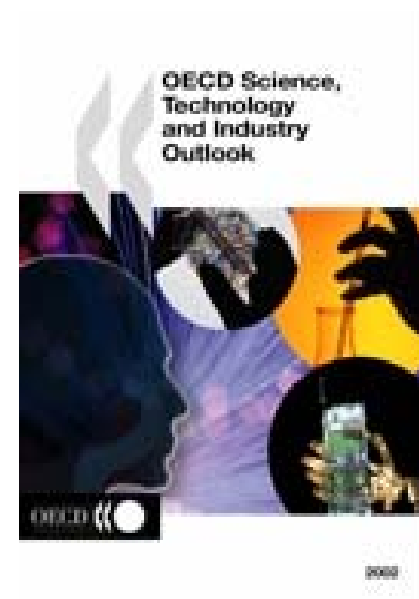


OECD Science, Technology and Industry Outlook 2002



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Outline of the STI Outlook 2002

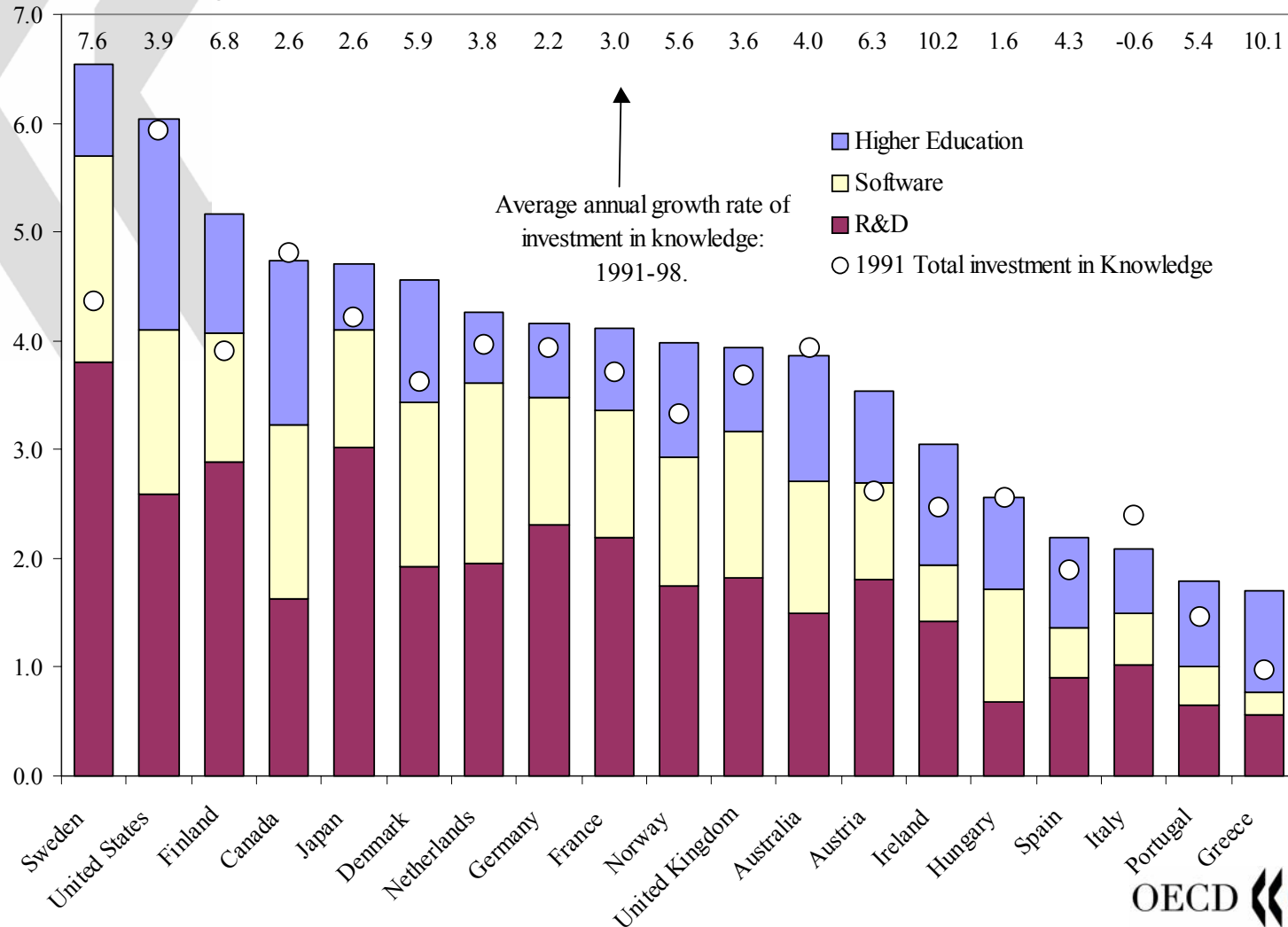
- 1 Strengthening the knowledge-based economy
- 2 Recent developments in science, technology and industry policy
- 3 Private and public financing of business R&D
- 4 Competition and co-operation in innovation
- 5 Changing government policies for public research: from financing basic research to governing the science system
- 6 Patenting and licensing in public research organisations
- 7 Industrial globalisation and restructuring
- 8 International mobility of highly skilled workers
- 9 Science and technology in China: Trends and Policy Challenges
- A Statistical annex

Overview

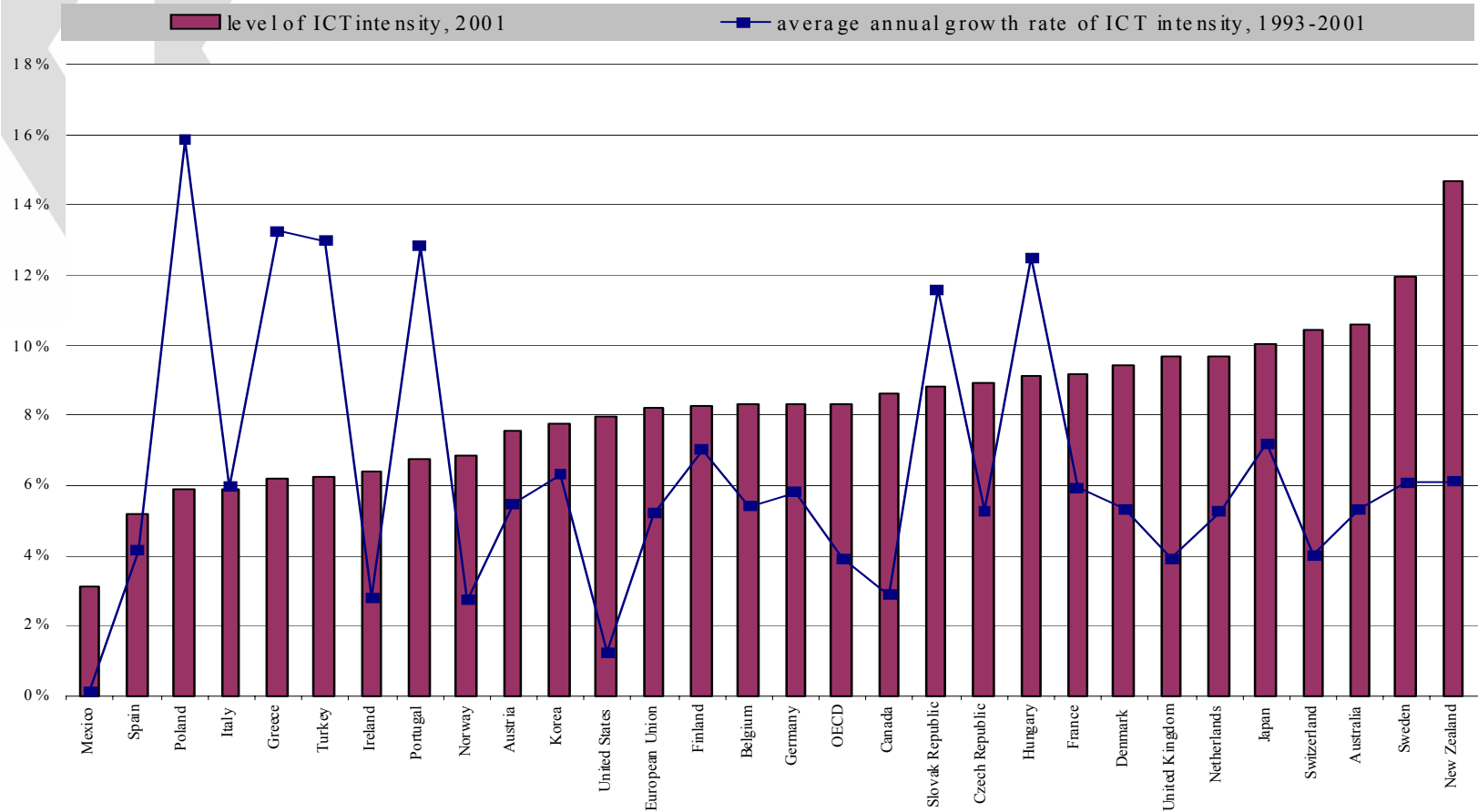
- Investments in knowledge remain key driver of economic performance despite economic slowdown.
- Shift toward knowledge-based economy is linked to emergence of networked economy.
- Networking is more than ICT: Knowledge creation and application is more collaborative, inter-linked
 - Industry-science relationships
 - Inter-firm collaboration
 - Public/private partnerships
 - Globalisation
- Improvement in knowledge inputs does not diminish significant policy challenges.

