China's Emerging Innovation Trajectory: Nanotechnology and the Role of the 15 Year Medium to Long-Term S&T Plan

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Key Questions Driving this Presentation

- What are the main drivers of technological innovation in China? What are the key features of China's "national system of innovation?" What are the chief "promotion" mechanisms?
- What does China's emphasis on "independent innovation" mean domestically and in terms of its external positioning?
- Does it make sense for China to build a "national system of innovation" in a world of globalization? Has China moved beyond the so-called NIS model, and if so, is there a way to sustain a "global system of innovation"?
- How will China's participation in the global R&D system change the dynamics of China's innovation strategy and role in international knowledge creation?
- What is the role of nanotech among China's innovation priorities?
- What roles are MNCs playing in terms of drivers of innovation?

In the new, innovation-driven world of the 21st century, is China positioned to be successful?

"The pattern of the US and Europe as pioneers and China as the follower will become less and less pertinent in the future."

George Wang,
Former Director IBM China R&D Labs

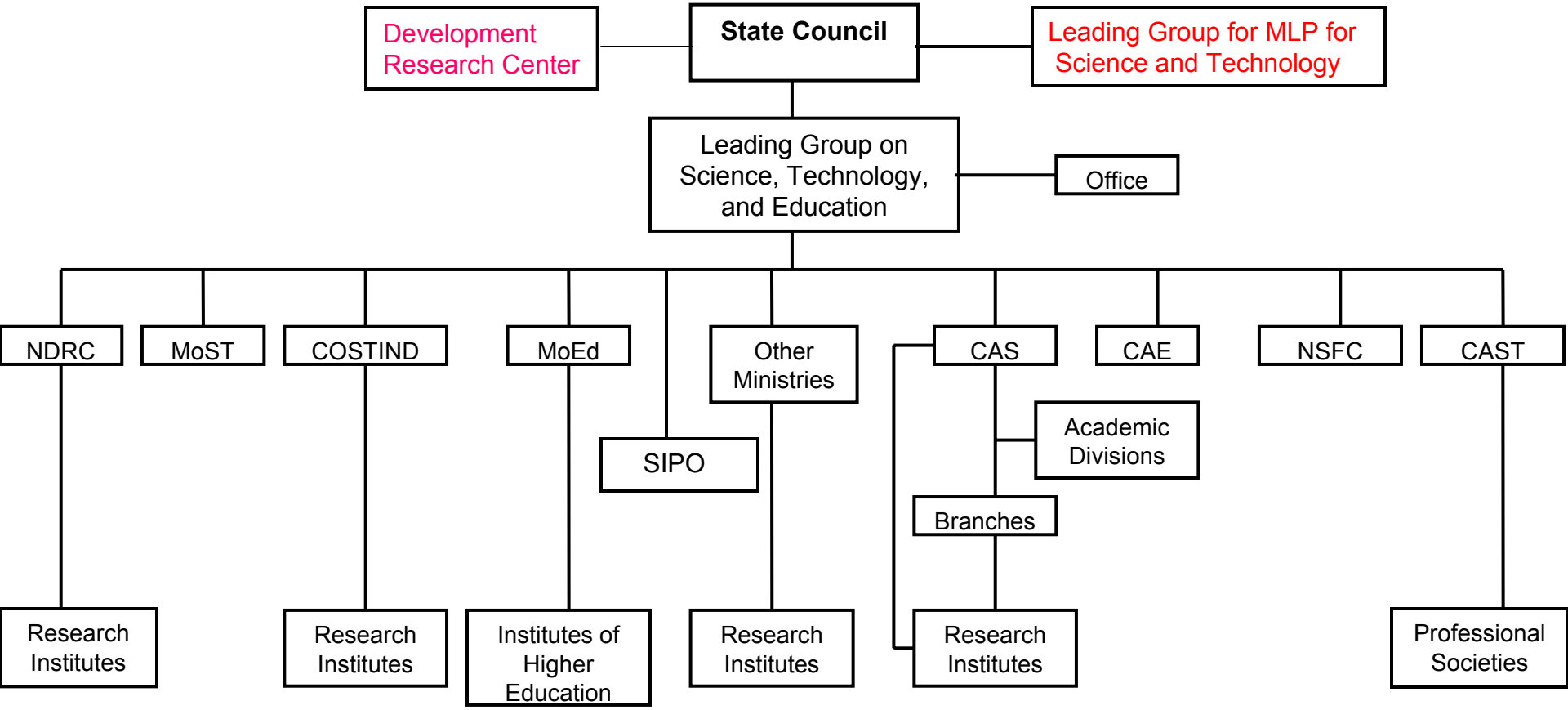
"You will have to put your best product in China in order to stay the world's leading producer"

Kurt Hellstrom
CEO, Ericisson

After more than a decade of reform, China's S&T system has started to show signs of progress

- Spending on S&T has increased significantly
- The # of scientists & engineers has grown *appreciably—though still talent shortage*
- Enrollments in higher education have expanded as has quality of programs/facilities
- Preliminary evidence of "brain drain" reversal
- IPR regime has started to show signs of improvement plus new emphasis on standards
- Venture capital starting to appear
- Steady expansion of international S&T coop
- Growing presence of foreign R&D operations

Organization of China's Science, Technology, and Education System (2006)

