R&D, Innovation, and Economic Impact Indicators

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Technology's Importance

Economic studies over several decades have shown that

1) Technology accounts for *one-half of output (GDP) growth* in all industrialized nations (except Canada)

2) For several decades, productivity in "high-tech" manufacturing has grown three times as fast as for all of manufacturing

3) The increase in U.S. productivity growth that began in the mid-1990s is *entirely due to technology* investments.

4) The productivity advantage of the U.S. economy over other OECD countries accounts for *three-quarters of the per capita income gap*

5) The rate of return to basic science is about *three times* that for applied R&D, which, in turn, has *twice* the return on physical capital

Technology's Importance

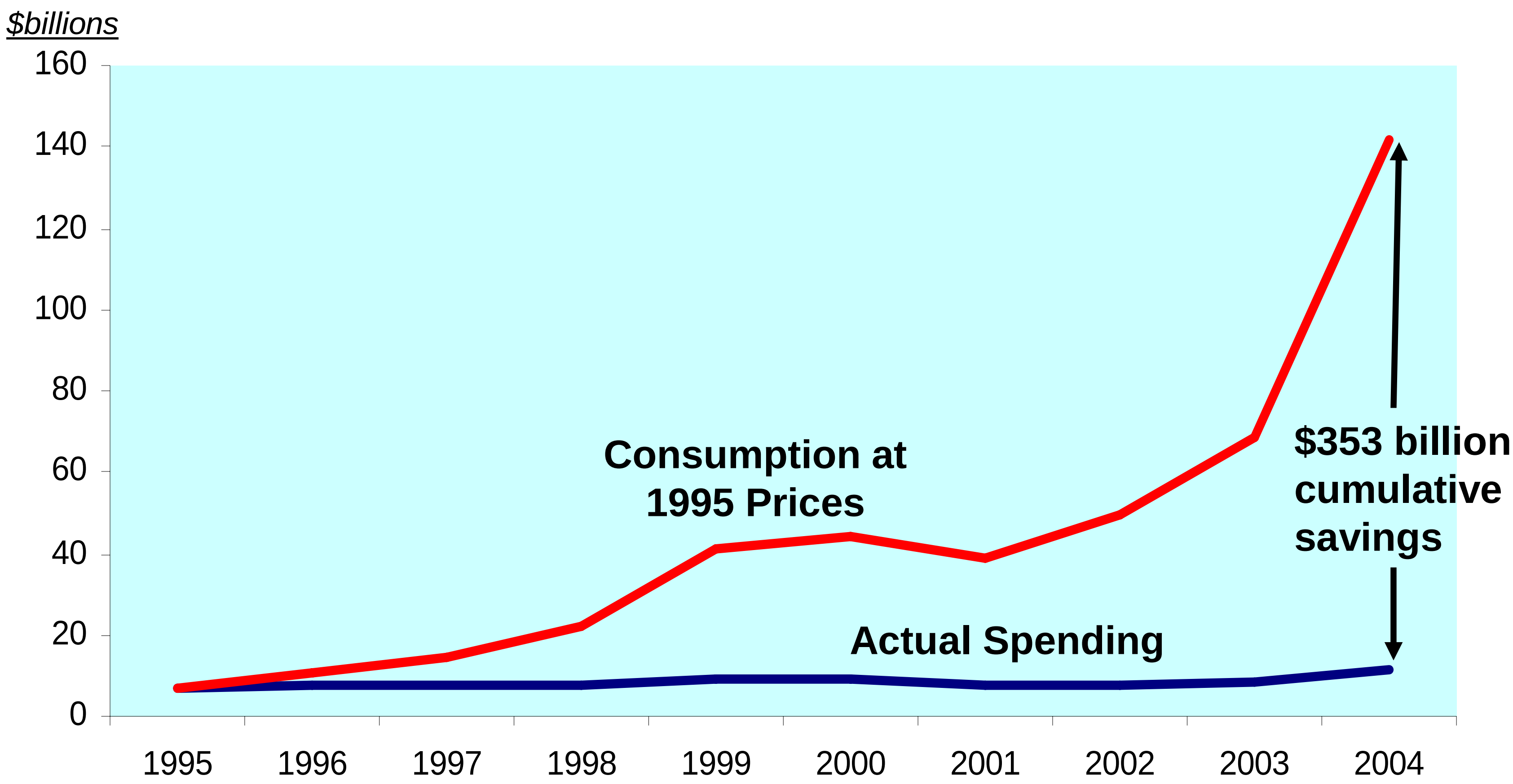
High-Tech Employment

- Median Wages in all 29 BLS high-tech industries exceeded the median for all industries
- In 10 of these industries (including 6 of 10 "high-tech intensive" industries), wages were more than 50 percent higher than the median for all industries
- Median wages in 7 of the 12 BLS technology-oriented occupations were more than twice the median for all occupations
- Even for technicians, the lowest paid of the high-tech occupational categories, the median wage was about one-third higher

Source: D. Hecker, "High-Technology Employment: A Broader View", *Monthly Labor Review*, June 1999