Growing investments in knowledge

Knowledge investments as % of GDP

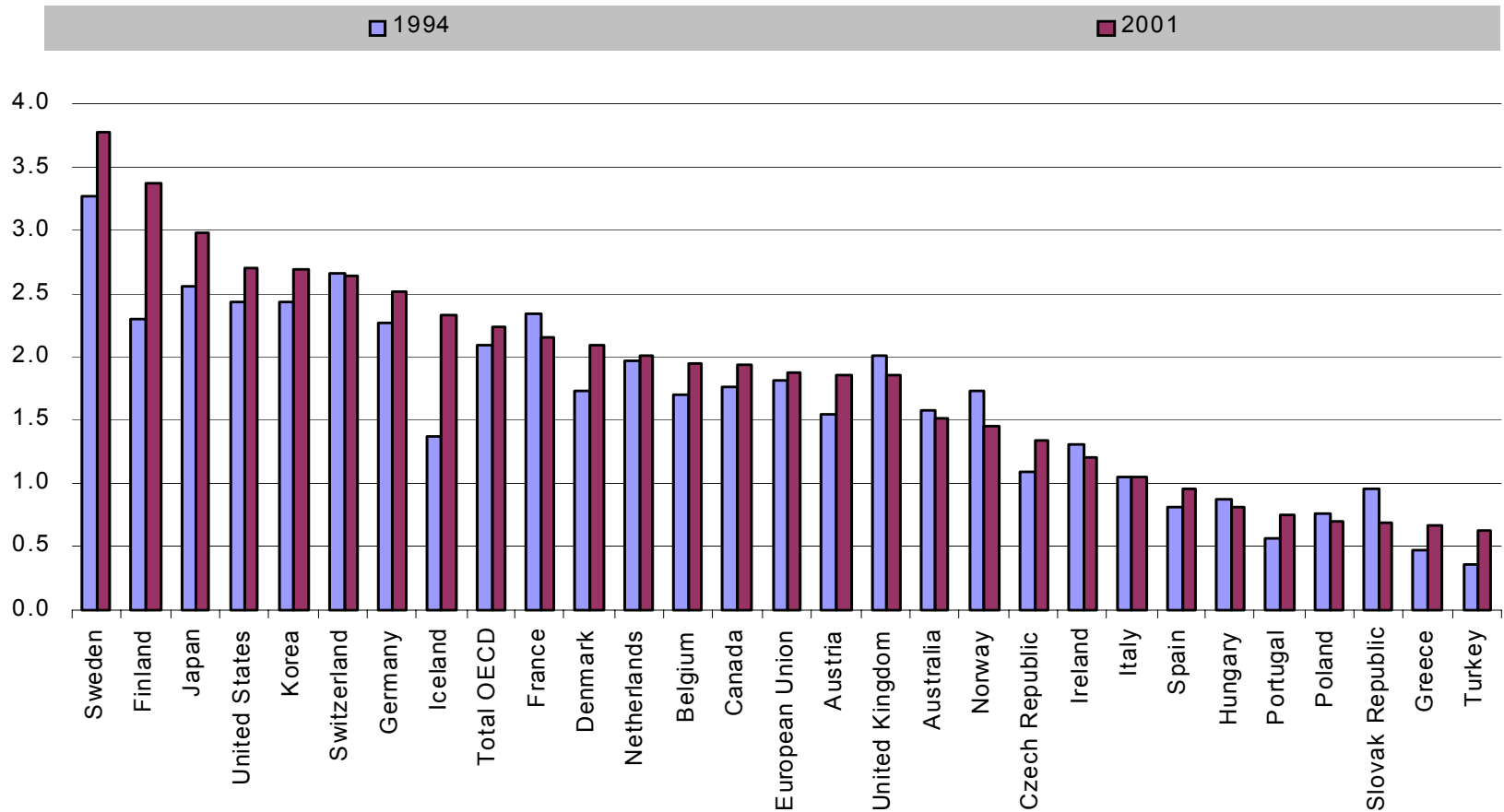


ICT investments a larger share of GDP



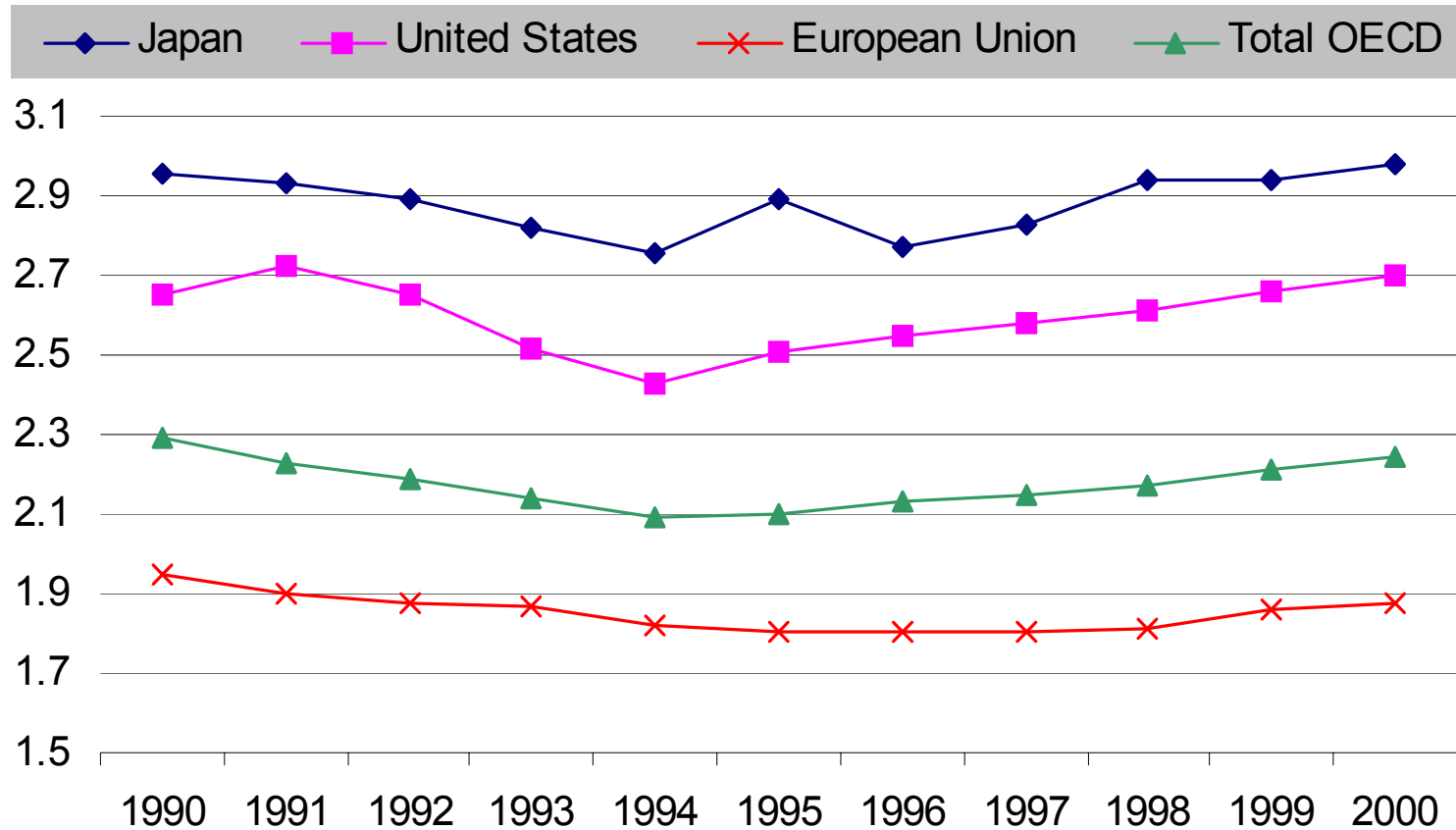
R&D intensity increasing across OECD. . .

GERD as a % of GDP (1994-2001 or nearest available years)