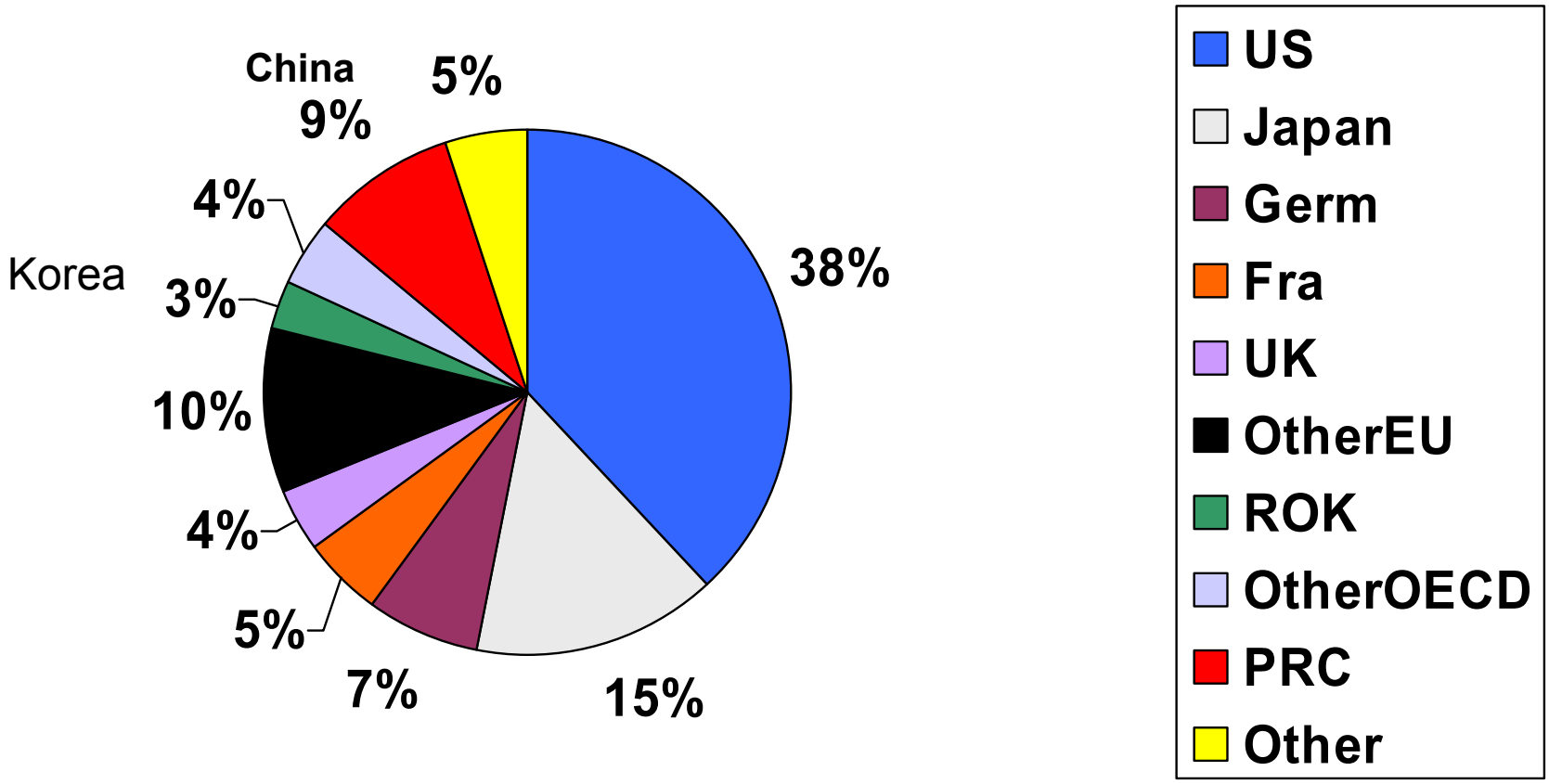


NDRC: State Development and Reform Commission; **MOST**: Ministry of Science and Technology; **MOE**: Ministry of Education; **COSTIND**: Commission of Science, Technology, and Industry for National Defense; **CAS**: Chinese Academy of Sciences; **CAE**: Chinese Academy of Engineering; **NSFC**: National Natural Science Foundation of China; **CAST**: Chinese Association for Science and Technology; **SIPO:** State Intellectual Property Office.

Note: Not included here are research institutes of enterprises and at the provincial levels.

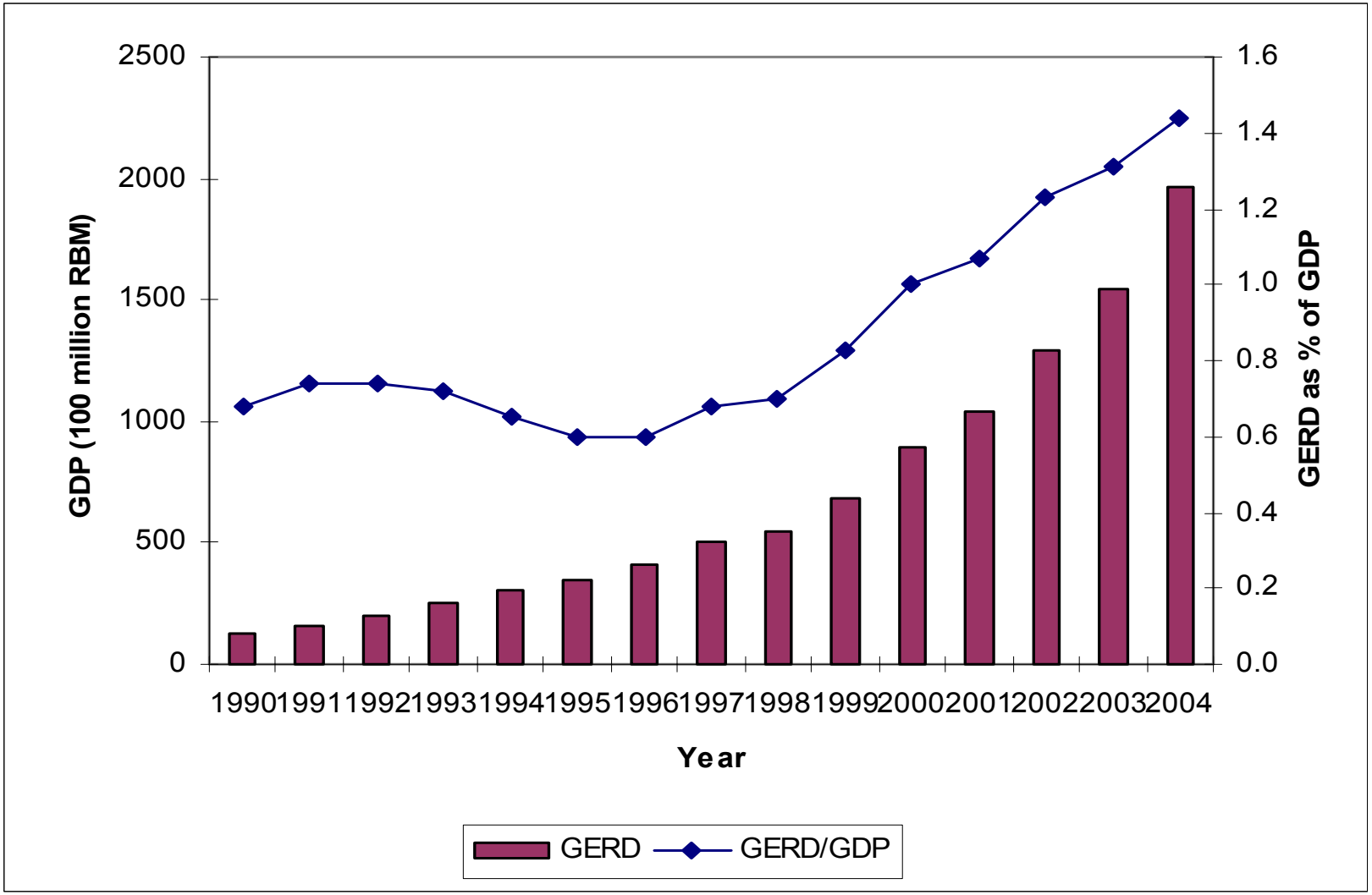
Global R&D Spending: China Moves to #3…and perhaps #2 according to OECD (2007)

Total World R&D = US$764 billion in 2003 and over US$1.0 trillion by beginning of 2007