Technology's Importance

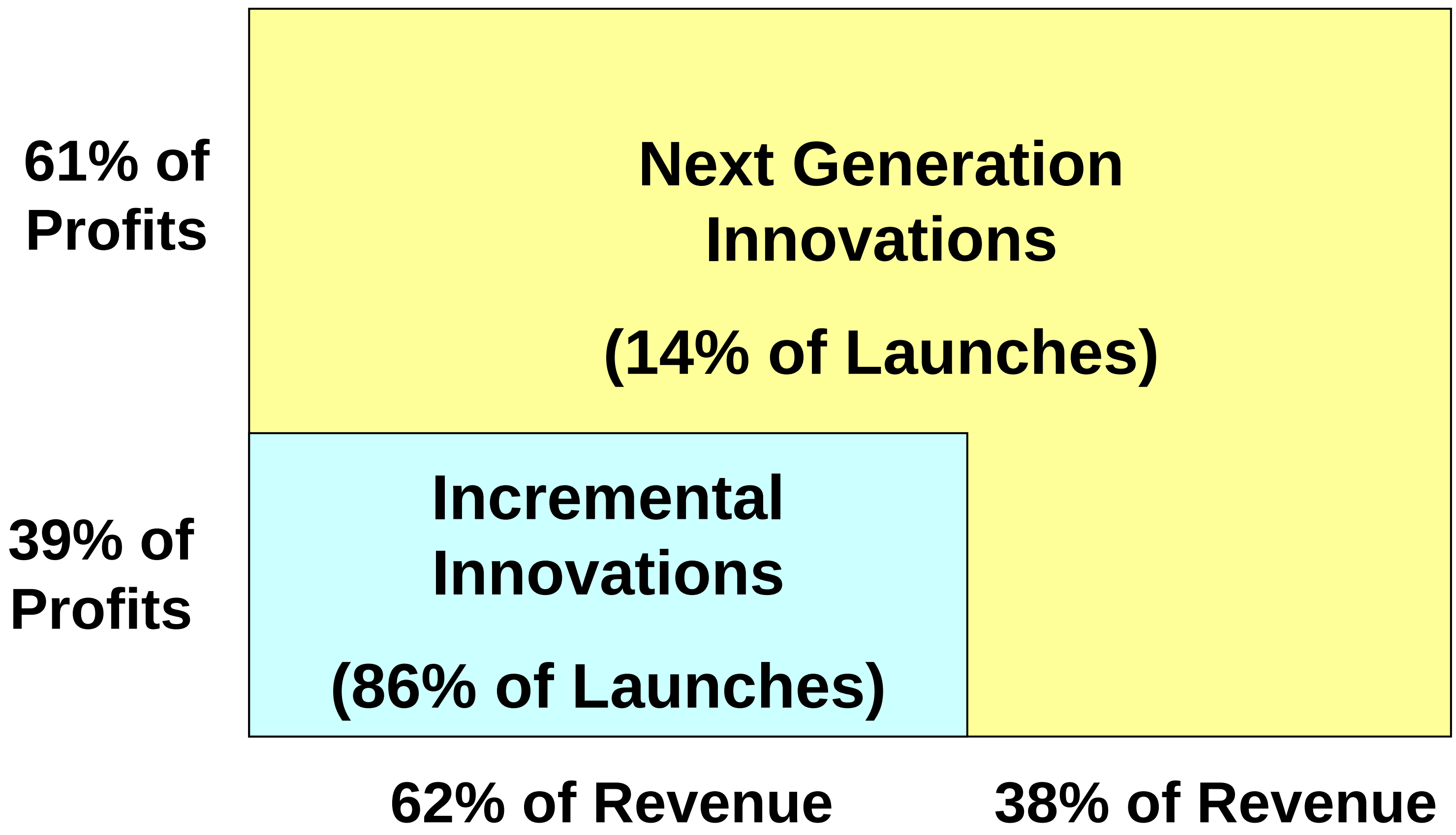
Impact of Technological Change:
Cost of Government Computer Purchases in Actual and 1995 Prices



Source: Bureau of Economic Analysis and Semiconductor Industry Association
Note: Consumption data include federal, state, and local governments

How Important is the Composition of R&D?

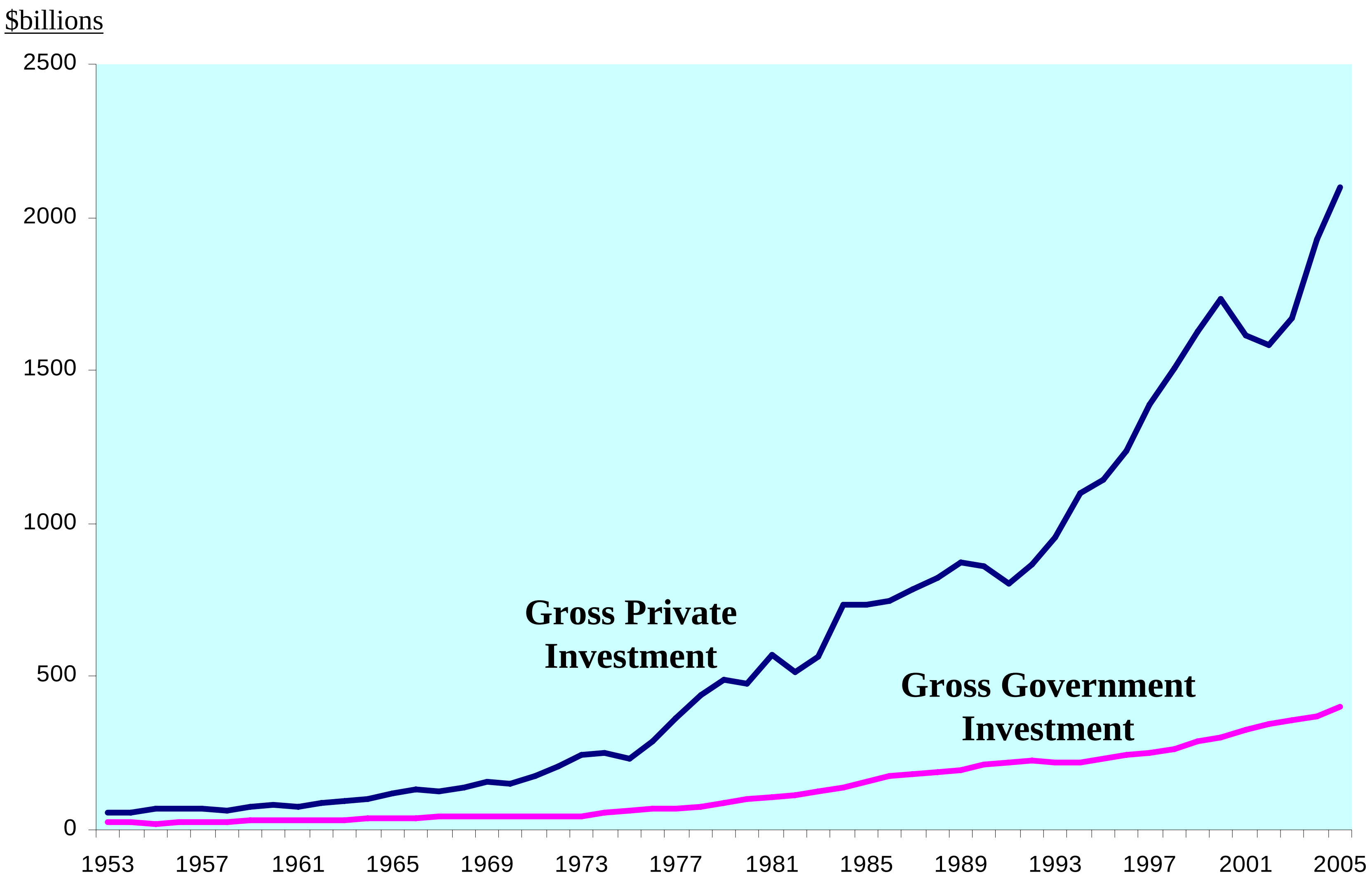
Profit Differentials for Major and Minor Innovations



Source: W. Chan Kim and Renee Mauborgne, “Value Innovation: The Strategic Logic of High Growth”, *Harvard Business Review*, 1997