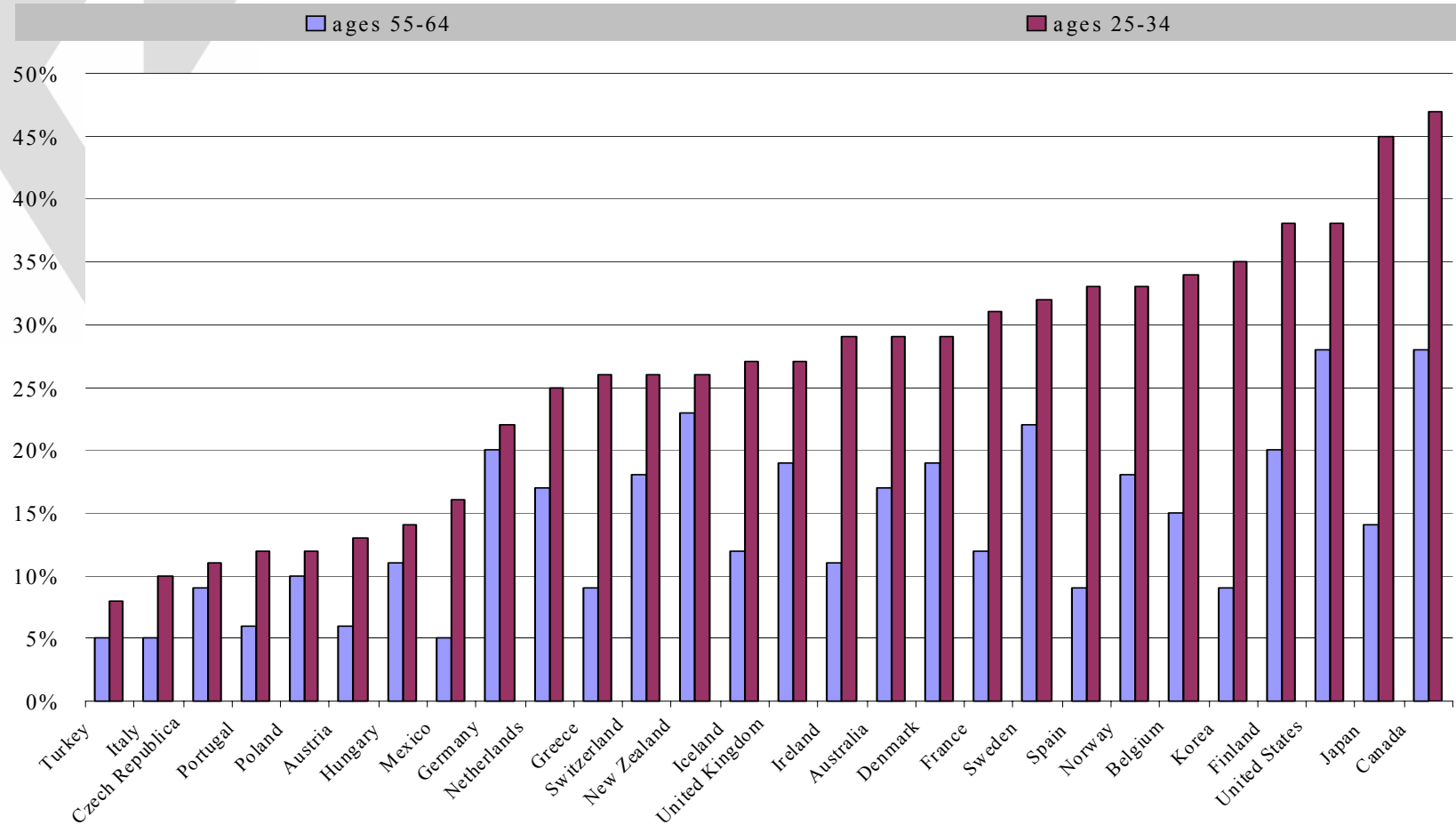
... but regional gaps are widening

GERD as % GDP



Educational attainment is improving

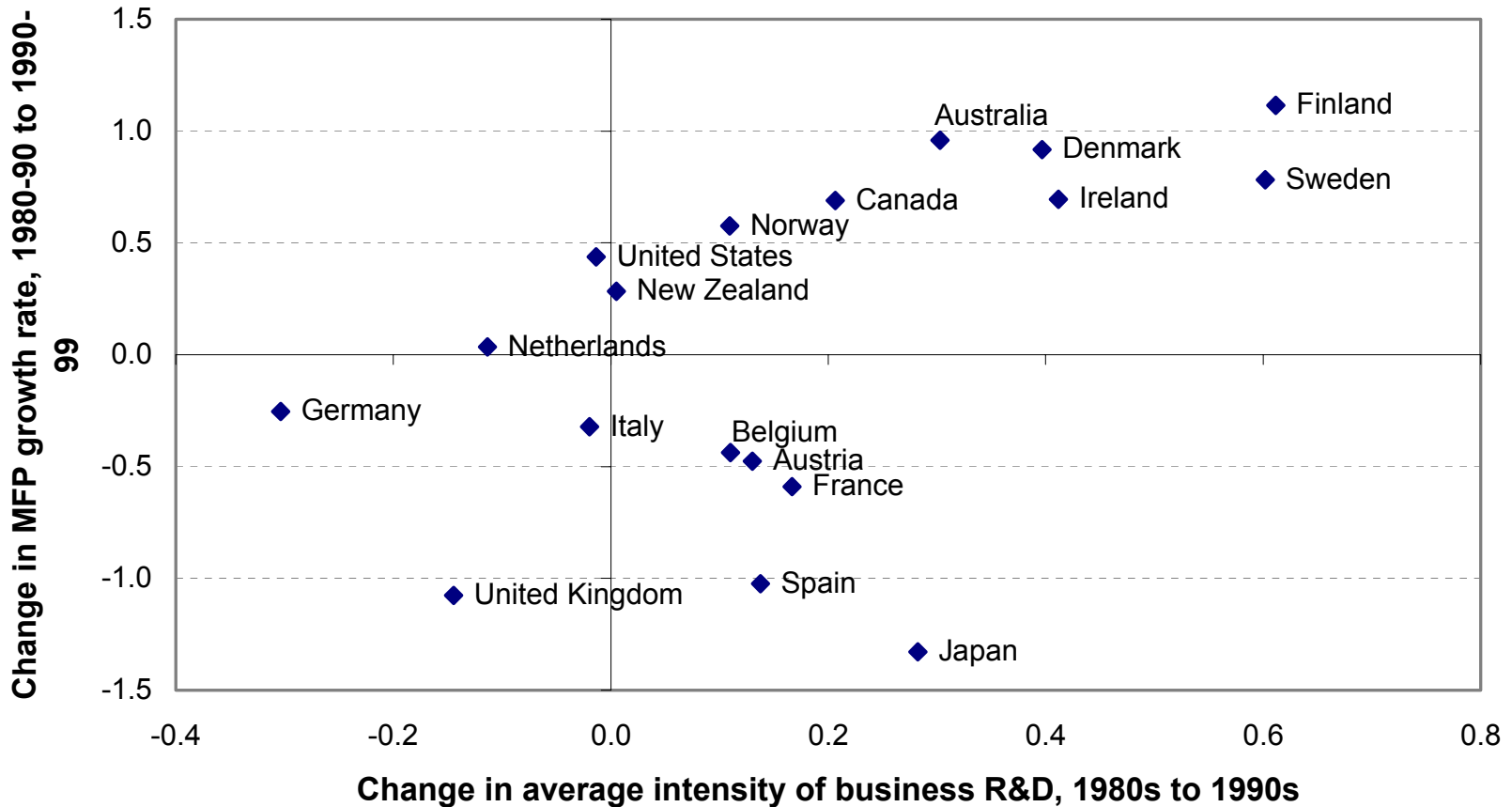
% of population with tertiary-level education



A number of issues still to address

- Significant differences exist among countries in shift toward knowledge-based economy.
 - Many issues to be addressed at national level
 - International implications also related to both markets for new products & services and to sources of knowledge.
 - International mobility of S&T workers
- Converting knowledge and innovation investments into economic gains remains challenging.
- The organisation and conduct of innovation is changing in ways that require policy responses.
 - Private sector (e.g., business R&D)
 - Public sector (higher education and government)

Links between R&D, innovation and economic growth

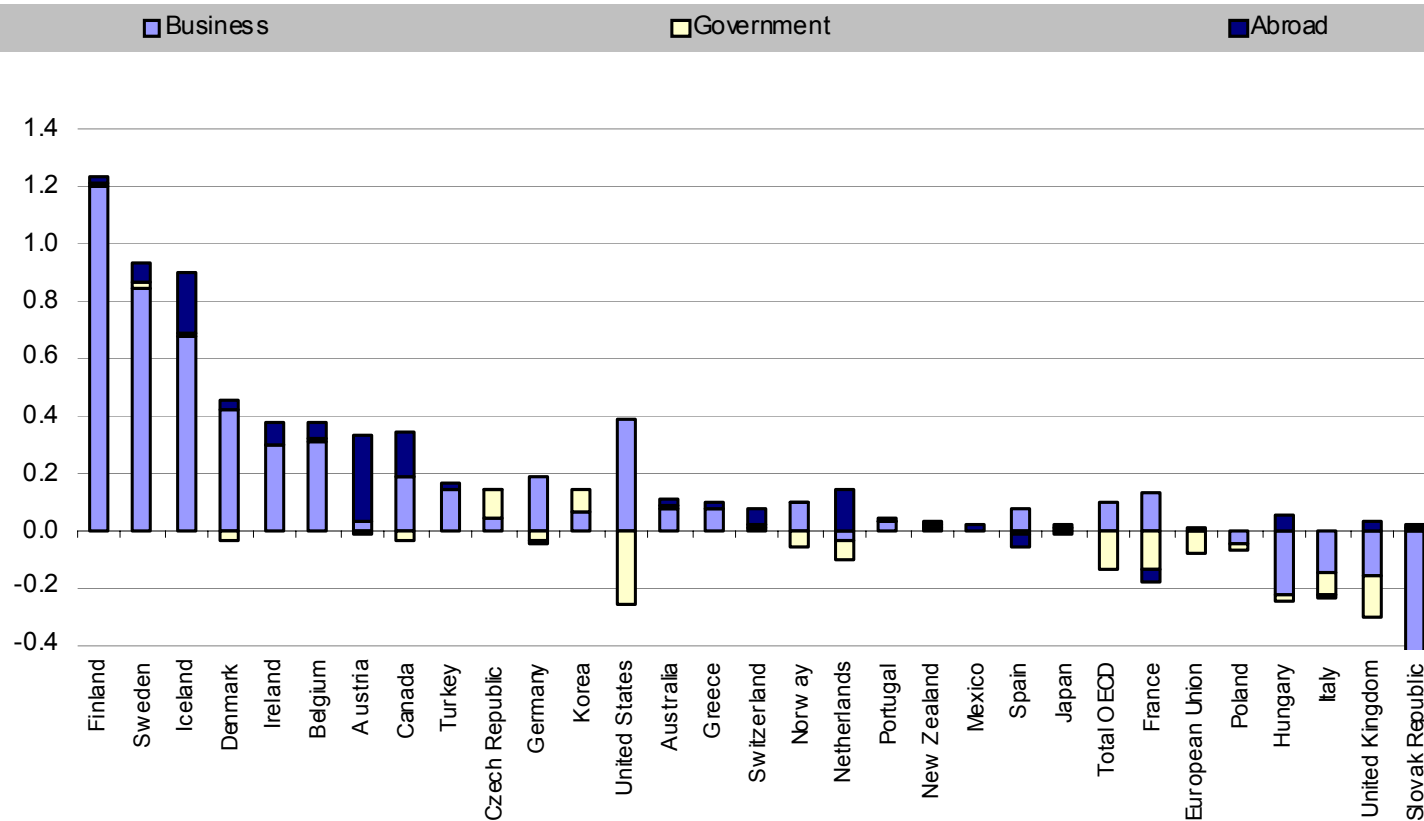


Improving business R&D and innovation

- *Increasing business R&D* is policy objective for many countries and regions.
- *Structure of business R&D* has changed in last decade: rapidly growing industry financing of R&D, and re-structuring of firms' R&D processes.
- *Patterns of government support* for R&D also changed: levels, motivation, and forms of support.
- *Issue*: how best to respond to and anticipate changing environment for business R&D in order to develop more effective & efficient S&T policies.

