdao, Shenyang, Shenzhen, Xiamen, Xi'an, Taiyuan and Wuhan.

to have great impact on its telecom sector. But given the gaps between the current regulatory framework and the one outlined in the Agreement, the lack of sound regulations creates hidden regulatory barriers. Therefore, the real effects on safeguarding competition and introducing foreign investment depend on the regulatory framework to be applied in telecoms after China's accession to the WTO.

Developing network infrastructure and information content

A realistic objective in the short term is to achieve universal access

In advanced countries, the information infrastructure went through three stages. First, it was used for access or communications such as telephone and email. Second, it was used as a resource for information. And third, it is also used for e-commerce, governance, and the delivery of such services as education and health. It is this third stage that can deliver the full benefit of the Internet to the economy and all society. China can make a two-step shift, first from the full benefit of Internet communication (email) to an information resource, and then from an information resource to an effective tool to reduce transaction costs and improve social welfare. People will pay first for access, next for content, and then for business and commercial transactions.

Establishing universal access

China's leadership clearly sees the potential that ICTs offer to create a networked society and help leapfrog China's development. They also know it will allow it to strengthen its ability to exercise administrative and political control over the country. Yet most of the economy has very limited and poor access to the information infrastructure. Basic telephone penetration is very low at about 10%. Internet services are even less developed; less than 2% of China's 1.2 billion people are online, compared with 50% of the United States.

The focus should be on providing public access to services. A realistic objective in the short term is to achieve universal access, whereby everyone can access telecommunications services within "reasonable" distance of their homes. (This is not "universal service," a phone in every household.) What "reasonable" distance actually means, what services are to be provided at every public access point (telephone, e-mail, real-time Internet), and which of these services are appropriate at what level in the hierarchy of towns and villages will depend on potential demand and ability to pay for these services.[16]

The operational costs in western China are believed to be exceptionally high because of the harsh natural conditions and the small and poor population. Cross-subsidies from eastern to western China—and from wireless and long-distance services to local phone services—were necessary for China

Telecom to cover most of the country. But the competition in basic phone services in the era after China joins WTO will force the Ministry of Information Industry to reconsider how to allocate universal service obligations fairly among different telecom service providers.

In a competitive environment the costs of provision of universal access, including rural expansion, can be financed through special funds. The sources of funds vary:

- Interconnection levies—incremental interconnection charges by incumbent operator providing universal access to compensate them through the use of their network by competitors.
- License or radio frequency fees—with part of the fees from license or spectrum auctions allocated to a special fund to foster universal access.
- Operator revenue contributions—a levy on telecom operators.
- Seed financing by a development bank or agency.[17]

Proceeding with the necessary investments to enlarge capacity, reduce prices, and improve connectivity and quality of services is critical

These transitory mechanisms can partly defray the initial investment costs of network expansion in rural and poor areas. In another possible post-WTO scenario, foreign carriers entering China could be encouraged to provide ICT services to rural, western areas before they are allowed a free hand to compete in the larger and richer eastern China market.

Proceeding with the necessary investments to enlarge capacity, reduce prices, and improve connectivity and quality of services is critical. Only 10% of the cable networks are "two-way", or interactive. To develop Internet-based cable networks, upgrading the remaining 90% of the system will cost about $50 billion. Add to that the investments to integrate regional cable TV networks into a national one. There is no choice but to liberalize and allow massive investments in the information infrastructure, perhaps one of the most important measures for China to catch up quickly with the advanced nations.

China is still constrained by low bandwidth[18] and slow access. Normal household access in China is through a 56-Kbps modem (in North America, faster tools are often used, such as integrated services digital network (ISDN), cable modems, and asymmetric digital subscriber lines). Bandwidth is key to determining online duration. Surveys have shown that Internet users prefer a fast access for pay over slow access for free. With richer multimedia content being offered—such as images, audio, video, and virtual reality—further development for network and e-commerce will stall if China doesn't create more bandwidth.

Accessing the Internet through alternative means—such as mobile phones, personal digital assistants, and home appliances—is showing strong growth, from 200,000 in March to 590,000 in June 2000, almost tripling in three months. The number of mobile phone subscribers is now 85 million, roughly 4 times the number of Internet users, and continues to grow substantially. Advantages over PCs include lower cost, easier use, and convenient porta-

bility. So, mobile commerce seems to have bright prospects and great market potential. Although Internet access charges are still high and the bandwidth is low, rapidly improving telecom technologies, such as general packet radio service and 3G technologies, will soon change the situation.

Enriching Chinese information content

The Internet is above all a source of information. But the Chinese government is very strict in regulating content, and the telecom administration bureau in the Ministry of Information Industry insists that the government retain control. Regulations of Internet Content Providers (ICPs) will be strict because of the government's intention to supervise Internet content by issuing new rules,[19] supervising Internet cafes (the primary access point for most young Chinese users), deliberately holding back private web development while selectively favoring government supervised web content.[20]

Content should not be restricted to Chinese languages or from sources only inside China

However, with a population of 1.2 billion consumers, China is the world's largest developing market. And China's burgeoning economy has drawn the interest of statesmen, economists, financiers, and businesspeople eager to learn more about the country. For its economic development, China needs to understand the world and to help the world get to know it better, making Chinese websites two-way windows. That is why content should not be restricted to Chinese languages or from sources only inside China.

The Chinese government, concerned with what end-users can get access to, has developed a hierarchical system of companies and organizations controlling access to the Internet at different levels. Currently, there are two academic networks (CERNet and CSTNet) and four commercial networks (ChinaGBN, CHINANET, UNINET, and CNCNET). The state has (some) control over the specific websites to be blocked. But the flow of content and the rapid change of technologies, make it impossible to block every objectionable site on the Internet. And the attempt to control content has restricted access, slowed access speeds, and raised prices.

Developing effective e-commerce

Commercial websites have been springing up rapidly in China in recent years. There are now 99,734 registered .cn domain names and 27,289 websites, three-quarters of which are commercial. Such numbers and huge growth are exciting and encouraging. The commercial societies are especially enthusiastic about this growth. The combination of government-driven networks and the big companies looking to exploit them for commercial gain means that e-commerce has arrived in China.

But these developments do not automatically translate into a broad-based and rapid take-off for e-commerce. There still is a long road ahead before China reaches a critical mass of e-commerce activity.[21]

Upgrading payment and delivery systems

The Chinese credit system is a large obstacle to developing e-commerce. China so far has no banking mechanism or credit system to check credit online for business. Nor is there a way to obtain individual or corporate reports, so debit rather than credit cards are used. It may be a long time before China uses credit cards for online payments to the same degree as western countries. But assessing the credit of Internet users cannot be overlooked. Some auction websites such as Eachnet—a Chinese E-bay—have encountered this tricky problem.

There is no tradition of credit or an efficient way to check credit in China

There is no tradition of credit or an efficient way to check credit in China. More time will be required for China to develop a complete system for checking credit efficiently. In addition, concerns exist about online security, such as personal privacy and credit card numbers. And the cost of online transactions, often not convenient because of the incomplete delivery system, could exceed the price from the store. Uncertain delivery times—including delayed or canceled deliveries—and poor post-sale service, are depressing the enthusiasm of users. Because of these constraints, China still does not have real B2B and B2C systems but it has the potential to develop e-commerce.[22]

Some payment alternatives are available. Online ordering could be paired with offline payment by cash on delivery through the postal ministry or other logistics companies.[23] Bank-issued, debit-only cards could also be a substitute. For payments to vendors in other cities, such cards are now widely used as payment mechanisms by companies that previously had to do transactions with suitcases full of cash. Currently, deals can be done with reasonable certainty that a corporate credit card charge will be paid. China is MasterCard's second largest market, even without a nationwide card verification system. And pre-paid cards could be another means to enable payments online. Experiments with such cards have proven to be successful in countries like India.

Modernizing the postal system can also improve the quality of the delivery system, especially for rural and low-income communities with little access to communication and delivery networks. Along with letter and parcel mail, money orders can be provided to more areas more dependably. These services also support local small businesses in need of secure and rapid means of communication, financial payment, and order fulfillment.

Low incomes of Internet users also create barriers to e-commerce. The average Chinese Internet user is 25 years old, a graduate of college or junior col-

lege,[24] and earning $2,176 a year. The average American Internet user is 33, a college graduate, earning $66,900. China's Internet users cannot be expected to afford the rapid development of e-commerce.[25] Compare U.S. e-commerce revenues of $71 billion in 1999 with $6.9 million in China. Even if China becomes the largest Internet country after the United States by 2002, China's e-commerce development will still lag behind other countries.

Businesses in China are also slow to establish e-commerce capabilities. Of the 10 million enterprises in China (especially small-to-medium size enterprises), only 0.8% have websites for e-commerce, which is seen as a "storefront," simply another medium for information publishing, due to the lack of necessary capital, IT talent, technologies, and experience. Some application service providers are offering outsourcing services to these markets, but they are still learning e-commerce implementation. Such vendors as IBM, Microsoft, and Oracle offer e-commerce software, platforms, and solutions, but the number of such vendors in China is small.

Entry to the WTO will also provide a conduit for the import of foreign technical expertise, implementation experience, and management

Accession to the WTO will help the Chinese manufacturers leverage their cost base and efficiencies to drive into the U.S. and European markets. Chinese enterprises should thus take full advantage of the Internet to enhance their competencies on the global market. E-commerce is a good platform for Chinese enterprises to employ. Although most of the Chinese enterprises are still in the primary stage of web development, some integration systems, independent software vendors, and the burgeoning application service providers will contribute much to the improvement of such websites.

The entry to the WTO will also provide a conduit for the import of foreign technical expertise, implementation experience, and management, and open further the highly competitive but regulated telecom equipment market to a new wave of competition, with vendors bracing themselves for technology and price wars. For equipment manufacturers, this will entail more complex marketing arrangements to address customer profiles. And the proliferation of alternative wireless access technologies, the competition among provincial service providers, and the sophistication of value-added services will create a far richer technology mix than in the past. The Chinese government should take this opportunity to promote competition, invest in IT development, foster talent, and encourage development of state-of-the-art core technologies.[26]

Applying ICTs to enhance Chinese public services

Ever evolving and ever more powerful, ICTs enable more extensive delivery of education and new mechanisms for delivering education. They can also bring new educational options to those previously denied access. Public and private universities are already embracing the Internet and distance education.

Many stand-alone universities can offer world-class education because they have access to much larger, more up-to-date, and cheaper online libraries. University researchers are also forming networks.

Governments can support lifelong learning initiatives by restructuring the education system to create new opportunities for citizens of all ages.[27] Distance learning has become very important as a means of extending high-quality, world-class education. The "telecenter" is a useful means of extending distance learning and virtual education and linking students from different social, cultural, and economic backgrounds. Distance education has also been used on a large scale for teacher education at all levels, and there is merit in exploring the use of ICTs in this area. In addition to training children and adults on computers and the Internet, the government can work to foster the creation of Internet and high-technology businesses through publicly-funded incubators that finance new companies while supplying "intellectual capital," including training, mentoring, and partnership.

ICTs can improve the internal operations of governments and the government's interface with the public

ICTs can improve the internal operations of governments and the government's interface with the public. They can increase administrative efficiency by making the collection, maintenance, flow and management of information faster and easier, reducing the unit cost of information. This affects tax administration, land registry, public financial management, pensions and social security administration. ICTs can also help to fulfill the strategic objectives of decentralization, and accountability—combating corruption and improving service delivery and dispute-resolution, by making information more easily available to the public. State-of-the-art technologies also enable better government-citizen interaction, allowing, for instance, filing forms or registering concerns online, increasing both efficiency and transparency. While a few government organizations in China are going online, putting information on publicly-available websites, this kind of sophisticated and interactive feedback component has not yet been significant.

Earlier this year, Wu Jichuan, China's Minister of Information Industry, unveiled China's strategy for the new century at the ITU Telecoms Asia—making government supported development of the telecom industry a priority. China is aware of the emerging importance of e-government and other Internet applications. It is building capacity in the government by training civil servants to facilitate e-government and developing computer-based training packages for government employees. Both are necessary to enable government organizations to use the new technologies.

Notes

1. Recent econometric studies have confirmed evidence of high returns on investment in the telecommunications sector. The privatization of infrastructure services, in particular, has had a strong effect on the decision making process of foreign investors. For each dollar a country raises through the pri-

vatization of infrastructure, an additional $2.42 is attracted in FDI (Frank Sader, *Privatizing Public Enterprises and Foreign Investment in Developing Countries, 1988–93,* Washington, D.C.: World Bank, 1995, p. 31).

2. As FAO reports: "It was estimated that transmitting price and market information through the Internet-based rural information service cost 40% less than using traditional methods. In addition, the information was more timely, reaching farmers much faster." (Silvia Balit, Food and Agriculture Organization, Rome, 1998, p. 4).

3. India's software export industry is perhaps the best known case of a low-income country exploiting the opportunities presented by the new networked economy. Analysts predict that Indian software exports, now about $6 billion, could reach $50 billion by 2008, or a third of the country's exports. (*Business Week,* 3/6/00 p. 83).

4. The government's "Golden projects" have played a major role in developing information networks. Initially (1993), these projects comprised three elements: Golden Bridge (National Public Information Communication Network), Golden Card (Electronic Payment Project) and Golden Gate (Foreign Trade Information Network). Since then a series of other programs (more than ten, such as Golden Sea—Leadership Information Network, Golden Tax—Computerized Tax Return and Invoice System Project, Golden Intelligence—China Education and Research Network, Golden Health—National Health Information Network) have emerged. While the agenda of the initial projects was the rollout of information networks, these later projects have generally involved applications to use the information infrastructure.

5. "Competitive Wireless Pricing Around the World," Yankee Group, June 1999.

6. China Telecom (the commercial name for the Directorate General for Telecoms of the separated former Ministry of Posts and Telecommunications) and China Unicom are essentially controlled by MII. While the Ministry of Railway's telecom assets belong to China Unicom, it also owns a stake in China Netcom, China's third telecoms operator, with the State Administration for Radio, Film and Television, which has another 25% stake.

7. Bing Zhang and Mike W. Peng, "Telecom Competition, Post-WTO Style," *China Business Review* May–June, 2000: 12–21.

8. One case in point is that of Great Wall Communications, a new player competing with China Telecom and China Unicom. Great Wall developed experimental CDMA networks in several major cities, and these projects apparently are continuing. Great Wall is partly owned by the People's Liberation Army, which was barred from owning and operating businesses in 1999. Although Great Wall appears able to continue operations, some doubts about its future persist (Baker and McKensey Inc., *E-Commerce in China,* Hong Kong: Asia Information Associates Limited, 2000).

9. See J. Grace, C. Kenny, J. Liu, C. Qiang, and T. Reynolds, "Telecommunications, the Internet and Broad-Based Development," mimeo, World Bank, Washington, D.C., 2000.

10. See Carlo Maria Rossotto, Michel Kerf, and Jeffrey Rohlfs, *Competition in Mobile Telecoms,* Viewpoint Note 184, Washington, D.C.: World Bank, 1999.

11. The regulatory functions normally include: numbering plan, tariff approval, technical standards, interconnection rates, arbitration of disputes, frequency allocation, type approval, monitoring service quality, and the establishment of licenses fees and licensing (ITU, *World Telecommunication Development Report 1999,* Geneva, 1999). The autonomy and functions of the separate regulator need to be clearly defined once it has been established in China.

12. Unbundling of telecom services refers to the provision of components on a stand-alone basis. The large capital costs of building duplicate networks raise a significant barrier to entry. Competitors may not be willing or able to finance the construction of complete networks. However, they may be willing to build parts or such networks. Therefore, with unbundling, new entrants can obtain access to single unbundled component and mix their self-built network components with those of the incumbent in an efficient manner. (Hank Intven, Jeremy Oliver, and Edgardo Sepúlveda, *Telecommunications Regulation Handbook,* Washington, D.C.: World Bank, 2000).

13. Despite the official ban on foreign investment, 21 foreign investors injected $1.3 billion between 1995 and 1998 into Unicom's provincial cellular networks via their Chinese-foreign joint ventures—hence the term "Chinese-Chinese-foreign." But in 1999 Unicom unilaterally ordered these investors

to withdraw their investments in exchange for the refund of their principal plus a nominal return far below what the foreign investors had expected. By December 1999 the withdrawals were complete, despite the protests of investors. Such adverse publicity naturally discourages future foreign investors (Bing Zhang and Mike W. Peng, "Telecom Competition, Post-WTO Style," op. cit.).

14. The Yankee Group, Vol. 7, No. 18, December 1999.

15. WTO does have a strong tool in case a WTO member feels that another member country is not fulfilling its obligations—the Dispute Settlement Body (DSB). When a schedule of commitments is in force, the former can try to solve differences on a bilateral basis. In the case of failure, it can then raise the issue at DSB. At the end of the process if the latter is found "guilty", it has to accept to apply the right interpretation or to compensate economically the affected member(s). One example is the case of US against Mexico regarding high interconnection taxes applied by Telmex to American operators.

16. In China, the charge for an Internet connection comprises a phone connection fee and an Internet Service Provider (ISP) fee. CNNIC statistics (July 2000) on the average tolerable online fee per month was over $200 a month for more than 60% of the surveyed households while an absolute majority of the household had a salary income under $2,000 a month. Note that the samples in the survey cover 31 provinces all over the country. But as it was conducted online, the results tend to be biased upwards.

17. For example, a recent World Bank telecommunications project in Nicaragua includes a small portion of seed financing for a rural development fund. Similar schemes are under discussion in Nepal and Nigeria.

18. China's total bandwidth capacity for the five major Internet service providers, in terms of international service, reached only 355 megabytes in 2000 (after a recent increase of 20%, to be increased to 1GB in that year, according to MII). This can be compared with the 37 gigabytes of Taiwan (China) (with one-fiftieth of China's population), 233 megabytes of Hong Kong, and 256 megabytes of Intel's international connection networks (Credit Lyonnais, China Internet Sector, CLSA, Spring 2000).

19. The Chinese government has issued new rules on web content in another attempt to repress dissent and control the Internet. New regulations published in the state-run newspaper People's Daily stipulate that websites must have government permission before publishing news stories. Commercial websites are forbidden from writing news stories themselves but must use stories from official state media. All stories published must carry attribution of source, and stories from foreign sources can only be run with official approval. Website owners will be held responsible for ensuring users do not post messages in chat rooms that express views against the constitution, are a threat to state security, or harm's China's reputation (*Total Telecom News,* 2000, "China issues new rules on Internet content," [http://www.totaltele.com/view.asp?articleID=33796]).

20. The government is experimenting with alternative networks shielded from the rest of the world. ChinaNet's '163 Internet' is an attempt to build a China-only Internet. Started in 1998, it is run by China Telecom's Data Communications Bureau and all its material is in Chinese. If this was created to control content, it has the danger of isolating China from the external linkage and the global system.

21. Recently, the government has announced a number of initiatives aimed at providing nationwide infrastructure and standards to support e-commerce.

22. In summer 1998, the Ministry of Foreign Trade and Economic Co-operation opened its China Market website (http://www.chinamarket.com), the country's first export-oriented B2B e-commerce site.

23. China Post's Express Mail Service is perfectly happy to handle cash-on-delivery business. It takes a 2% commission on top of its delivery fee and gets goods to customers within two days.

24. The profile of Internet users shows that 80% of Chinese Internet users have a higher-education background (12 million hold a university degree). The total number of graduates in China is 30 million. So, new Internet users will tend not to have a university degree.

25. According to the CNNIC survey, only 9% of users purchased a commodity or service over the Internet in 1999. Nevertheless, the number of Internet users who have had online transaction experience (such as online shopping and access to stock exchanges) is increasing, indicating that Chinese

people are gradually accepting the concept of purchasing on the web.

26. However, to be a global leader in ICT requires large investments in R&D. For example, investment in R&D in 2000 by Nokia was $2.3 billion—roughly a third of China's total R&D budget.