Indicators of Underinvestment

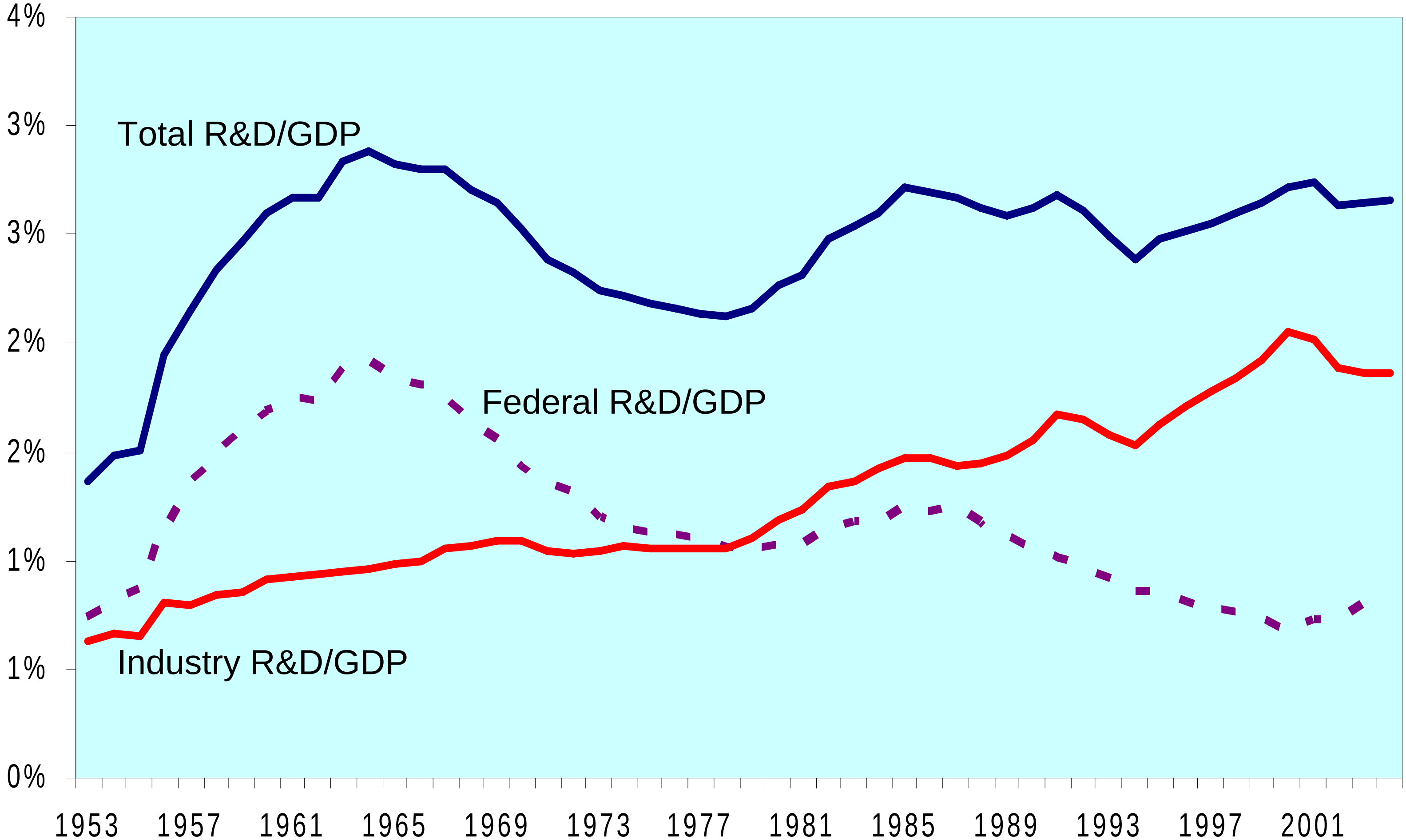
Public and Private U.S. Domestic Investment Trends, 1953-2005



Source: Bureau of Economic Analysis

Indicators of Underinvestment

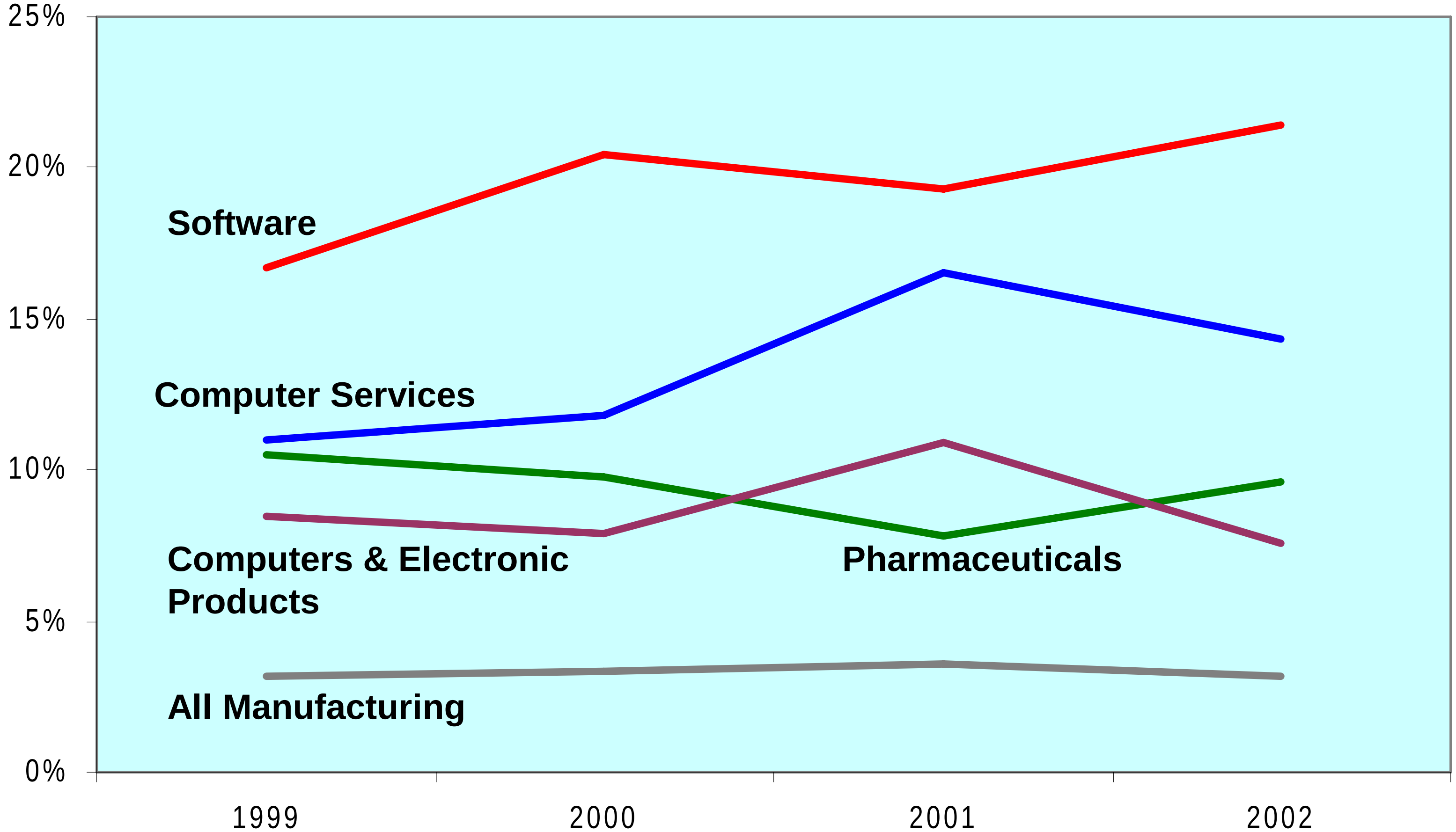
R&D Intensity: Funding as a Share of GDP, 1953-2004