Variable growth in business R&D

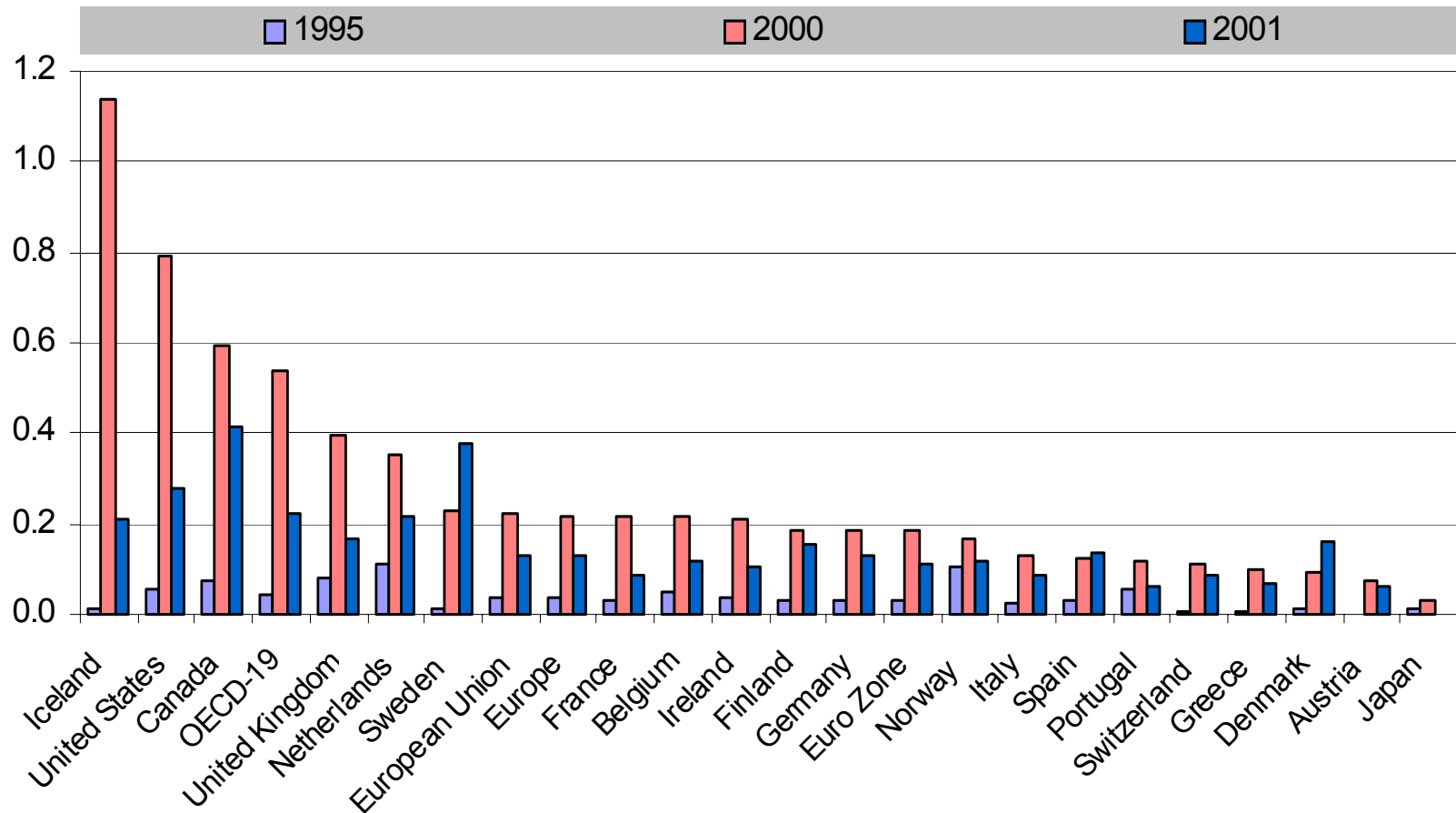
Change in business R&D as percentage of GDP, 1990- 2000 (or nearest available year), by source of funds



Source: OECD MSTI database, January 2002.

VC investments boosted business R&D

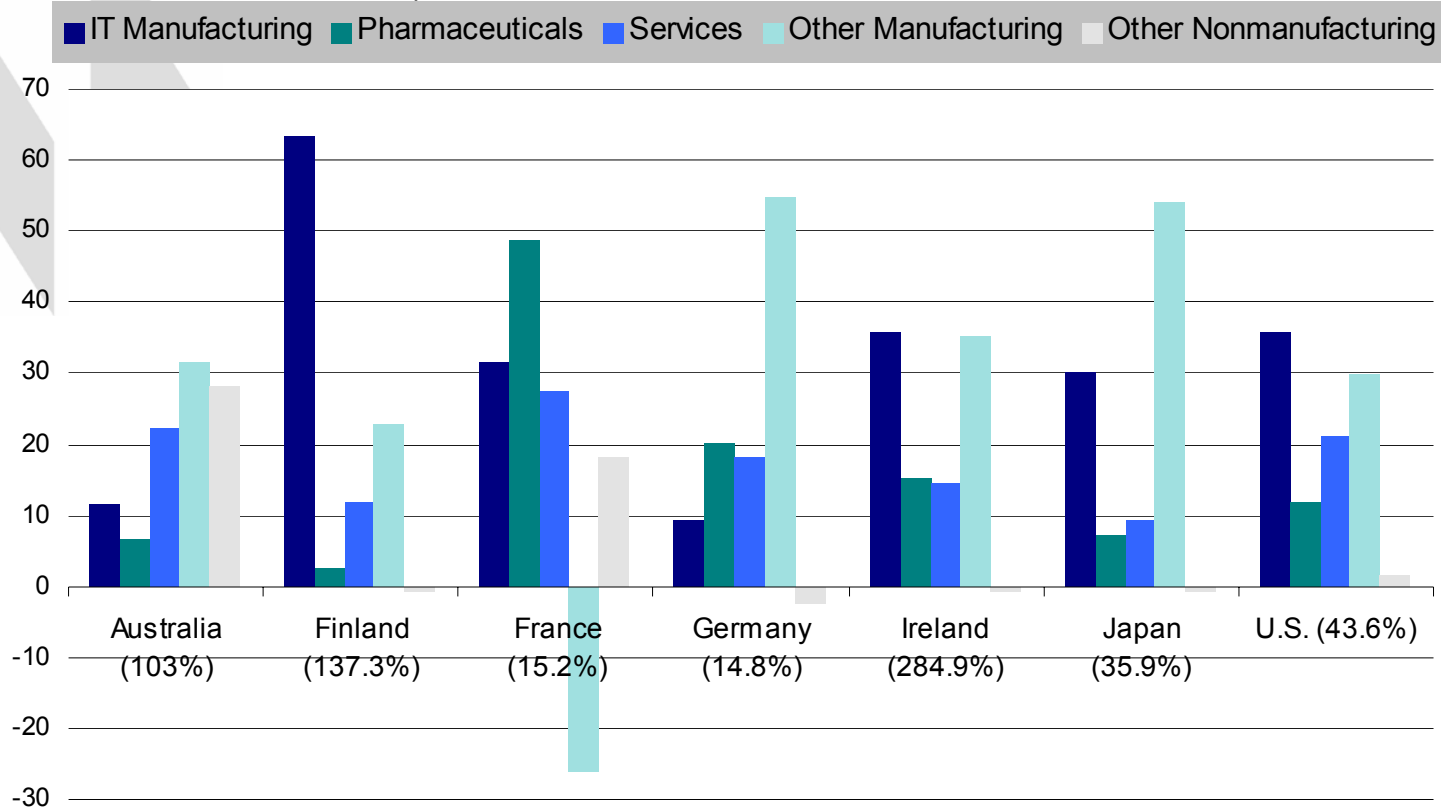
Early stage and expansion financing as percentage of GDP, 1995-2001 (or nearest available year)



Source: OECD, STI Scoreboard, 2001.

High-tech manufacturing and services drove business R&D growth

Distribution of the growth in business R&D by industry, 1990-1998 (as percentage of total increase in BERD)



Source: OECD ANBERD database, 2001

A Changing Environment for Business R&D

- *Shorter time-to-market.* Greater competition, shorter product life-cycles.
- *Expanding technological opportunities*--Hard to maintain necessary competencies in-house; uncertainty about future technology & markets
- *Increased cost and risk.* Cost of innovation is growing, in many capital-intensive industries.
- *Globalisation* of markets, S&T capabilities.
- *Increased mobility* of S&T workers. Increases rate of diffusion of knowledge
- *Erosion of dominant positions.* Greater competition makes it harder to appropriate returns.

Firm Strategies: From Closed to Open Business R&D

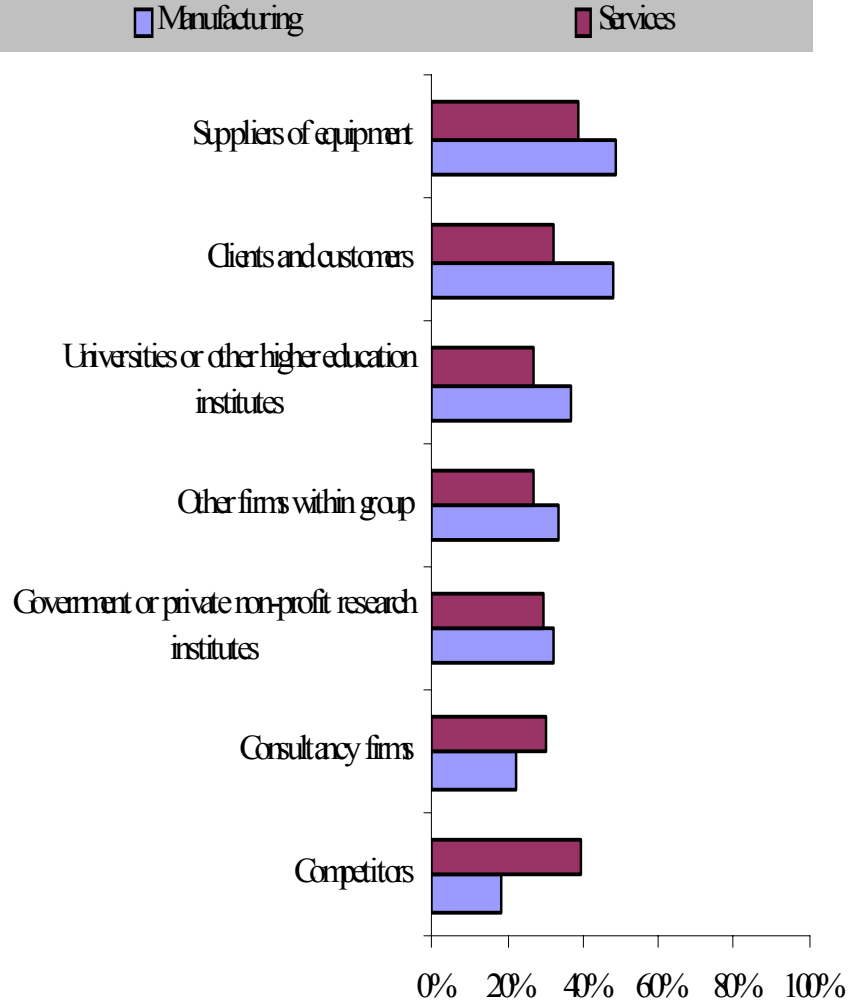
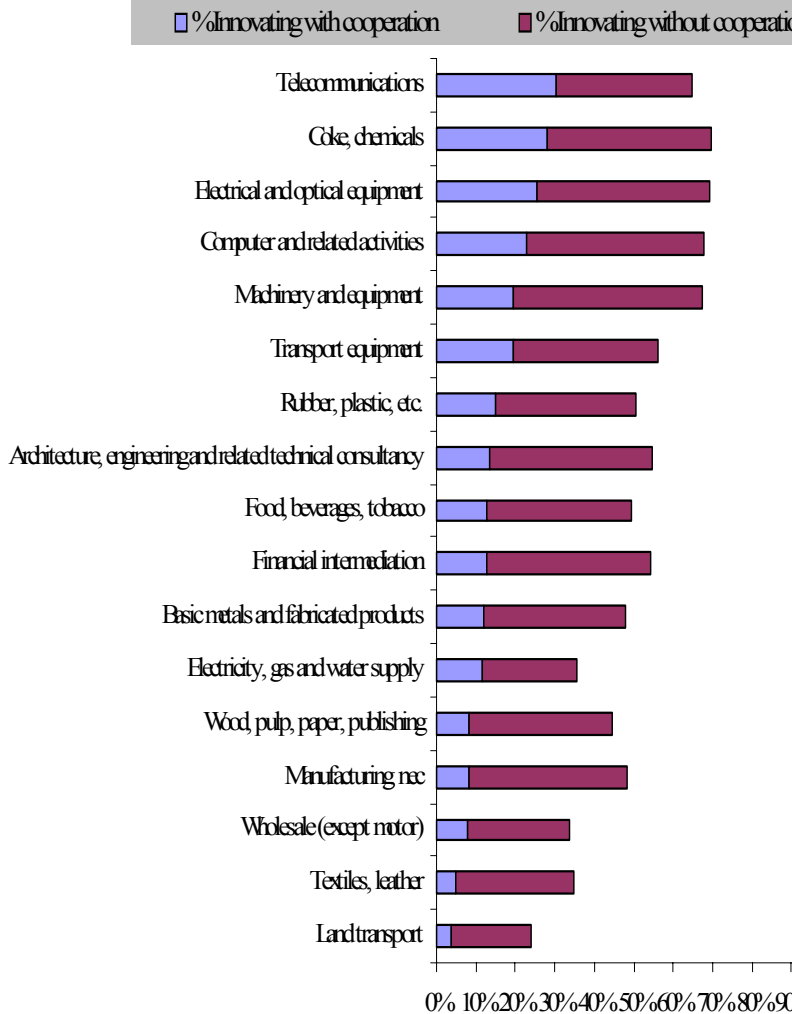
Old model: closed innovation