27. For example, Singapore is establishing a Life-Long Learning Fund: When the economy performs well, a special dividend can be paid into each citizen's account, and the money (or equivalent in study credits) can be used to further an individual's study or to acquire additional employment skills or knowledge.

PART 3 **Raising the technological level of the economy**

The primary goal of mastering the transition to the knowledge-based economy is to raise the technological level of the Chinese economy. Much remains to be done for this, in addition to establishing the foundations discussed in part two. The discussion can be put in the perspective of improving the Chinese innovation system. It should be clear, however, that innovation is to be understood as products, processes, practices that are new in the local contexts of China, down to the different regions and localities. In no way should innovation be perceived as referring only to brand new technologies in a global context. What matters for China's development is the concrete application and use of available modern technologies, not so much the development of new ones. At least for the time being.

Addressed first is the strong need for more effective and expanded policies aiming at the diffusion of new technologies throughout the economy (chapter 7). Next, the improvement of the domestic research and development effort, affected both by a questionable combination of an excessive market-based approach and top-down conceptions of government programs is discussed (chapter 8). Finally considered are several ways for China to more effectively exploit global knowledge: especially by making better use of foreign investment, the most efficient means to raise the technological performances of the economy in the short and medium runs (chapter 9).

7 Diffusing technology throughout the economy

In the middle ages China was the most technologically advanced country in the world, creating the earliest mechanized industry and advancing to the experimental investigation of nature. The period was the climax of many centuries of scientific and technical progress. Then in the 14th century a new climate deterred further progress. Many techniques remained close to the imperial court, almost exclusively for the pleasure of the ruling class.

This new climate developed due to a lack of resources. China also closed itself to the outside world, cutting off competitive pressures and new ideas, two essential factors in progress. There was, in addition, a tendency to stay away from experimental science, decisive in the development of western technology. Reinforcing all this were bureaucratic structures and social tendencies to preserve the status quo. China, though remarkably positioned, missed the Industrial Revolution and entered the industrial age only half a century ago with the ascension to power of the Communist regime (box 7.1).

If the climate for innovation is not significantly improved, China risks another technological standstill

Technological weaknesses and disparities

Today again technological disparities throughout the economy are enormous, and if the climate for innovation is not significantly improved, China risks another technological standstill, like the one several centuries ago.

Productivity and competitiveness

The industrial performance of enterprises across provinces, especially the profit-asset ratio, shows considerable dispersion between the best and the rest (figure 7.1). And the performance of foreign-funded enterprises appear to be about twice that of the domestic firms, all across the country, both in profitability and productivity. (This statistic confirms what foreign enterprises can contribute to modernizing the economy.)

There has also been a recent decline of industrial competitiveness,[1] with the specialization of manufacturing remaining a problem. Comparative advantages remain in labor-intensive industries (textiles) and mass high-tech industries employing skilled, but cheap labor (color TV). But standard con-

China missed the Industrial Revolution and entered the industrial age only half a century ago

BOX 7.1

How the most technologically advanced country in the middle ages missed the industrial revolution

Mark Elvin, a specialist in China's economic history, notes:

> From the tenth to the fourteenth century China advanced to the threshold of a systematic experimental investigation of nature, and created the world's earliest mechanized industry. In mathematics, a general technique was found for the solution of numerical equations containing any power of a single unknown. In astronomy, a new level of observational accuracy was achieved with the casting of much larger instruments and the perfection of hydraulic clockwork. In medicine, a start was made upon systematic anatomy with the dissection of cadavers; more precision was attained in the description of diseases; and a vast number of new remedies were added to the pharmacopoeia. In metallurgy, coal certainly (and coke possibly) was used for the extraction of iron from iron ore. In warfare, gunpowder changed from a material for fireworks into a true explosive . . . This period was the climax and also the end of many preceding centuries of scientific and technical progress. Its foundation, above all else, was the art of woodblock printing, invented in the ninth century and in general use by the tenth.

Elvin identifies three events in the fourteenth century making it a turning point, and creating a climate deterrent to innovation.

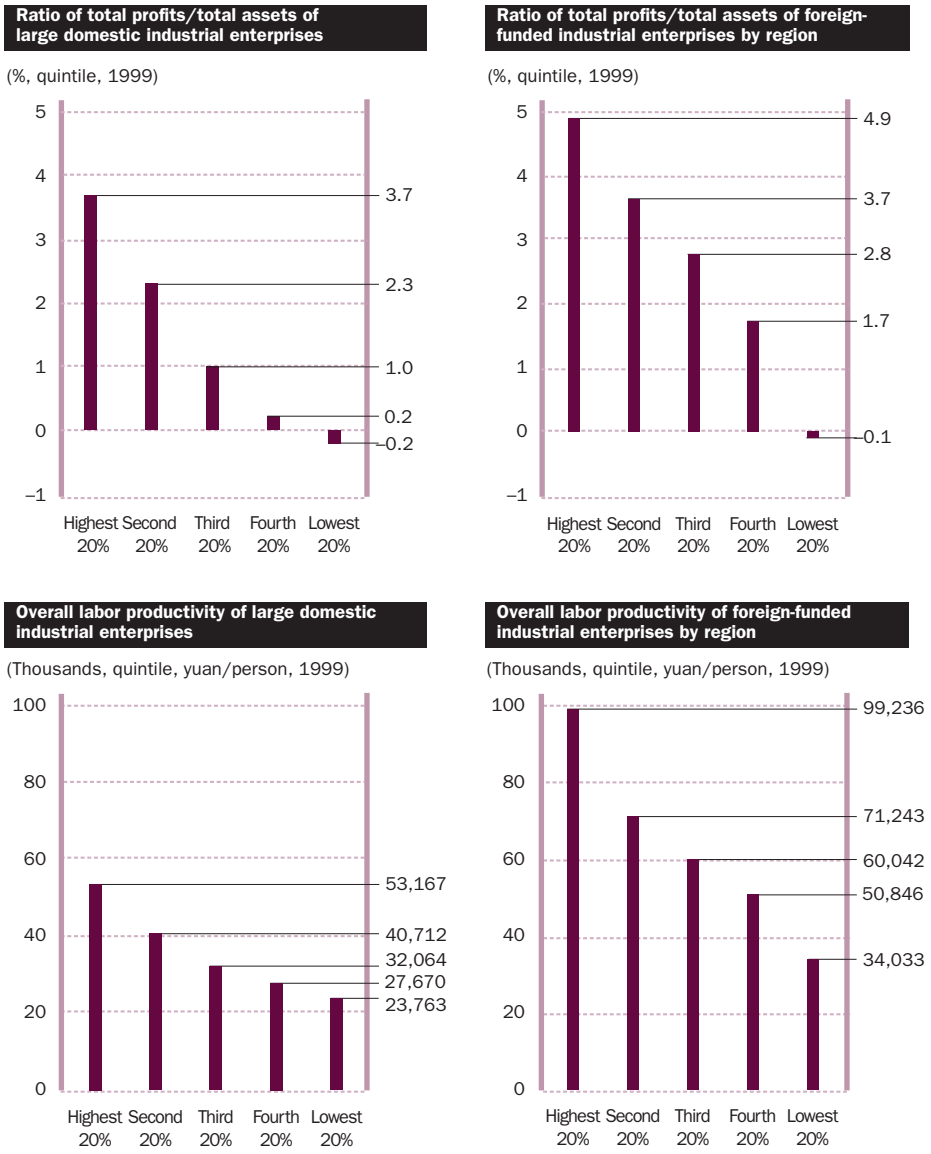
- "An economy in which an expanding frontier had played an important part had begun, in terms of people and resources, to "fill up." (The economic growth of the medieval ages was moved by a migration into the South accompanied by an agricultural revolution based on the exploitation of rich farming lands. A reversal process took place in 1300 with people migrating back to the North, but the demographic swing was smaller in size and not associated with any increase in labor productivity with the occupation of dry-farming lands.)
- "Next in importance was the reduction in overseas trade and in contacts with foreigners. The Chinese economy was temporarily denied much needed supplies of foreign silver, and Chinese society became inward-looking."
- "Lastly there was a change in the attitudes of philosophers towards nature. Interest in systematic investigation was short circuited by a reliance on introspection and intuition. There were therefore no advances in science and to stimulate advances in productivity technology."

Under those circumstances, "in late traditional China, economic forces developed in such a way as to make profitable invention more and more difficult. With falling surplus in agriculture, and so falling per capita income and per capita demand, with cheapening labor but increasingly expensive resources and capital, with farming and transport technologies so good that no simple improvements could be made, rational strategy for peasant and merchant alike tended in the direction not so much of labor saving machinery as of economizing resources and fixed capital. Huge but nearly static markets created no bottlenecks in the production system that might have prompted creativity. When temporary shortages arose, mercantile versatility, based on cheap transport, was a faster and surer remedy that the contrivance of machines."

Source: Mark Elvin, *Pattern of the Chinese Past,* Palo Alto: Stanford University Press, 1973.

sumer electronics, about 15% of China's exports, are produced almost entirely under foreign licenses and by foreign-owned firms. Some sectors requiring somewhat sophisticated technologies—such as automotive, where there are too many producers (more than 140)—are being hit hard by entry into

FIGURE 7.1
Industrial enterprise performances, domestic and foreign-funded



Technological disparities throughout the economy are enormous

Source: World Bank staff analysis based on data from, China Statistics Bureau, *China Statistical Yearbook,* Beijing: China Statistics Press, 2000.

the WTO. The gaps between Chinese industries and foreign competitors are enormous in certain sectors. For instance, in iron and steel, productivity is a sixth of the world average—a twentieth that of the best world performers (table 7.1).

In agriculture the dispersion of productivity in cereals production among the different provinces reaches more than a factor of two between the best performing provinces and the worst (figure 7.2). Moreover, the progress in agriculture productivity in GDP per capita has been slower than in other countries, an effect of

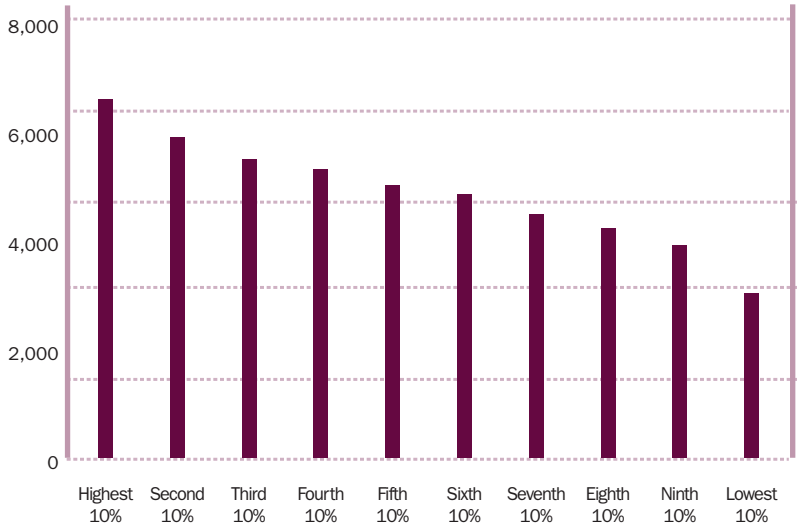
TABLE 7.1
Productivity in iron and steel, selected countries
(1996, ton/person)

	World	Australia	Japan	Korea	United States	India	Russia	China
Productivity	182	681	637	585	398	78	70	32

Source: Yongding Yu and Yuxin Zheng, *Research Report on China's Entry into WTO,* Beijing: Social Sciences Literature Publishing House, 1999, p. 230.

A major obstacle is the poor capability of transforming scientific and technological advances into practical productive forces

FIGURE 7.2
Cereal yields in Chinese regions
kg/hectare, 1999, deciles



Note: The 31 provinces, autonomous regions and municipalities are grouped by deciles from the highest to the lowest according to their cereal yields in 1999.
Source: World Bank staff calculations based on data from China Statistical Bureau, *China Statistical Yearbook,* Beijing: China Statistics Press, 2000, p. 386.

deteriorating extension infrastructure and of the nature of the property structure, favoring the individual but hampering intensive cultivation.

Throughout the country, the strong S&T infrastructure contributes little to the economic development, evident in remarkably low correlations between them. This is clearly demonstrated by a recent statistical study[2] covering the whole set of economic development (GDP, per capita GDP, exports, total factor productivity) and correlating it with S&T inputs (funding and personnel), outputs (patents and scientific publications), and potential (education expenditures and students enrolments).

The government, aware of current limits and drawbacks, admits that "the problem of science and technology divorcing from the economy has not been solved thoroughly. A major obstacle restricting China's economic development is the poor capability of transforming scientific and technological advances into practical productive forces, the low level of applying new and high technology to production, and the poor capability of enterprises in technological innovation."[3]

To improve the situation the government is increasing its effort in science and technology and notably in R&D programs for new and established industries and for agriculture ("863" and Key Technology Programs). But raising the technological level of the Chinese economy depends first on well-functioning market structures throughout the economy.

Strengthening markets for technology dissemination

New and improved technologies diffuse throughout an economy under the pressures of competition. It forces firms to adopt innovations, modify their products for better serving their clients, and change their processes to improve productivity. Least efficient enterprises are deemed to follow rapidly best performers or to disappear. Main diffusion agents are providers of these new technologies and related services—large as well as small firms. Customers, well informed on goods' prices and quality, play an essential role too.

China's exceptionally poor technical regulations and standards are a major obstacle to proper diffusion of modern technology and know-how

The primary measures to be taken to strengthen markets should be:

- More open trade among Chinese provinces, allowing economies of scale and scope, and facilitating the diffusion of best products through price- and quality-based competition. Eliminating tariff and non-tariff barriers between provinces—erected to protect local enterprises and related interests—is essential.
- Improve competition by establishing and enforcing appropriate laws, and eliminating privileges from personal and political connections.
- Support small firms providing services, consulting, technologies, and seeds to producers, farmers, and local communities. This requires adequate incentives and removing regulatory and bureaucratic obstacles to their establishment and operation.
- Improve the system for technical norms and standards. China's exceptionally poor technical regulations and standards—such as product quality, work safety, and environmental protection—are a major obstacle to proper diffusion of modern technology and know-how in China (box 7.2).

Redirecting technology-related policies

The mediocre diffusion of modern technology and related management methods owes much to the ways technology and industry policies are conceived and implemented:

- Overconcentration of attention, support, and incentives on designated industrial zones and high-tech parks, conceived to attract foreign firms and domestic firms for exports. This policy has been successful in many respects (box 7.3), but parks are a small part of the economy.

High-technology parks have been growing very fast but technology diffusion beyond the parks has been limited

BOX 7.2

Improving the infrastructure for technical standards

In principle, norms and standards are to be defined by central government ministries in their respective domains of responsibility. But their resources are limited, and technical regulation functions are at the bottom of their priorities. The provincial authorities are charged with enforcing the standards and regulations, but they have limited ability to adapt them to local circumstances. More often than not, enforcement mechanisms are nonexistent, ineffective, or inconsistent, with provinces establishing different norms for similar products to create nontariff barriers to interprovincial trade.

Product certification is rather obscure, often agreed on by informal commissions of business, government, and academic representatives using arbitrary criteria. These opaque, anti-competitive practices impair economic efficiency, and hinder development in all regions of China.

Metrology and measurement standards are also essential technological services. The National Institute of Metrology, established in 1955 and affiliated with the State Bureau of Quality and Technical Supervision, is responsible for researching, establishing, maintaining, and using national primary standards of various measurement units. It also disseminates quality values, such as verification, calibration, and testing, and ensures their international comparability and traceability. With a state budget of 50 million yuan, doubled by contract-based resources, and about 1,000 employees, the institute is underfunded and understaffed. A major upgrade requires additional resources. The system's responsibility should be expanded to include secondary standards (measuring instruments and procedures), tertiary standards, and industrial applications to ensure consistency and traceability.

BOX 7.3

Development of high-technology parks

In 1999 the 53 technology parks officially registered and supported by the government accounted for about 10% of industrial production. A large part of their activities, about 45% of their total output, was in electronic products and telecommunication equipment. They were responsible for producing more than 55% of the whole country's computer-related products. Foreign enterprises of non-Chinese origin were responsible for more than 62% of the parks' exports (Hong Kong, Macao, and Taiwan, China, enterprises add another 14%).

The parks included 17,498 enterprises, employing 2,210,487 people. The most important park is the Beijing Zunguanccun, which accounted for 4,421 enterprises and 246,422 employees. The 10 largest parks employed more than one million persons, showing a relatively strong concentration of activity: 36 of the 53 parks had more than 100 enterprises.

The growth of the technology parks has been more than 25% a year on average. The contribution of such high technology parks to employment, output, and exports will continue to grow. But the technology diffusion beyond the parks has been limited, evident in gap in labor productivity, which is two times higher in the parks than in the overall industrial sector.

The central government recently decided to concentrate its support on only five parks, in Beijing, Shanghai, Xi'an, Shenyang, and Yanglin. It has also decided to support, on a pilot basis, some 15 university-related parks now being developed.

Source: Zhaoying Chen, "High-Tech Parks in China," World Bank, Washington, D.C., 2000.

- Excessive fascination for high-tech production, without using high technology in the modernization of agriculture, manufacturing, and services.
- Neglect of the policy instruments increasing the receptiveness to, and adoption of, new technologies in the industrial and rural tissues.
- Too much technology push in R&D projects—supported by government funds, designed by government institutes, with little involvement of users.
- Disproportionate focus on large firms, even though smaller ones are a major source of technological dynamism and renewal.

A new mindset is needed in the design and implementation of the government promotion of technology. Priority should go to:

- Technology fertilization of the "average industry" over "high tech" productions.
- Technological culture over advanced research.
- Bottom-up initiatives over top-down ones.
- Support to smaller firms over larger ones.

Three sets of measures are at the core of what needs to be done:

- Redeploying government programs for technology diffusion.
- Stimulating innovation in enterprises.
- Promoting innovation sites and clusters.

The government should create an environment to facilitate development, commercialization, and use of improved technologies

Redeploying government programs for technology diffusion

Some of China's policy measures for technology diffusion have had reasonable success, but most leave considerable room for improvement (appendix 7.1). Massive efforts are needed for retooling and expanding overall government support to disseminate knowledge and technology. The government should not directly support or push the adoption of technology by enterprises and other economic agents. Instead, it should create an environment to facilitate development, commercialization, and use of improved technologies, including establishing appropriate organizations (box 7.4).

The government should expand technology diffusion programs by:

- Restoring and expanding the networks of centers that support manufacturing technology.
- Revamping the design and infrastructure for agricultural and rural development.

Engineering research centers and productivity centers

The mission of engineering and research centers is to design and develop new technologies up to the demonstration stage, often jointly with enterprises, leaving commercialization and production to business. The centers should limit their activities to technical research, information, and assistance, with a clear

BOX 7.4

Conditions for efficient technology diffusion programs

Based on the experience accumulated both in industrial and developing countries, four general principles are important:

- The status of disseminators should be clearly recognized wherever they operate (in specialized centers, universities, and so forth). They should be adequately remunerated for the services they provide and not penalized in their careers (for example, academics involved in technology extension). In addition, the private sector's involvement in technology consulting services should be encouraged. Currently, most technology diffusion agents, converted from former government-affiliated institutions, are still largely controlled by line ministries, which do not allow private sector involvement.
- The appropriate status of a dissemination entity is generally a nonprofit organization, the status adopted by the efficient organizations in China (for instance, head offices of science parks). But such a legal status is not yet well established, and the tax advantages normally associated with it seem to be nonexistent.
- A minimal guaranteed core funding is necessary for these organizations to operate efficiently in the long term. The amount will vary with the specific public good and the level of privatization. In most cases, core funding should start with at least 30–50% of the budget, and higher when the organizations have to operate in depleted or developing areas or are involved in research. As demand takes shape, the proportion of core funding from the sponsoring government institutions can be reduced gradually.
- Operations of a significant size generally should be financed jointly by the central government and the local or provincial authorities, with the funding of the former conditional on the capability of the latter to respond with a similar amount. Sometimes, alternatively or in addition, private business resources should join the programs to fund infrastructure elements, such as buildings, equipment, and personnel.