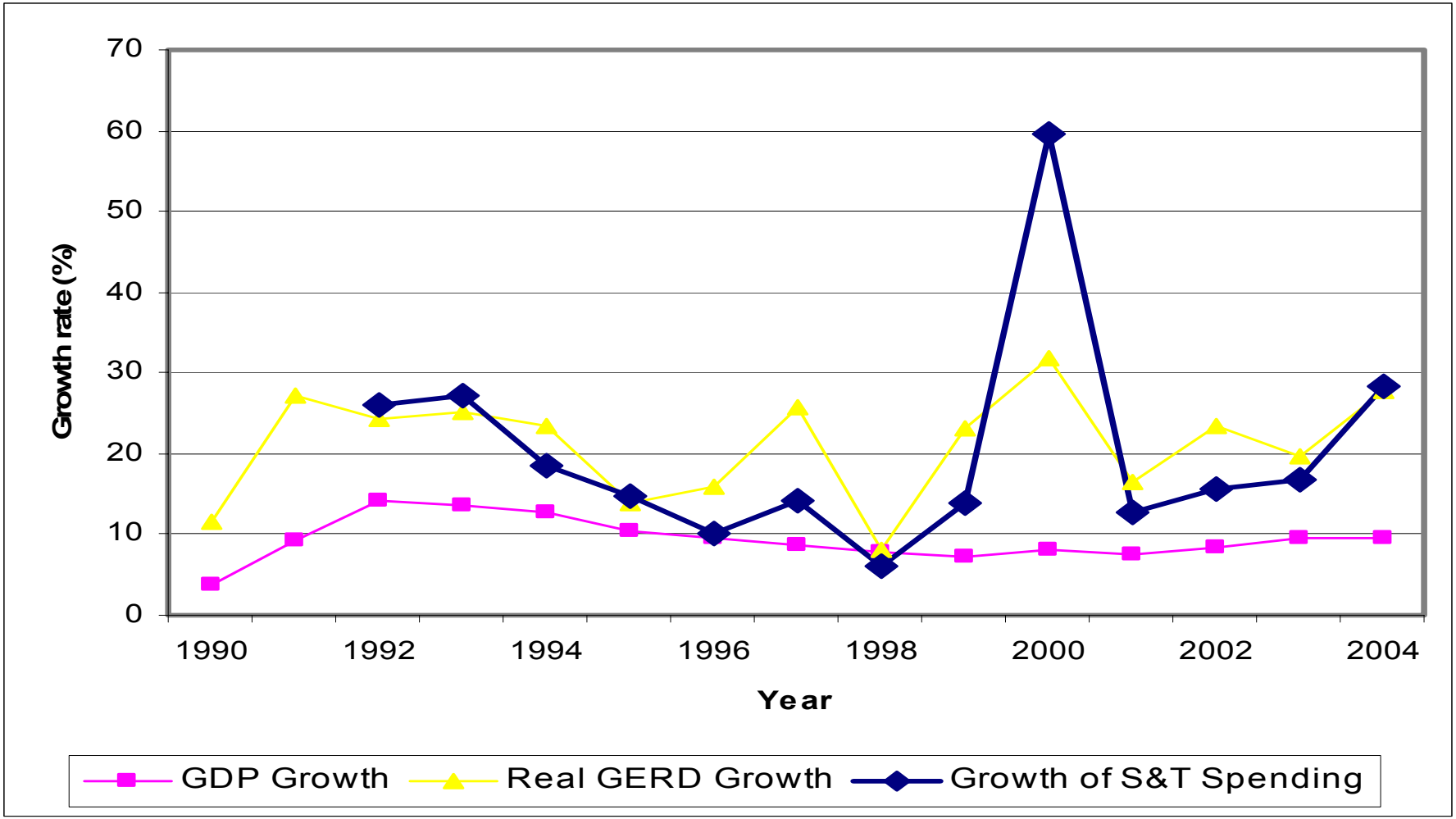
Source: AAAS, Washington DC, 2005 (numbers adjusted for purchasing power)

Growth of GERD…goal is to reach 2.5% of GDP by 2020



Growth of GDP vs. GERD, S&T Spending

Since 1990, S&T spending has been growing twice as fast as the overall economy

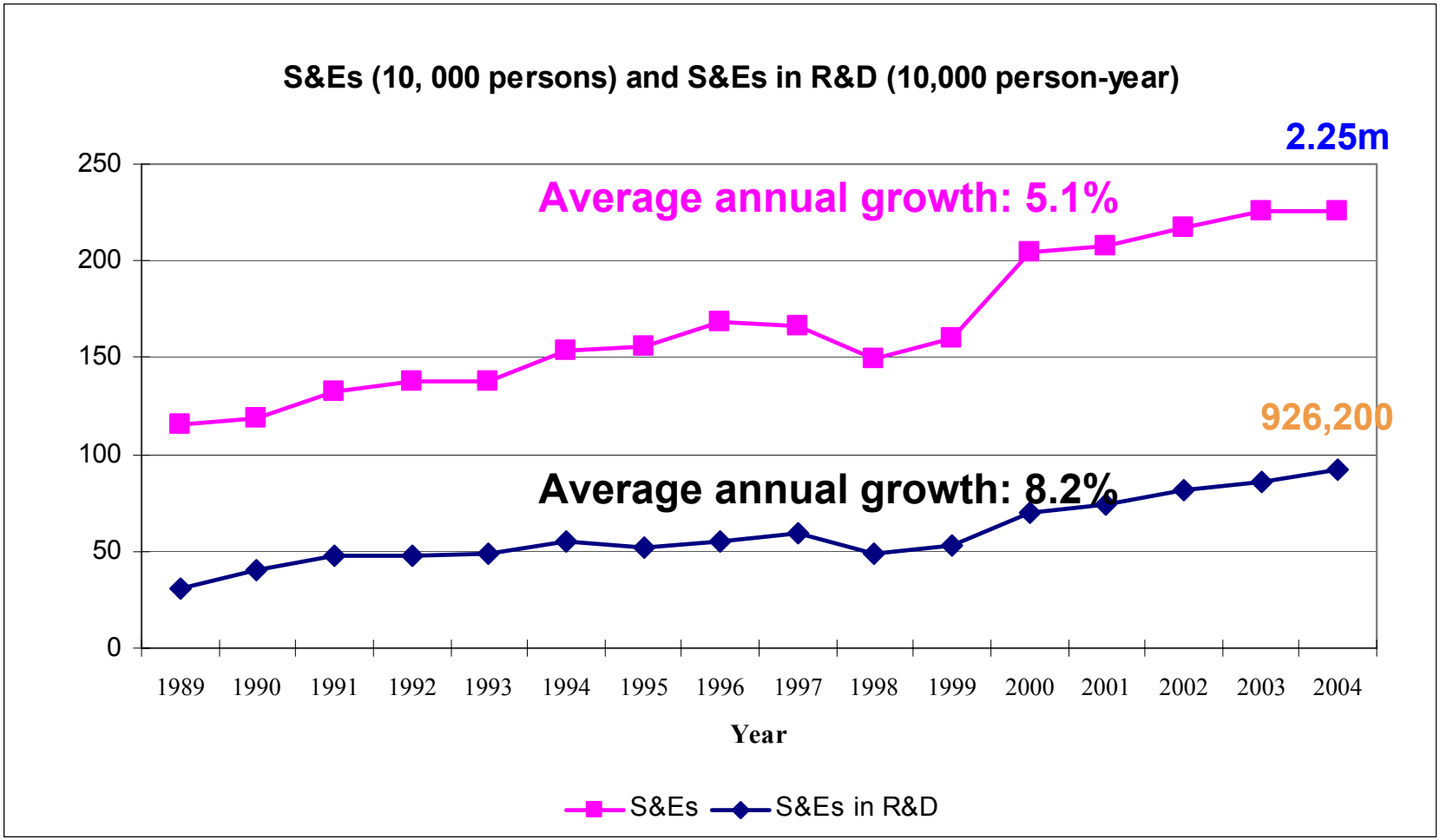


The Role of Talent

“Today, the heightened international competition boils down to a competition for human resources.”