- Virtuous circle
- Firms identify needed technological advances
- Firms conduct R&D internally
- Firms incorporate advances into new products & services
- Product revenues finance additional R&D

New model: open innovation

- R&D linked to business strategy (new funding models, incentives for workers)
- Acquisition of external technology (licensing, corporate VC, M&A, collaborative research)
- Externalisation of R&D results (licensing, spin-offs)
- Globalisation to tap into world-wide talent pools

Inter-firm co-operation in innovation



Implications for R&D Policy

- Direct government support mechanisms (e.g., direct financing and tax incentives) need to be re-evaluated and re-balanced.
- Government support for *basic research* increasingly important, meaning that support to business R&D must be made in the context of support for *public sector institutions*.
- Government called upon to target specific fields and sectors (e.g., ICT, biotech, nanotech), but must counter-balance market forces, too.
- *R&D in SMEs* is increasingly important, but support must be balanced against availability of private VC.

Shift to creation of more supportive environment for innovation

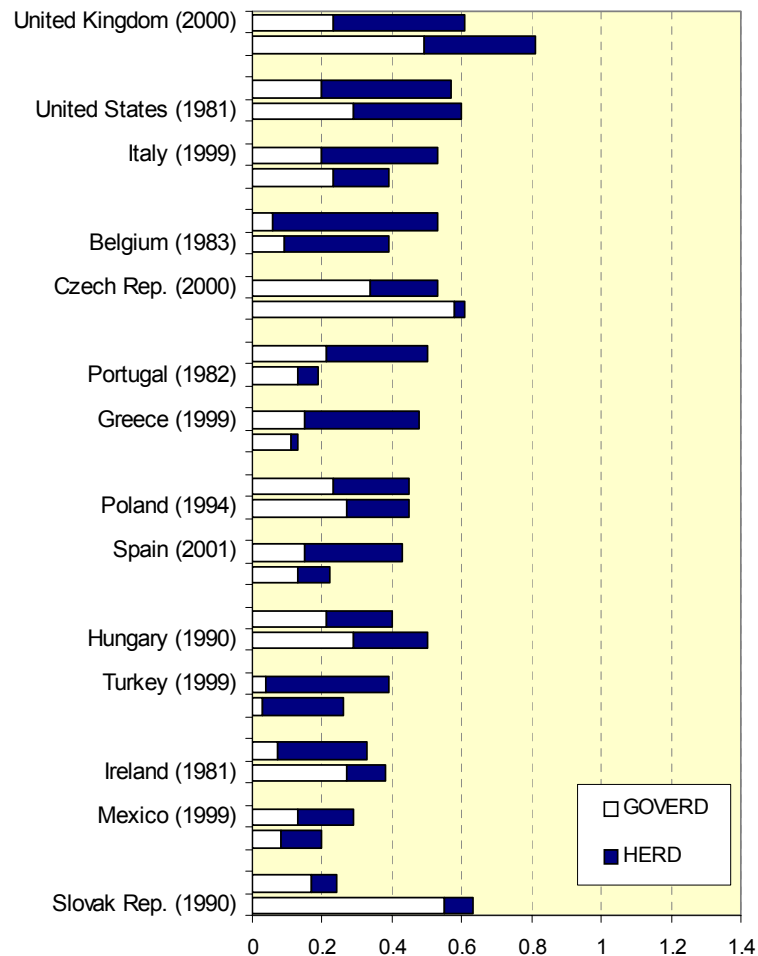
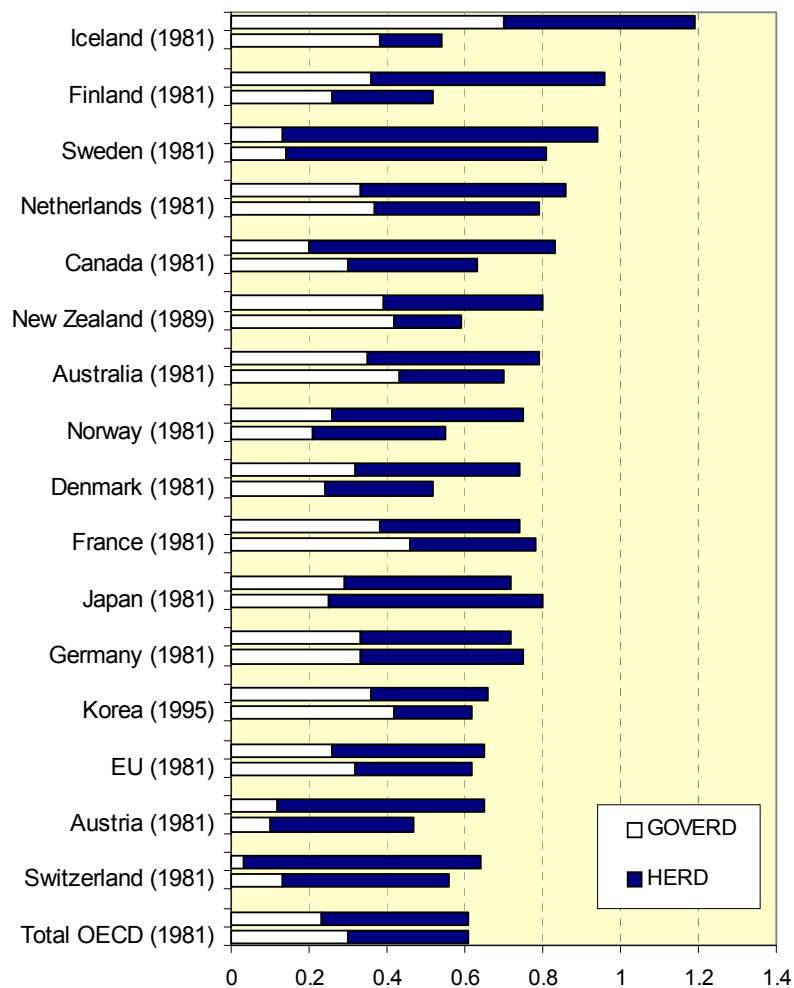
- *Experimentation* via new firm creation: capital, labour and product market issues.
- *Ensuring linkages* among innovating organisations (large firms, small firms, universities, public laboratories, service intermediaries) is increasingly important--systemic aspects of innovation
- *IPR* is both a motivator of business R&D (appropriability) and a facilitator of knowledge dissemination (e.g., through licensing).
- *Human resources*--skilled scientists and engineers are basis of business R&D.

A changing paradigm for public research

- Traditional approach: *Funding basic research*
 - Government funding of basic research, often through institutional funding (i.e., block grants).
 - Universities have autonomy in setting research objectives
- Emerging approach: *Governing the science system*
 - Link government funding to social and economic objectives
 - Universities accountable for research spending and results.
 - Encourage multi-disciplinary research and links to industry
- How to enhance contribution of universities and other PROs without undermining their unique capabilities?