Restoring the engineering and productivity centres to their initial research and technical assistance functions is essential for effective technology dissemination

focus on technologies for the public good. Adequate funding is essential, supplemented by fees for services and for licenses, or royalty payments, for the patented technologies they transfer.

Two main networks of centers have been set up in the last decade. Since 1991 the Ministry of Science and Technology Policy has established 84 engineering technology research centers. Operating in many fields, they have been based in advanced R&D institutes, technology enterprises, and universities—with highly qualified personnel, well-equipped R&D facilities, and strong ties to enterprise. But, underfunded, their results are modest (appendix 7.1).[4] Since 1998 the State Economic and Trade Commission, with World Bank support, has established 79 National Engineering Research Centers (NERCs). The NERCs have benefited from robust initial funding. Covering a large and diversified range of technologies, it is still too early to judge their impact. It appears, however, that several of them, forced to support themselves by selling their services, have gradually ceased fulfilling their mandate of carrying out technical research and providing information and assistance. They are performing production activities rather than technology demonstration or pilot testing as intended.[5]

Productivity centers have also been established to provide comprehensive services — such as technology information, consulting, diagnosis, training, innovation, and marketing support — to small and medium-sized enterprises and TVEs. Launched in 1993 the program had 500 centers, employing more than 80,000 people by the end of 1997. Because productivity centers need to self-finance most of their operations, they too have also entered business and production activities to pay their personnel. Similar centers in the industrial countries receive at least minimal support from their sponsoring organizations, preventing them from being diverted from their chartered tasks.

Restoring the engineering and productivity centers to their initial research and technical assistance functions is essential for effective technology dissemination. Sufficient core funding and adequately remunerated personnel are but two of the prerequisites necessary to facilitate their dedication to these core functions. If the centers prefer to continue their business and production activities, they should clearly have some sort of enterprise status. When the reforms are complete, the engineering and productivity centers should be expanded, possibly doubling their number in the next 10 years, mostly in the central and western regions.

Agricultural productivity must be boosted to cope with the foreign competition that will result from accession to the WTO

Agriculture extension services and related activities

The problems in agriculture are complex. Agricultural productivity must be boosted to cope with the foreign competition that will result from accession to the WTO, yet this will lead to more unemployment. Creating other employment opportunities by diversifying production is vital. Fruit and vegetable production, animal husbandry, and other agriculture activities have potential for significant expansion.

A three pronged approach is recommended:

- *Rebuilding extension services.* China's extension services have been greatly under funded.[6] Wages and benefits have declined relative to other agriculture personnel, and extension staff have been encouraged to trade in fertilizers, pesticides, and seeds, creating unavoidable conflicts of interest. But the infrastructure of the command era has not been destroyed: 190,000 extension units still exist, with 1.2 million staff, including 500,000 part time technical personnel. If these units were properly equipped with modern information technology, telecommunications systems and well-educated, adequately paid personnel, they could act as intermediaries between farming communities and the diverse sources of expertise, materials, and finance that communities need. The restructuring of extension programs should be based on the impact on production, which will require extensive analysis and evaluation.[7]

- *Establishing a dynamic market of service and materials providers.* Companies should be allowed to deal directly with farmers. For instance, state-owned or private dairies and forage companies could set up joint raw material bases together with groups of farmers using new technologies. Non-governmental organizations, particularly the more than 75,000 spontaneously organized farmers' cooperatives represented by agricultural associations, should have more freedom and responsibility. And private diffusion agents, such as fertilizer, seed, and equipment suppliers, should be encouraged to reduce inefficient activities now performed by extension staff.
- *Establishing media-based training.* A training program that provides awareness and basic education should be designed for the farmer's communities nationwide. Web-based or TV-based education and training programs, such as those produced by the Central Broadcasting and Television University and Central Education TV, should be broadly promoted.

In addition, it is essential to link the farmers, extension services, and private providers of services, materials, and seeds to R&D programs, including those aimed at the development of such new technologies as biotechnology-based cultures. Considering the needs and know-how of users is crucial for ensuring the success of R&D (chapter 8).

Making the climate more conducive to innovation in Chinese enterprises depends primarily on measures to improve the conditions of firm management and the business climate

Support to rural industries

In 1986 the Ministry of Science and Technology launched the Spark program to help develop TVEs, a program which has contributed to create as many as 20 million jobs in 1986–95 at a remarkably low cost (see appendix 7.1). Central to the program were assistance packages in technology, management, and marketing, generally delivered through repeat projects with selected enterprises and a large group of experts.

The current program no longer seems applicable to the needs of the TVEs, which have gradually upgraded their technology and now face more intense competition. TVEs are moving from collective to private ownership. And credits have been significantly reduced, partly the result of tighter overall credit, and partly the result of reluctance of the banks to support enterprises without more guarantees.[8] An overhauled and expanded Spark program should provide a package of technological, business, and marketing services—mobilizing universities, consulting firms, and other powerful resources. These services could be disseminated through local hubs, possibly with the TVE bureaus as the nucleus, supported by provincial and local governments. In addition, a well-designed financial support program should provide seed money and credit guarantees—based on the technology, market potential, and managerial aspects of TVEs.

Stimulating innovation in enterprises

Innovation in large enterprises

Innovation centers and programs to stimulate industry-university collaboration have had spectacular results (see appendix 7.1, section 10). But making the climate more conducive to innovation in Chinese enterprises depends primarily on measures to improve the conditions of firm management and the business climate.

A consistently stated goal of China's industrial policy has been to construct powerful companies—business groups with wide networks of second and third tier firms—that can compete on the global playing field, and it has used similar measures to Japan and Korea to attempt to create comparative advantage—but within the context of the planned economy. Despite significant progress, none of China's leading enterprises has become a globally competitive giant corporation. At the end of the nineties, China had just five companies in the Fortune 500, without even one company in the world's top 300 R&D companies (ranked by R&D expenditure). Whatever industrial sectors are considered, large Chinese companies do not seem to be in a position to compete successfully in world markets. Evolving in an overall business climate with little incentive for true innovation, they have not kept up with the dramatic growth of business capabilities of leading global firms.[9] Alliances with those global firms is probably the most effective and efficient way to proceed, providing that the overall reforms to improve (state-owned) firm management are implemented (chapter 4).

The stimulation of innovation in enterprises should also benefit from broader knowledge management policies

It should also be noted that if the creation of large conglomerates served a notable purpose in both Korea and Japan, it also generated structural problems that affected management, domestic demand, and overall innovation. If the Chinese government pursues such a policy in an attempt to create a competitive advantage, it must be careful to employ it selectively, permitting innovation and growth to occur in an organic, demand-driven fashion.

The stimulation of innovation in enterprises should also benefit from broader knowledge management policies. Firm strategies should go far beyond R&D issues to deal with changes in corporate cultures, with information and knowledge sharing in enterprises, and with capturing and disseminating local knowledge in global operations (box 7.5). Firms in Hong Kong (SAR), Taiwan, China, and Singapore should be examples to business leaders in mainland China in the fast-developing area of knowledge management.

The military has been encouraged to disseminate technology by entering into production for civilian markets. This effort led to significant civilian production activity as well as some conversion efforts (box 7.6). However, as part of the move toward a more market-based economy, the production activities

BOX 7.5
Knowledge management for enterprises

Firms have captured knowledge for years, but there has not always been an emphasis on accessibility, dissemination, and use of knowledge within the enterprise. A recent study by McKinsey and Company reached the following conclusions about successful knowledge management:

- Strategies are independent of industry or firm size.
- Firms that use a top-down approach are generally unsuccessful.
- Effective organizations create demand for knowledge through financial and other rewards for employees to create, tap, and use internal and external knowledge resources.
- Knowledge management is most effective when it is a part of the corporate culture, and every function of the company maximizes efficiency of knowledge creation, distribution, and application.
- Storage of knowledge is common across all firms, but distribution and application of that knowledge are not. Successful companies create cross-functional and vertically integrated project teams, synchronize firm strategies and goals across functions, use internal and external benchmarking, pull in experts from outside, and create user-friendly, regularly updated databases that allow all actors in all functions and regions to tap a firm's knowledge.

Source: Susanne Hauschild, Thomas Licht, and Wolfram Stein, "Creating a Knowledge Culture," *The McKinsey Quarterly 2000,* Number 1, pp. 74–81.

New methods of disseminating military technology to civilian use such as research, licensing, privatization, and spinoff will need to be strengthened

BOX 7.6
From military to civilian technologies

The military industry, with nearly 500 enterprises and over 200 research institutes, has more than half of its two million employees in civilian production, 80% of the productive value of the sector, 10% in 1978. The military industry dominates the development of such technologically advanced products as missiles, satellites, telecommunications equipment, aviation equipment, and nuclear power stations, but also several heavy industries, such as shipbuilding, of which a large part is exported.

To a large extent, military enterprises face the same problems as traditional SOEs, though some significant differences make their life easier. They operate with more resources, using more sophisticated technologies. In addition, the military industry probably has stronger negotiating capabilities within power structures. But it seems to have suffered an important brain drain of talented personnel, despite nonmonetary advantages.

Bureaucratic problems hampered innovation, with various jurisdictions intervening in decisionmaking. R&D activities are compartmentalized and operating in a culture not familiar with consumer-oriented mass production. And contacts with university and civilian government R&D institutes are severely controlled, although fairly significant (notably with elite establishments).

To facilitate technology transfers to the civilian sector, more than 1,000 show-window enterprises have been set up in the coastal regions (about 600 in Shenzen). In the central and western regions where many military enterprises are concentrated, conversion operations to spur local development have brought some results and will be extended.

Source: Jianxiang Wang, *A Research Report on Enterprises Technology Innovation of China,* background paper for this study, Beijing, 2000.

of the military are being cut back. New methods of disseminating military technology to civilian use such as research, licensing, privatization, and spin-off will need to be strengthened, as in other countries.

Innovation in small enterprises

For the small and medium-size firms the government provides financial support through the Innovation Fund. Established in 1999 with approximately 1 billion RMB, the Fund is devoted to the support of innovation in small and medium enterprises. More than 1100 projects (out of more than 3,000 applications) have benefited from the Fund's support after a year of activity. The management of the fund has mobilized a set of intermediary organizations to detect and evaluate potential projects. It has also stimulated the establishment of numerous provincial funds that operate on a matching basis with the central funding.[10] This "regionalization" facilitates contact with the local needs and demands, following trends observed in industrialized countries. It is important to:

The entrepreneurial spirit of the Chinese people is an exceptional asset that can lead to the creation of a myriad of new firms

- Diversify the range of incentives and support provided to innovative enterprises, and notably to include grants that help employment of researchers by paying some or all of their salaries, and grants to encourage the contracting out of R&D work that pay for some of the related costs.
- Provide a package of support, including assistance to marketing, firm management, business plan development, and contact with sources of technical information and expertise. More than financial support, a large number of smaller innovators need this kind of intangible support.
- Address the diversity of firms engaged in innovation. These can be broken into four categories: the technology developers which in advanced economies do not represent not more than 3% of the SME population; the leading technology followers (10–15%); the potential innovators (about 40%); and the noninnovative SMES (40–45%).[11] While the first two categories of enterprises have sufficient R&D capacity to apply for R&D grants or subsidies under the traditional technology policy structures, the other categories should be primarily approached through awareness, information and technical assistance initiatives, as part of broader support programs for management and marketing.

Promoting innovation sites and clusters

The entrepreneurial spirit of the Chinese people is an exceptional asset that can lead to the creation of a myriad of new firms, key vectors for technologically upgrading the economy. The importance of providing adequate support to enterprises in their early stage of development is well understood by the Chinese authorities. They established high tech parks in which firms, both domestic and

foreign, have benefited from a range of privileges—both financial and administrative—making the "parks" almost free of constraints for dealing with tax, patents, customs, and so on. In addition, these zones have been made not only attractive, but to a certain extent compulsory.

However, creation of these special regimes led to an opportunity for rent-seeking by firms, a practice detrimental to the entire economy. And most of the designated high tech areas have been located in the coastal regions, expanding the development gap between the eastern and central and western regions. The "constraint free" policy regime should be generalized throughout the whole economy. However, there is still a need to provide hands-on support to start-up firms in the form of incubators offering management and marketing services as well as common infrastructure and services.

Going beyond incubators, it is worthwhile to promote the development of enterprise clusters

Incubators

The initiatives for incubators should come from local authorities, local business or professional associations, or even academic communities. They should be well-designed, properly staffed, and sufficiently funded. Many emerging initiatives, already throughout China, could be designated as registered innovation sites and receive adequate government support, with the best current practices in China as models for future efforts, including the Suhzou initiative, which combines a series of complementary support schemes for intending new technology based entrepreneurs (box 7.7).

Key locations for such incubators are universities and academic institutions, important sources of spin-off firms (chapter 8). The government has once again taken the decision to support a selected sample of 13 such places. It is important that other places throughout the large and diversified Chinese territory not be neglected. Moreover, measures should be taken to prevent possible conflict of interest and undue exploitation of public investments to the benefit of private individuals (for example, when they exploit university premises or equipment paid by the collective).

Clusters

Going beyond establishing incubators, it is worthwhile to promote the development of enterprise clusters—agglomerations of firms in related lines of business. These are essential in the economic landscape in advanced countries (box 7.8) and in less advanced ones.

Based on OECD economies,[12] several principles should inspire government policies towards clusters:

BOX 7.7

Suzhou Technology Park

Suzhou New and High-technology Innovation Service Center, Suzhou International Business Incubator, and *China Suzhou Pioneering Park for Overseas Chinese Scholars* (the three functions are basically carried out by the same staff; hereafter they will be referred as "park") is a nonprofit technological service institution. In 1994, the first incubation site was put into use. In 1996, the United Nations Development Programme and the Ministry of Science and Technology approved it as one of the first four international business incubators in China. In 1998, the Ministry of Science and Technology, the Ministry of Education, and others jointly set up China Suzhou Pioneering Park for Overseas Chinese Scholars.

So far, 300 enterprises are located in the park, out of which 90 were set up by overseas Chinese and 10 were set up by R&D institutes and universities. Forty-six enterprises are high technology enterprises, accounting for 20% of all enterprises in the park. About 450 projects have been conducted in the park, and 60 of them are national-level key projects. By now, the park has yielded an output of 6 billion yuan. By the middle of 2000, the park employed about 3,000 people, out of which around 400 are employed by overseas Chinese firms, 100 have Ph.D.s, and about 200 are overseas Chinese. The park has attracted many high-quality overseas Chinese with active information campaigns (visits abroad, web communications, etc), and use of central ministries programs.

Key factors for the success of the park is due to include the following:

- *Investment.* The Suzhou government set up a venture capital of 100 million yuan to provide seed money; meanwhile, the park attracted overseas venture capital to invest in the park. In addition, banks and financial organizations, such as the China Trust and Investment Company, the Chinese Commercial and Industrial Bank, and the Transportation Bank, also provided loans to small private firms with more dynamism and flexibility.
- *Infrastructure building.* The park built an incubation site of 38,000 square meters with Internet connections every 10 square meters, conference rooms, a multimedia room, a technical trading room, information centers, product testing centers, public labs, and so on. In addition, the park also provides resources such as an accounting office, law firm, business planning space, and other services for all the enterprises, reducing the burdens on start-ups.
- *Import-export service.* The park provides free import-export services, including customs declaration, bounded warehouse, and so on.
- *Human resources support.* The park has a labor market, which holds three big recruiting events each month and has a human resource database. In addition, some recruiting firms also help to identify qualified people.
- *Management consulting services.* University professors and successful entrepreneurs give management and business training, including seminars and case studies. To promote products, the park set up networks to help relevant enterprises introduce their products, organizes public media visit. hosts exhibitions. Most importantly, enterprises gain membership in the Shanghai Technology Stock Exchange, thus obtaining investment, projects, new products, and market-related information.

BOX 7.6

The importance of regional clustering in OECD economies

While clustering is not present in all industries, it is an important part of the economic landscape. For example, it has been estimated that there are about 380 clusters of firms in the United States operating across a broad spectrum of sub-sectors, which employ some 57% of the workforce of the United States and produce 61% of the country's output. Local industrial districts account for some 30% of employment in Italy and are responsible for about half of exports. Clustering is also found in Germany (Baden-Wurtenberg and Bavaria), in the United Kingdom (London and the M4 region), Australia (North Sydney), and several other places.

Such clustering takes place in function of a geographic competitive advantage, where a certain level of competencies has been reached, leading to virtuous concentration. But as globalization has accelerated, the emergence of clusters of firms in nonlocation-sensitive activities is subject to clustering. Demonstrating the trend are Nebraska in telemarketing, South Dakota in credit card processing, Dublin, Ireland in back office processing for financial services, Sydney in information processing, Bangalore in software services, and Manila in data entry.

Source: Michael J. Enright and Ifor Ffowcs-Williams, "Local Partnership, Clusters, and SME Globalisation," OECD, Paris, 2001.

- Let businesses lead in cluster-development initiatives, with the public sector playing a catalytic role.
- Facilitate access to accommodation for new and small firms.
- Establish suppliers' associations and other forms of collaborative undertaking.
- Allow specialization and local adaptation in university-industry linkages.
- Ensure effective technical support and information services.
- Ensure access to specialized infrastructure, communications, and transport.
- Try to attract investments through appropriate information campaigns, including overseas.
- Refrain from building new sector-specific clusters of firms. There should be market tests before public resources are committed to a cluster.

These principles should inspire Chinese policymakers, both at the local and central level. They might find difficulty in applying such principles, which go against traditional tendencies to push new technology undertakings from scratch, in a context where business activities and political networks are still strongly intermingled.

Notes

1. In the ranking by the *World Competitiveness Yearbook,* the manufacturing location attractiveness falls to 39 in 2001, from 36 in 2000. IMD, Lausanne, 2001.

2. Regional Distribution of China's Science and Technology and Economic Development, Wu Guisheng, presentation to the International Seminar on Technological Innovation, Beijing, September 5–7, 2000

3. Speech of Professor Xu Guanhua, Vice Minister, Ministry of Science and Technology, at the International Seminar on Technological Innovation, Beijing, September 5–7, 2000.

4. Centers are found in the following sectors: agriculture (13 centers), energy (4), information and communications (5), materials (19), textiles and resource development (4), manufacturing (9), construction and the environment (9), and pharmaceuticals (9).

5. See World Bank, "Supervision Mission Aide-Memoire," China Technology Development Project, Washington, D.C., 2000.

6. An index measuring expenditure on agriculture extension services as a percentage of agricultural GDP shows a decline of 25% over the decade 1986–95 and stood at 0.31% in 1995, far below the average of neighboring countries. Data collected in 1988 indicated an average for the Asia Pacific region of 0.56%. The United States ratio was 0.81% in 1993 (Albert Nyberg and Scott Rozelle, *Accelerating China's Rural Transformation,* Washington, D.C.: World Bank, 1999).

7. See Nyberg and Rozell, *Accelerating China's Rural Transformation,* op. cit.

8. In the past, TVEs relied on land as collateral for loans, but this no longer works well.

9. For a forceful and documented discussion of these issues and the lack of success of China's industrial policy, see Peter Hugh Nolan, China and the WTO: the Challenge for China's Large scale Industry, 21st Century Forum, Beijing, June 14–16, 2000, which contains a detailed analysis of strategies followed and problems encountered by leading Chinese firms in a series of sectors, including steel, automotive, electrical equipment, oil, chemicals, and pharmaceuticals. Major inhibiting factors to efficient innovation and growth strategies included: lack of autonomy in management, limited domestic demand for high-value added products, local protection, strong incentive to diversify into unrelated businesses as a source of growth, profits, and employment.