Source: National Science Foundation

Indicators of Underinvestment

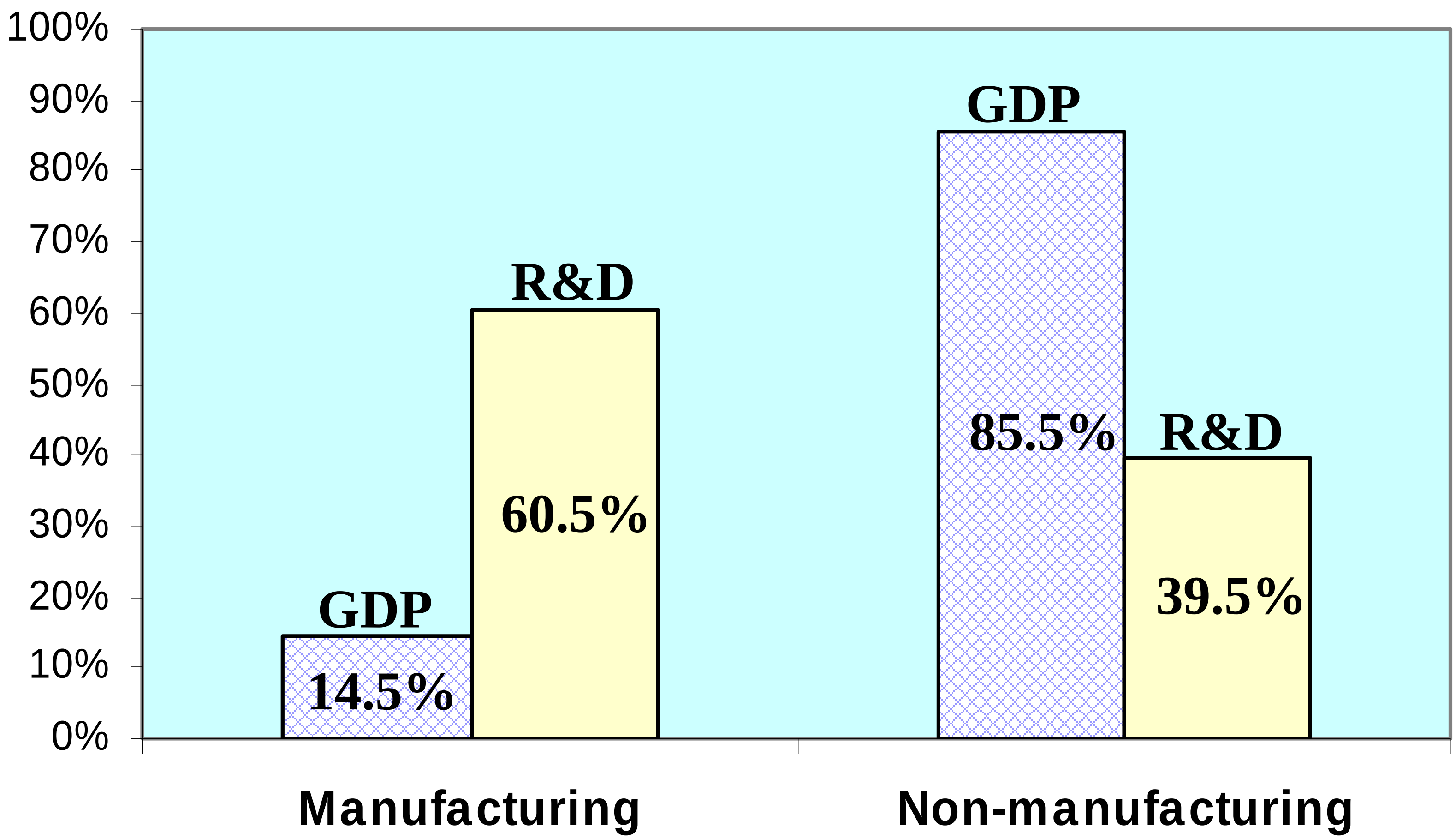
R&D Intensity:
Company Funds for R&D Relative to Sales, 1999–2002



Source: National Science Foundation. R&D funds include “other nonfederal” as well as company funds

Indicators of Underinvestment

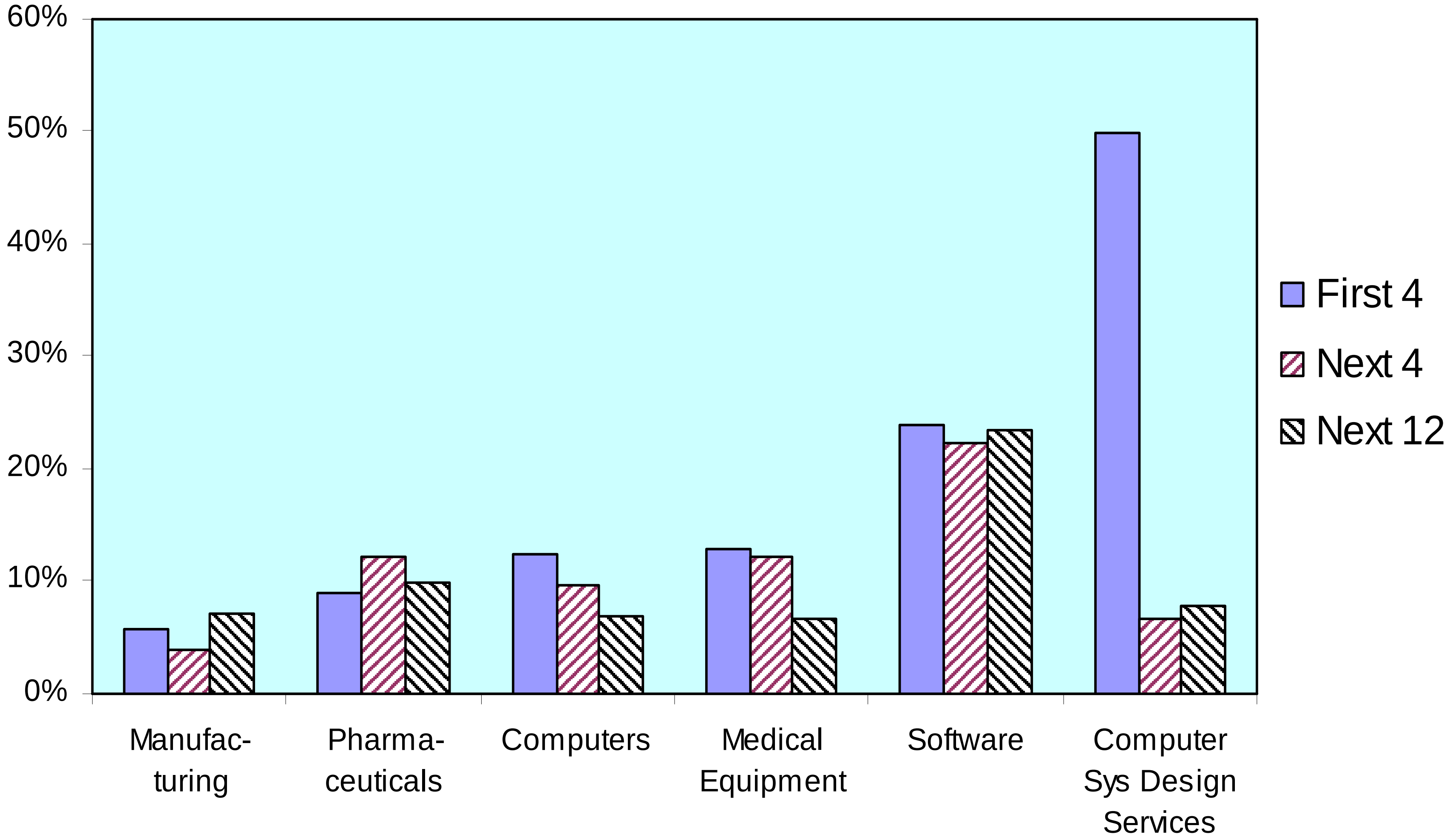
Major Industry Sector Shares of GDP and Industry R&D Performance, 2003



