



# **The Changing Roles of Universities in China's National Innovation System**

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# Outline

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- I. Motivation
- II. The starting point
- III. The first wave of reform
- IV. The second wave of reform
- V. lessons learned and future issues

# I.Motivation

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- The key that determines the performance of a knowledge economy is the innovative capability that is embeded in a national innovation system;
- Capabilities exist in two ways:
  - Strong organizations: enterprises, universities, public research institutes and etc;
  - Unique institution arrangements: including linkages and mechanisms such as joint research, personnel exchanges, cross-patenting, contract research, licensing;
- The roles of universities
  - Knowledge creation: basic and applied research
  - Knowledge diffusion: training S&T talents
  - Knowledge application: service to economic development
  - Platforms for knowledge-intensive activities

# The “traditional-academic” model

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- University's role=>disseminating knowledge through teaching; and generating knowledge through basic research
  - Arrow (1962) and Nelson (1959):
    - Profit-seeking firms will under-invest in basic R&D and there is a need for public support of basic R&D in universities and public research institutes;
  - Merton (1973), Dasgupta and David (1994) etc:
    - Institutional designs of universities are for the production of scientific knowledge;
    - Institutional designs of industrial firms are for the production of technological knowledge.

# The “Triple Helix-entrepreneurial” model

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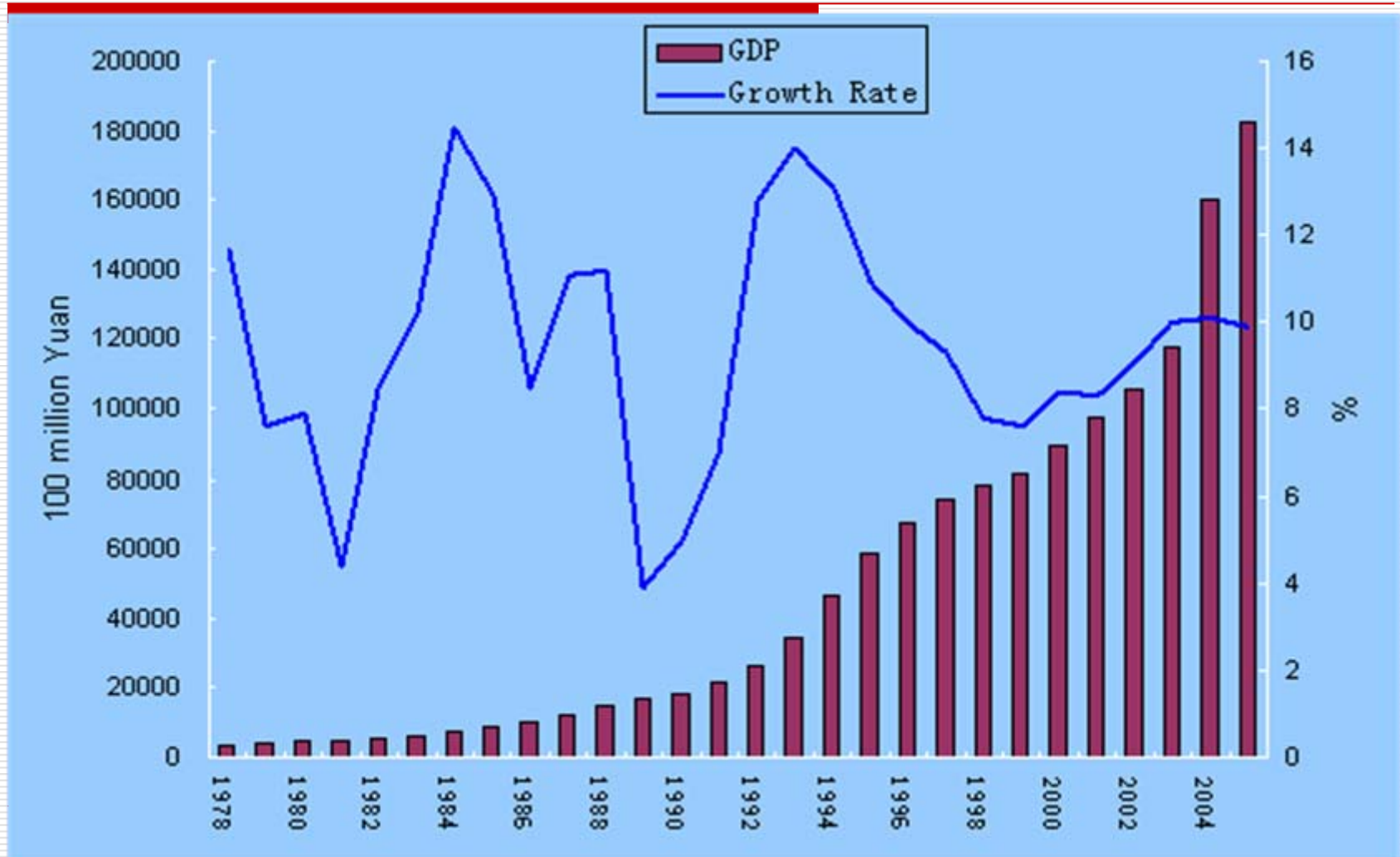
- Rosenberg (1982), Rosenberg and Nelson (1994)
  - Differentiating between Scientific and technological knowledge is impossible and there are two way linkages between production of scientific and technological knowledge;
- Mowery (1983), Pavitt (1987), and Cohen and Levinthal (1990)
  - transferring and utilizing scientific knowledge is itself a costly and knowledge intensive process. This process is heavily influenced by the networks and coordinating mechanisms in an innovation system;
- Etzkowitz (1990), Etzkowitz and Loet (2000)
  - Entrepreneurial universities can play enhanced roles in innovation that contributes knowledge-based economy;
  - The dynamic evolution of relationships among the institutional spheres of university, industry, and government can help to generate alternative strategies for economic growth and social transformation.