10. Many local governments have set up their own innovation fund, S&T achievement transformation fund or STF development fund. By the end of October 1999, the matching fund allocated by 36 provincial or municipal governments to support awarded Innofund Projects had reached 1.1 bil-

lion yuan. Actions have also been taken to attract investment from financial institutions. Four major commercial banks signed cooperation agreements with Innofund in 1999 to give preferred support for Innofund projects awarded with interest subsidies.

11. See OECD, *Enhancing SME Competitiveness,* Paris, 2001, p.83.
12. See OECD, *Enhancing SME Competitiveness,* op. cit.

APPENDIX TABLE 7.1
Summary of China's technology programs[a]

Program	Means and funding	Effect
1. **Agriculture extension services** (early 1970s)	In 1997 190,000 units in operation (19,000 county based and 170,000 village based); total staff of 1.35 million (885,000 technical personnel).	Low level of activity and inadequate functioning.
2. **Spark** (1986) Multifaceted support to rural industries (technology, management, and marketing)	1995 government budget: yuan 350 million, 80% financed by local and provincial governments, 6.1 billion of state and bank loans. Investment of yuan 130 billion in 1986–97 (in 1997, funded at 20% by bank loans, 80% by enterprise self-financing, and for 0.3% by governments).	20 million of jobs created or secured in 1986–95. More than 84,000 projects launched in 1986–97 and about half completed. 30 million persons involved in training. Program almost discontinued (very low level of activity).TVE sector in trouble.
3. **National industrial demonstration projects** (1984) Support to development of key R&D projects through experimental application of R&D results to industries	Investment in 1984–97: 3.35 billion yuan (1.01 billion yuan from central government and 0.66 from local government).	190 projects supported, 100 completed.
4. **Technology innovation centers** (1980s)	28 national new and high-technology innovation service centers (22 set up in high-tech zones) 52 national innovation service centers.	
5. **Torch** (1988) Multifaceted support to small and medium-size enterprises located in high-tech parks, including incubator program (entrepreneur service centers)	Loans of 10 billion yuan over ten years. 100 incubators established in 10 years (including the 28 high-tech innovation centers mentioned in item 4).	12,600 projects supported, 2,500 enterprises incubated, one third graduated, 57,500 new jobs, 3,500 new technology items on the market.
6. **National S&T extension projects** (1990) Support to industrial and agricultural R&D projects developed by enterprises	State S&T development loans; self-funding by enterprises.	Loans made to 7,500 enterprises during 8th five-year plan. 1,155 RD projects supported (703 industrial).
7. **Engineering technology research centers** (1991) Provide technical research, assistance and information to industry, based in universities and government institutes.	84 centers established for 1.5 billion yuan.	Turnover of 7 billion yuan; 800 technological items transferred to 1,400 firms. Involvement in productive activities.
8. **Industry-University-Research Partnership Program** (1992) Strengthening the linkages among industry, universities, and R&D institutes.	Government budget: yuan 55 million in 1994–95, and 527 million state loans.	410 state-level major high technology projects implemented; 360,000 organizations joined in 140,000 projects.
9. **Productivity centers** (1993) Provide technical, business, and commercial information and training to enterprises.	160 nationally recognized centers and 350 other ones in operation in 1997.	Statistics covering 70 centers in 1993–97: involvement of 134,000 enterprises, 119,000 technology and management experts, 17,000 technologies transferred to enterprises. Training provided to 9,400 enterprises and 56,000 employment created. Centers to undertake business activities and to target solvable clientele.
10. **Technology Innovation Program** (1996) Support to technical center building in large firms, cooperative R&D between industry and academia, development of innovation service support for small and medium-size enterprises.	Budget 745 million yuan a year. Estimated induced investment by enterprises of 14 billion yuan.	19 large companies (groups) selected as experimental in three cities: 294 centers approved. Cooperative program involved participation of 65,000 enterprises, 3,800 R&D institutes, 2,500 HE institutions.
11. **Engineering research centers** (1998)	79 centers established with total investment of 4.3 billion yuan (40% by World Bank loan).	Important number of centers involved in productive activities. Only half of loan used due to procurement procedures.
12. **Conversion of government R&D institutes into technology enterprises** (1999)		242 research institutes converted, 217 transformed into enterprises, and others converted into technical services institutes. 10 listed on stock market.

a. Some of the programs have an important R&D component and are discussed in chapter 8.

Source: Background papers *Technology Diffusion and Intermediaries and Enterprises* and *Technology Innovation; Theory and Policy For National Innovation System,* MOST, 1999.

8 Improving the research and development system

Overview of China's R&D system

China's research and development effort amounted to about 0.7% of GDP, much less than in advanced countries

China's research and development effort amounted to about 0.7% of GDP in 1998, a much smaller percentage than in advanced countries (table 8.1) and very small compared to total world effort (table 8.2, figure 8.1).[1] At the same time China's effort is significant in terms of resources invested (about $7 billion) and people mobilized (about 800,000 scientists and engineers).[2]

The military absorbs an unknown but far from negligible share of the country's investment—official statistics are silent on this point. Successes in developing missiles, satellites, submarines, and space technologies show the ability of the Chinese to keep up with world leaders in advanced fields, although

TABLE 8.1
Chinese research and development spending

Country	1994		1996		1998	
	R&D spending percent of GDP	Total R&D spending, US$ millions	R&D spending percent of GDP	Total R&D spending, US$ millions	R&D spending percent of GDP	Total R&D spending, US$ millions
China	0.66	3628	0.60	4,905	0.69	6,655
United States	2.52	175,180	2.67	204,241	2.79	227,934
Japan	2.84	133,320	2.83	130,186	2.92 *	122,275
Korea	2.58	10,446	2.79	14,622	2.52	—
Russia	0.84	2,761	0.88	3,620	0.94 *	—

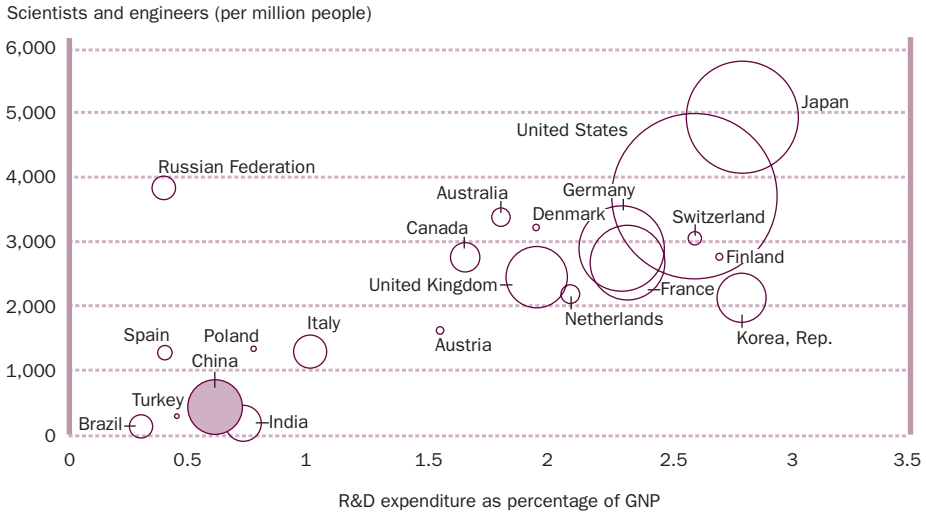
— Not available
Source: National Bureau of Statistics, and Ministry of Science and Technology, *China Science and Technology Indicators,* Beijing: Science and Technology Literature Publishing, 1999, table 8-1; exchange rates are from http://www.oanda.com.

TABLE 8.2
China's spending on research and development compared with the world, 1996

	China	World	China as percent of world
Total research and development expenditure (billions of 1995 dollars)	4.5	651	0.69
Total research and development expenditure (billions of PPP dollars)	20	796	2.5
Total research and development expenditure (percent of GNP)	0.6	2.2	

Note: PPP: purchasing power parity
Source: World Bank staff analysis.

FIGURE 8.1
China's research and development effort in the world perspective



Note: Circles reflect relative size of GDP.
Source: World Bank Institute and World Bank staff analysis.

It is hard to find science and technology fields in which China is a world leader

not much is known about the quality of the output (this is an area that this report does not address). More doubtful is the performance of research for civilian purposes.

Scientific accomplishments remain modest relative to those of other countries

The number of Chinese scientific articles appearing in mainstream journals has increased gradually over the years, but it remains low at 1.4% of total contributions. Scientific strengths in traditional disciplines—physics, mathematics, chemicals—are not matched in newer fields such as life sciences.[3] More generally, it is hard to find science and technology fields in which China is a world leader. Even in fields where Chinese research is first class (as in rare earths and environmental systems), China loses its advantage at the application level.

The number of patents granted internationally to Chinese residents remains remarkably low. The U.S. Patent and Trademark Office granted only 90 patents to Chinese residents in 1999 (compared with 3,693 in Taiwan, China and 3,562 to the Republic of Korea), a statistic that has shown few signs of significant increase.[4] Only 10% of China's total exports of high-technology products have autonomous Chinese property rights. Part of the explanation may be the Chinese tendency to neglect intellectual property protection, but more fundamental weaknesses lie behind this poor achievement.

Problems stem from history and some policy choices

The problems of the Chinese research and development system derive from the history of the system and some of the policy choices of the Chinese government over the last two decades:

- The government attempted to restructure the research and development system by cutting direct appropriations to government institutes, which did most of the country's research and development (following the Soviet model), forcing the institutes to earn their resources from the "market."
- And it developed a series of applied research and development programs to spur national research and technological capability in a broad range of disciplines and fields. Those programs were defined by state agencies and largely executed in government institutes.

This policy has had positive effects. It made much more economically relevant the research activities of the government institutes and stimulated strong interactions between the different actors of the innovation system. But it has had several drawbacks as well.

- Government programs developed with a top-down, supply-driven approach have not appreciably boosted Chinese scientific and technological capabilities, in part because enterprises were not involved in defining and implementing the programs.
- China's ability to pursue long-term, basic research, and research of a public good nature remains undeveloped. The policy that forced institutes to "rush to market" impaired their long-term research capabilities. In 1997 investments in basic research accounted for less than 6% of all research and development in China, compared with 15–20% in large industrial countries.[5] Aware of the problem, the government recently increased its support through new programs, but there is still some way to go. In a similar vein, government support for research and development structures and for research of collective interest—research in environment, health, and agriculture, and generic technological research—is insufficient.
- The research and development capabilities of the universities, which perform only 10% of research and development, are unevenly exploited because policy toward this sector is unclear.
- The enterprise sector has not developed strong capabilities in research and development. Enterprise research efforts, mostly performed in the state-owned subsector, remain quite weak, representing about 40% of the country's research and development effort in the late 1990s.
- Resource allocations are far from optimal. China lacks the ability to reposition its research structures and capabilities in response to worldwide trends.

These five issues will be addressed in turn, after a brief discussion of reforms and policies over the last decades.

China's ability to pursue long-term, basic research, and research of a public good nature remains undeveloped

Changes in China's research and development system

China's innovation system after 1949 was very much influenced by the Soviet model. Mission-oriented, it was strongly centralized and operated from the top down. Labor was divided among three distinct types of research and development institutions:

- Public research institutes (PRIs) conducted most of China's basic and applied research.
- Universities were responsible for science and technology training, with limited involvement in research and development.
- Enterprise research and development units were responsible for development, prototyping, and other downstream activities.

The share of research and development performed by enterprises rose in recent years

In 1987, when China began to reform its innovation system, PRIs received about 61% of China's research and development funding; enterprises, about 35 percent; and universities only about 4 percent.

The major deficiency of this system was the separation of research and development from production. True to the Soviet model, most PRIs, including the research institutes of the Chinese Academy of Sciences, operated in isolation from production activities. Funded by an annual budget from the central or local governments, PRIs conducted research projects guided by five-year national plans or other central or local plans. Rarely were industrial managers consulted about such plans. Scientific and technological knowledge was perceived as a free public good, leaving little incentive for researchers in PRIs and universities to transfer their research results to commercial applications. As a result, transfers from PRIs and universities to industry were left mostly to serendipity.

To respond to these problems and force research and development organizations to "jump into the sea," the government initiated major changes in funding and managing research organizations, and in technology markets. After more than a decade, the country's innovation system has indeed changed. For example, government appropriations as a share of PRI income decreased by an average of 5% each year from 1986 to 1993. By 1993, only 28% of the income of PRIs came from direct government appropriations, compared to 64% in 1986. PRIs were able to generate close to 60% of their income from nongovernmental sources—half from technical services rendered to industrial enterprises. Similar changes took place in universities.

The share of research and development performed by enterprises rose in recent years, whereas the share of government institutes, including those associated with both the Academy of Sciences and the branch ministries, fell (table 8.3). Total person-years devoted to research and development personnel have been significantly reduced before increasing again in recent years (table 8.4).

TABLE 8.3
Research and development spending by performing organizations
(Percent)

Type of organization	1994	1996	1998	1999
Government research and development institutes	43.2	41.1	42.6	38.5
Universities and colleges	14.5	13.0	10.4	9.3
Enterprises	32.4	36.8	44.8	49.5
Others	9.9	9.1	2.2	2.6

Note: Columns may not add up to 100% because of rounding.
Source: Lanxiang Zhao and Fang Xin, "The Chinese Research and Development System," World Bank, Washington, D.C., 2000.

TABLE 8.4
Personnel involved in R&D
(Thousands of people)

Categories	1994	1996	1998	1999
Government research and development institutes	258	232	228	234
Universities and colleges	172	148	169	176
Enterprises	—	347	310	350
Others	—	—	408	61
Total	783	804	755	822

— Not available.
Source: Lanxiang Zhao and Fang Xin, "The Chinese Research and Development System," World Bank, Washington, D.C., 2000.

The government has significantly increased allocations to basic and technological research programs

The late 1980s saw the deployment of programs such as the 863 Program to stimulate applied and strategic research, and the creation of the National Natural Science Foundation, modeled on western organizations such as the U.S. National Science Foundation, to support the science base. In more recent years the government has been reorganizing the institutes of the academies of sciences and turning 242 branch institutes into technology enterprises (box 8.1).

The government has also significantly increased allocations to basic and technological research programs, as explained below, with the intention of boosting the national research and development effort to 1.5% of GDP by 2005. Local governments have been increasingly involved in funding research and development. Their share now amounts to about 30%—still much lower than their share of national budget expenditures (70%).

Restructuring government research and development programs

Several national programs to boost applied and technical research have been funded over the last two decades (table 8.5).

- Program 863 is China's national high-technology research and development effort. Administered by the Ministry of Science and Technology (MOST) and by the Commission on Science, Technology, and Industry for National Defense, it has both civilian and military components. MOST takes responsibility for programs in biotechnology, information technology, automation, energy,

Research institutes formerly under government ministries have been subjected to radical reforms

BOX 8.1

Transformation of government institutes

Freestanding government research institutes, affiliated with government ministries or the Chinese Academy of Sciences, were signature features of China's Soviet-inspired system of research and development. Because most of China's science and technology spending went to such organizations, they have been important—and often reluctant—targets of reform, sharing similar problems with the higher education institutions. During the last five years, efforts to change the institutes have been renewed.

Within the Chinese Academy of Sciences, a major new knowledge innovation program is leading to a significant reorganization of the academy and a redefinition of the roles of its 120 institutes. According to the academy's Policy Management Department, the program—which amounts to 75% of the academy's budget (5.2 billion yuan over three years)—aims to refocus the work of the institutes on priority areas and to dramatically upgrading its personnel. Plans are to allocate one-third of the posts funded through the program to selected scientists within the academy; one-third to scientists from other institutions; and one-third to personnel transferred to nonresearch fields, such as teaching in universities or setting up enterprises in municipalities. In the last two years, more than 10,000 people have left the academy. The average age of academy personnel is now 38.

Research institutes formerly under government ministries have been subjected to even more radical reforms in recent years as a result of reforms in science and technology policy and the reorganization of central government ministries. Reform policies have led to three patterns of change. First, some institutes remain as important national research centers despite being reorganized. Second, some institutes have been merged with existing enterprises. Third, 242 institutes have been transformed into enterprises, with many seeking to relocate to one of China's 53 nationally recognized high technology zones. Ten of the new enterprises are already listed on the stock market.

Source: World Bank staff analysis of information communicated by the Chinese Academy of Sciences and Ministry of Science and Technology.

TABLE 8.5

Government funding of research and development programs, 1997

(Hundreds of millions of yuan and percent)

Project	Central government	Percent	Local government	Percent
Total	29.62	100	10.55	100
National Natural Science Foundation	2.49	8.4	0.68	6.4
Program 863	2.3	7.8	—	—
Program of Key Technology Projects	6.16	20.8	2.77	26.2
Torch	0.59	2.1	0.28	2.7
Spark	0.09	0.3	0.12	1.1
Climbing	0.28	0.9	—	—
Social development	0.02	—	0.06	0.6
Other[a]	17.69	59.7	6.64	63.0

— Not available.

Note: This table is the only consolidated, publicly available information on Chinese government program allocations. The table concerns only the funding reaching the government institutes (which receive a very large part of the support provided by the national and local governments.)

a. No information is available about the destination of expenditures in this category.

Source: Ministry of Science and Technology, *China Science and Technology Indicators,* Vol. 4, Beijing: Science and Technology Literature Publishing, 1998, p. 42.

advance materials, and marine science and technology. The military commission oversees research relating to lasers and space technology.

- The Program of Key Technology Projects is linked to the objectives of the five-year plans for economic and social development.
- The Torch plan is intended to facilitate the commercialization of research results and is closely related to the development of China's 53 high-technology zones.
- The Spark program (discussed in chapter 7) focuses on rural development and rural industry.
- The Climbing program is a program to support large projects in basic research.

The Program of Key Technology Projects and Program 863 have received substantial resources. Views of their effectiveness differ. Evaluations by a specialized center of the Chinese Ministry of Science and Technology (notably of Program 863, box 8.2) do not make it clear whether the programs have helped China to catch up with advanced countries, or even to prevent a widening of the gap. They have produced few patents.[6] A major drawback of the programs is their supply-driven design.

A major drawback of government programs is their supply-driven design

More than 90% of the funding for Program 863 program and the Program of Key Technology Projects comes from the state, and almost all of the proj-

BOX 8.2
An evaluation of Program 863

Over the last 15 years, the central government has allocated 5 billion yuan to Program 863—so named because it was established in March 1986. Approximately 5,000 projects have been supported.

The central government typically finances about 40% of the total project cost, with the balance being provided, largely in kind, by the government and university institutes that benefited from the projects.

Projects have been selected by committees made of scientists from government institutes and universities. Enterprises have not been involved in project selection or implementation. About one-third of the funded projects were performed by institutes of the Chinese Academy of Sciences, one-third by other government institutes, and one-third by university laboratories. In 1999, 8% of the total expenditures went to basic research, 64% to applied research, and 26% to product development. Main beneficiary fields include biology (25%), information technology (27%), and automation (14%).

Not surprisingly, most scientists involved in the program—surveyed recently by the National Center for Science and Technology Evaluation—believe that it has had a positive influence on Chinese science. Respondents were less certain about how much the program had reduced the gap with the advanced countries. The survey also revealed a lack of transparency in project selection procedures (affected by personal bias and vested interests) and in the use of funds.

Source: National Center for Science and Technology Evaluation.

ects are executed by government institutes, with the enterprise sector having little say in defining projects and allocating funds. Selection committees have consisted largely of scientists in research institutes, and selection procedures have not been transparent. Even with recent attempts to remedy this situation, problems remain. It is essential that efficient and sound mechanisms be built into all government programs—at the central and provincial levels—to ensure involvement of the enterprise sector in project selection and funding. Following established international practices, enterprises should get support on the condition that they match state funding one to one or at least one to two.[7]

Decreases in support for Chinese universities and research and development institutes have weakened the long-term research capability of the entire system

The time is ripe for change, because both programs have recently increased in scale. Program 863 will receive 22 billion yuan over the next five years, with 7 billion for defense projects. The Program of Key Technology Projects will receive 7 billion yuan for the same period.