Source: Bureau of Economic Analysis, National Science Foundation

Indicators of Underinvestment

Distribution of Industry/Sector R&D by Size of Company, 2002



Source: National Science Foundation. R&D funds include "other nonfederal" as well as company funds

Indicators of Underinvestment

Geographic Distribution of U.S. R&D: Top Ten States by Share of R&D Performance

State	% of Population	% of National R&D
California	12.0	20.7
Michigan	3.5	8.1
New York	6.7	6.1
Texas	7.4	5.4
Massachusetts	2.3	5.3
Pennsylvania	4.4	4.6
New Jersey	3.0	4.6
Illinois	4.4	4.2
Washington	2.1	3.6
Maryland	1.9	3.5
Total	**47.7**	**66.1**

Source: National Science Foundation

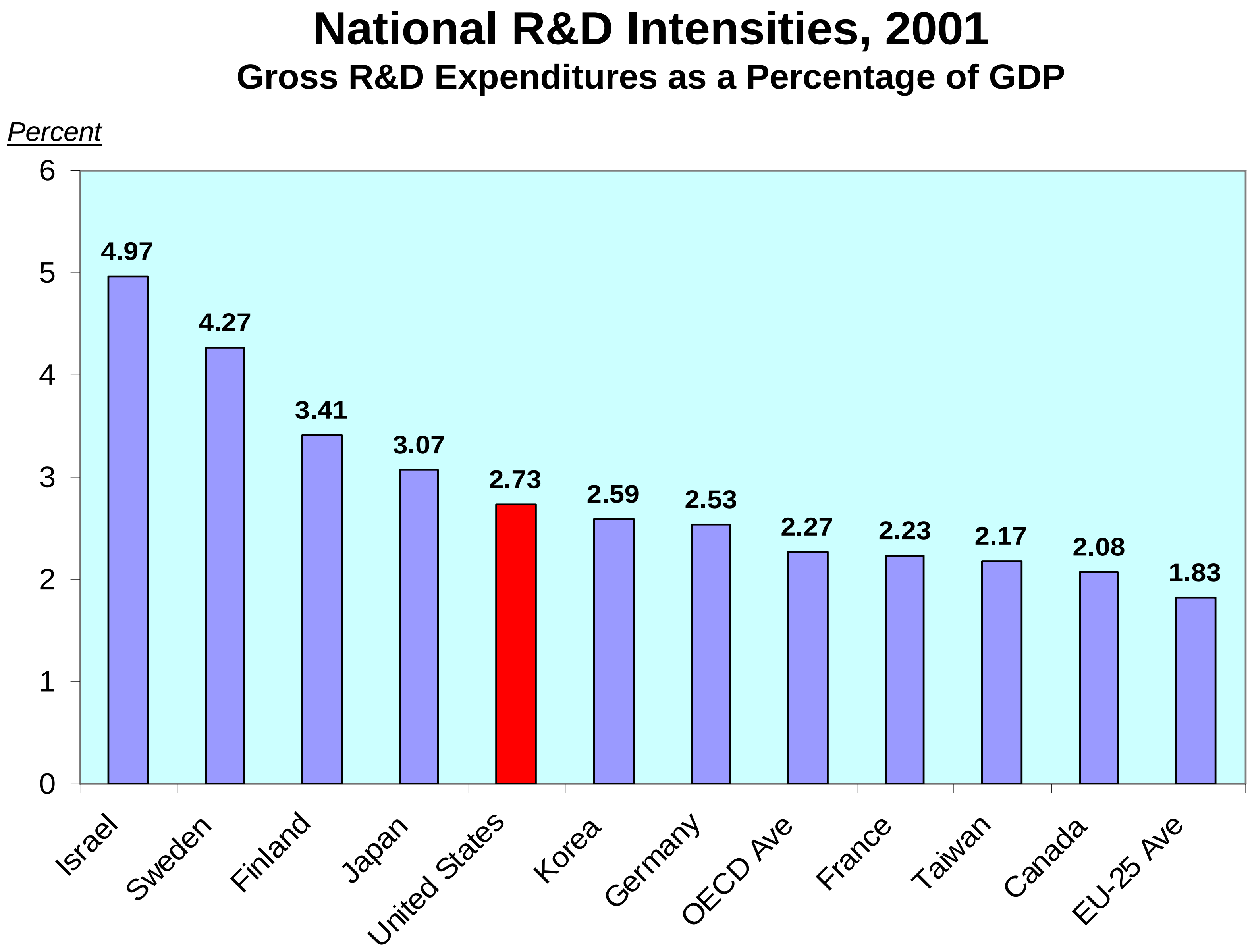
Indicators of Underinvestment

Geographic Distribution of U.S. R&D: Top Ten States by R&D Intensity

State	R&D/GSP (%)
New Mexico	7.12
Maryland	5.84
Massachusetts	5.10
Michigan	4.85
Washington	4.65
Oregon	4.54
Rhode Island	4.28
District of Columbia	3.94
California	3.75
Idaho	3.41

Source: National Science Foundation (GSP = Gross State Product)