# The case of China: Major changes in two decades

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- Economic system:
  - Central planning=>market-based;
  - Sustained high growth (see graph)
- Industrial structure:
  - Agriculture + Manufacturing=> high-tech and service industries
- Society:
  - Rural=>Urban (urban population: 1982: 20.6% => 2005: 43%)
  - Closed=>Open (overseas travel 1998=8.43million => 2004=28.85 million)
- Governance
  - Personal charisma and authority=>broad participation and rule of law

# Economic growth (1978-2005)



# The case of China: wide range of experiments

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- Reforms and experiments in universities
  - Reform of the innovation system;
  - Reform and expansion of higher education system;
  - A full cycle of changes with wide range of institutional experiments
    - From traditional to entrepreneurial in the 1980-1990s
    - From the “radical entrepreneurial” to the “moderate entrepreneurial” in the 2000s
      - Licensing, spin-offs, technology alliances and etc.;
      - University-run enterprises
- Learning from the process and developing visions for the future.

## II. The Starting point: Chinese universities prior to the reform (1949-1985)

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- The first structural change(1949-1955):
    - 65 private universities=>public universities;
    - 227 universities were restructured into 181 universities:
      - Comprehensive universities;
      - Polytechnic universities (and specialized technical institutes);
      - Normal universities; medical universities; and others.....
    - Administrated by Ministry of Higher Education, Industrial Ministries, and Provincial or Municipal governments.
  - Major expansions afterwards (1950-1979)
  - Reform and openness (1979-1985)
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# Universities in the national innovation system:

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- 1949-early 1980s--Establishment of a centralized system based on the Russian model: Separation of functions and mission orientation;
    - human resources=>universities & technical colleges;
    - basic research=>Chinese Academy of Sciences (CAS);
    - applied research=>ministerial/provincial Research Institutes
    - development=>in house services in enterprises.
  - Assessments
    - Great achievements in selected missions (e.g. in defense);
    - Weak linkage to economic development.
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# III. The first wave of reform: from traditional to entrepreneurial

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- The innovation system reform in 1980s
    - Opening up in the coastal areas and FDI, and the growth of township enterprises=> Market demand for S&T;
    - Success in agricultural reform led to reforms in other areas;=>impetus for reform;
  - The reform strategy
    - Creating Incentive regime for R&D organizations to serve for the economic development.
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- Policy decree in 1985 by the Central Government with the reform measures:
    - Gradual funding cuts to all research institutes;
    - new R&D funding from competitive projects
    - establishment of horizontal linkages
    - creation of technology markets
    - new approaches to the management of research organizations
    - incentive for S&T personnel to “jump into the sea (becoming entrepreneurs)”;
    - sending out visiting scholars and relaxing policies for overseas studies.
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□ Starting new S&T initiatives:

- Torch program (aimed at tech. diffusion in agriculture);
- 863 program (aimed at high-tech sectors)
- National Natural Science Foundation;
- Key bottleneck projects;

□ Creating platforms for high-tech enterprises:

- Establishing 53 new and high-tech development zones at the national level, and many more at the local level;
  - Establishing over 40 economic and technical zones to attract foreign high-tech FDIs;
  - The formation of high-tech enterprises based in public research institutes;
  - High-tech incubators development.
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# The outcome: Changing pattern of R&D spending

<u>Year</u>	<u>1986 (%)</u>	<u>1997 (%)</u>	<u>2001 (%)</u>
<u>Organization</u>			
business	<b>35.3</b>	<b>42.9</b>	<b>60.4</b>
Research Institutes	<b>60.7</b>	<b>42.9</b>	<b>27.7</b>
Universities	<b>4.0</b>	<b>12.1</b>	<b>9.8</b>
Other	<b>0</b>	<b>2.1</b>	<b>2.1</b>

## The outcome: Characteristics of R&D Work in Chinese R&D Organizations (2001, %)

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R&D work Organization	Basic research	Applied Research	Development
Business	0.25	6.6	93.1
Research Institutes	11.6	27.7	60.6
Universities	18.6	55.3	26.2

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# Impacts of the reforms on universities