The fields given the highest priority in national programs during the 1990s were power, electronics, telecommunications, and electrical engineering. Other fields important to China's people—agriculture, biology, and the environment—were largely neglected.[8] The Program of Key Technology Projects is expanding into research and development benefiting agriculture and other traditional industries such as textiles and furniture. If projects are properly selected and implemented, the expansion should be beneficial.

The government should link research and development projects to efficient, justifiable procurement. Well-designed and well-implemented procurement policies—such as those of NASA and the Defense Department in the United States and of European governments in transportation and energy technologies—can nudge enterprises toward research and development and innovation.[9] During China's rapid modernization, when large infrastructure components such as health, housing, and transport are being renovated or built from scratch, efficient government procurement policies at all levels—central, provincial, and municipal—are essential. Public servants in large numbers will need to be trained to establish standards and requirements to ensure competitive, productive, and effective procurement.

Increasing support to basic and public-good research

Two types of research should receive particular attention and support from the government: basic research and technological research in the public interest. Examples of the second type include research in health and the environment and collective industrial research. Enterprises rarely fund either type of research, because profitability is rarely assured. In all advanced countries the state provides crucial support to both types of research.

Decreases in support for Chinese universities and research and development institutes have weakened the long-term research capability of the entire system.[10] The institutional (or core) funding provided on a permanent basis to government laboratories for basic and applied research is about 30% of the overall budgets of the laboratories, an amount significantly lower than in advanced economies.[11] The growing gap between the costs of research and the amount the state pays to support it has led research institutions to avoid long-term research projects, and to seek funding from the market, which ultimately leads them undertake projects that would probably be carried out by the enterprise sector.

The recent increase in research funding under Program 863 and the development of Program 973 (see below) do not respond fully to the problem—inadequate core funding. A better approach would be to establish solid criteria for allocating more direct, fixed appropriations to qualifying universities and public research structures, enabling them to pursue the high-quality public-good research that the country needs.

Needed are solid criteria for allocating more direct, fixed appropriations to qualifying universities and public research structures

Basic research

In some areas, China's scientific achievements are world-class, whereas in many others the country's research base is quite shallow. Overall, basic research appears to be a good investment as measured in patents and publications, if properly funded (see note 6).

Until recently the main source of such funding for basic research was the National Natural Science Foundation (box 8.3). Modeled on similar western institutions, it is heralded internationally for its efficiency and success. It is well

BOX 8.3
The National Natural Science Foundation

Set up in 1986, the National Natural Science Foundation (NNSF) is the Chinese arm for supporting basic research on a project basis. Its 1999 grant budget was some 1 billion yuan. Grant selection procedures are based on peer review involving some 20,000 experts, mostly Chinese scientists. The standard program provides grants of 180,000 yuan for three-year projects. In 1999, about 3,500 grantees were selected from among 20,000 research proposals.

Other NNSF programs provide support to "key projects" (1 million yuan per project) and "major projects" (5 million yuan). A young scientist program support 600 persons each year. Sixty-five percent of NNSF's support goes to universities, with the remainder going to government research and development institutes (including the institutes of the Academy of Sciences institutes). Beneficiary fields include life sciences (32% of total funding) and physics (12%).

Source: World Bank analysis of NNSF data.

equipped to assume additional responsibility for basic research and the related tasks of setting funding priorities and evaluation procedures.

Concerned with China's inadequate investment in basic research, the government launched a new program in March 1997. Entitled Program 973, its purpose is to support cutting-edge science projects in selected fields, among them biology, mathematics, astronomy, and chemistry. The program, well funded at 2.5 billion yuan, may boost Chinese research performance significantly, although it may add to the concentration of the scientific capabilities as it alters the balance between support for free research, as opposed to directed research.[12] For this reason, very solid and transparent selection procedures are needed. The involvement of foreign experts, or at least of overseas Chinese, in the selection of research projects would be useful. The fate of Program 973 may determine the future of a significant portion of the Chinese science base.

Government support for research and development should be allocated to selected centers involved in high-quality technical research

Public-good research

Part of public-good research is technological—multisectoral or sector-specific but useful for all enterprises. All industrial countries conduct such research in government laboratories or public institutes that collaborate closely with industry.[13] It is important that in the process of reforming China's government research and development institutes the capability for generic technological research not be lost or significantly altered. The reforms may have created serious problems that affect the ability of Chinese industries to evolve competitively.[14] The same may be true of research in agriculture—a vital sector (box 8.4). Government support for research and development should be allocated to selected centers involved in high-quality technical research. Because the

BOX 8.4
The decline of China's agricultural research

The intensity of agricultural research, defined as investments in agricultural research as a proportion of agricultural GDP, declined from 0.49 in the late 1970s to 0.38 in the mid-1990s. An international rule of the thumb is to spend about 1% of agricultural GDP for agricultural research (FAO 1990). Although national agricultural research budgets increased during the reform period, the number of research scientists increased even more rapidly. However, research funds per scientist declined by 25–30% in real terms (inflation deflated) during the 1990s. Real spending for research projects declined at an annual rate of 4% during the decade. These trends should be a source of concern for the Chinese authorities. Research on the determinants of agricultural supply, as summarized in the World Bank's Food Security Report (1997), demonstrated that increases in China's cereal production after 1985 were ascribable largely to agricultural research and technology.

Source: Albert Nyberg and Scott Rozelle, *Accelerating China's Rural Transformation,* Washington, D.C.: World Bank, 1999.

nature of the research, as well as the clientele, will vary considerably from one center to another, establishing standards for the level of support may be difficult, but should be between 40 and 60% of the recipient's total budget, depending on its mix of basic and applied research.

The second type of public-good research relates to public purposes and amenities—environmental protection, health care, utilities. The Chinese government needs to make a serious effort to raise the country's research capabilities in these areas by exploiting unique Chinese resources, such as traditional medicine, and solving China-specific problems such as environmental issues and the sustainability of growth. Such research should proceed by establishing standards and regulations (for industrial and automotive pollution, water usage and treatment, and building codes, among others)—and ensuring their enforcement. Such a program would require research and development to explore longer-term issues of developing more sustainable, environmentally friendly technologies. In all cases, a significant part of the research funding should be provided to established centers, entrusted to pursue long-term public research and evaluated periodically (as opposed to being awarded contracts on the basis of project-specific competitions), so as to promote institutes of increasing quality.

Centers of excellence should be established, following a practice broadly developed in advanced economies

Strengthening the contribution of higher education institutions

China's universities are an important source of progress and new blood for the economy. This is particularly true of the elite institutions, which are at the apex of the knowledge economy (box 8.5). The allocation of government support to university research structures and the regulation of relationships of universities with the market place both merit comment.

Allocation of government support to university research

The universities have significant capability for basic research, as shown by the resources awarded to them by the NNSF's peer-review-based allocation system (see box 8.3). However, their share in the research and development effort remains fairly small. Support should be focused on the best research teams to stimulate concentration of human resources and facilities. Given the large number of higher education establishments (more than 1,100), there has been a proposal to adopt a model used in several countries, notably Anglo-Saxon, that distinguishes between research universities and teaching universities. That approach has some merit. The proposal to develop 100 Chinese research universities appears reasonable and should be encouraged.

At the same time, centers of excellence should be established, following a practice broadly developed in advanced economies. Because advancements

Advancements in communications technologies make possible decentralized research networks

BOX 8.5

Elite Chinese universities are key actors in the knowledge economy

The top Chinese universities are becoming major actors in China's transformation into a knowledge-based economy. Not only are they training the future thinkers and leaders of China, they are also directly involved in generating and applying knowledge.

Beijing University celebrated its centennial last year by organizing a meeting of the presidents of 157 prestigious "sister universities" around the world.

The university is the site of 10 of China's 150 key state laboratories. Some, such as the one focusing on rare-earth materials, are world leaders in their disciplines. The university has reorganized research institutes to facilitate cross-fertilization. For example, it regrouped biotechnology, cellular, and molecular laboratories in a life sciences college and created a nanotechnology center that integrates biology, physics, and microelectronics labs.

Beijing University benefits from major collaborations with large multinational corporations. It received a $10 million grant from IBM for equipment (the largest ever in China) and, with Monsanto, developed one of the world's largest test fields for genetically modified organisms. It has spun off about 60 high-technology companies, one of them a major company on the Chinese stock exchange. A significant share of its revenues comes from profits from the spin-offs, in which it has capital shares, and from royalties and income from companies that license its technologies or contract for research.

Located close to Beijing University, *Tsinghua University* distinguishes itself through multifaceted entrepreneurial activity. More than 60 companies have spun off from the institution in recent years; three listed on stock exchanges had a total value of 26 billion yuan in July 2000. Last year the spin-offs contributed about 600 million yuan in revenues to the university. Tsinghua has been developing a science park in the Zhongguancun high-technology zone (China's largest), which surrounds Beijing and Tsinghua. The science park includes an incubator that in a year has hosted more than 20 companies, half of which are expected to be listed on the stock exchange in the next two years or so. The university has a specialized patent office that receives an average of 150 deposits and 600 licenses a year. It hosts 15 key state laboratories and is investing enormous sums in new ones, including a postgenomics institute built in two years with 20 million yuan and a core of overseas Chinese attracted back from world-class research teams in Oxford, Rochester (New York), and elsewhere.

Shanghai Jiao Tong University has doubled the number of its graduates in the past five years—from 2,265 in 1995 to 5,170 in 2000—and tripled its volume of research to almost 300 million yuan in 2000. A science park, part of a multi-institutional high-technology complex, has hosted more than 200 companies, 30% of which have been created by university researchers and graduate students. The university has cooperative agreements with 80 world-class foreign universities. Its research institutes have made major contributions to Chinese achievements in satellite, marine, nuclear, and other advanced technologies.

To spur on these elite universities, the central government created a special fund of 6 billion yuan for 1999–2001, allocating 3.6 billion yuan to Beijing and Tsinghua universities to improve their facilities, raise professors' salaries, and invest more in research.

Source: World Bank staff analysis of information provided by the universities.

in communications technologies make possible decentralized research networks, it is less important to concentrate resources in a limited number of geographic sites. Cutting-edge practice in industrial countries is to fund "networks of excellence" that link high-level research teams at multiple sites that have similar or complementary competencies. Those centers are linked in turn to foreign counterparts through the Internet and other means of telecommunication.

China should proceed without delay to establish well-balanced and transparent committees to select the research universities and develop a network of excellence centers. So far, the main measure taken by the government has been to allocate 6 billion yuan to support elite institutions—3.6 billion of which is shared by Beijing and Tsinghua universities. Those allocations may be justified, but they should be made under more transparent conditions. Moreover, the potentially perverse effects of excessive concentration of government support should be considered, as overconcentration contributes to inequality: The more government funding an establishment receives, the better able it is to attract funding from private, foreign, and other sources.

Clear regulations are needed on how the results of research conducted as part of university duties and on university premises may be exploited

Regulating university and business partnerships

Stimulated by the government's financial pressures on research and development structures, and by strong incentives such as allowing researchers to keep at least 50% of the earnings from commercializing technologies, new companies have spun off from universities and government institutes. In addition, many researchers have set up enterprises affiliated with their organizations. There were about 7,000 such enterprises in 1997, generating sales of more than 35 billion yuan (3% of which was returned to the mother organizations).[15]

Also remarkable is the entrepreneurial spirit of the universities and elite institutions, which are investing massively in new fields of research, increasing student intake, promoting science parks, and expanding cooperation with foreign partners. These universities are able to generate considerable income through their links with the marketplace, through the profits of their affiliated enterprises, or through their contracts for technology development, services, and transfers.[16]

There are contrasting views on this distinctive feature of the Chinese innovation system. Some see it as essential for China's knowledge economy: It can supplement government funding and it is an important source of technology transfer and renewal at a time when industrial research and development capabilities are weak. Others argue that universities were not set up to make a profit, that they must first fulfill their role as generators of knowledge for the common good, and that they face increasing conflicts of interest.

These issues need to be resolved. The universities' research and training functions should not be put in jeopardy by an excessive business orientation. Clear regulations are needed on how the results of research conducted as part of university duties and on university premises may be exploited. But the dynamism of the universities and elite institutions, and the way they relate their activities to the marketplace, is a positive and unique asset of the Chinese economy that needs to be fully exploited.

Stimulating research and development in the enterprise sector

Many large and medium-sized state-owned enterprises (SOEs) are losing money and cannot repay their debts. Many simply do not have the financial resources needed to invest in research and development. Without fundamental changes in the external financial environment and internal management of these SOEs, there is little hope that they can be productive in research and development.[17]

There have been positive developments with the emergence of new, smaller enterprises

There have been positive developments in recent years with the emergence of new, smaller enterprises. In 1998, SOEs were still responsible for about 55% of all science and technology spending by the enterprise sector, but other types of enterprises—private concerns, small and medium-sized enterprises (SMEs), and foreign-based firms—are responsible for the 12% growth in the research and development effort of the sector from 1997 to 1998 (table 8.6).

Enterprises self-finance about two-thirds of their efforts, with the rest of the sectors' funding coming from direct government subsidies (less than 10%) and bank loans (often encouraged or arranged by the government). A significant component of government support is to encourage innovative effort through the establishment of in-house technical centers and increased interactions with universities and institutes. Some of these measures seem quite efficient (see sections 8 and 10 in the appendix of chapter 7). In view of the growing role played by SMEs in generating innovation, growth, and employment, the redeployment of government support to encourage research and development in these enterprises—for example, through the Innovation Fund discussed in the previous chapter—is a step in the right direction.

The expansion of technology oriented programs (Program 863 and the Program of Key Technology Projects) should be also lead to a more efficient research and development effort in the enterprise sector if enterprises are effectively involved in project selection and implementation. All such changes will

TABLE 8.6
Funding of R&D within the enterprise sector

	1997				1998			
	Total (100 million yuan)	Source of funds (percent)			Total (100 million yuan)	Source of funds (percent)		
		Government	Enterprises	Bank loans		Government	Enterprises	Bank loans
Total	499.8	6.3	69.7	17.7	556.4	7.9	72.3	16.1
State-owned (large and medium-sized) enterprises	317.6	8.8	64.4	17.0	314.4	11.8	70.2	12.7
Foreign, Taiwan, Hong Kong, and Macao affiliated companies	62.4	1.2	87.1	10.9	99.9	2.0	80.9	16.4
Other	119.8	2.2	71.9	23.2	142.1	3.4	71.0	23.2

Other refers to private firms, town and village enterprises, and collective enterprises.
Data refer to science and technology expenditures, not strictly to research and development
Source: State Statistics Bureau and Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology,* Beijing: China Statistics Press, 1999.

depend in the end on the quality of the signals sent by the markets in which the enterprises operate and therefore on the effectiveness of reforms to improve the broader regime of incentives under which Chinese enterprises operate (as discussed in chapter 4).

Appropriate tax incentives can stimulate research and development in the enterprise sector. Measures should apply particularly to contracts entered into with university and government institutes for technological research, development, or absorption. They should create incentives for the dissemination of technology, while contributing to the funding of universities and research institutes. China could draw upon and adapt successful international tax schemes,[18] but several features of the Chinese system are unique: business taxes are modest compared to those in advanced countries, accounting systems are rather opaque, and diverse taxation arrangements have already been implemented by all levels of government. It will be important to extend schemes to all enterprises without sector- or area-specific requirements. Such restrictions reduce the autonomy of innovators while increasing interference by bureaucrats.

Appropriate tax incentives can stimulate research and development in the enterprise sector

Improving evaluation, foresight, and monitoring

China confronts considerable problems and difficult choices in allocating government resources to research and development. These difficulties can be cut if appropriate evaluation and technology foresight mechanisms are put in place, as previously noted. In view of the need to allocate resources to fields critical to the long-term development of the economy, China's public research structures—governmental and academic—should be thoroughly evaluated with the help of foreign scientists, following procedures established in an increasing number of advanced countries and countries in transition.[19] The need for such involvement is particularly obvious in China, which for decades was cut off from the international community and developed evaluation and reward mechanisms that are inward-oriented. The objective of the evaluation would be to assess the quality of the research work performed in a broad range of organizations and disciplines, and the amount and structure of funding for the scientific community, including funds for equipment.

Over the past decade or so, industrialized and emerging economies have engaged in technology foresight exercises that allowed them to position their research and development efforts and competencies in a global perspective, taking into consideration trends in leading countries. Various foresight procedures have been tried, from select panels of experts to broader consultations among the academic and business communities.[20] The exercises have proven useful in helping the government and other actors to identify long-term science and tech-

nology trends, evaluate national capabilities in various disciplines and fields, and consolidate research networks and partnership arrangements. China should conduct such exercises—with the participation of foreign and overseas Chinese experts. This would be particularly useful for defining long-term research and development programs and suggesting appropriate resource allocations.

Finally it is of the utmost importance to improve monitoring of research and innovation efforts and outcomes. Statistics are abundant, but many are not very relevant. For ideological and other reasons they miss important elements of the system—such as the research and development and innovation activities of small firms. Most problematic, because they are not based on international (those of the Organisation for Economic Co-operation and Development) they are poorly comparable at the international level. China's recent application for membership in the OECD Committee for Science and Technology Policy should facilitate the adoption of these standards and help benefit from international experience in science and technology policy.

It is of the utmost importance to improve monitoring of research and innovation efforts and outcomes

Notes

1. Hence the importance of exploiting the outcomes of global research and development, as discussed in the next chapter.

2. Chinese statistical practices produce somewhat lower estimates than the standard methods of the Organisation for Economic Co-operation and Development. Chinese statistics distinguish between research and development expenditures and science and technology expenditures. Research and development expenditures are funds made available for research activities. Science and technology expenditures include research and development expenditures, expenditures on science and technology infrastructure, and some funds allocated to technical developments of three types: product development, production tests, and special grants for major research projects. Unless otherwise indicated, the statistics presented in this report are for research and development spending.

3. Ministry of Science and Technology, *China Science and Technology Indicators,* Beijing: Science and Technology Literature Publishing, 1998, pp. 95–97. There are no recent data on the citation rate, which assesses the quality of papers by measuring the number of times they are cited. Estimates for 1989–93 placed China at a very low level; the average citation rate for a Chinese paper was 0.97 for all fields combined, while the world average was 3.47 and the average for the most advanced countries (United States, Sweden) about 5.

4. Not surprisingly, more patenting occurs in the Chinese patent system. In 1997, 12,713 domestic applications for inventions were numbered (including 931 from Taiwan), up from 7,407 applications in 1991, with a gradual increase from year to year over the period. See Ministry of Science and Technology, *China Science and Technology Indicators,* Beijing: Science and Technology Literature Publishing, 1998, p. 197.

5. Ministry of Science and Technology, *China Science and Technology Indicators,* Beijing: Science and Technology Literature Publishing, 1998, p. 34.

6. The number of patents obtained by projects funded by Program 863 is on the order of 700 over the period 1986–98, approximately half the number obtained by basic research projects supported through the National Natural Science Foundation—for which the government spent about one-third as much money over the 12 years.

7. Typical examples that might inspire Chinese authorities are the U.S. Advanced Technology Program and the British Link Program. Both programs rely more on university research units than on government structures in their joint efforts with industry.

8. See Ministry of Science and Technology, *China Science and Technology Indicators,* Beijing: Science and Technology Literature Publishing, 1998, Figure 11.5, p. 164.

9. UNDP, *The State in Transition,* New York, 1999.

10. Xielin Liu and Steven White, "Comparing Innovation Systems: A Framework and Application to China's Transitional Context," Research Policy 1255, 2000, pp. 1–24.