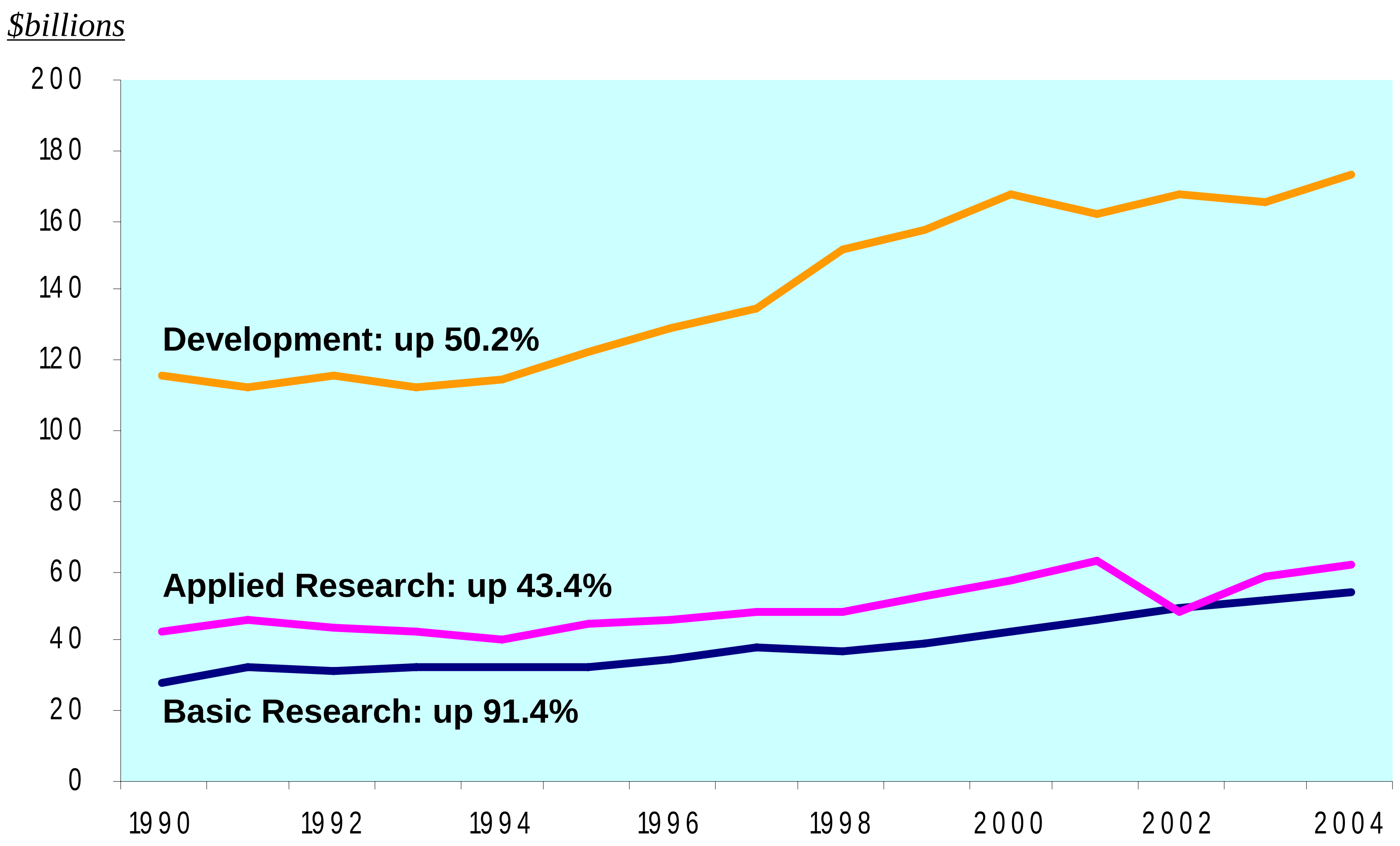
Indicators of Underinvestment



Source: OECD, Main Science and Technology Indicators, May 2005

Indicators of Underinvestment

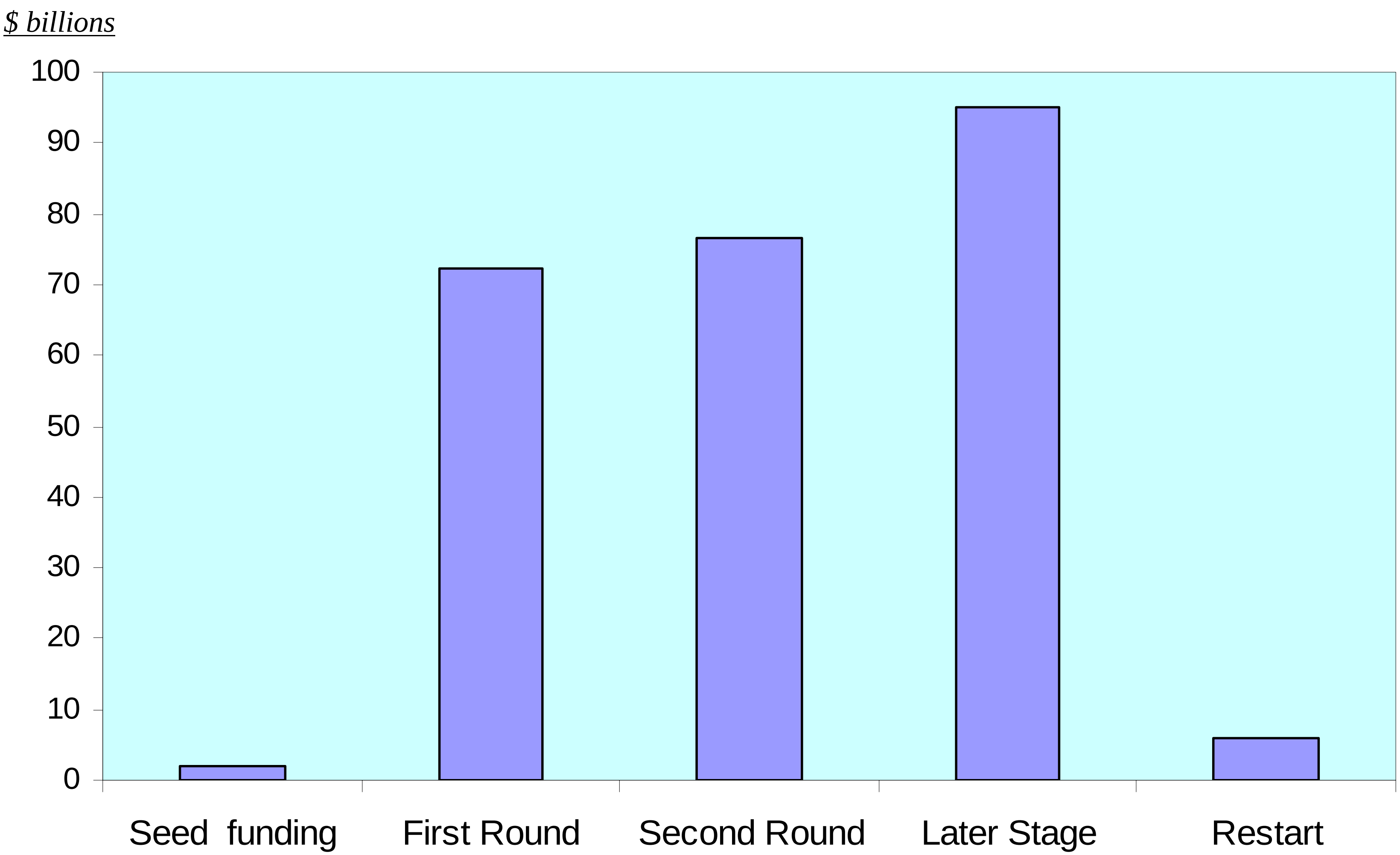
Trends in National R&D by Major Phase of R&D, 1990-2004 (in constant 2000 dollars)



Source: National Science Foundation, *National Patterns of R&D Resources*

How Important is the Composition of R&D?