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- Focus shifted from teaching to research
    - Funding opportunities through competitions
  - Developed close ties with the industry through various means:
    - Opportunities due to weak industrial R&D capabilities;
    - Financial need due to funding shortage;
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- Forms of ties with industry:
    - Technology service (through contracts with Ind.)
      - Close to 80% of R&D spending by universities are non-basic;
    - University patenting
      - Close to 1/3 of domestic patents were granted to universities
    - University-based science parks:
      - about 40 parks nationwide;
  - Jumped into the “sea” due to low entry barrier and policy encouragement-running enterprises
    - Difficulties to transfer technology to the industry;
    - Policy encouragement
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# University-run enterprises: a special case

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- University-run enterprises:
    - Companies totally owned by universities;
    - Shareholding companies in which universities have shares;
    - Companies started with university money but now have fuzzy ownership.
  - There were 5451 of UREs in 2000 in China.
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# Growth of university-affiliated enterprises

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- Early 1980s-1990==initial development: university-run factory, technology service companies, and JV (1989=470 million yuan);
  - 1991-2000==rapid growth: expansion and getting on the stock markets (see tables below)
  - 2001-current==Reflection and adjustment: doubts about university-affiliated enterprises and new policy initiatives
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# Growth of university-affiliated enterprises (1997-2000, billion Y.)

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<b>Year</b>	<b>Sales</b>	<b>Profit</b>	<b>Income to University</b>
<b>1997</b>	<b>29.55</b>	<b>2.72</b>	<b>1.58</b>
<b>1998</b>	<b>31.56(6.8)</b>	<b>2.59(-5.6)</b>	<b>1.50(-5.1)</b>
<b>1999</b>	<b>37.90(20.1)</b>	<b>3.05(18.0)</b>	<b>1.59(6.0)</b>
<b>2000</b>	<b>48.46(27.9)</b>	<b>4.56(49.5)</b>	

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# Growth of University-affiliated S&T enterprises (1997-2000)

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<b>Year</b>	<b>Sales</b>	<b>Profit</b>	<b>Income to university</b>
<b>1997</b>	<b>18.49</b>	<b>1.82</b>	<b>0.68</b>
<b>1998</b>	<b>21.50(16.3)</b>	<b>1.77(-2.7)</b>	<b>0.66(-3.8)</b>
<b>1999</b>	<b>26.73(24.3)</b>	<b>2.16(21.8)</b>	<b>1.39((111.6)</b>
<b>2000</b>	<b>36.81(37.7)</b>	<b>3.54(64.3)</b>	

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# Characteristics of university-affiliated enterprises

<b>Enterprise Characteristics</b>		<b># of enterprise</b>	<b>Total Income</b>	<b>Total Profit</b>
<b>Business Orientation</b>	<b>Production</b>	<b>1995</b>	<b>28.61</b>	<b>2.66</b>
	<b>Trade</b>	<b>849</b>	<b>4.35</b>	<b>0.24</b>
	<b>Others</b>	<b>2607</b>	<b>15.50</b>	<b>1.66</b>
<b>Ownership Structure</b>	<b>university</b>	<b>4793</b>	<b>32.18</b>	<b>2.51</b>
	<b>JV with D. partners</b>	<b>556</b>	<b>14.37</b>	<b>1.81</b>
	<b>JV with F. partners</b>	<b>102</b>	<b>1.90</b>	<b>0.24</b>
<b>Level of Management Control</b>	<b>University</b>	<b>4217</b>	<b>45.53</b>	<b>4.38</b>
	<b>School, Department</b>	<b>1234</b>	<b>2.93</b>	<b>0.18</b>

# Characteristics of universities with strong enterprises

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- Highly concentrated in selected universities (see tables below)
    - Sales of top 10 universities=55% of total
    - Elite universities with engineering background;
    - Prestigious comprehensive universities;
    - Universities with special niche;
    - In major cities (Beijing, Shanghai, etc)
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# Characteristics of uni.(1-10)

Name	Sales	Class.	Ranking	Location
Beida	11006.71	Com.	1	Beijing
Tsinghua	6287.89	Engr.	1	Beijing
Shanghai Jiaotong	1728.72	Engr.	7	Shanghai
Haerbin Polytechnic	1654.20	Engr.	11	Haerbin
Northeast	1324.84	Engr.	30	Shenyang
Petroleum	1239.74	Engr.	52	Beijing
Nankai	1200.06	Com.	8	Tianjin
Fudan	1157.02	Com.	3	Shanghai
Xian Jiaotong	1128.05	Engr.	6	Xian
Zhejiang	1120.96	Eng.	5	Hangzhou