11. In 1997, the government institutes classified as "research institutes" received fixed appropriations amounting to about 30% of their total budget, while, strangely enough, institutes classified as "development institutes" received appropriations amounting to 42 percent. "Agriculture institutes" received appropriations of only 15% of their budgets. See China Science and Technology Indicators, 1998, p. 49. The ratio for this type of institutes in advanced economies is on the order of 50 percent. Chinese universities are estimated to receive about 50% of their total research budget in the form of government appropriations (Ministry of Science and Technology, *China Science and Technology Indicators,* Beijing: Science and Technology Literature Publishing, 1998, p. 78).

12. Selected projects receive about 10 million yuan each year for an initial period of three years. So far, fewer than 100 projects have been supported each year. Sixty were selected in mid-2001.

13. The most remarkable example from this view point comes from Japan with the network of the 18 National Laboratories of the Industrial Science and Technology Agency, operated by the MITI. In addition there is a network of some 80 prefectural laboratories, partly funded by local governments.

14. Brief visits to Chinese research and development laboratories confirmed a lack of equipment for this type of vital public-good research. For instance, the central iron and steel laboratory and its institute of continuous casting pursue research vital to an important industry employing some 2 million people and facing severe competition. The institute has demonstrated creativity and developed innovations of world significance. This has taken place under relatively poor working conditions, with equipment that is 10–15 years older than that found in similar laboratories in the industrial countries.

15. Ministry of Science and Technology, *China Science and Technology Development Research Report,* Beijing: Economic Management Press, 1999. Among the spin-offs are phenomenal success stories such as Legend, created by Academy of Science researchers. Legend is now the most important computer hardware and software manufacturer in China. Another example is Founder, spun off from Beijing University, which holds more than 85% of the world market in Chinese character printing thanks to an innovative, patented method that will soon enter the public domain.

16. See Xue Lan, "University-Market Linkages in China," speech at International Seminar on Technological Innovation, Beijing, 5–7 September 2000.

17. Even those SOEs that engage in innovative activities do not turn in exceptional performances. This applies in particular to the upper end of the spectrum of enterprises operating in high-tech industries. The overall level of research and development intensity (as measured as research and development expenditure as a percentage of sales) is at least twice as low in Chinese firms as in similar enterprises in more advanced economies, and the level of innovation as measured by the share of new products in sales does not increase with research intensity (Ministry of Science and Technology, *China Science and Technology Indicators,* Beijing: Science and Technology Literature Publishing, 1998, p. 68).

18. Some national tax schemes offer a complete write-off of expenditures made during the year. Others provide this only for expenditures exceeding those of the previous year. Some defer tax payments until the enterprises show a profit, an arrangement particularly convenient for start-up firms. For a full discussion of such measures, see OECD, *Managing Innovation Systems,* Paris, 1999.

19. The most remarkable approach to evaluation is the one established by the Swedish Foundation for Natural Sciences, which systematically reviews the state of science in Sweden. The teams are composed entirely of foreign experts internationally recognized in their domains.

20. For a critical review of foresight exercises, see the publications of Ben Martin (Science Policy Research Unit, University of Sussex, United Kingdom) including his article in the proceedings of the 2001 OECD Conference on Innovation and Social Sciences.

9 Exploiting global knowledge

The challenge is to strike the right balance of knowledge creation and knowledge acquisition

China needs to exploit rapidly growing global knowledge to advance its own development and its transition to a knowledge-based economy. The challenge is to strike the right balance of knowledge creation and knowledge acquisition: adapting foreign knowledge to the Chinese context rather than engaging in expensive duplication of effort, while budgeting for domestic R&D efforts to increase knowledge within China. This chapter reviews four methods of accessing foreign know-how[1]:

- Attracting foreign direct investment (FDI).
- Engaging in international technology trade.
- Collaborating in public and private international scientific initiatives.
- Exploiting the network of overseas Chinese.

Attracting foreign direct investment

Transnational corporations are the main drivers of the rapid expansion of global knowledge. Attracting foreign direct investment (FDI) is one of the most effective ways to gain access to this foreign know-how. Under the right circumstance FDI can:

- *Help build of high-quality personnel.* FDI can attract back well-educated and high-quality overseas Chinese and persuade talented staff in science and technology to remain.
- *Promote the free flow of labor.* FDI has a short history in China, but evidence so far points to a net inflow of Chinese to staff foreign-funded projects. In the long run, more personnel with experience in advanced technologies and management will leave foreign firms to become core staff of domestic enterprises.
- *Stimulate domestic firms through competition.* Competition can promote domestic innovation and help separate healthy, productive Chinese firms from the weak, inefficient firms of the command era.
- *Promote economic, academic, and technological exchanges and cooperation, at home and abroad.* Foreign firms often organize international seminars, workshops, and training sessions, which can facilitate exchange and cooperation between China and the international community.

• *Implement new technologies,* including production processes and management techniques. New technologies can stimulate growth and bring firms in China up to internationally competitive levels of productivity (box 9.1).

Foreign investment in China is high but unevenly distributed

There is still room for significant improvement in China's use of FDI

China's ability to court foreign investors is envied worldwide. China was third in the world in total FDI stock in 1999, trailing only the United Kingdom and the United States (figure 9.1) and was home to more than a third of the foreign affiliates of multinational corporations.

The technologies that these corporations bring to China have already accelerated China's modernization. The contributions are obvious in people's day-to-day activities, in the high-technology practices in newly established Chinese firms, and even in some more traditional enterprises. Foreign enterprises were also responsible for some 45% of exports in 1998, a significant contribution to Chinese economic activity. Their role was even more important in the early years of developing technology parks, as foreign firms formed the nuclei of these important building blocks of Chinese high-tech industry. However, there is still room for significant improvement in China's use of FDI, particularly in the sectoral composition of investments, the source countries, and the regions that receive FDI.

BOX 9.1
Foreign investment generating domestic industry

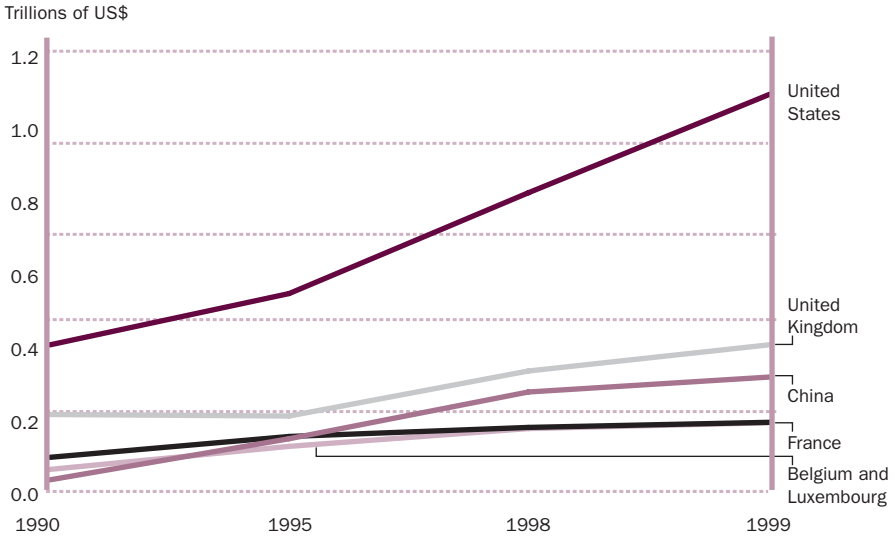
Volkswagen's Shanghai plant has increased production more than 100-fold—from assembling 2,000 cars in 1985 to 230,000 in 1999. Revenues rose from 60 million yuan in 1985 to 26.6 billion in 1999. Labor productivity—the value of sales per person—increased from 40,000 yuan in 1985 to 3 million yuan in 1999.

Besides producing cars for the Chinese market, the plant has developed an extensive domestic supplier network to increase its local content. Its first model, the Santana, went into production in 1985 with 2.7% local content. By 1999 local content was 93% of value. For its second model, the Santana 2000, local content increased from 70% in 1995 to 88% in 1999.

When the Passat 2000 (technically identical to the German version) entered production in 2000, local content was 53% because of the more demanding specifications. With competition likely to increase once China joins the World Trade Organization, Volkswagen is strengthening the training of its Chinese suppliers to enhance their quality and competitiveness. It is promising domestic parts suppliers able to meet its price and quality standards that they will become part of its global supplier network.

Source: World Bank staff, visit to Shanghai Volkswagen plant, June 2000.

FIGURE 9.1
Total FDI: Top five countries



Source: UNCTAD, *World Investment Report 2000,* Geneva, 2000, pp. 294–99.

The underdeveloped services sector has the greatest potential for creating jobs and attracting foreign capital over the short and medium terms

FDI is limited in the service sectors

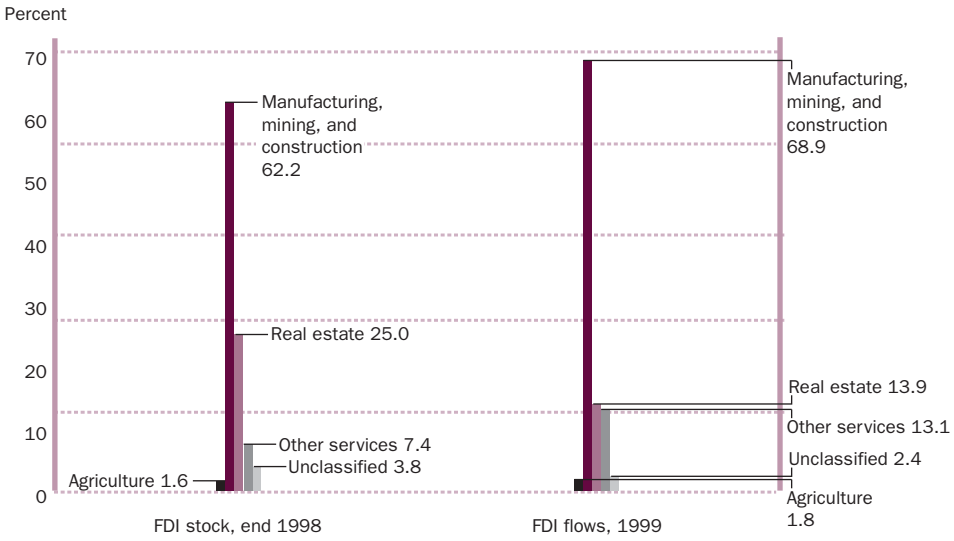
When performing a cursory analysis of the Chinese economy, China's stock of FDI is impressive. However, a more detailed analysis of these foreign investments yield some remarkable insights that have important policy implications. The first striking point is that the majority of China's FDI (62%) is concentrated in manufacturing and related industries, with only 32% in services (figure 9.2). However the bulk of this investment (25% of total FDI) is concentrated in real estate management, leaving only 7% in other service industries. And while inflows of foreign funds are beginning to shift toward the service sector; internationally, the amount of total FDI flows that went to service industries in 1999 was just over 50%. Even including real estate, China's FDI into services was only 27% of total flows in 1999, just over half of the world average, with non-real estate services attracting only 13.1% of total flows. This shortcoming is mainly due to a policy bias that promoted foreign investment in traditional industries—especially manufacturing—while restricting foreign participation in services.

The underdeveloped services sector has the greatest potential for creating jobs and attracting foreign capital over the short and medium terms. But much depends on the will of the government to deregulate the sector, introduce more competition, and open it to foreign participation. Practically all services are dominated by state monopolies in distribution, telecommunications, banking, health care, tourism, transportation, logistics, utilities, and many others.

Many restrictions prevent foreign enterprises currently operating in China from

Many restrictions prevent foreign enterprises currently operating in China from developing activities in most of the service industries

FIGURE 9.2
FDI stocks and flows by sector



Source: Chinese Statistics Bureau, *China Statistical Yearbook.* Beijing: China Statistics Press, 2000, and Luolin Wang, *Report on Foreign Direct Investment in China, 2000,* Beijing: Chinese Academy of Social Science, 2000.

TABLE 9.1
Barriers to foreign involvement in the Chinese service sector

Service industry/ trade barrier	Regional restrictions	Regulatory opaqueness	Foreign ownership limitation	High state-owned enterprise concentration	Excessive non-tariff barriers
Insurance	■	●	■	*	■
Telecomm	■	●	■	●	■
Legal Services	●	*	●	*	●
Banking	●	●	●	●	●
Securities	*	●	●	*	*
Tourism	■	*	●	●	●
Transportation	■	*	●	●	●

● High level of restrictions
■ Moderate level of restrictions
* Low level of restrictions
Source: World Bank Institute analysis of European Union Chamber of Commerce (China), *Position Paper from Sectoral Working Groups,* Beijing, 2000.

developing activities in most of the service industries—not only traditional industries, such as distribution and transport, but also in services with strong value-added such as insurance, banking, and legal affairs. The European Chamber of Commerce in China published a report in October 2000 on issues surrounding foreign participation in twelve service industries. A summary of their findings can be found in table 9.1. According to the report, banking and telecommunications are currently the most closed of the industries analyzed, with foreign ownership being a problem across all the sectors detailed.

A recent study by McKinsey and Company on how World Trade Organization (WTO) membership may affect some of these service industries predicts that banking and insurance will change dramatically in the next three to five

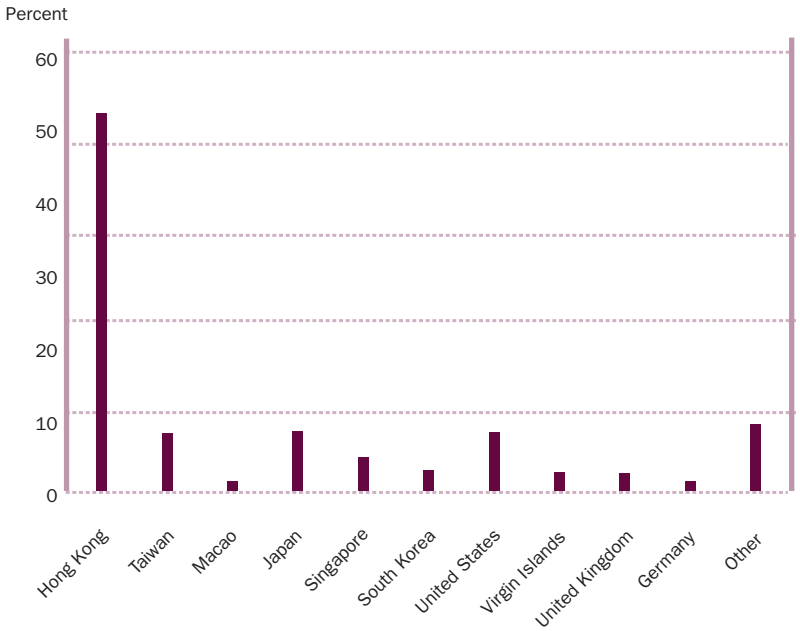
years with extensive liberalization. Foreign ownership in telecommunications and Internet services, by contrast, will be capped at 49%, and participation in the securities industry will remain limited. The Chinese government should tap foreign expertise in these sectors, especially to gain experience in operating in open environments, as quickly as possible by encouraging foreign investment in state-run enterprises. Allowing limited foreign participation in the near term may improve the longer-term health of these enterprises.

More than half of FDI in China is Chinese-related

The Chinese government should tap foreign expertise to gain experience in operating in open environments

The second striking point about the stock of FDI in China is that less a third has come from Japan or Western countries. Sixty percent of realized investment for 1979–98 has been Chinese related, emanating from Hong Kong, Macao, and Taiwan, China (figure 9.3). Adding Singapore brings the total to more than two-thirds. Hong Kong alone has accounted for 50% of the total. Its high share may in part be due to "round-tripping" investments that are actually from within China, but are illegally routed through Hong Kong to receive the tax and other benefits given to foreign investment. Until recently most of this Chinese-related investment was in low-technology labor-intensive activities that were attracted by China's low wages. Only in the last few years has higher technology investment from these regions been flowing into China (particularly from Tai-

FIGURE 9.3
FDI in China by source country, 1979–98



Source: China Financial and Economic Publishing House, *2000 Report on Foreign Direct Investment in China,* Beijing, 2000.

wan, China). This means that the stock of Japanese and Western investment is much lower than might have been expected, with the majority of non-Chinese investment concentrated in manufacturing and other traditional industries.

China needs to leverage its foreign investment further. From both sources (but particularly from the non-Chinese), it should try to get higher value investments (high technology in manufacturing, and high value knowledge services). From the Chinese related investment it can draw on the large contingent of successful, entrepreneurial overseas Chinese for expertise and investment in a transition to a knowledge-based economy. Investment coming from Hong Kong, Taiwan, and Macao, and indeed, from Chinese in the rest of the world, takes less effort to attract due to the cultural connection felt by members of these communities. Therefore, China should focus more on attracting FDI from and forging relationships with other countries with which it currently has fewer historical ties.

China should focus more on attracting FDI from countries with which it has fewer historical ties

However, the Chinese government needs to be fully cognizant that to obtain foreign investment with a higher knowledge content it will have to improve the intellectual property rights regime. Problems with enforcement of current IP laws still remain in China, with many companies, and indeed, industries, still claiming huge losses from IP violations. U.S. companies alone estimate that losses in China due to counterfeiting, piracy, and exports to third party countries are more than $2 billion. Some U.S. firms put the losses from counterfeiting at 15–20% of their total sales in China. China has revised its laws to provide criminal penalties for violations, but there is concern that the level of punishment assessed by Chinese courts does not act as a deterrent, particularly because the judgments are often inconsistent and suspect, with judges being open to influence.

This laxity threatens the long-term viability of foreign businesses in China and discourages additional FDI, trade, scientific collaboration, and other forms of knowledge sharing. Indeed, establishing a sound IP regime is essential to attracting foreign involvement and expediting China's shift to a knowledge-based economy, an issue discussed in detail in Chapter 4.

The regional distribution of FDI is uneven

Most foreign investment in China has gone to the coastal provinces, where it has been very productive and helped to fuel the growth of the Chinese economy. But the central and western provinces have had much less success in courting foreign investment, attracting only 18% of total FDI stock (table 9.2). The Chinese government is trying to encourage more FDI to the central and western regions through investment and tax incentives. These may do little to overcome some of the locational disadvantages of these regions, such as smaller

TABLE 9.2
FDI in China by region

Region	Number of projects	Percent of total	Contracted foreign capital (billions of yuan)	Percent of total	Actual investment (billions of yuan)	Percent of total
Coastal	266,564	82.12	5059.03	88.35	2347.95	87.83
Central	41,813	12.88	449.99	7.86	237.55	8.89
Western	16,243	5.00	216.93	3.79	87.65	3.28
Total	324,620	100	5724.95	100	2673.15	100

Source: China Foreign Investment Statistics 1998.

regional markets, higher transport costs, lower-skilled labor, and less developed physical and social infrastructure, constraints that will also need attention.

Chinese investments abroad are underdeveloped

The Chinese government must also provide incentives for Chinese companies to invest abroad

In addition to attempting to attract more foreign investment to bring global knowledge to China, the Chinese government must also provide incentives for Chinese companies to invest abroad. Technological leaders increasingly work on a worldwide scale. Therefore, Chinese enterprises need to operate in the global arena to keep up with advances in technology and management, and acquire complementary assets (knowledge, access to markets) by buying foreign companies and research labs with these capabilities, and exploiting their own knowledge assets on a global scale Chinese enterprises. To integrate themselves into the global economy, they will need to develop active foreign investment strategies of their own.

Successful foreign companies in knowledge industries, such as Nokia (see box 9.2), have significant investments abroad. Nokia clearly demonstrates the need for keeping abreast of technological advancements, as they spend US$2.3 billion (approximately 10% of revenues) on R&D. In fact, they have R&D centers in more countries (15) than they do production (10), proving their ability to reach beyond the borders of their home country, Finland. Chinese outward FDI flows have been modest (less than $3 billion over 1978–98). Chinese authorities, notably the Ministry of Foreign Trade and Economic Cooperation, are beginning to encourage such initiatives, but strict regulatory controls on financial outflows create serious disincentives to invest abroad. The handful of Chinese companies—such as the Konka Group, Haier, and Little Swan—that have significant investments abroad could serve as models for Chinese firms seeking to expand internationally.