Funding of public research

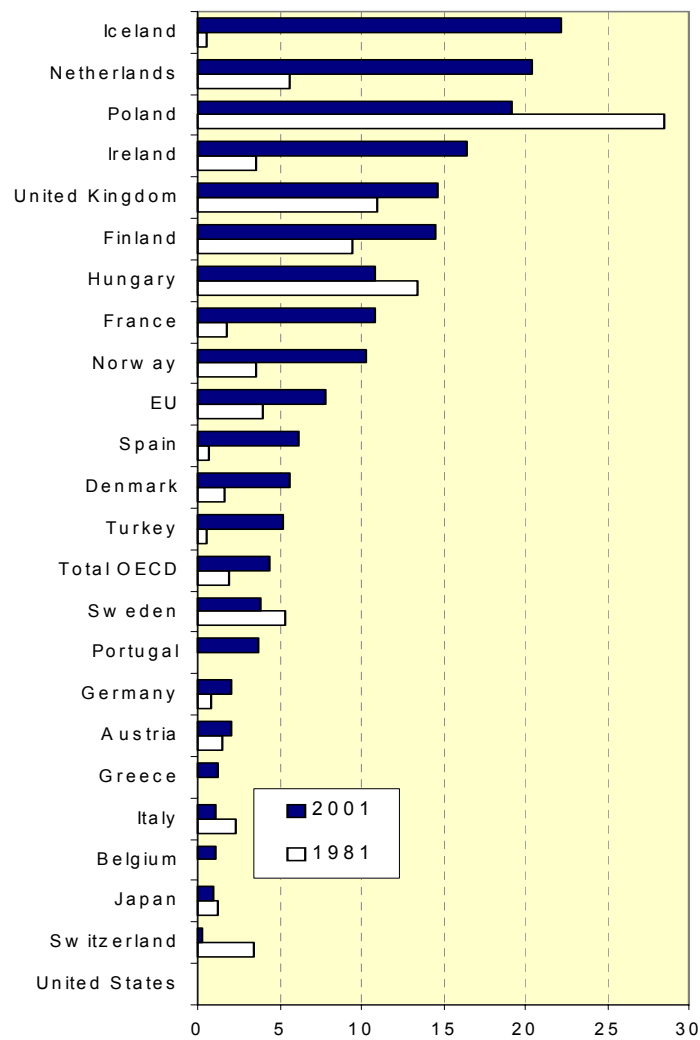
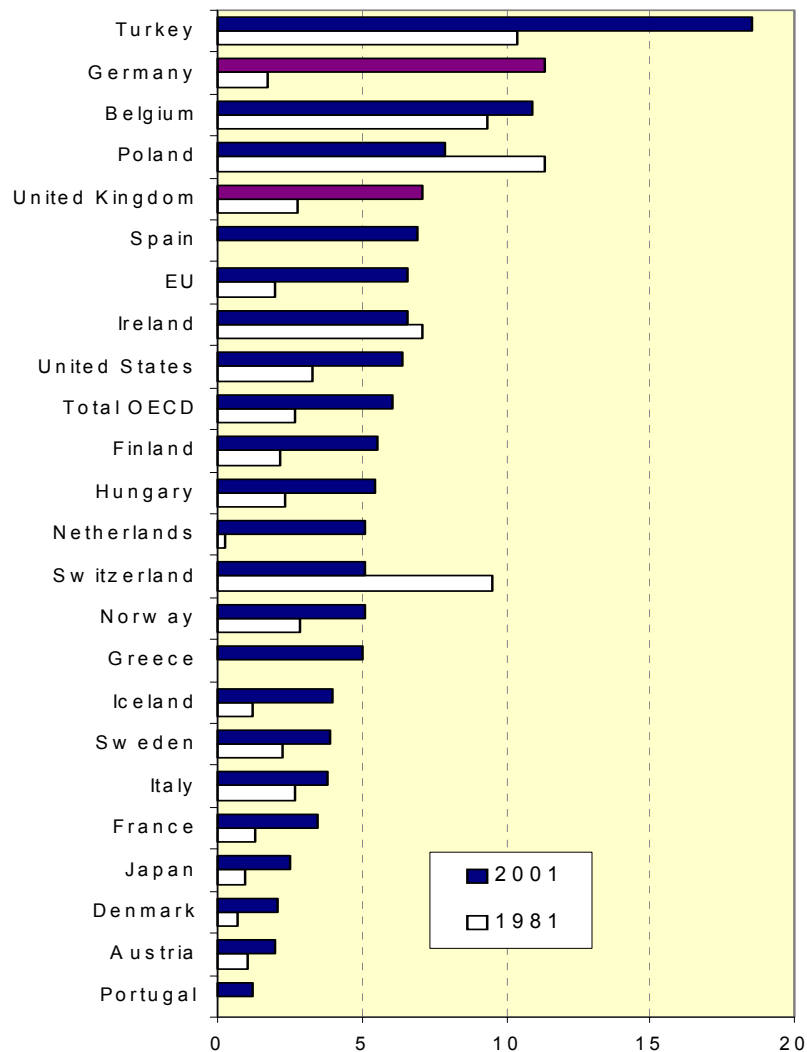
R&D in the higher education and government sectors as a % of GDP, 1981-00



Business funding of public research

Higher education

Government

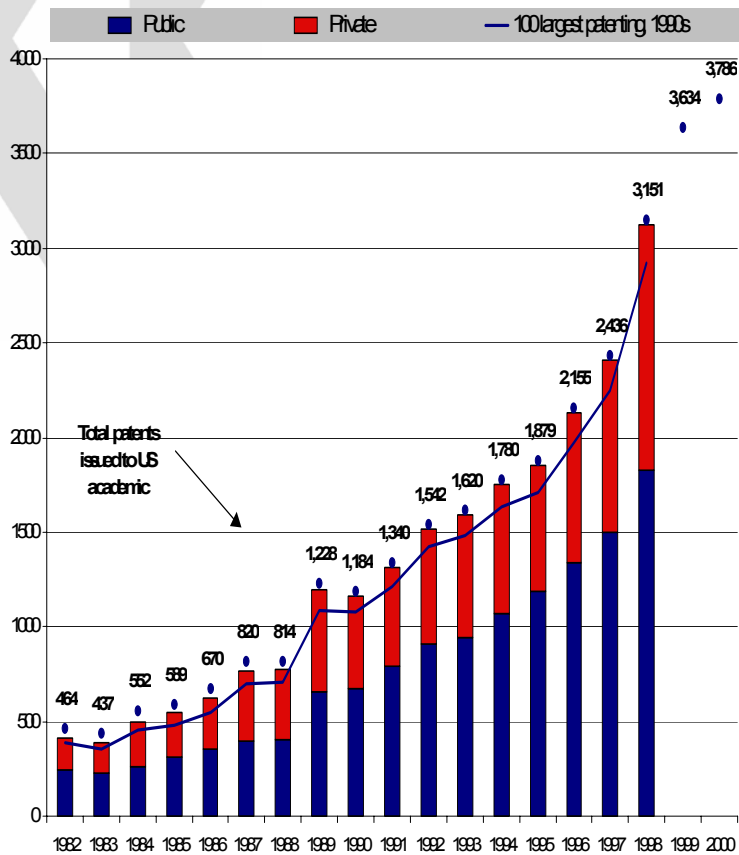


Policy responses

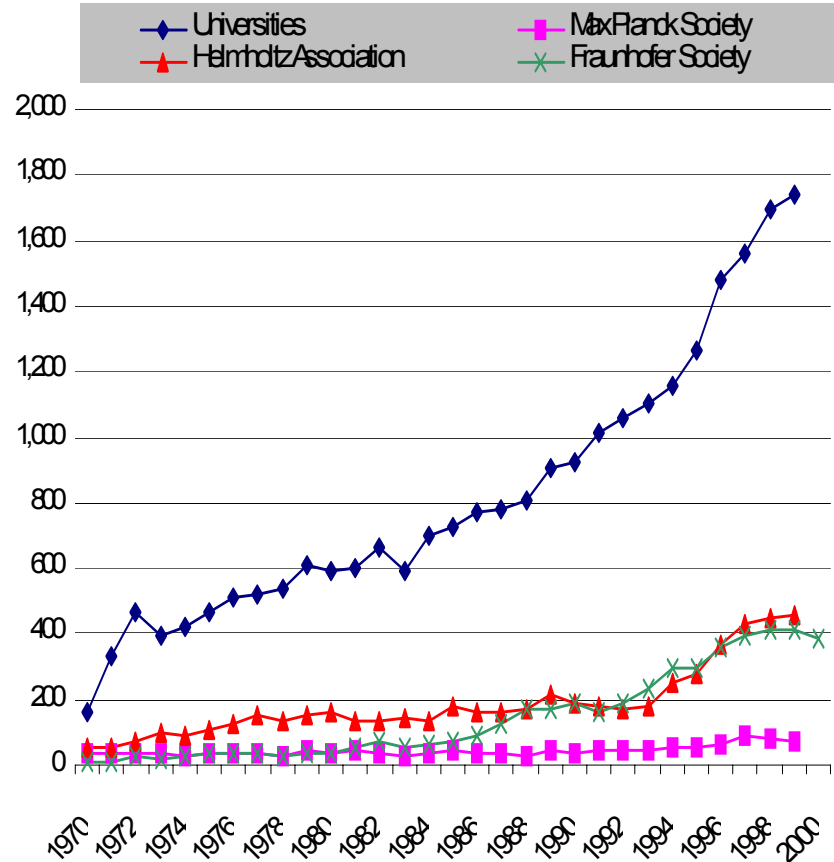
- *Priority setting.* Increasing role of business and social groups; more extensive use of Foresight
- *Funding schemes.* Greater use of competitive awards, often linked to national priorities (e.g., French Fonds National de la Science).
- *Assessment & evaluation.* Linking funding to evaluations of research excellence (e.g., UK Research Assessment Exercise).
- *Centres of excellence.* To encourage multi-disciplinary research and create critical mass. Linked to *cluster* approach to innovation (e.g., Austria, Australia, Germany, France).

Patenting by public research organisations

United States



Germany



Ownership of IP at PROs

	Ownership of patentable inventions		
	PRO	Inventor	Government
Australia	◆		
Austria ¹	◆ (P)	◆ (U)	?
Belgium	◆		
Canada	◆	◆	
Denmark ²	◆		
Finland ³	◆ (P)	◆ (U)	
France	◆		
Germany	◆		
Hungary	◆ (P)		
Iceland	◆ (P)	◆ (U)	
Ireland	◆		
Italy	◆ (P)	◆ (U)	
Japan ⁴	◆ (P)	◆ (U)	?
Korea	◆		
Mexico	◆		
Netherlands	◆		
Norway	◆ (P)	◆ (U)	
Poland	◆		
Russia			◆
Sweden		◆ (U)	
United Kingdom	◆		
United States ⁵	◆	?	?