# Characteristics of uni (11-20)

Name	Sales	Class.	Ranking	Location
Tianjin Uni.	963.25	Engr.	8	Tianjin
Tongji Uni.	874.70	Engr.	18	Shanghai
Southwest Jiaotong	408.82	<b>Engr.</b>	40	Chengdu
Jiangxi U. Of C. Med.	376.94	Medicine		Nanchang
Nanjing	371.86	Com	4	Nanjing
Huazhong U. Of S&T	367.99	Engr.	14	Wuhan
China CAF College	344.80	Engr.		Tianjin
Chongqing	329.37	Engr.	38	Chongqin
Shanghai F.L. Inst.	323.89	Language		Shanghai
Beijing F. L. Inst.	286.65	Language		Beijing

# Characteristics of university-affiliated enterprises listed on the stock market

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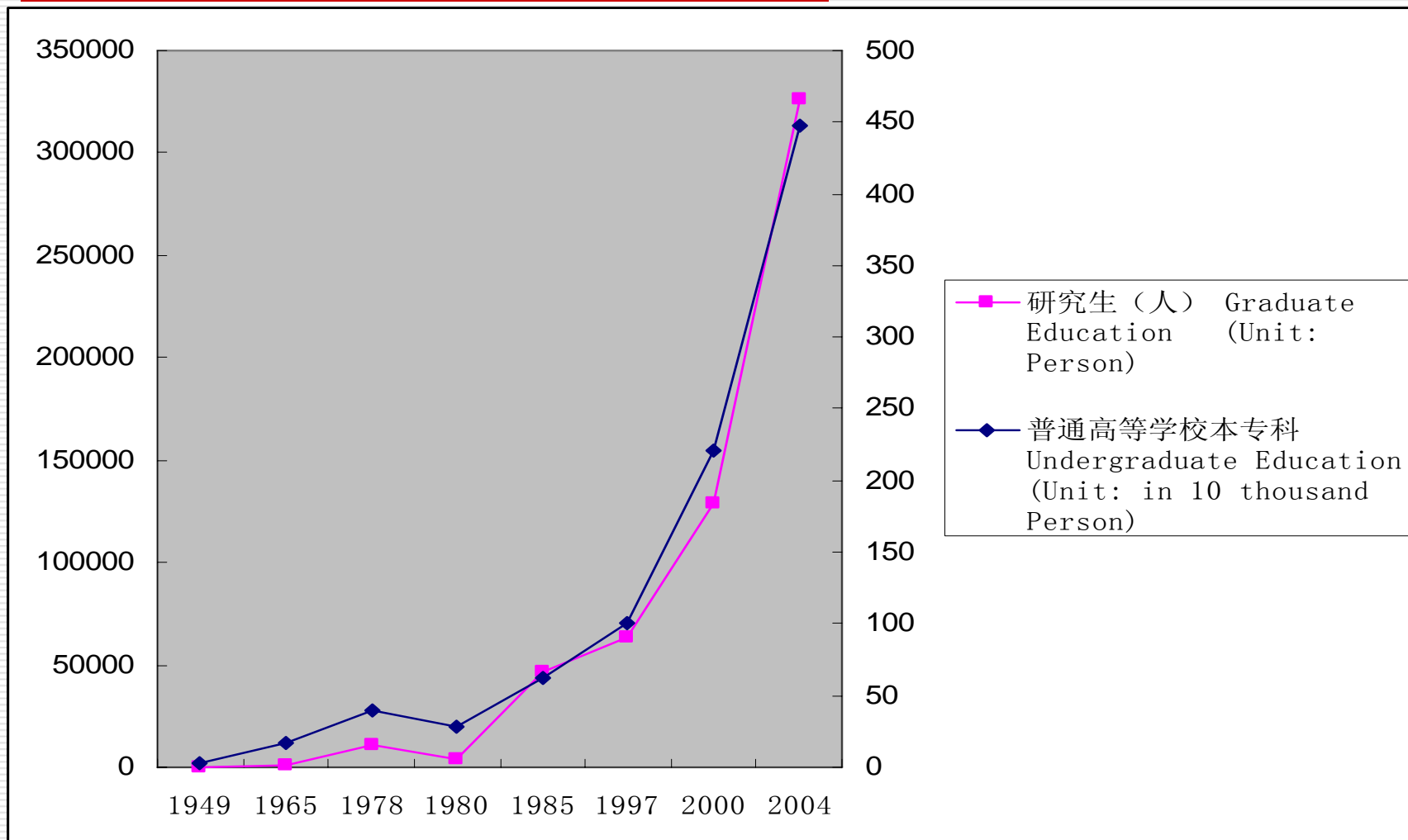
- By mid-2000, 25 companies with university background were on the stock market;
    - IPO + shell transfer
    - Most are in high-tech industry, especially in IT industry;
    - Universities have strong control in these companies (largest shareholders).
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## IV. The second wave: moving back to traditional?