Particular attention should go to supporting patenting abroad (chapter 8), technological alliances, and the purchase of foreign firms and R&D labs, a pattern followed to great effect by Taiwan, China, and the Republic of Korea. Financial incentives could defray the expenses of patent deposits in foreign countries and

Particular attention should go to supporting patenting abroad, technological alliances, and the purchase of foreign firms and R&D labs

BOX 9.2
Nokia's global presence

Facts and figures

	Global staff distribution	*Global sales figures*
Global sales–U.S.$27 billion	Finland–40%	Europe–52%
Net profits–U.S.$3.5 billion	Other Europe–25%	North America–25%
R&D spending–U.S.$2.3 billion	Americas–20%	Asia-Pacific–23%
R&D centers–15 countries	Asia-Pacific–15%	
Total staff–60,289		

Source: Nokia website.

stimulate the development of information networks and databases through public and private initiatives. With the right incentive structure, the knowledge base of Chinese firms and the economy as a whole could be expanded dramatically.

Engaging in international technology trade

International trade is another way to tap into global knowledge and technology. Manufactured goods, from high-technology products to capital goods and components, embody a tremendous amount of knowledge. Since China opened to the outside world, the value of its imports has increased several fold (table 9.3). From the beginning roughly 80% of the imports were manufactured goods, half of them capital goods and transport equipment.

Active participation in trade also brings beneficial externalities to a country's economy:

- Competition from imports and in export markets forces domestic firms to compete with the most productive, efficient firms on the world market. This increased competition leads to product and process changes within domestic firms, allowing nimble, efficient, well-run firms to improve, while driving inefficient, unproductive enterprise out of business.
- Foreign buyers (of finished products or components and even mass retail-

TABLE 9.3
Imports by sector, 1985–98

Year	Total value (millions of $)	All food items	Agricultural raw materials	Fuels	Ores and metals	Total manufactured goods	Manufactured goods: Chemical products	Manufactured goods: Other manufactured goods	Manufactured goods: Machinery and transport equipment
1985	39,795	4.4	6.1	0.4	5.3	78.0	10.4	28.6	38.9
1990	53,345	8.7	5.8	2.4	2.9	79.7	12.5	26.8	40.3
1995	132,084	7.0	5.0	3.9	4.4	78.5	12.8	26.0	39.7
1998	140,237	4.7	4.1	4.9	5.0	80.7	14.2	26.0	40.5

Source: UNCTAD, *World Investment Report 2000,* Geneva, 2000, p. 148.

China has been less active as an importer of disembodied technology

ers) often provide detailed design specifications and technical assistance in production, management, and quality control to ensure that the products they buy are delivered on time and to high international quality standards. Volkswagen fostered development of Chinese parts suppliers for its Shanghai plant and also offered suppliers the opportunity to export if they achieved quality and price competitiveness in world markets (see box 9.1).

- Exporting drives change, forcing firms that supply foreign companies to maintain discipline in production and to keep up with technological developments and global best practices.

When it joins the WTO, China will expose itself to more foreign competition and gain greater access to foreign markets, strengthening incentives to improve technological and management practices and to acquire the best the world has to offer.

However, while China has been a prolific importer of technology embodied in goods, it has been less active as an importer of disembodied technology, which normally entails royalty or other licensing fees. China spends about 12% of what the Republic of Korea spends as a share of GDP on licensing foreign technology and about 15% of what Japan spends as a percentage of merchandise imports (table 9.4). Low imports of disembodied technologies reduce the inflow of effective technological knowledge. In addition, Chinese firms tend to purchase equipment without the management and other knowledge transfer support needed to maximize the productivity of the technology investment, which reduces the productivity gains from the technology.

While importing capital goods is an important way to acquire foreign technology, more must be done to insure that knowledge is imported along with goods. Two complementary measures can help to harness the full potential of foreign technologies introduced in China:

- *Deregulation.* Different levels of government regulate most technology licensing between Chinese companies and foreign partners, squeezing small enterprises out of technology trading and licensing. Restrictions on technol-

TABLE 9.4
Licensing fees by country
(Percent)

License fees	China	India	France	United States	United Kingdom	Republic of Korea	Brazil	Japan
As share of GDP	0.08	0.07	0.16	0.15	0.44	0.65	0.17	0.23
As share of merchandise imports	0.48	0.71	0.79	1.25	1.97	2.22	2.48	3.17

Source: World Bank, *World Development Indicators 2000,* Washington, D.C., 2000.

TABLE 9.5
Domestic R&D versus foreign technology spending in large and medium-sized Chinese industrial enterprises
(100 million yuan)

Category	1991	1992	1993	1994	1995	1996	1997
R&D expenditures	58.6	76.1	95.2	122.0	141.7	160.5	191.3
Spending on domestic technologies	3.7	..	4.7	13.2	25.5	25.8	14.6
Spending to introduce foreign technologies	90.2	116.1	159.2	266.7	360.9	322.1	236.5

Source: Ministry of Science and Technology, *China Science and Technology Indicators,* Beijing: Science and Technology Literature Publishing, 1998, p. 64.

As Chinese enterprises get closer to the world frontier, becoming globally competitive will require investing more in R&D

ogy licensing also impose heavy burdens on foreign partners. The approval process requires, for instance, royalty limits, high withholding tax rates, disclosures of confidential information, and a 10-year maximum license.

- *Training.* The Chinese tend to believe, once the equipment is on the factory floor, that there is no need for further investment in skills and related competencies, such as maintenance. More resources need to go for training and hiring foreign experts, to make the best use of imported equipment.

Right now Chinese enterprises report that they spend far more on adapting foreign technologies than on conducting domestic R&D (table 9.5). The largest importers of foreign technology have been traditional and heavy industries—and more recently such high-technology industries as electronics and telecommunications.[2]

As Chinese enterprises get closer to the world frontier, becoming globally competitive will require investing more in R&D, not only to scan for, acquire, and adapt foreign technology, but also to develop their own R&D capabilities in core areas of activity.

International collaboration in research and scientific initiatives

Collaborating with foreign firms, universities, and research centers provides a largely untapped means for China to upgrade its innovation system while providing other important benefits:

- *Encouraging knowledge sharing and modeling.* The R&D centers of for-

eign firms provide access to new production processes, technological breakthroughs, and other important know-how to their Chinese counterparts. That exposure accelerates progress toward the forefront of technological advances, while the new products and new technologies often provide good models for future development.

- *Strengthening China's capacity for technological development.* China has emphasized imports of production capabilities over development capabilities. Establishing foreign R&D centers in China will increase development capabilities.
- *Making China's enterprise R&D more market-oriented.* State enterprises receive substantial R&D subsidies, reducing their incentives to interact with other market participants. Removing these subsidies and encouraging R&D collaboration with foreign enterprises will make R&D more market focused, efficient, and productive
- *Improving the technology of Chinese enterprises through upstream linkages.* Much foreign R&D will strengthen the localization of foreign products, requiring the Chinese enterprises linked with foreign companies to follow their technological and quality standards, greatly improving the technology of Chinese companies.

Efforts must continue to establish advanced joint research centers

Foreign companies had established 32 laboratories in China by 2000.[3] Nineteen other companies have plans to establish R&D centers in China. Efforts must continue to establish advanced joint research centers, to adapt technologies to the Chinese market, and to develop new projects that advance China's pursuit of a knowledge-based economy, while serving the global strategies of multinational corporations.

The involvement of Chinese scientists in multinational corporations creates tension in China's scientific and political communities, which resent the exploitation of China's human resources for what they perceive as foreign gain. While there is some basis for such concern, the benefits of cooperating with multinational corporations are considerable. Such cooperation provides opportunities for participation in global technological alliances, highly competitive spin-offs, and other beneficial ventures, as already evidenced in some of the R&D centers of foreign companies in advanced sectors. And even more valuable long-term benefits become available as these staff re-enter Chinese industry or start their own ventures.

International cooperation in science and research is also crucial for expanding and deepening China's science and technology base. Yet scientific cooperation through bilateral and multilateral agreements is stagnating, and the number cooperative efforts remains low relative to the size of the Chinese R&D effort.

It has been two decades since China's scientific community benchmarked itself against other countries. China belongs to more than 900 international science and technology organizations and has signed bilateral cooperation

TABLE 9.6
Chinese personnel involved in international science and technology cooperation

Category	1995	1996	1997	1998
People involved in projects abroad	58,883	68,485	69,115	45,020
Cooperative research	6,873	5,620	5,112	3,607
People involved in foreign projects in China	35,098	31,493	37,504	24,913 [a]
Cooperative research	4,029	2,932	3,413	3,144

a. Principally from the United States (5,069 people), Japan (2,698 people), Germany (1,431 people), and France (998 people).
Source: State Statistics Bureau and Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology,* Beijing: China Statistics Press, 1999.

The number of Chinese scientists engaged in international cooperation activities is also low

agreements with more than 150 countries. But overall international cooperation remains low, at about 1.5% of total R&D expenditures (600 million yuan in 1998).[4] Other countries with a similar science base spend at least three times that percentage.

The number of Chinese scientists engaged in international cooperation activities is also low—and has been declining since the mid-1990s (table 9.6). In 1998 some 45,000 Chinese went abroad on science and technology exchanges. Most participated in international conferences, exhibitions, field trips, and training, with fewer than 8% taking part in cooperative research. About 25,000 Chinese science and technology staff were involved in foreign projects in China, but again just 12% engaged in effective cooperative research.

The need to increase funding and participation is clear. So is the need to decrease bureaucratic obstacles—set up mainly to control and monitor activities with foreigners—and barriers between Chinese ministries and organizations, including excessive competition for funding and projects. China should increase its participation in large multilateral projects, which can develop research skills and give researchers access to exceptional technology, processes, equipment, and databases.

The Internet and other forms of scientific research using modern telecommunications—such as joint, but geographically separated labs linked by instantaneous telecommunications (collaboratories)—are dramatically changing the conditions for global scientific research.[5] The dedicated networks being set up by Chinese universities and research centers are a step in that direction (chapter 6). But China is still hampered by the limits of its infrastructure and by administrative obstacles to developing the Internet and other forms of advanced international communication.

Tapping Chinese talent abroad

China should also do more to tap Chinese talent abroad by severing the brain drain and by exploiting the network of overseas Chinese.

From "brain drain" to "brain gain"

Approximately 320,000 Chinese students have gone to study abroad since 1978, but only 110,000 have returned.[6] Of these, 90% are in Australia, Canada, Japan, and the United States. Most work in higher education, but many are also have significant experience in the global business system. Recent surveys in the U.S. (table 9.7) show Chinese students receiving doctorates in science and engineering had the second highest stay rate in 1995–97 (after India). Moreover, the percentage of Chinese students who received doctoral degrees with firm plans to stay in the United States increased, despite the gradual opening of China's economy.

Approximately 320,000 Chinese students have gone to study abroad since 1978, but only 110,000 have returned

The substantial loss of talent has seriously affected China's domestic research and advanced education. But many Chinese in science and engineering academic posts abroad have been reestablishing ties with universities and research institutes in China. To encourage this, the Chinese government has established special programs with dedicated funding. Other efforts involve joint research, lecturing, and visits back to China—as well as encouraging regular professional communication with Chinese colleagues and recruiting graduate students and postdoctoral students from China for training abroad (box 9.3).

Ensuring sufficient financial support in payments or other benefits, especially for young and middle-aged intellectuals, is essential to retain talented Chinese academics. It is important to implement satisfactory working conditions, creating a favorable environment for talented individuals to return from their studies abroad. Particularly important is developing dynamic R&D centers in Chinese enterprises to offer returning students challenging and lucrative careers.

The experience from India and Taiwan, China is that returns grow once the local conditions turn more favorable. When there is fertile ground—research, financially lucrative opportunities, rule of law, private property protection, and some intellectual freedom and intellectual property rights—more of these Chinese who have remained abroad will begin to return to their homeland, potentially turning China's "brain drain" into a "brain gain."[7]

TABLE 9.7
Foreign doctoral recipients from U.S. universities with firm plans to stay in the United States, 1995–97
(Percent)

	Science and engineering			Natural sciences			Social sciences		
Country	**1995**	**1996**	**1997**	**1995**	**1996**	**1997**	**1995**	**1996**	**1997**
China	45.1	56.9	57.8	48.9	59.1	60.2	39.0	46.4	51.1
Taiwan, China	22.2	27.8	36.6	27.9	33.5	47.3	7.4	5.2	13.7
Japan	31.0	26.7	32.9	37.3	38.9	54.1	33.8	24.1	30.6
Korea	21.0	24.3	30.0	35.5	34.0	44.2	7.0	10.0	14.5
India	52.4	59.0	60.9	56.3	60.8	59.3	43.7	46.6	50.5

Source: National Science Foundation, *Science and Engineering Indicators 2000,* Washington, D.C., 2000.

BOX 9.3
Existing policies concerning overseas Chinese talent

- Ministry of Education: policies for overseas talent to come back for short-term academic activities (Chun Hui Plan); policies for overseas talents to participate in education and science research (Chang Jiang Scholar Project); start-up funds for research by Chinese overseas talent.
- Ministry of Personnel: financial aid for short-term work in non-educational departments for overseas talent and financial support for overseas talent to come back for science activities in noneducational fields).
- National Natural Sciences Foundation: funds for overseas talents to do short-term work or teaching; regulations on the use of funds for international cooperation and communications.
- Chinese Science Academy: One-Hundred Talents Project; high-level visiting scholar project; funds for overseas talent to come back and work in China.

Source: Xue Lan and Xu Fan, "China's Demand for Overseas Talents and Relevant Policies," World Bank, Washington, D.C., 2000.

China has a unique resource in the many overseas Chinese

TABLE 9.8
Overseas Chinese share of population, GDP (selected countries)
(Percent)

Country	Share of population	Share of market capitalization
Indonesia	3–4	73
Malaysia	30	69
Philippines	2	50–60
Singapore	78	81
Thailand	14	81

Source: Economist Intelligence Unit, *China to 2010,* London, 1998.

Exploiting the network of overseas Chinese

China has a unique resource in the many overseas Chinese with a strong attraction to their native country. To strengthen these cultural connections and speed the development of China's knowledge economy, the government could give tax, contractual, and other incentives to overseas Chinese to promote technology, process, or information transfers and to encourage their return. Opening branches of ethnic Chinese-founded companies in China could provide a model for Chinese entrepreneurs, changing national perceptions about entrepreneurs and creating new jobs.

The overseas Chinese now make up a large share of many Southeast Asian economies (table 9.8), and they are well represented in the United States, Canada, and other industrial economies. In particular, entrepreneurial Chinese in Hong Kong, Macao, and Taiwan, China, can position China to take advantage of innovation and business opportunities in more developed economies.

The government has already taken some steps to encourage greater participation of overseas Chinese (see box 9.3). It could do even more by:

- Coordinating policies at the central government and local government levels and guaranteeing their implementation.
- Creating more networking channels for overseas talent to increase domestic demand—for example, by organizing teams to visit foreign countries and using the overseas Chinese networks, associations, media, and Internet sites.
- Simplifying procedures—for example, by recognizing dual citizenship, since overseas Chinese who have given up their Chinese citizenship often find it difficult to undertake short-term visits. Simpler alternatives are needed to replace the long and complicated procedure for obtaining return visas for China.

The government has already taken some steps to encourage greater participation of overseas Chinese

NOTES

1. Other ways of gaining access to global knowledge are foreign education and training, foreign visits, technical literature, purchases of technical databases, and (more generally) through the Internet. Some of these measures are discussed in other chapters.

2. The definition of technology imports used by these enterprises appears to be hybrid combining imports of capital goods as well as of disembodied technology.

3. Ministry of Science and Technology, *China Science and Technology Development Research Report,* Beijing: Economic Management Press, 2000, p. 294. In 1998 there were only 18 foreign research and development centers, employing about 600 people.

4. The funds come principally from three organizations or channels: the National Natural Science Foundation, (250 million yuan; the Academy of Sciences, 150 million yuan; and the Fund for Science and Technology Cooperative Agreements, 200 million yuan (China Science and Technology Indicators, 1998).

5. See OECD publications on the Global Research Village (Proceedings of conferences held in Portugal in 1998 and in the Netherlands in 2000).

6. "China's Leader Commits to Basic Research, Global Science," *Science* 288 (5473): 1950–530.

7. Many of the best and brightest students from China leave and stay away for political reasons. The demand structure of the US/North American scientific human capital market is such that it attracts the best; in addition, the government is not averse to providing financial support and visa variances to those US institutions that hire or use this talent.

10 **Moving to action**

He who first occupies the field of battle to await the enemy will be rested, he who comes later and hastens into battle will be weary. Thus the expert in battle moves the enemy and is not moved by him.

—Sun Tzu, The Art of War

Finding a way between the twin dangers of moving too slowly or moving too quickly requires a fine-tuned approach

China needs to act in many different policy domains, deepening, complementing, or reorienting ongoing reforms if it is to use knowledge efficiently for sustaining its development in the long term. The challenges are daunting, and there is no time to lose. Many of the policies leading to a knowledge-based economy will not yield results overnight.

The main danger may be the temptation to address difficult situations with piecemeal solutions rather than with a long-term strategy. At all levels of the economy, there is a remarkable capability to manage available financial resources and reallocate them as needed. But the process is far from transparent, and in the absence of rule of law the many discretionary controls, restrictions, and other powers offer numerous opportunities for rent-seeking. In these circumstances, postponing even urgent reforms is always possible.

A big risk is that the economy may continue to grow, but at a cost of rising inequality, low productivity, and weak domestic capability for innovation. The risks of social instability are increasing. With rapid reform often exacerbating social tensions, the government has sometimes responded by slowing reform, as is evident with state-owned enterprises.

Finding a way between the twin dangers of moving too slowly or moving too quickly requires a fine-tuned approach. Some guiding principles include:

- Defining priorities and establishing budgets.
- Adopting systemic, integrated approaches for the different policy planks at all levels of government, beginning with the top.
- Mobilizing provincial and local governments, keys to the Chinese economy and its modernization.
- Multiplying experiments and publicizing concrete initiatives that clearly exemplify the move to a knowledge-based economy.

Defining priorities and related budgets

The Chinese authorities are facing several important issues requiring the mobilization of considerable resources, such as transformation of the state enterprise sector, establishment of nationwide social safety nets, and resolution of the contingent liabilities of huge nonperforming loans. Budgetary plans for the knowledge and innovation strategy therefore need to be well designed and calibrated. Implementing an efficient strategy requires that policies for all four policy planks—incentives and institutions, ICT infrastructure, education, and innovation and research—be developed simultaneously. Yet within each policy plank there is room for ranking and sequencing reforms and for roughly estimating the resources that need to be mobilized. Actions that will have the most influential and immediate impact on mindsets and behaviors should be clearly identified and their reforms accelerated.

Legal and regulatory reforms will contribute most immediately to greater economic efficiency and to innovation

Economic incentives and institutions

Legal and regulatory reforms will contribute most immediately to the development of greater overall economic efficiency and to innovation. The resource requirements are modest. What is needed is a decision at the highest level of policymaking embracing a new role for the state as architect of a new socialist market- and knowledge-based system rather than controller and producer of most goods and services. This will require establishing a strong rule of law and clearly defining property rights, for state assets and for individuals. And it will require establishing appropriate market supporting institutions by promoting economic competition, strengthening the financial system, facilitating flexible labor markets, developing an effective social security system, and promoting the growth of small and medium-size enterprises.

Though seemingly ideological, these reforms are fundamental for setting up the incentive and institutional structures underpinning the swift decision-making and adjustment needed to respond to rapidly changing opportunities and to exploit the creativity of individuals and groups that are characteristic of the knowledge-based economy. An essential step is to recruit enough personnel to prepare and enforce the laws and regulations and to establish an efficient judicial system of courts, fairly and consistently applied penalties, and market supporting institutions. A new regulatory and institutional framework is possibly the most critical element needed today in China, and adequate financial resources will need to be allocated.