HU Jintao, General Sec
of the CCP at the
1st CCP Conference on
“Creating a More Skilled
Professional Work Force”
Beijing, Dec, 2003

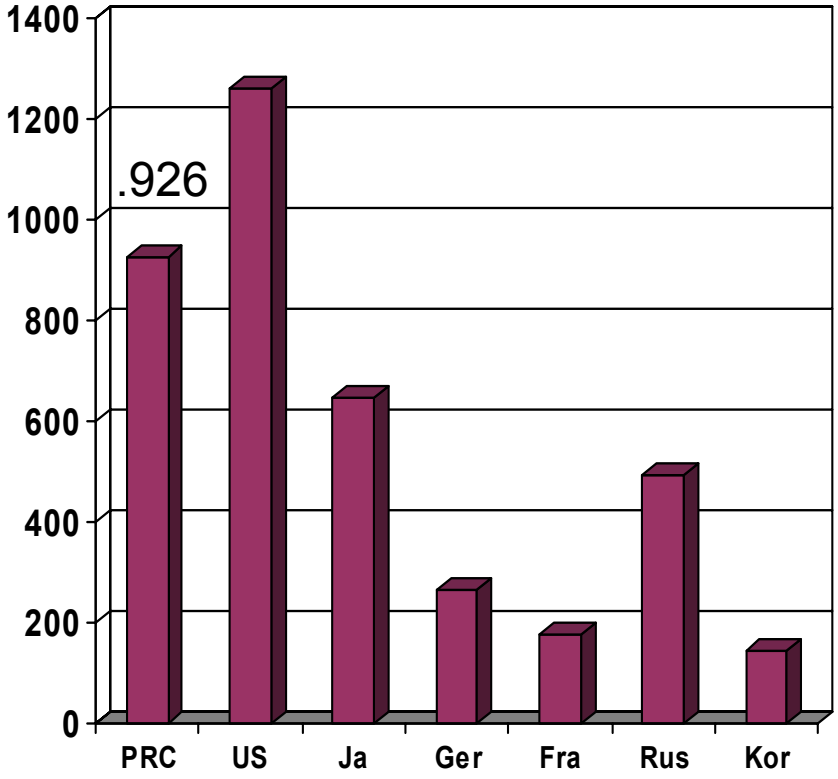
China's Growing S&E Talent Pool



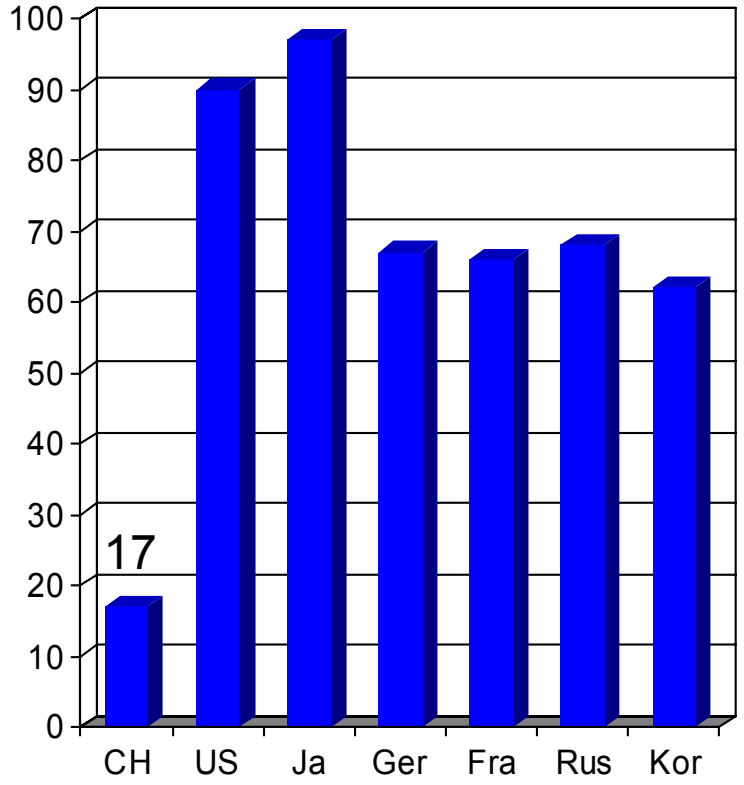
China Talent Pool in Global Perspective

(China – 2004; other countries – most recent available year)

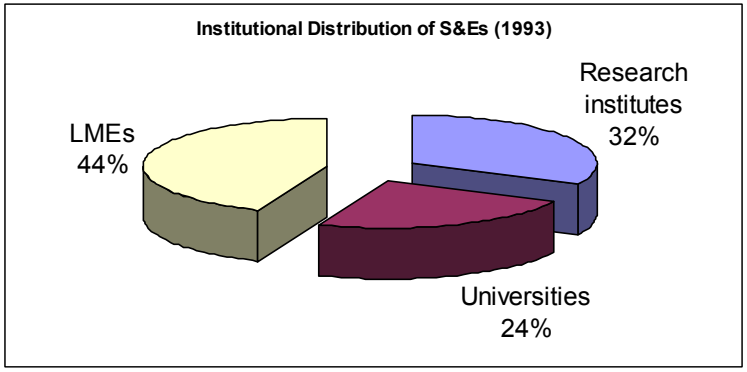
S&Es in R&D (1,000 person-year)

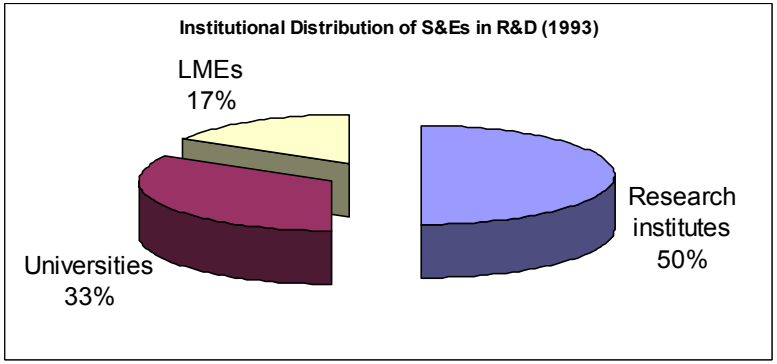


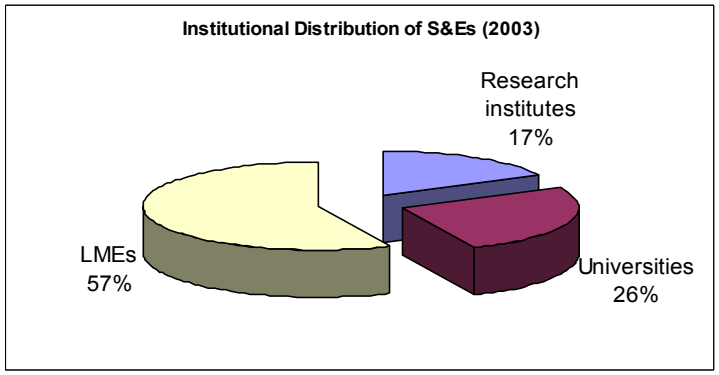
S&Es in R&D per 10,000 labor force

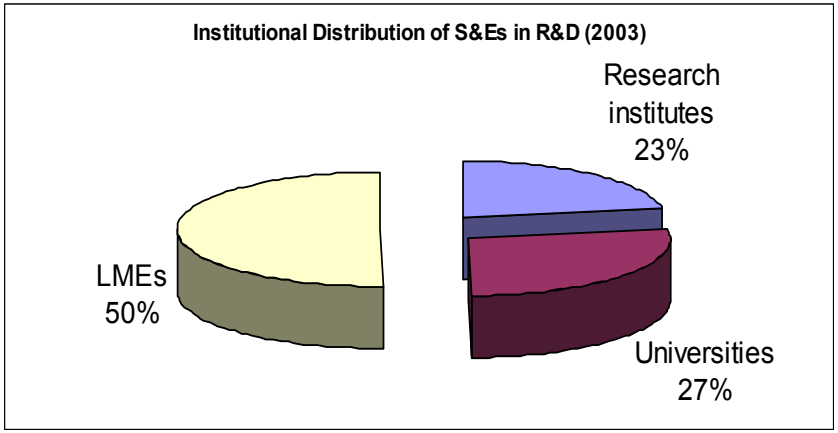


Institutional Distribution of S&Es: Increased focus on industry---talent + R&D spending