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- Reforms in higher education system:
    - Dramatic increase in university enrollment (see graph);
      - Gross enrollment rate
        - 1990=3.7%; 2001=10%; 2005=21%
      - Total enrollment
        - 1998=3.41 million; 2004=13.34 million
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# Number of University Entrants by Level & Type



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- Consolidation of universities:
    - Merging specialized universities and institutes (637)  
=>comprehensive universities (270);
    - Delegations of administrative authorities:
      - Universities administrated by different central ministries:  
367=>120 ( 73 national universities by Ministry of Education);
      - The authority of issuing permit to start advanced professional college/associate college is decentralized to provincial government.
  - Market-based reform on university infrastructure development and service provision.
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# Reforms in China's national innovation system

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- China's S&T reform-2nd phase (since mid 90s)
    - CAS knowledge innovation program
      - Strategic planning process for CAS and for each institute in CAS;
      - Consolidation of research institutes (from a total of over 120 to about 80);
      - Establishment of innovation centers (lean and mean, with high pay and high pressure) within research institutes;
      - .....
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- Reforming Public Research Institutes —> pushing them into the market
    - 242 ministerial research institutes were transformed into business entities in 1999 government reform;
    - 134 ministerial research institutes followed the path;
    - Over 600 provincial research institutes also followed.
  - Strengthening universities' R&D capability
    - World class university (985)" project
      - Focused support for 2 (Tsinghua and Beida) +9 universities;
    - 2<sup>nd</sup> phase of 211 program
      - Focused support for selected centers of excellence in about 100 universities.
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## Industrial R&D

- Supporting the establishment of R&D centers in major SOEs
    - Close to 300 centers were certified by the central government;
    - Over 2000 centers were certified by provincial governments;
  - Supporting small business innovation
    - SME innovation fund;
  - Helping MNCs to establish R&D centers in China
    - Over 100 MNC R&D centers were established in Beijing, Shanghai, Guangzhou, Chengdu, etc.
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## The outcome: Industry becomes major performer of R&D

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<u>Year</u>	<u>1986 (%)</u>	<u>1997 (%)</u>	<u>2003 (%)</u>	
<u>Organization</u>				
Business	<b>35.3</b>	<b>42.9</b>	<b>62.4</b>	
Research Institutes	<b>60.7</b>	<b>42.9</b>	<b>25.9</b>	
Universities	<b>4.0</b>	<b>12.1</b>	<b>10.5</b>	
Other	<b>0</b>	<b>2.1</b>	<b>1.2</b>	

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The outcome: heavily biased toward applied research and development (2003, %)

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R&D work Organization	Basic research	Applied Research	Development
Business	0.7	7.9	91.4
Research Institutes	11.7	35.4	52.9
Universities	20.3	55.3	24.4

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# Basic research in university has been rising

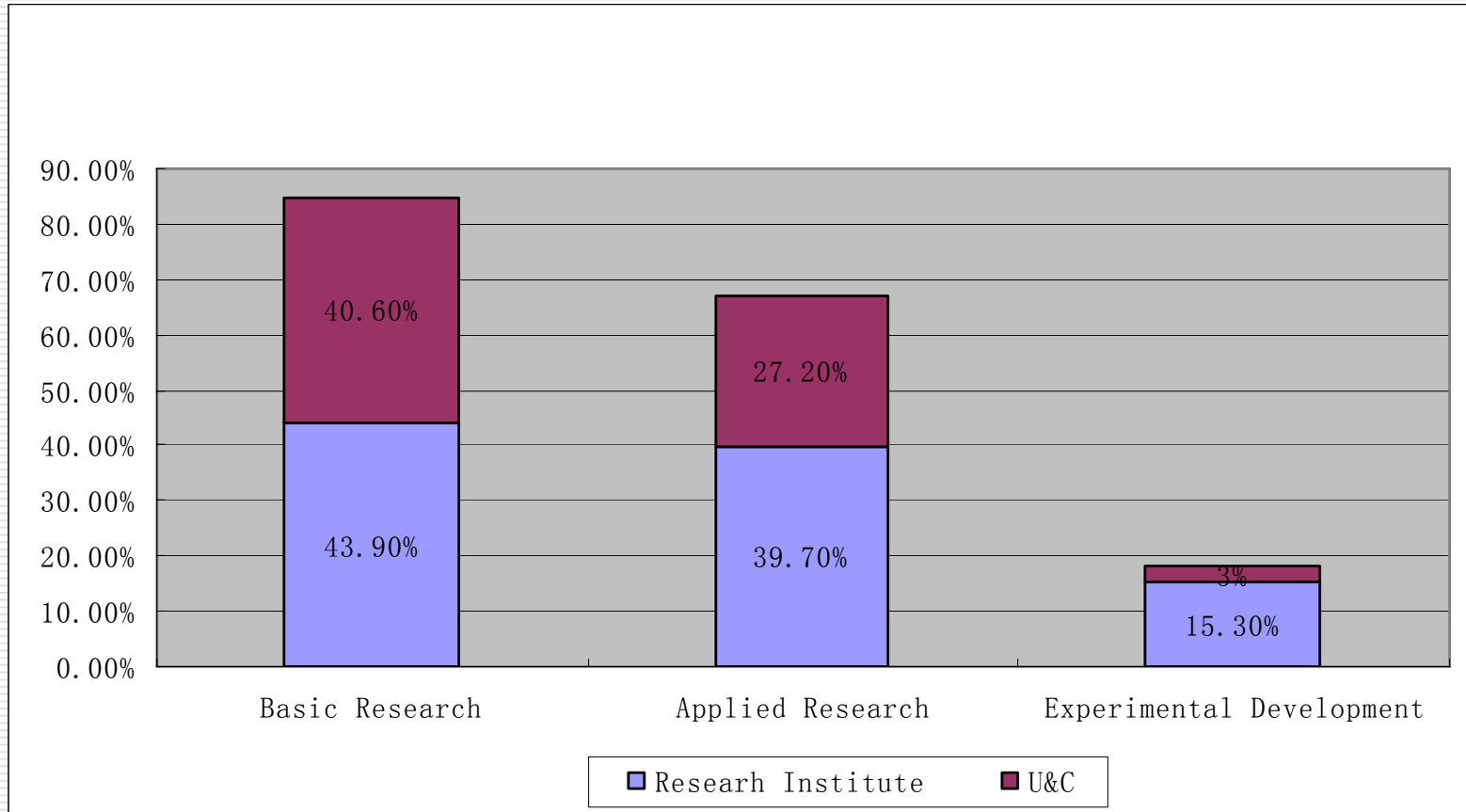
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	<b>Basic research</b>	<b>Applied research</b>	<b>Development</b>	<b>Total</b>
1991	1.9 (13.9)	7.6 (55.5)	4.3 (31.4)	13.7 (100)
1993	3.4 (12.2)	14.9 (53.6)	9.5 (34.2)	27.8 (100)
1995	6.5 (15.4)	23.3 (55.1)	12.5 (29.6)	42.3 (100)
1997	9.7 (16.8)	31.6 (54.8)	16.4 (28.4)	57.7 (100)
1999	11.4 (18.0)	40.0(52.2)	18.9(24.6)	76.7(100)
2001	19.0(18.6)	56.6(55.3)	26.8(26.2)	102.4(100)
2003	32.9(20.3)	89.7(55.3)	39.7(24.5)	162.3(100)