Venture Capital Funding by Stage of Company Development
Cumulative Funding, 1997–2004



Source: VentureSource

Indicators of Underinvestment

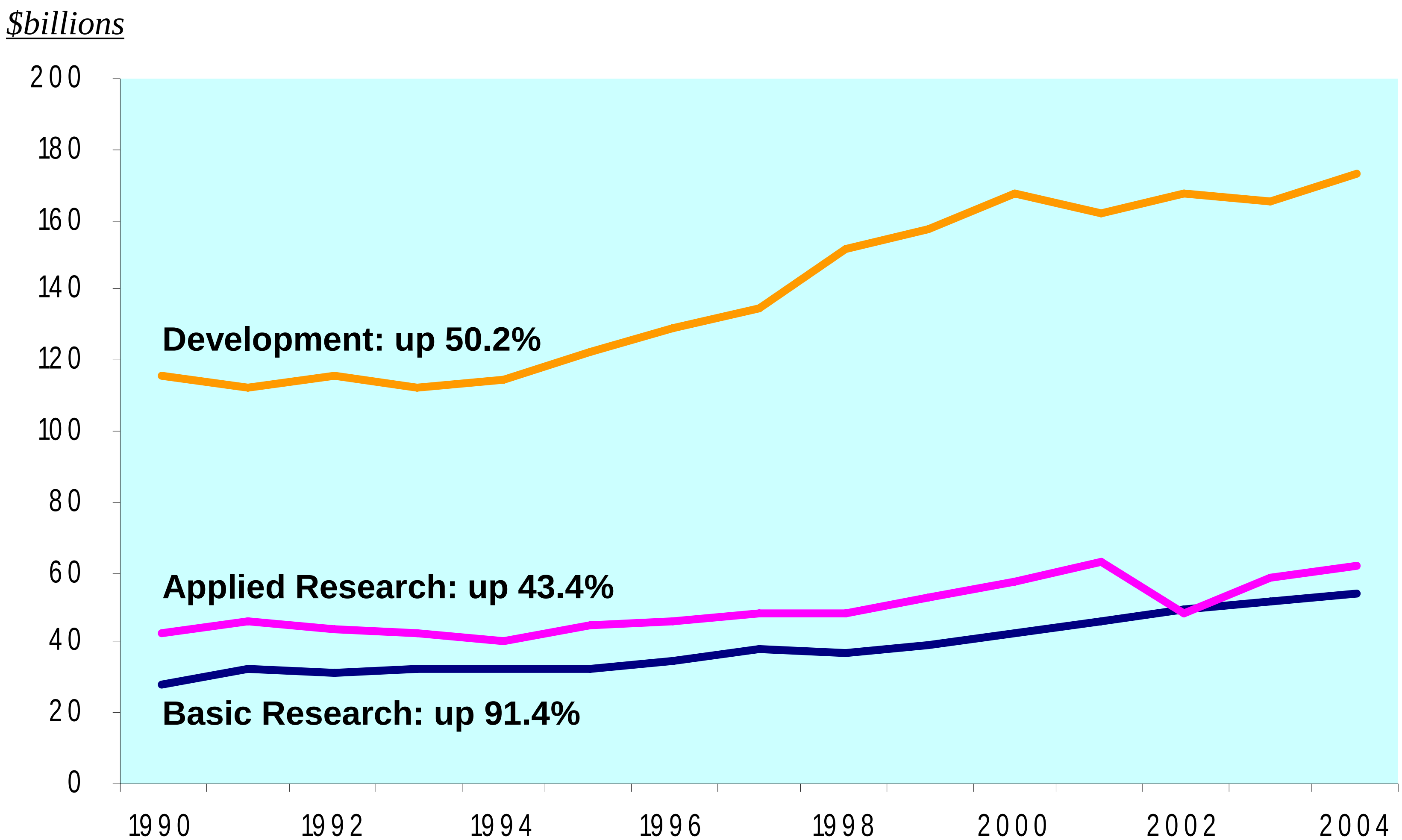
IRI "Sea Change" Index:
Significant Changes in Member Firms' Annual Planned Investments

Forecast Year	"Directed Basic Research"	"New Business Projects"
1993	**-26**	**+18**
1994	**-26**	**+18**
1995	**-19**	**+31**
1996	**-6**	**+39**
1997	**-26**	**+28**
1998	**-14**	**+24**
1999	**-23**	**+31**
2000	**-9**	**+34**
2001	**-21**	**+44**
2002	**-11**	**+30**
2003	**-21**	**+7**
2004	**-17**	**+1**
2005	**-21**	**+8**
2006	**-8**	**+31**

Source: Industrial Research Institute's annual surveys. The Sea Change Index is calculated by subtracting the percent of respondents reporting a planned decrease in the particular category of R&D spending from the percent planning an increase of greater than 5 percent. Sample size varies from year to year, but is approximately 100 firms.