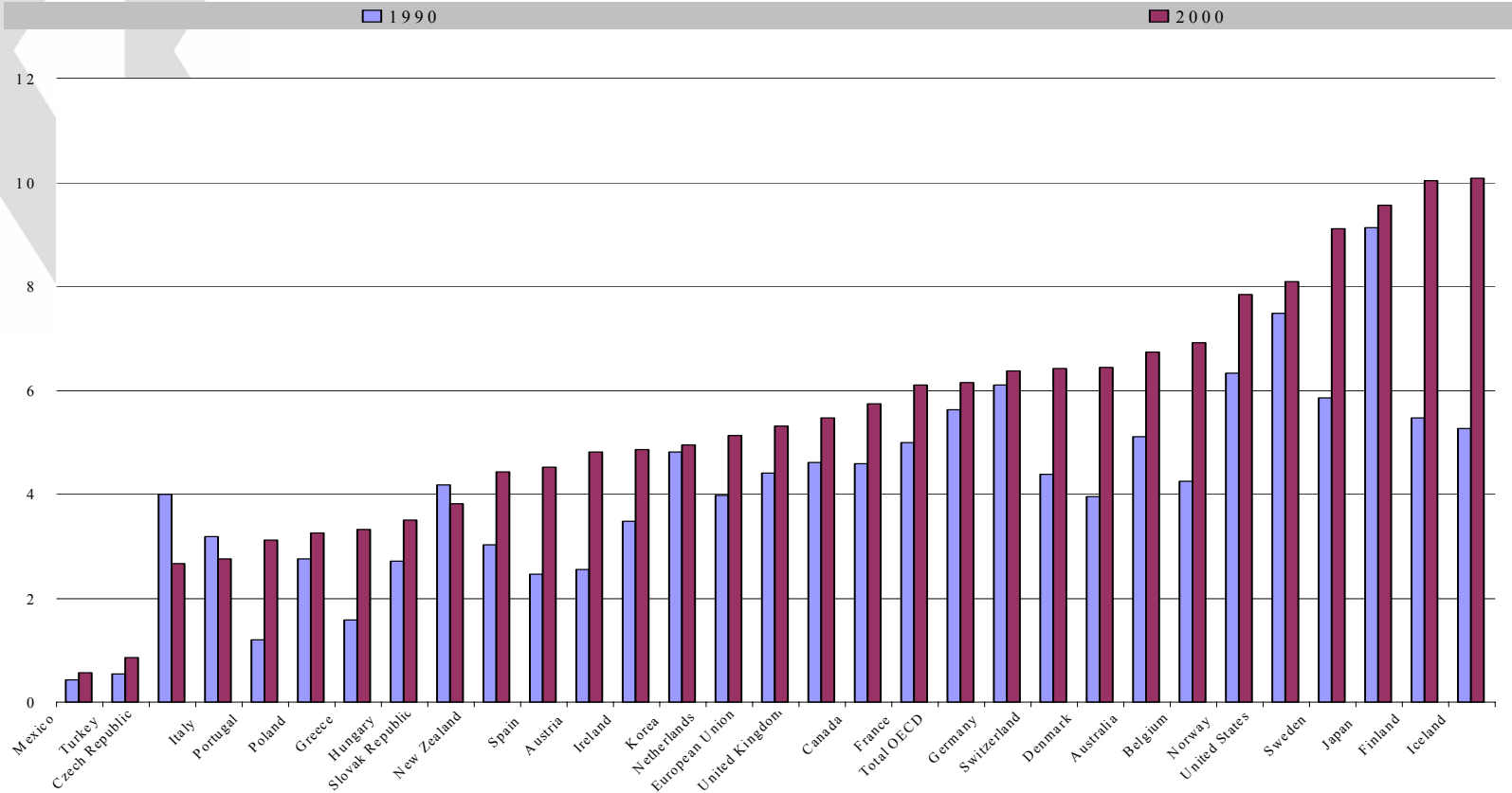
- ◆ = legal basis or most common practice; ? = allowed by law/rule but less common.
- ◆ (P) = Applies to non-university PROs (public labs, academies, etc.).
- ◆ (U) = Applies to universities.

Effects on public science system

- Experience in UK and US suggests that use of shorter term, contract based funding does not conflict with performance of fundamental research.
- OECD survey provides no evidence yet that emphasis on IP management has affected research agendas.
- OECD survey does indicate that universities are developing ways to protect scientific enterprise in their licensing agreements.

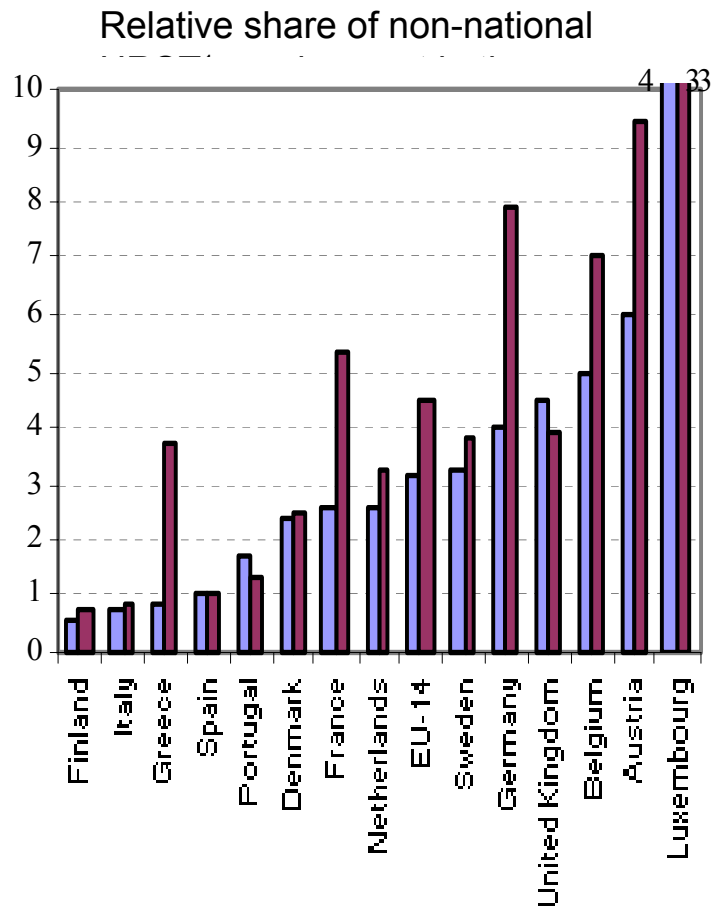
S&T Workforce continues to expand

Total researchers per thousand in labour force



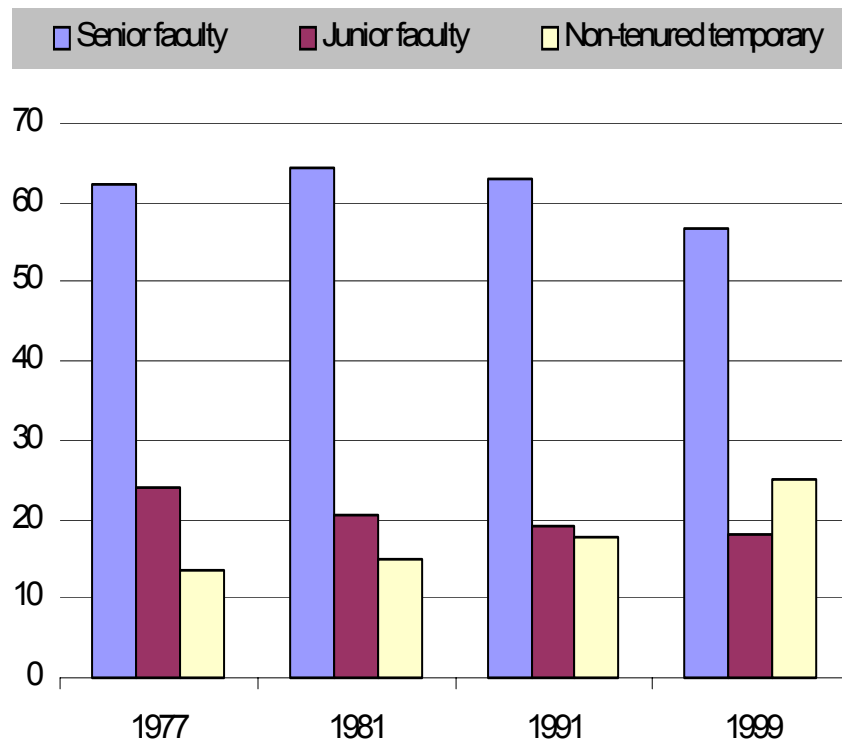
Growing mobility of skilled S&T workers

- Labour shortages and skills mismatches remain
- High-technology sectors areas particularly affected.
- Mobility within OECD is mainly circulation.
- Migration from Asia to US, Canada, UK, and Australia



Human resource strained in public research sector

Growth in temporary employment in the U.S.



Trends

- Competition between public & private sectors increasing
- Shortages in skills and numbers
- Greater industry support of academic positions
- Temporary employment increasing (US, Japan, Italy)

Responses.

- Performance-based pay; greater autonomy for hiring
- Attract more students.

Policy responses

- Active recruitment of students at university and post-graduate levels.
- Revision of immigration policies
 - US raised limits on H1-B visas for skilled workers
 - Germany established new programme for computer and technology specialists
 - France and UK simplified procedures for admitting computer specialists and skilled workers in shortage occupations
- S&T policy can help attract and retain skilled workers
 - increased salaries for public researchers
 - establishment of centres of excellence

Developments in China's S&T system

- R&D expenditures growing (1% of GDP in 2000), but still low, especially in business sector.
- Structure of R&D system improving, but system still not operating efficiently
 - Universities a small share of national R&D and conduct relatively little basic research.
 - Industry's innovative outputs (patents, new products and services) low compared to R&D inputs.
- Enterprise sector weak contributor to innovation.
- Mobility of human resources remains a concern, but educational output improving.
- Significant regional disparities remain