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# University becomes a major force in basic research (R&D work by sector and character of work, 2004)

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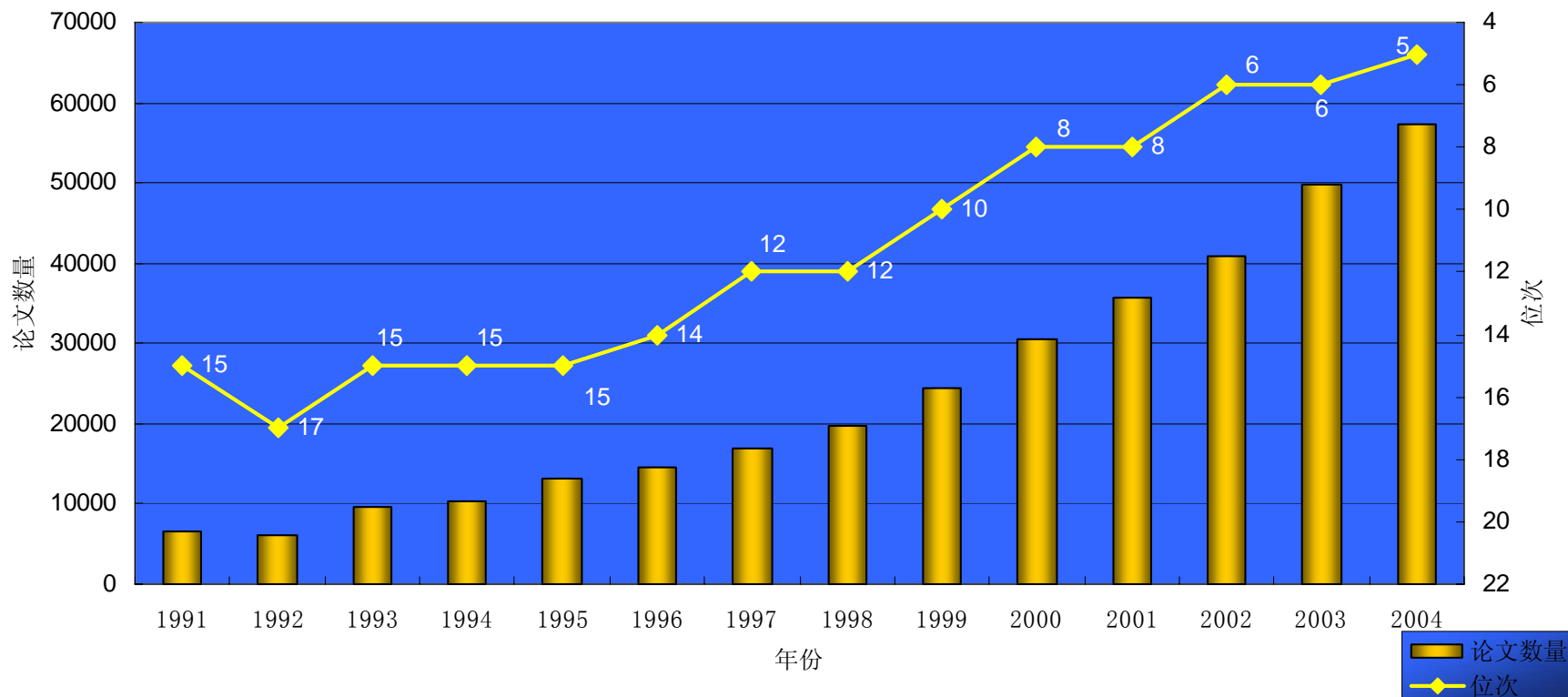
# The impact of reforms on universities