A massive training program for government cadres at all levels and for a large part of the growing entrepreneurial population would do much to support this exceptional effort, which involves changing mindsets and behaviors (box 10.1).

BOX 10.1
Mass training for the knowledge-based economy

China has embarked on an enormous education effort for knowledge-based development. The private sector has to update the knowledge and competency of its employees, and the state has to train its employees, particularly those in charge of public institutions and goods.

Training programs have also been established through multilateral and bilateral operations, some to respond to pressing issues (entering the World Trade Organization, managing state enterprises) and some to educate civil servants in top schools abroad. These efforts should be expanded by identifying best practices and taking advantage of international experience, including relevant initiatives in OECD countries (see chapters 4–9). Visits should be organized accordingly to see these measures at work in the OECD countries.

How does the government fit into this? The public administration schools for the different provinces include both civil schools and Communist party schools. It has to educate its members to the new form of public management required by the new era of development. And it needs to promote massive training of public officials to knowledge-based development, from high-level civil servants, to managers of government programs, to provincial government officials, to local township officials.

Professionals have to manage the new market supporting institutions, such as banking, social security, the judicial system, and high value service industries. Training opportunities should be provided for individuals in basic business skills and small business management. This new environment should promote entrepreneurship and people should be exposed to best practices in management, including those in human resources development, teamwork, leadership, and networking.

The government should also consider ways of providing training, materials, access to microcredit and support services for new business start-ups, and access to business support services for small and medium-size enterprises. The training would address basic business skills, such as accounting, assessment of market opportunities, development of business plans, business registration, and tax filing. Banks, business associations, municipal agencies, and reemployment and retraining institutions should be brought together to coordinate this training—whether for party leaders, entrepreneurs, or small and medium-size enterprises—which should include the use of new information and communications technologies, including the Internet.

Despite large investments in information infrastructure, much more is needed

Information infrastructure

A well developed and liberalized telecommunication infrastructure is also critical for a knowledge-based economy. Despite large investments in information infrastructure, much more is needed to boost low levels of penetration. But the bulk of the resources do not have to come from the government. They could be raised from private investors or through international capital markets. Among the most important measures are:

- Further opening the telecommunications market to competition and private investment and rapidly expanding the Internet. These actions will facilitate communications and improve the efficiency of the whole economy by reducing transaction costs and increasing transparency.

• The government must ensure that a competitive market develops, so that the tremendous dynamism of the underlying technology generates benefits for users through lower prices and better service, complementing that market with investments that the private sector might not be willing to undertake, and providing broad ICT access to prevent the digital divide from growing.

Education

Investments to expand and rationalize the education system are essential

Investments to expand and rationalize the education system are costly, and their benefits are evident mainly in the long run. Yet they are essential for the knowledge economy. Involving the private sector in an integrated solution could augment available resources. A step by step approach for the mobilization of public resources is recommended.

• For the medium term, appropriate tools, including broad nationwide tests, are needed to evaluate learning achievements. These tests can build on internationally available assessment instruments such as the OECD's International Adult Literacy Survey or Programme for International Student Assessment. For a country of China's size, the high costs can be substantially reduced through appropriate sampling. Such tests should help to define the needs and create awareness of new types of content and pedagogy. From this assesment, a well articulated strategy can be developed for improving the capabilities of the education system, both the formal system and post-school education, to ensure an efficient learning process nationwide. This effort will take more resources and time, but development and application of the evaluation tools needs to begin now, so that the reforms can be implemented in the medium term.

• Massive public investments are needed in all forms of teacher training and recruitment, curriculum reform, and expansion of the public and private education system, to both boost enrollments and improve the quality of education. In the vocational and training system the curriculum should put more emphasis on general competencies that promote adaptability and lifetime learning, rather than focusing on job-specific skills. An appropriate role for the state may be to ensure that lifelong learning opportunities are facilitated, learning achievements are recognized, and artificial barriers to adult participation are removed, rather than providing or financing such opportunities.

• Down the road, China should be at least doubling its expenditures on public education from the 1997 level of 2.3% of GDP to 4.9%, the average for middle-income developing countries. It should also expect that the private sector would spend another 2–3% of GDP on education and training—and later as much as the public sector if the government reforms the education system along the lines suggested in this report.

• Another critical parallel initiative is making better and more extensive use of information and communication technology and distance learning. China should leverage the potential of the new generation of Internet-based distance education with which it is already experimenting. China has a large market for learners over which to amortize the required investments. Investments in a further roll-out of the basic Internet infrastructure for education should not be very costly. Considerably larger investments will be required to train teachers and facilitators for this new medium and to develop new learning materials (and converting traditional teaching materials to the new medium), though the work can be done on a modular basis with testing and refinement and ways should be found to interest private suppliers as well. A system of accreditation and certification will be necessary to provide information to the market on the skills that students acquire through this process. A large national learning system of Internet-based education will also require a market for pricing and collecting fees for different types of programs—from specific skills training to graduate degrees.

High priority should go to strengthening and expanding technology dissemination mechanisms

INNOVATION AND RESEARCH

While the government is already working to increase the scale and scope of R&D programs, more is needed to strengthen the innovation system:

• High priority should go to strengthening and expanding technology dissemination mechanisms. The benefits of enterprise creation, jobs saved or created, and wealth generated should begin to emerge within three to five years. Additional resources of some 8–10 billion yuan a year will be needed to support a significant network of technology dissemination mechanisms. This level of investment could be reached gradually over three to five years. Matching fund procedures with central government allocations can be established so that local authorities can share in the effort.

• A rationalized R&D effort may involve a reallocation of resources to public good research. The first step should be a reevaluation of current subsidy schemes with a view toward dropping or consolidating some of them. This action should free up resources for reallocations to new priorities with more justification for subsidies, such as agriculture, public health, environment, precompetitive, and other public good research. This rationalization of government expenditures on R&D, which will have to be done on a case-by-case basis, will probably take two years if pursued vigorously and matched by staff training in monitoring and evaluation procedures. Once the efficiency of public resource use is improved, the level of effort can be raised. The enterprise sector and a growing private sector of new technology-based firms should increasingly raise the national R&D effort. With appropriate reforms in the overall

incentive and institutional framework, it is reasonable to envisage that by the end of the decade China can double spending on R&D to 1.6% of GDP and within 15 years to 2.2%, the level in OECD countries today.

Adopting a systemic approach, coordinated at the highest level

Reforms should progress simultaneously on all policy planks since lagging reforms in one plank can jeopardize the whole strategy

Reforms should progress simultaneously on all policy planks since lagging reforms in one plank can jeopardize the whole strategy. A systemic approach requires a detailed analysis of each situation. For instance, to boost technological capability, Chinese enterprises need to enter into technology alliances investing abroad with foreign partners, following well-established worldwide practice. But this is not possible today—or at best is very difficult—under the restrictions imposed by the foreign exchange authorities. Similarly, without the entry of foreign firms to compete and cooperate with Chinese firms, modernization of the services sector will be very slow, especially in high added value services such as logistics, finance, and tourism, causing an important source of wealth and job creation to be lost. For these reasons, and because WTO accession requires it, these restrictions should be eased.

Using knowledge to develop China requires an integrated policy at the highest level of the state—that is, the Premier or the State Council. The leading body should have the authority to coordinate all ministries, which is essential for designing the overall strategy. It would then be the responsibility of the State Planning Commission to carefully monitor implementation.

Because of the strong compartmentalization of ministries, implementing an integrated approach will not be easy. However, China can find inspiring models of pragmatic approaches used elsewhere and explicitly design a plan for a national transition to a knowledge-based economy. Notable examples are Finland and the Republic of Korea (after experiencing severe crises). Both countries are much smaller than China, but the organizational principles they applied have universal validity (box 10.2).

China needs a well-considered plan to start the integration at the highest level. Agencies close to the Premier, as well as leading universities and research institutes, have been accumulating analytical studies and proposals in many policy domains relevant to a knowledge-based development. These and other influential bodies can define a coherent knowledge strategy at the national level and elaborate concrete steps for its implementation.

A series of workshops, with support from international organizations, can facilitate the process and gather ideas from other countries that are grappling with similar concerns. The workshops could focus on different policy planks and prepare proposals to present to the Premier for consideration and action by an appropriate interministerial coordinating structure.

BOX 10.2

Implementing Finland and the Republic of Korea's knowledge strategies

More than a decade ago Finland established a Science and Technology Policy Council, chaired by the prime minister, to develop a broad knowledge and innovation strategy. The council includes all ministers and representatives of civil society (trade unions) and business. It contributed to move Finland to its leading economic position in the world, after the fragmentation of the Soviet Union greatly reduced its exports. Supported by a light secretariat, the council initially met about once a month to discuss and decide on key policy issues in the various policy domains of developing a knowledge and innovation strategy. Its actions are closely coordinated with other major initiatives, such as the informaticization of Finnish society.

The Republic of Korea, at the initiative of the president, launched a national strategy to move to a knowledge-based economy in the wake of the financial and foreign exchange crisis of 1998. The initiative was led by the Ministry of Finance and Economy, with the intellectual support of the Korean Development Institute, which coordinated the work of a dozen think tanks. A joint World Bank and OECD report provided a framework, outlining concrete steps for reforms in the various policy domains. Close monitoring of progress has been important to keep up with the reform process and to identify areas of inertia or resistance, as in education.

Korea's knowledge strategy of April 2000 evolved into a three-year action plan for five main areas: information infrastructure, human resources, knowledge-based industry, science and technology, and elimination of the digital divide. To implement the action plan, five working groups were formed involving 19 ministries and 17 research institutes, with the Ministry of Finance and Economy coordinating the implementation.

Every quarter, each ministry submits a self-monitoring report to the Ministry of Finance and Economy, which puts out an integrated report detailing progress. The mid-term results and adjustments to the plan are sent to the executive director of the National Economic Advisory Council, which reports on the progress of implementation and gives an appraisal of the three-year action plan to its private advisory members. If necessary, ministries coordinate their policies at the economic policy coordination meeting.

Source: Carl Dahlman and Thomas Anderson, eds., *Korea and the Knowledge-Based Economy: Making the Transition Work*, Paris, World Bank and OECD, 2000, and Finnish National Fund for Research and Development website, http://www.sitra.fi/tietoyhteiskunta/english/st51/eng206b.htm

Using knowledge to develop China requires an integral policy at the highest level of the state

Mobilizing local governments

China has a strong capability for action at local and regional levels, which have crucial roles in developing the country and managing the economy. Local governments (provincial, county, municipal) command 70% of the state budget, and many have autonomous development strategies. At the same time China has a strong tendency toward centralization, with the hierarchy and networks of the Communist Party giving general direction from the top and reflecting reactions from the bottom. China should use this dual power structure to facilitate a nationwide transformation.

It would help to design a knowledge-based development strategy for each province, taking into consideration the capabilities and comparative advantages of each province. There already are several exemplary initiatives, the

most impressive being from Shanghai. Its strategy covers all the key policy planks, including 20 well-focused programs that reinforce one another (table 10.1). Another is Shenzhen's, which had the first Special Economic Zone open to foreign investments and built its strategy on an international knowledge base, linking its universities to dozens of institutions throughout the world.

Several provinces have overall development plans, but they all tend to look similar, based on using incentives, primarily tax holidays, to push high-technology industries and attract foreign investors. Each should now identify its strengths and weaknesses and design more specific development strategies.[1] Some provinces have shown remarkable private sector dynamism (Jiangsu). Others have found a way to renovate their state enterprise and turn them into an important pillar of the economy (Shanghai). Still others struggle with reform of their state enterprises (Liaoning). Some have strong capabilities in science and technology but mobilize and exploit them with difficulty (Xi'an). Others make good use of tiny science and technology competencies to develop thriving local science parks (Suzhou). And there is a great diversity among cities: for example, in the Sichuan province, Chongqing shows remarkable dynamism while others suffer from inertia.

It would help to design a knowledge-based development strategy for each province

The poorest provinces have special needs. The government has put in place a vigorous strategy to develop the western part of the country, building up infrastructure and establishing strong incentives to attract foreign investors (box 10.3). The strategy includes investments in knowledge-based structures, especially universities. Note, however, that relatively low cost, fine-tuned, integrated strategies seem to be very efficient for developing the poorest areas of the country, as illustrated by projects of the World Food Program.[2] Thanks to coordinated programs for infrastructure, microfinance, environment, and agriculture—including a large training component—local communities have the means for economic self-sustainability, preventing starvation, and migration.

To begin the elaboration of provincial and local strategies, a conference could be organized to present and discuss selected experiences of provincial and local governments.

Multiplying experiments and evaluations

Traditional practice in China is to experiment before launching broad policy reforms. If the experiments prove successful, they can be replicated throughout to the country with appropriate regulations and incentives.[3]

A nationwide experiment program, including ongoing, planned, and new initiatives, could help guide the move to a knowledge-based economy. A few points to keep in mind:

- Take the diversity of regions and localities into account.

TABLE 10.1
Shanghai's knowledge strategy

Strategic elements	Details
1. Focus on biotechnology industries	As Beijing has a strong information technology industry and Shenzhen a strong manufacturing base, Shanghai focuses on further exploiting an advanced biotechnology base and building the Pudong Bio Science and Technology Park.
2. Help enterprises to invest in R&D	Preferential tax regime and financial assistance help high technology startups invest in R&D.
3. Put more public resources in R&D	Public resources establish new basic research institutions focused on Shanghai's strengths and interests, to encourage cooperation between universities and corporations, and to reorganize old research institutes.
4. Catch up information industries through competition	To develop bio-tech as a mainstream industry, IT is a driving force. To close technology gaps, it is necessary to establish companies through intensifying market competition.
5. Encourage use of the Internet	Telecommunication and Internet access costs are lowered by government instructions given to monopolistic, state-owned companies.
6. Provide reliable information	Information from Chinese governments and corporations used to be questioned for its credibility, raising transaction costs and impeding information exchanges. The reliability of information is being re-established by adopting international standards and regulating markets with more transparent rules.
7. Stimulate information diffusion through networking	Discussion and information exchange networks are being created among various institutions, including government agencies, universities, researchers, and businesses.
8. Expand knowledge service industries	Specific areas of focus include education, software, consulting, design, advertising, culture, and health, attracting outside professionals and cultivating students' skills.
9. Attract high-quality professionals to Shanghai	Restrictions on wages and immigration should be gradually eliminated, with a market-oriented reward system to attract high-quality people.
10. Establish a venture investment system	Laws and regulations should normalize venture capital operations and management, with tax deductions, preferential loans, and risk compensation to encourage venture financing. The venture investment system comprises a venture capital market, venture capital funds, venture investment management corporations, and numerous high-technology firms.
11. Establish a venture capital market	In addition to enterprises and individuals, venture capital markets need security secondary boards and intellectual property rights exchange markets. They also need a stronger "macro market," coordinating capacities of the government.
12. Mobilize Shanghai's education sector	A highly educated labor force can be developed by increasing student intakes in universities and allowing private investment in education (reducing the fiscal burden). The market sense and managerial ability of educators should be strengthened to leverage education resources.
13. Form an innovative education system	An innovative and open education system should be established by reforming traditional exams and courses by adopting optional courses and emphasizing creativity.
14. Turn bureaucracies into learning organizations	Government departments should be instructed to act as models of learning organizations by focusing on cooperation and knowledge-sharing through good social networks.
15. Improve knowledge management in enterprises	Enterprises should acknowledge the value of their knowledge capital, setting up such incentives as stock options and estimating intellectual property as part of their value. Such intangibles as brands, trademarks, and patents, should be emphasized. And firm-based training and labor mobility should be encouraged.
16. Establish a sound income redistribution system	To ensure balanced development and social fairness, governments should build an appropriate tax system on personal income and inheritance. Also to be emphasized is education and Internet access for low-income families.
17. Establish social security system, and efficient employment retraining	Unemployed people must be retrained to meet the demands of the new economy. For a stable social security system, government should provide incentives to enterprises that create new jobs. The employment system should be gradually changed from government-led to market-led, with many more employment opportunities in small and medium-size industries.
18. Build the capacities of communities	Communities are encouraged to become the basic units of education, retraining, public health, and social welfare services. At the same time, improved information networks and connections should be built to strengthen them.
19. Design an information city	Information technology should be used for public transportation systems and other infrastructure to improve urban management.
20. Adapt city architecture	City land use should be balanced: residence and leisure, work and study, and information and transportation, combining physical and virtual spaces.

Source: Shanghai Science and Technology Committee, "Formation of Shanghai Knowledge Economy Strategies," Shanghai, 1999 (translated by World Bank staff).

BOX 10.3

China's preferential policies for the development of the western region

Increasing investment funding
- Increasing funds for infrastructure development (700–800 billion yuan).
- Increasing subsidies for agriculture, social security, education, science and technology, health, birth control, culture, and the like.
- Increasing bank loans to support large and medium projects in highway, electricity, oil, and natural gas.

Improving the investment environment
- Deepening state enterprise reform, encouraging individual and private enterprises.
- Lowering corporate income tax to 15% per year.
- Providing incentives for land and minerals resources exploitation.

Further opening up to both domestic and foreign investment
- Encouraging foreign investors to invest in all sectors including services and technology R&D centers. Promoting foreign trade, encouraging export-oriented productions, facilitating visas, and loosening controls.
- Encouraging regional cooperation with Eastern enterprises.

Attracting talents and developing science and technology and education
- Providing better work and living conditions to attract domestic and foreign talents
- Strengthening the science and technology capacity through key technologies projects, technology industrialization and military-to-civil technology transfers.
- Promoting compulsory education by increasing financial support, attracting universities of the eastern and central regions and providing subsidies for building cultural and broadcasting facilities.

Source: Western Region Development Office of the State Council, October 2000.

There must be strong monitoring and evaluation to feed the lessons back into the design and expansion of the reform programs

- Allow time for the experiments to produce effects.
- Favor success by avoiding political interference and setting up incentives for the concerned actors.
- Monitor progress and publicize the results to raise interest and to mobilize energies throughout the country.

In this nationwide effort of evaluation and experimentation, clear priorities are essential. We suggest launching well-designed evaluations and experiments for a small number of key issues. But they must not be scattered; rather there should be a coordinated approach involving policies relating to all four policy planks. Then there must be a strong monitoring and evaluation to feed the lessons from these experiences back into the design and expansion of the reform programs.

Conclusion

Caught between daunting internal challenges and a demanding external environment, China stands at a critical juncture in its development strategy. By making a concerted leap to become a knowledge-based economy, it can seize the

21st century. The recommendations here provide the rough outlines of such a strategy for overcoming some of the constraints. But they are only a starting point. They need to be expanded in detail and adapted to Chinese realities. There is also the issue of funding. The government will need to set priorities carefully and find ways to leverage its resources, those of the private sector, and those of foreign investors and international financial organizations.

China's leadership must not waiver in driving this transition or backtrack on reforms already made. There will be adversity along the way. But it will be better to face it from a position of strength, rather than to be overtaken by events. What is important is to launch a concerted and sustained effort. The slogan "Seizing the 21st Century through Knowledge" could mobilize support for all the required changes, by government and by civil society, for forging a new partnership to develop a modern, knowledge-based China for tomorrow.

The slogan "Seizing the 21st Century through Knowledge" could mobilize support for all the required changes

Notes

1. A recent publication entitled *The Knowledge-Based Economy and China's Economic Development* (China Planning Press, 2000) has begun to compile an inventory of knowledge related infrastructure and potential of a number of major Chinese cities and to outline corresponding strategies (in Chinese).

2. For information on integrated agricultural development projects in Anhui province, Qinghai province, Northeast Sichuan, and Guizhou province (Wuling Mountain), see the World Food Programme Field Operations website [http://www.wfp.org].

3. Illustrative of these is the launching of the social security initiative in Liaoning province, which would serve as a form of national test.

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