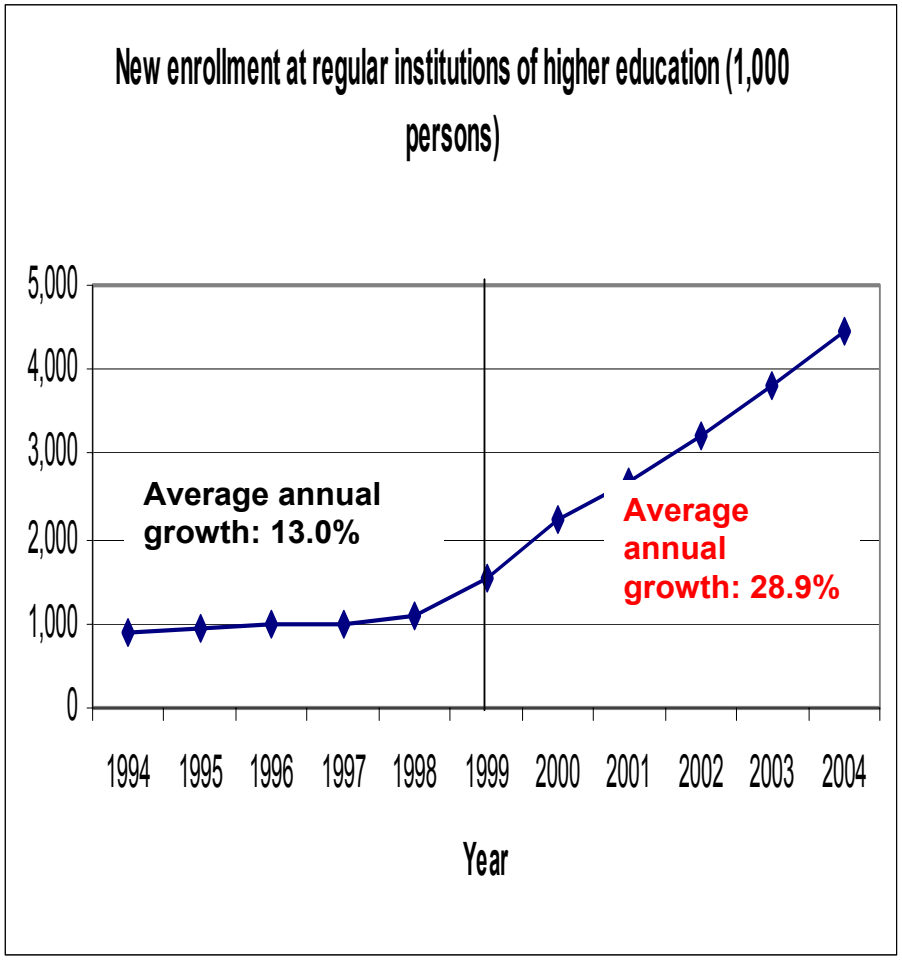


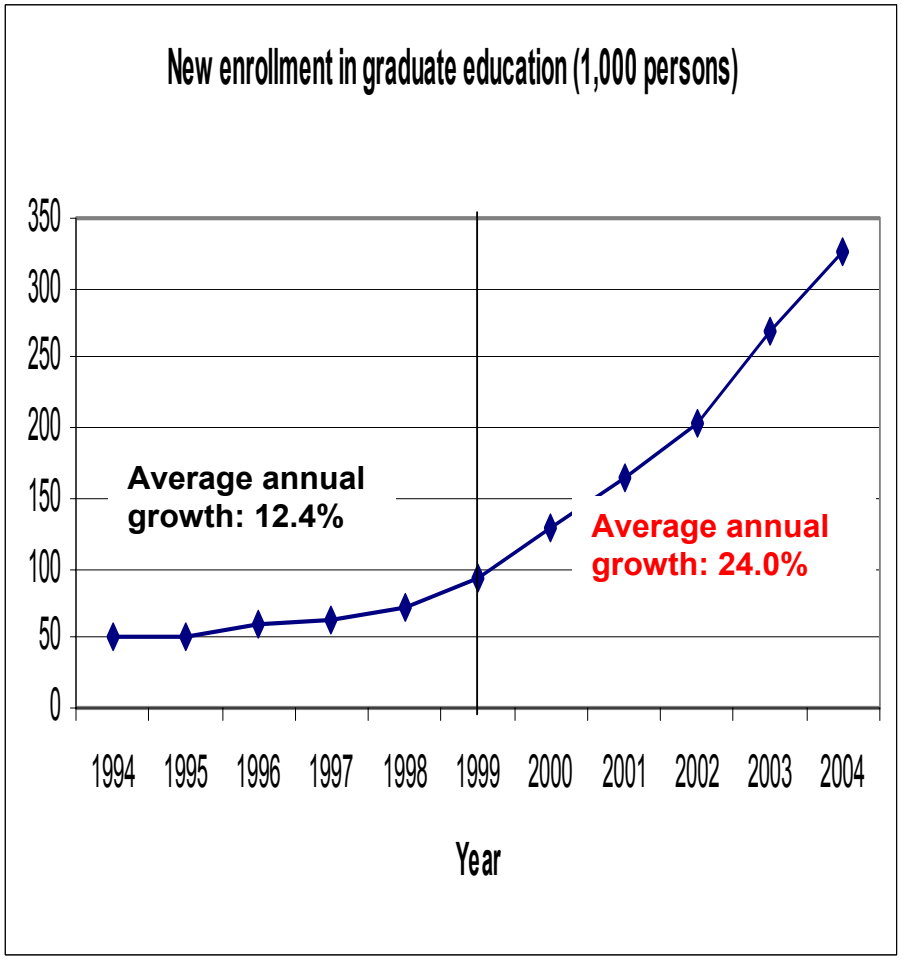




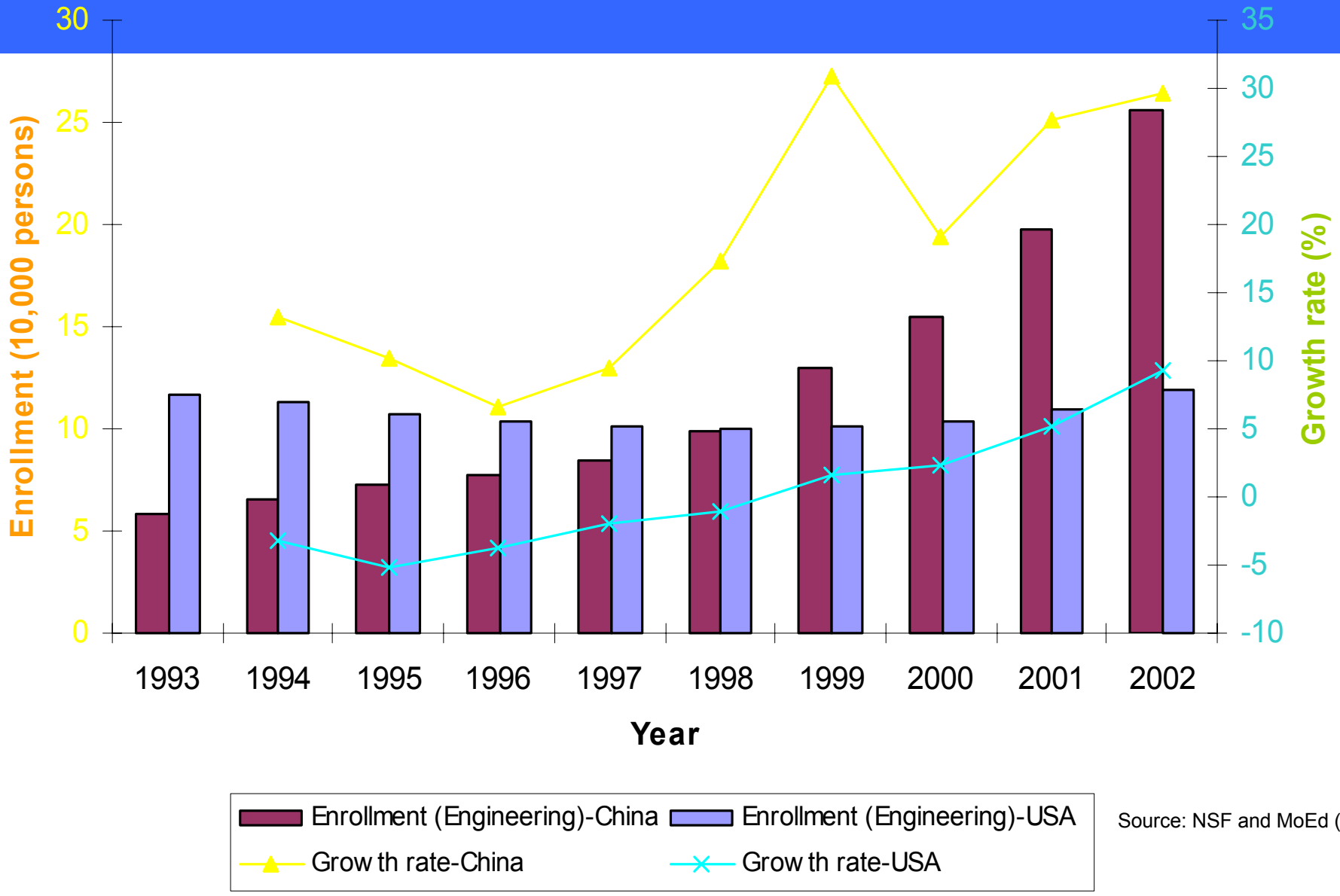


The Supply-Side of the Talent Pool



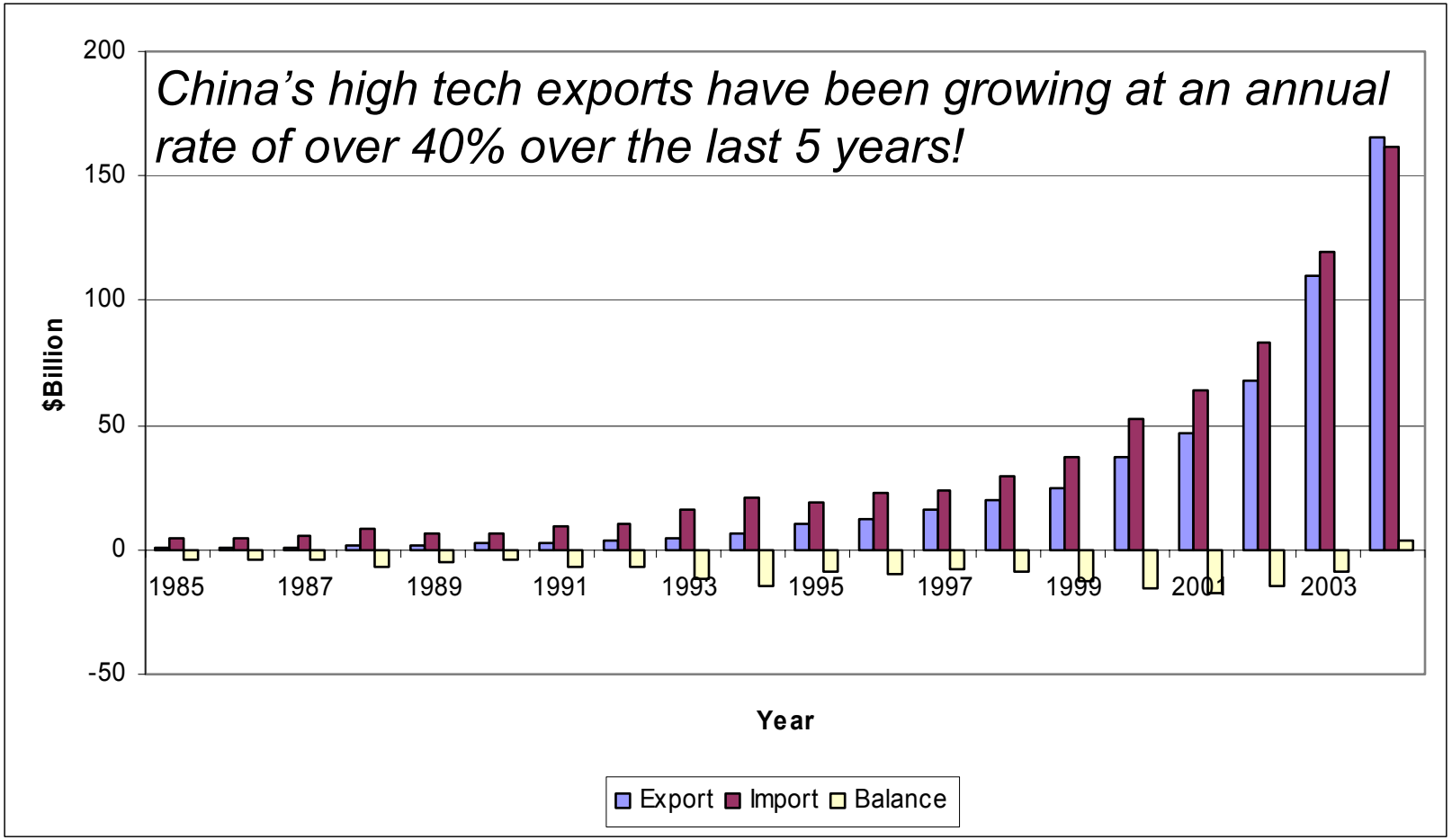


US and China Graduate Enrollment in Engineering



Source: NSF and MoEd (PRC)

High Tech Trade Growth—who controls most of the IPR?



High Tech Industry: How Advanced?

Sector	Gross output (Billion RMB)	%
Information chemicals	18.6	0.7
Pharmaceuticals	339.7	12.5
Aerospace and aeronautics	63.4	2.4
Electronic and communications equipments	1345.8	49.5
Computers and office equipments	832.6	30.6
Medical equipment and instruments	114	4.2
Others	3.8	0.1

China Statistical Yearbook, Beijing, 2005 (data is for 2004).

China's Emerging Innovation Trajectory: Reality or Exaggeration?