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- A gradual shift towards the traditional model of teaching and basic research
    - Open debates about the university-run enterprises and the rising cases of mis-management of UREs
      - New policies to change from UREs to UOEs
    - Social concerns about teaching quality after expansion;
    - Increased funding to research universities
    - International benchmarking on publications (SCI etc) changes the internal quality criteria (see graph);
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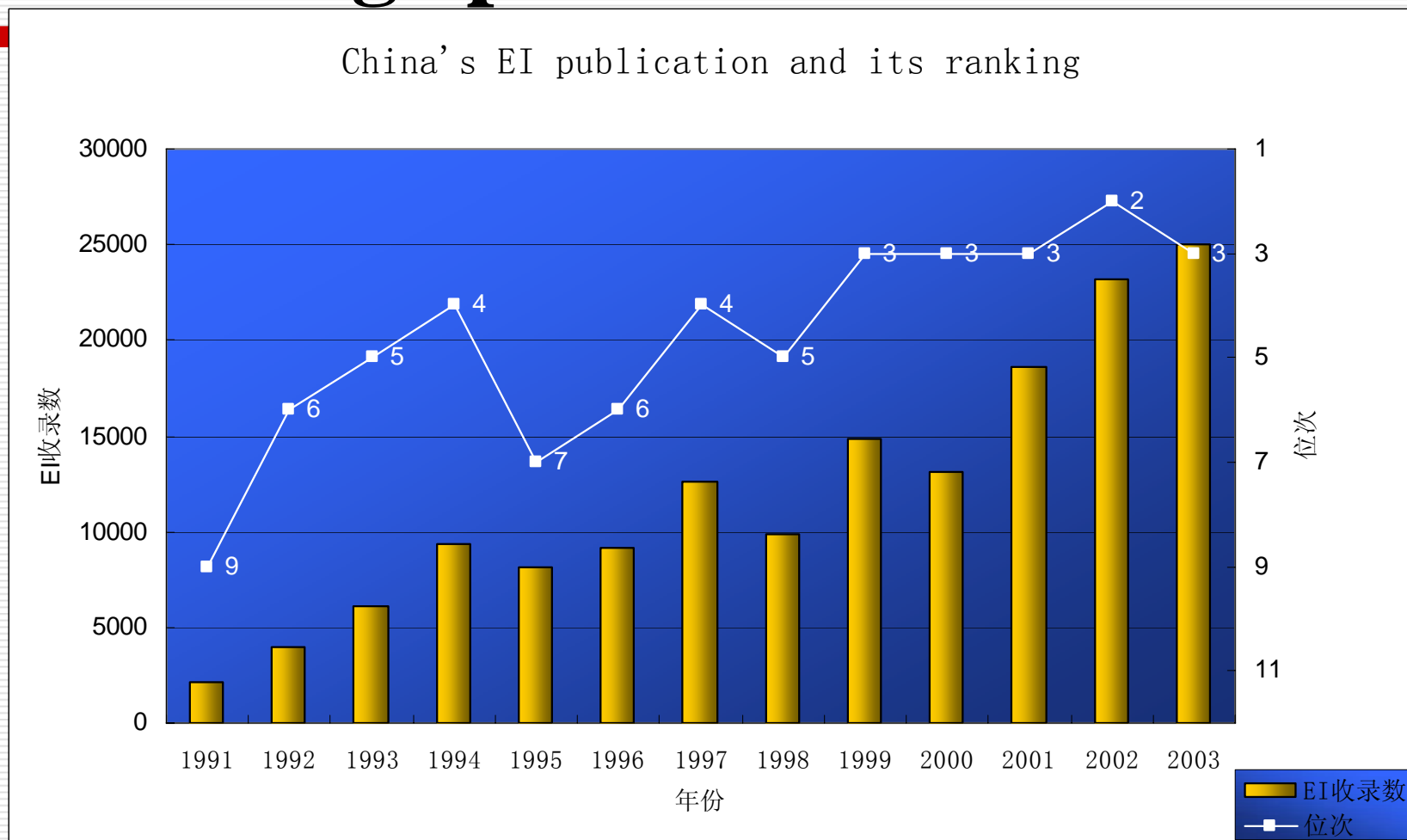
# Knowledge production-SCI