Large firms v. technology enterprises

Large and medium sized firms

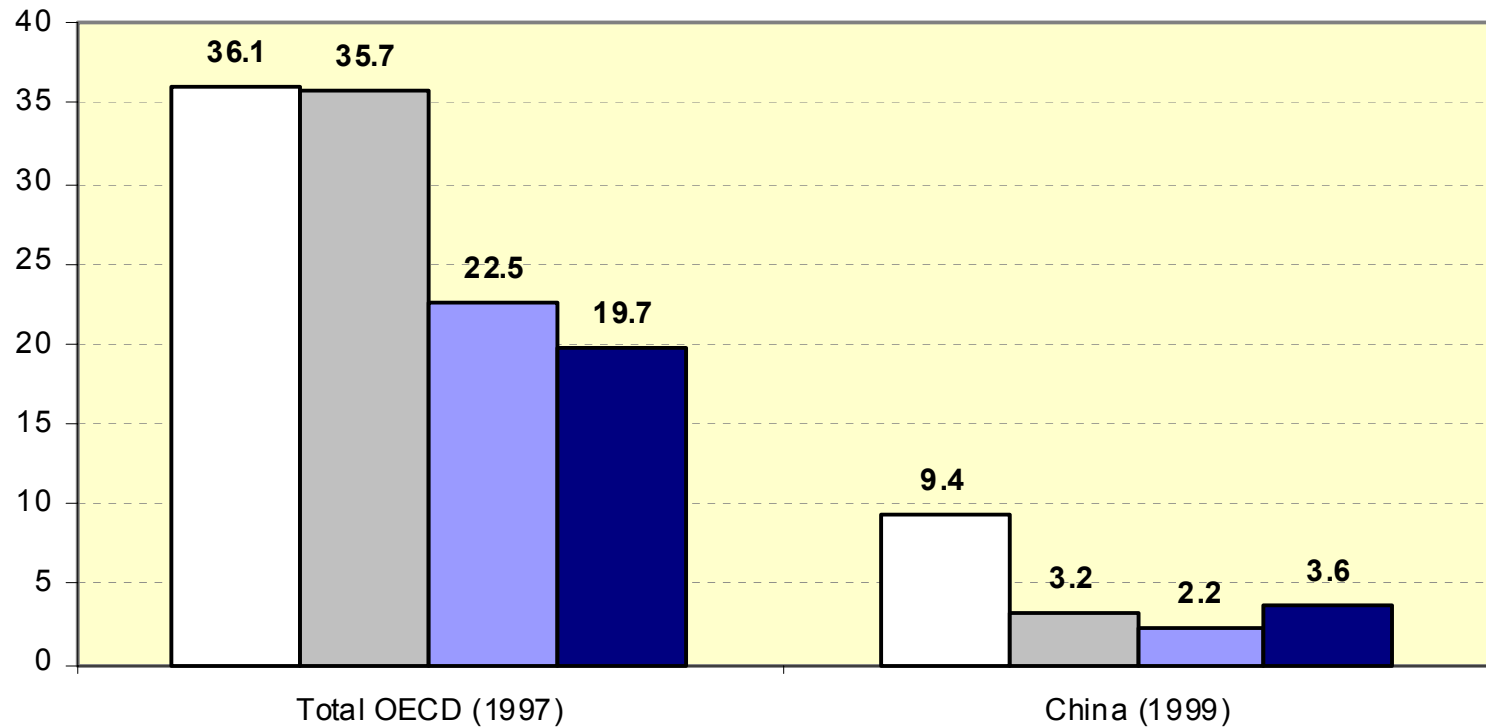
- Account for most of output and profits, as well as 37% of R&D.
- R&D capabilities expanding, but declining R&D intensity.
- R&D labs not operating at full capacity, under-utilised.
- Output low compared to share of inputs, but improving

Technology enterprises

- Start ups and spin-offs from government labs.
- Plan to convert 4000 government institutes into tech enterprises.
- Universities encouraged to establish enterprises.
- Most focus on commercialising R&D
- Technological strong, market oriented management.

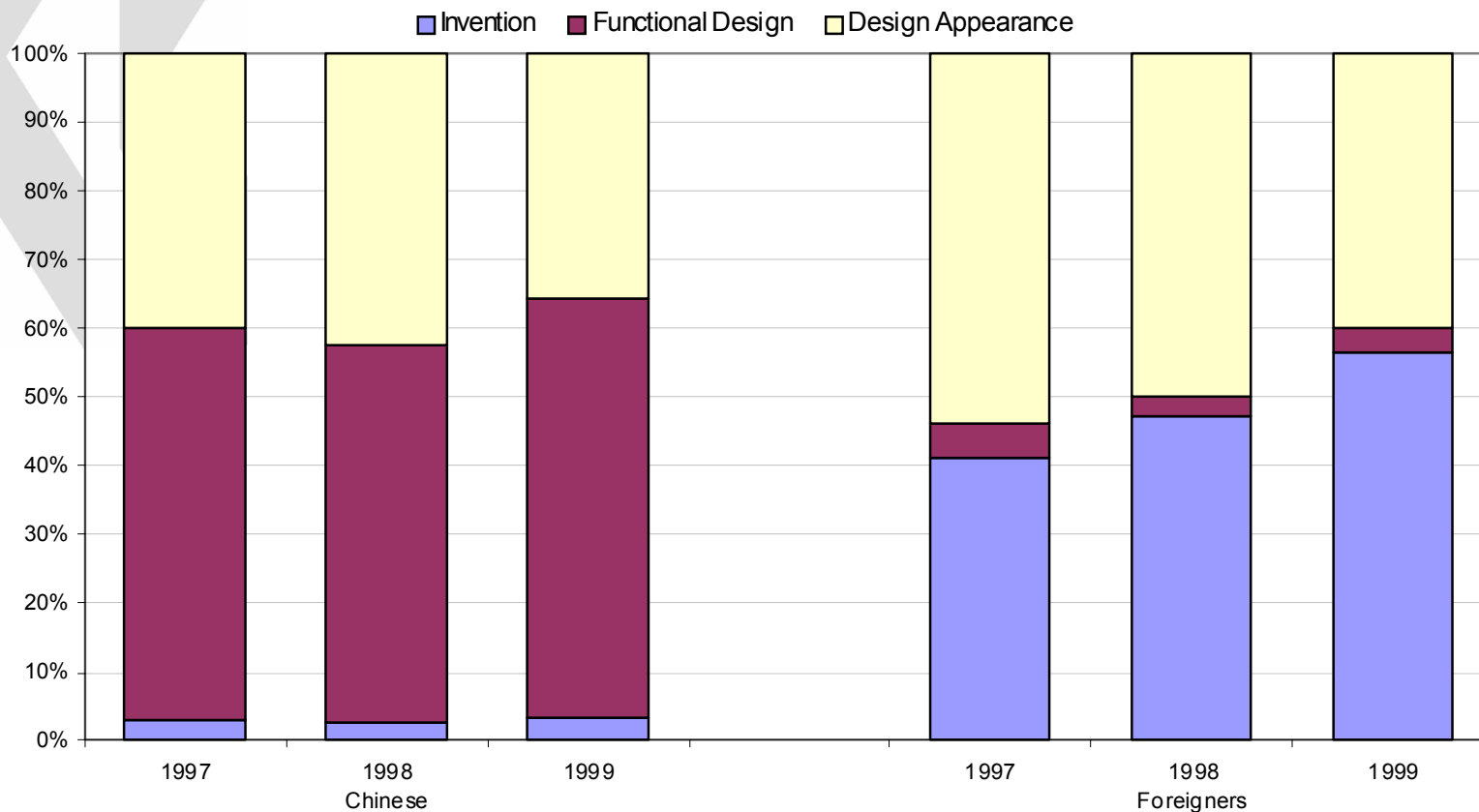
R&D intensity lagging in high-tech sectors

Legend:
Aerospace industry (white)
Office machinery and computer industry (grey)
Pharmaceuticals (light blue)
Electronic industry and communication equipment (dark blue)



Patenting designs, not inventions

Types of patents granted to Chinese and Foreigners, 1997-1999



Source: MOST 1999, p. 106 and MOST 2000, p. 26.

Role of FDI

- Important, but limited effect on innovation capabilities of Chinese industry.
 - Foreign affiliates primarily production bases.
 - Foreign owned firms have lower R&D intensity than state owned enterprises.
- Increasing investment in R&D facilities and R&D joint ventures (e.g., Microsoft, IBM)
- Imports of machinery and equipment dominate; little import of technology via licensing.
- Little attention to technology diffusion

Human resources for R&D

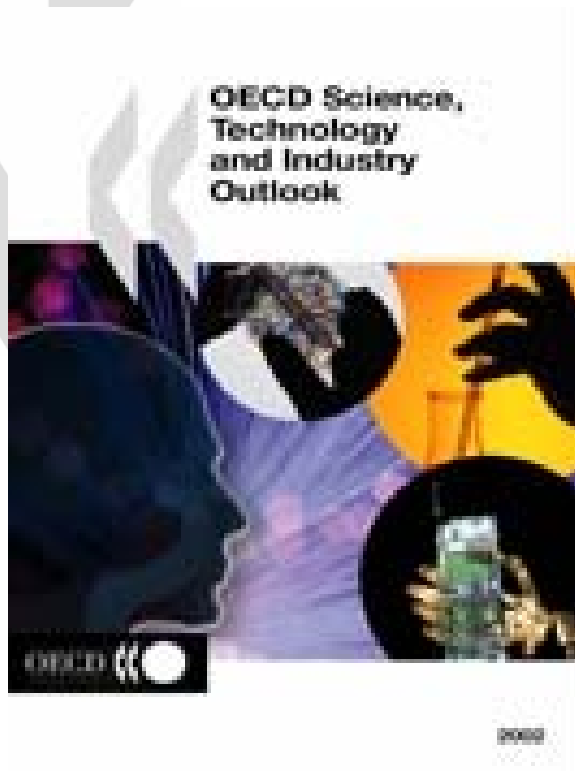
- Total number of S&T workers growing, but low as share of total population
- Share of scientists and engineers in S&T workforce has declined.
- Education system promises to be source of workers
 - 61% of undergraduates are in science and engineering
 - Graduate enrollments increasing; science and engineering accounts for 70% of masters and 80% of PhD students.
- Brain drain remains a concern, although repatriation of students improving.

Remaining policy challenges

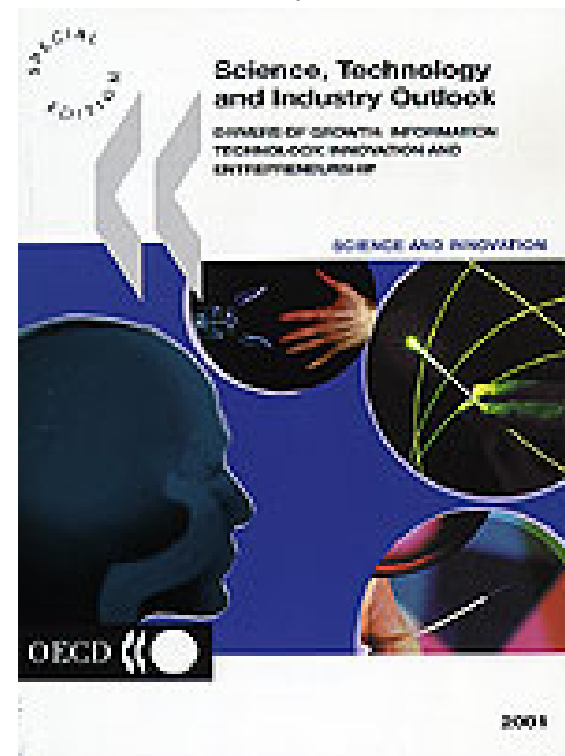
- Redefining role of government in innovation system-- shift from government led to market led.
- Improving innovation capabilities of business sector-- through financial reform, absorptive capacity
- Enhancing technology diffusion & commercialisation of R&D, while protecting science base.
- Tapping into global knowledge networks related to science, technology, and personnel.
- Framework conditions conducive to innovation: competition policy, IPR, financial stability, etc.

For more information. . .

STI Outlook 2002



*STI Outlook 2001
Drivers of Growth*



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