"Over the next 10 years, China will become 'a ferociously formidable competitor' for companies that run the entire length of the technological food chain."

Michael Moritz, Senior Partner
Sequoia Capital

"China is destined to become a science and tech superpower. It wont happen in 2005 or even 2010. But, …..China's sheer size, the will, the economic growth, and the openness to being part of the world…says that they have a greater opportunity than ever before."

Gordon Astles, President-Asian Operations
Cisco Systems

Changing Drivers of PRC Growth

Low Cost Labor Drives Growth

1985

Low Cost Capital Drives Growth

1995

Low Cost IP Drives Growth

2005+

Source: DeWoskin and Stevenson, April 2005.

The Origin of the New Emphasis on Innovation

"A breakthrough has been made in science & technology around the globe. Modern science characterized by information and life science is advancing by leaps and bounds. We are confronted with rare development opportunities and grave challenges. Under the circumstance of multi-polarization and economic globalization, China must accelerate scientific progress and innovation."

Jiang Zemin
June 7, 2000

From Self-Reliance to Independent Innovation: Changing the Innovation Equation!

- Chinese S&T policy has become focused on a new strategy—"independent innovation"
- Core priority within current 11th Five Year Plan
- The drivers behind this new focus derive from several considerations: *growing concerns about economic model* +
  - Growing perception of global tech protectionism
  - Growing pressures from global competition, e.g. textiles
  - Growing concerns about revenue loss/high fees, e.g. DVDs
  - Growing concerns about loss of political leverage
  - Growing concerns re: internal economic structure, esp role of enterprises versus government in driving innovation
  - Growing national security concerns
- Clarity of *meaning—indigenous, endogenous, home grown, autonomous, self reliance, independent*…..what is the real strategic intent?

Hu Jintao on “independent innovation”

“Independent innovative capability (zizhu chuangxin) is the core of national competitiveness. A nation should underscore independent innovation provided it wants to succeed in development and benefiting the world. China should do more to advocate the spirit of independent innovation, improve its mechanism for such innovation and its capability for original innovation, and innovation through integration or learning from imported technology.”

Hu Jintao
November 26, 2005

The Debate over "Independent Innovation"

"The economics community and the scientific and technological community have not reached a common understanding on whether we should take improving our ability to make independent scientific & technological innovations as the central link in the strengthening of the country's competitiveness. Some mainstream economists maintain that the cost of doing R&D is higher in China than in foreign countries; technology, like capital, can flow, and we can import the key technologies we need. …they lack sufficient understanding of the fact that during the coming 15-20 years at least will provide a rare opportunity for China to acquire a good command of the core and key information technologies through independent innovation. They probably do not realize that if we fail to make independent innovations now, we wont have the opportunity to make breakthroughs in information technology in 15 years even if we have sufficient financial resources then."

Prof. LI Guojie, CAS
Developer of Dawning Supercomputer

Core Elements of "Independent Innovation"

- China's 11th FYP gives specific emphasis to the strategic role of independent innovation. Success will be achieved through emphasis on five initiatives:
  - Accelerating establishment of a technological innovation system that takes the enterprise as the mainstay and market as the guide…and features the integration of production, emulation and research
  - Improving the market environment for technological innovation
  - Implementing policies related to finance, tax, banking and govt procurement
  - Making proper use of global resources of S&T
  - Strengthening protection of IPR
- The overall goals are to improve a) primary innovative ability; b) integrated innovative ability; and c) re-innnovative abilities for introduction, assimilation and digestion of technology

Source: The Communist Party of China, Central Committee Proposal on the Formulation of the 11th FYP (2006-2010) for National Economic and Social Development, 2005.

Medium & Long-term S&T Development Plan, 2005-2006: Major Strategic Priorities

- Eight (8) target areas designated: equipment manuf, IT, agric, energy/environment, healthcare, defense S&T, talent, and scientific research
- Five (5) major strategic priorities:
  - Development of energy resources and protection of the environment
  - Controlling IPR, esp. regarding core IPR linked to equipment manufacturing, information technology, & new materials
  - Make biotechnology a priority to keep pace with future global trends (food, food safety, disease control, & manuf of new drugs)
  - Speed up development of space & maritime technologies
  - Tighten up basic research and cutting edge technologies
- These 5 priorities are tied into 16 major projects—means to jump start, expedite and build momentum
- Strong emphasis on mega-projects reflects little deviation from "old style" S&T planning of the 1950s (*liangdan yixing*)

Wen Jiabo, "Speech at the National Science and Technology Conference," January 9, 2006, Beijing.

Areas & Programs Identified in China's MLP

Key areas	**Mega engineering programs** (*)
Energy	Core electronic components, high-end generic chips, and basic software
Water and mineral resources	Extra large scale IC manufacturing and technique
Environment	New generation broadband wireless mobile telecommunication
Agriculture	Advanced numeric controlled machinery and basic manufacturing technology
Manufacturing	Large-scale oil and gas exploration
Transportation	Large advanced nuclear reactor
IT industry and modern services	Water pollution control and treatment
Population and health	Genetically modified organism new variety breeding
Urbanization and urban development	Drug innovation and development
Public securities	AIDS, virus hepatitis, and other major diseases control and treatment
National defense	Large aircrafts
	High definition observation system
	Manned aerospace and moon exploration
Frontier technology	**Mega science programs**
Biotechnology	Protein science
Information	Quantum research
New materials	**Nanotechnology**
Advanced manufacturing	Development and reproductive biology
Advanced energy	
Ocean	
Laser	
Aerospace and aeronautics	

Source: State Council, *Nation's Medium to Long Term Plan for the Development of Science and Technology*.
(*) The MLP only identifies 13 mega engineering programs.

Implementation Facilitators…tightening up the system and improving performance

- Promote reform of the S&T system: establish a new system where *enterprises (LMEs & SMEs)* are the players, the market is the guide, and academia/enterprises/research units all coordinate together
- Role of government is to create appropriate policy supports and institutional environment
  - Tax and financial policies --industrial policies
  - Policies for hi-tech zones --IPR protection policy
- Increase overall investments in S&T—starting with 11th FYP
  - Support more basic & cutting edge research; IPR
  - Tighten up supervision over the use of budgets-avoid bias
- Build stronger S&T talent pool + overseas recruitment
  - Develop a culture that values innovation & creativity
  - Tolerance for failure and taking risk

Wen Jiabao, "Speech at the National Science and Technology Conference," January 9, 2006, Beijing.

Impediments to "Independent Innovation"

- *"Feeding off Others"*—lack of homegrown core and key technologies, e.g. ¾ of patents granted in China are to foreigners and total # of patents registered by top 10 Chinese IT firms over last five years equals the # registered by IBM in one year
- *"Break in the Chain"*—over-emphasis on the "small, but inclusive" approach to innovation (doing everything by yourself)—not a question of money, but a question of how SMEs and larger firms collaborate or work together in clusters
- *"Financing System Requires Reform"*—monies go to older SOEs and do not make their way to new, more dynamic non-state firms
- *"Unfair Playing Field"*—foreign firms get preferential treatment as well as SOEs over non-state firms—monies need to be allocated on performance basis rather than ownership
- "*Emphasis on Quick Success and Instant Benefits*"—firms are unwilling to invest in longer term results and sustainable brand building as they search for immediate profits through low cost

Underlying Issues Confronting Innovation Possibilities under the MLP

- Is a strategy seemingly derived from the experience of the 1950s (*liangdan yixing*) relevant to the 21st century environment?
- Are mega-projects embodied in the MLP the way to go in terms of optimal investment allocation?
  - Guihua vs. Jihua
- Will more funding mean improved performance?
- Role of MoST: 2004-05 criticisms
- Future Role of CAS (KIP project) and Universities
- Governance and accountability questions, e.g. MoST $$ allocations
- Emerging evidence of fraud and scandal: corruption
- Is the prevailing political culture conducive to creating a "culture of creativity?"
- How risk tolerant is the system? Failure?
- Nonetheless…there are many bright spots……impact of returnees!