China's SCI publication and its ranking



数据来源：中国科技统计年鉴2005、中国科技论文统计与分析 2005 年

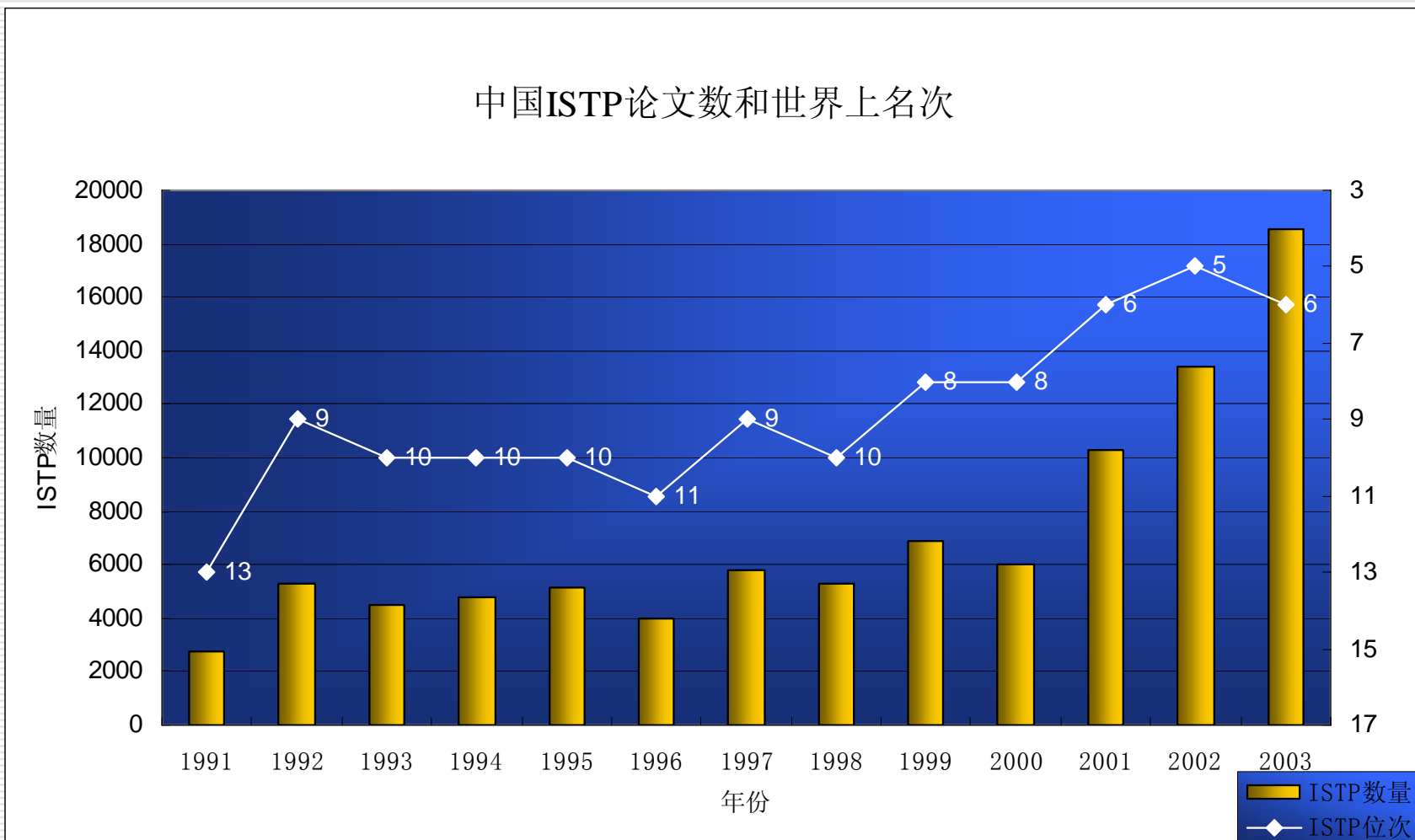
# Knowledge production-EI



数据来源：中国科技统计年鉴2005、中国科技论文统计与分析 2005 年

# Knowledge production-ISTP

中国ISTP论文数和世界上名次



数据来源：中国科技统计年鉴2005、中国科技论文统计与分析 2005 年

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- Institutional legacy from entrepreneurial model has also left its impact (Tsinghua University as one example):
    - University-industry liaison office;
    - S&T development office (regional focus);
      - IPR office
    - International technology transfer center;
    - Tsinghua Science Park Co.;
    - Tsinghua Holding Co.
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# V. Lessons and future issues

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- The roles of universities are defined not only by its internal logic but also are shaped by the external environment;
  - There is a delicate balance between the academic and entrepreneurial model; the two are not mutually exclusive;
  - Future issues:
    - What is the intrinsic comparative advantages of universities over other forms of organizations?
    - What should be the roles of universities in NIS in a developing country like China? Do they play different roles compared with their peers in developed countries?
    - What are the roles of non-research intensive universities?
    - What is the role of government in supporting universities? Financial support? Policy support?
    - .....
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Thank you!

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