Table 5.3
Ten Technologies Where China Is Most Likely to Achieve Major Breakthroughs in the Next Ten Years

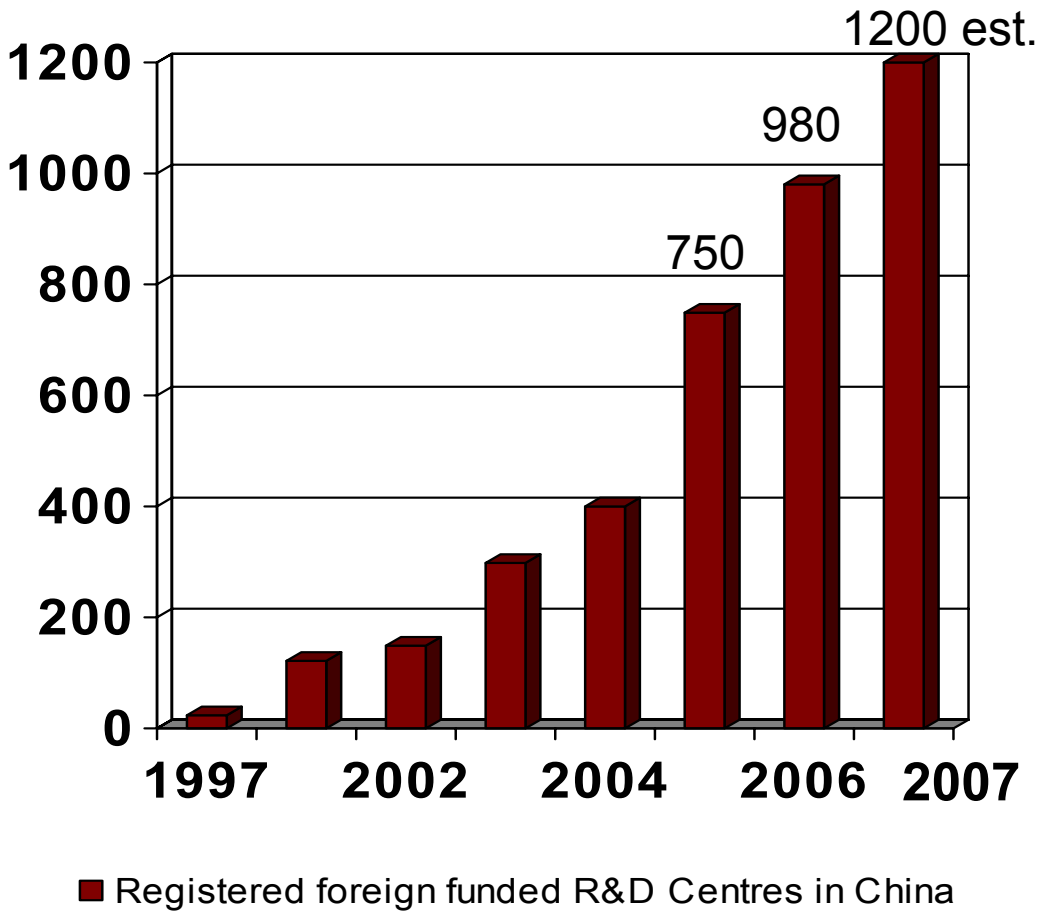
Field		Technology
Information and telecommunication	1.	Next-generation mobile telecommunication (beyond 3G/ultrawide band)
	2.	Next-generation networks
	3.	Nanometer chips (targeting 12" 90/65nm chip technology)
	4.	Chinese information processing
Life sciences and biotechnology	5.	Functional genomics
	6.	Medical biotechnology
	7.	Bioinformatics
	8.	Functional proteomics
	9.	Technology for breeding new trans-gene farm crops
New materials	10.	Nanomaterials and nanotechnologies

Source: Rand Corporation, "Strategic Choices in Science and Technology: Korea in an Era of a Rising China," 2005

China's Nanotech Initiatives

- In 2001, Chinese government created the National Nanotech Development Program—by Dec 2004—R&D investment totaled RMB830 million
- NSFC actually began funding nano projects in the mid-1980s, with big push coming starting in 2000
  - *973 Program: RMB80.0 million for basic research*
  - *863 Program: Nanomaterials & MEMS (RMB170m + RMB200m)*
  - *CAS "KIP": Carbon nanotubes & nanomaterials (RMB58.5m)*
  - *Key Tech Program: Nanomaterials (RMB60m)*
  - *Torch Program: 4 major projects (RMB80m)*
  - *15 Yr MLP: part of mega-projects—big investment*
- Approximately 800 enterprises are involved with nanotech in China, with 100+ having "nano" in their registered names
- Budget for 2006-2010 in RMB2.0 billion from Beijing and RMB2-3 billion from local government: PRC investment, however, is est. only about 5-10% of the US investment

The number of R&D centers established by foreign companies in China has witnessed a dramatic increase over the last 4 years—reaching 980 by end of 2006



- MNC R&D centers are expanding focus from only the Chinese market to global markets
- Foreign companies have changed their core strategy in China. They now are bringing world class technology rather than simply 'tweaking' existing products for local market.
- At end of 2006, India had 150+ foreign R&D units.

Whither China as Innovator?

- China has taken a new strategic step in focusing on “independent innovation” as the driving force underlying its economic strategy and focus
- Global competition, transplanted into the Chinese market, will mean MNCs will continue to bring advanced know-how and related activities to China as part of their strategic positioning
- While the China lags behind the West in most areas of innovative capability, as a preferred site for R&D-FDI, it is now strongly embedded in global knowledge system
- “Ownership” issue re: innovation, may be a short term “political” problem or concern, but eventual labor circulation means currently MNC-employed local talent will become part of a projected upsurge in domestic technological entrepreneurship
- As China becomes more integrated into fabric of global R&D activities, it will gradually, but steadily command and demand a greater share of the associated revenue streams…
- Sensitivities over technology sharing and IPR issues will continue to drive Chinese government behavior in terms of efforts to strengthen the competitiveness of its domestic players

Whither China (continued)

- The largest unknowns regarding China's innovation trajectory remain on the "software" side not the hardware or technology side of the equation
  - Skills and comfort levels re: managing technology in a fluid, fast changing environment
  - Skills and comfort levels re: managing collaboration across borders
  - Uneasiness with working outside of guanxi networks as well as ethnic networks
  - Ability to stimulate creativity in an environment where petty jealousies and ad hoc interventions often occur
  - Ability to develop/educate managers who are flexible, adaptive, problem-solvers with a capacity for critical analysis and thinking across disciplines: where in the system does this happen?
  - Ability to adopt "open systems approach to innovation and reduce baggage of "techno-nationalism"—e.g. tech standards
  - Ability to grow a leadership contingency with the global outlook needed to compete effectively in China's increasingly open economy