Indicators of Underinvestment

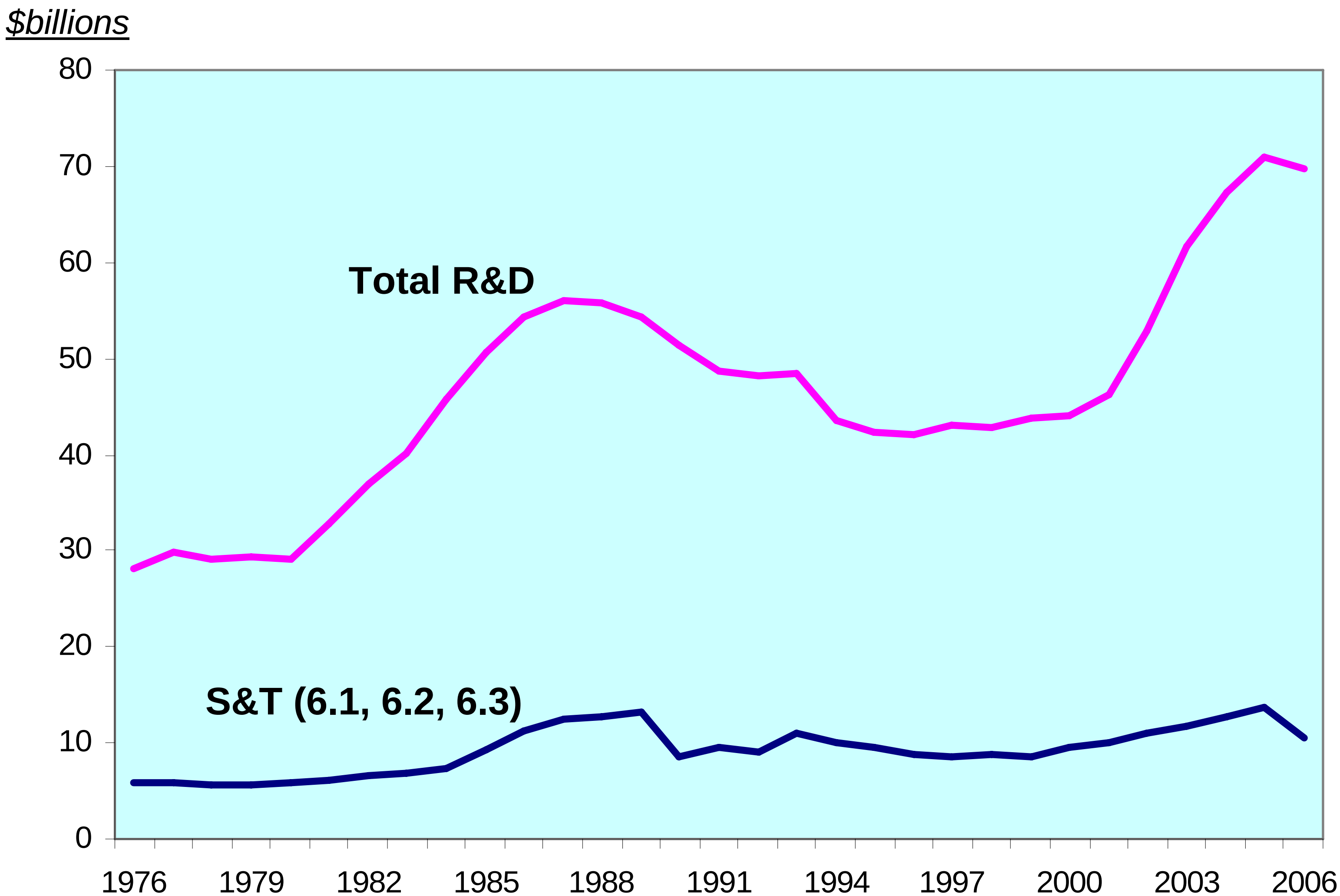
Trends in National R&D by Major Phase of R&D, 1990-2004 (in constant 2000 dollars)



Source: National Science Foundation, *National Patterns of R&D Resources*

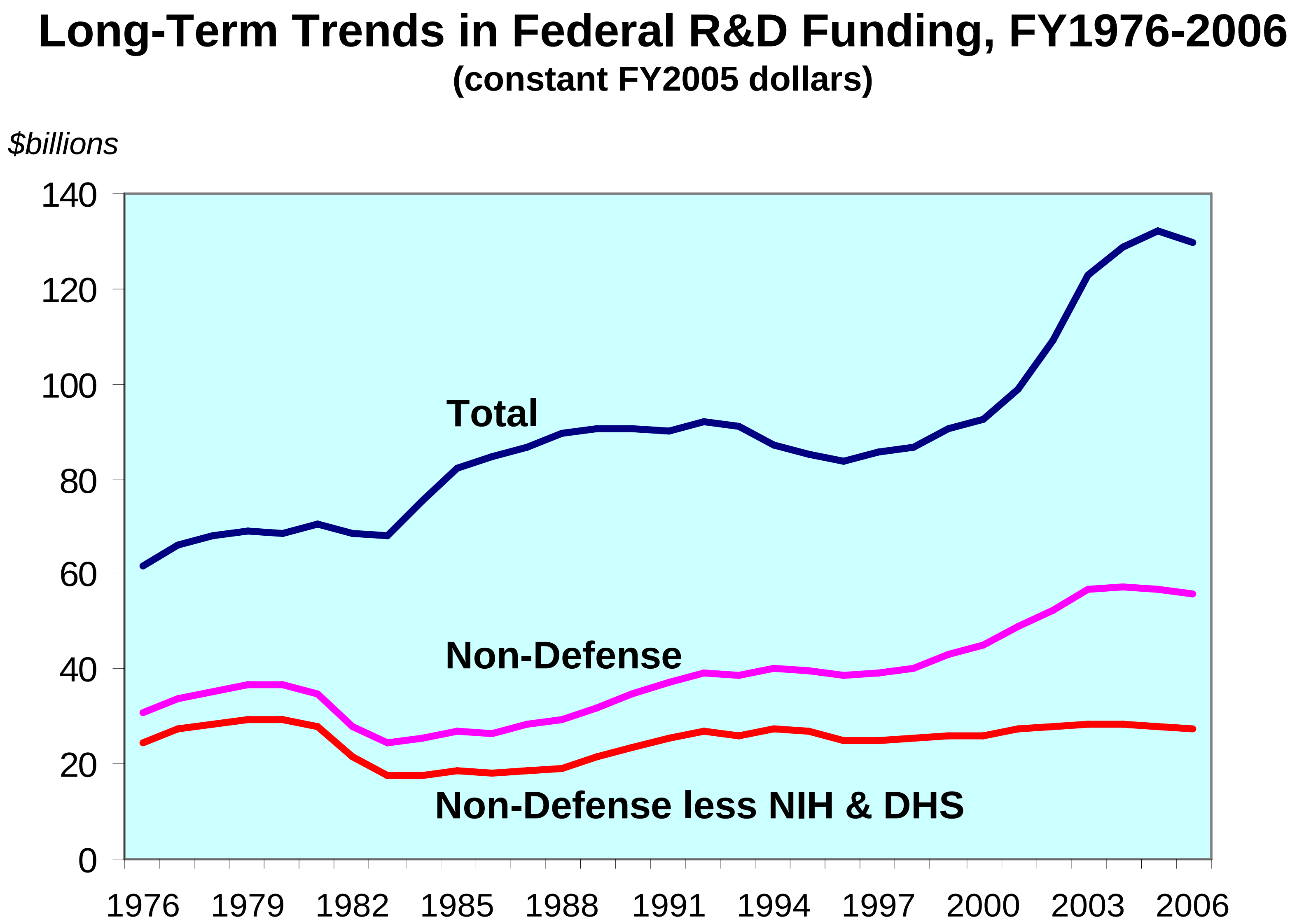
Indicators of Underinvestment

DoD S&T Funding vs. Total DoD R&D, FY1976–2006
(constant FY2006 dollars)



Source: AAAS; FY2006 estimate is President's request

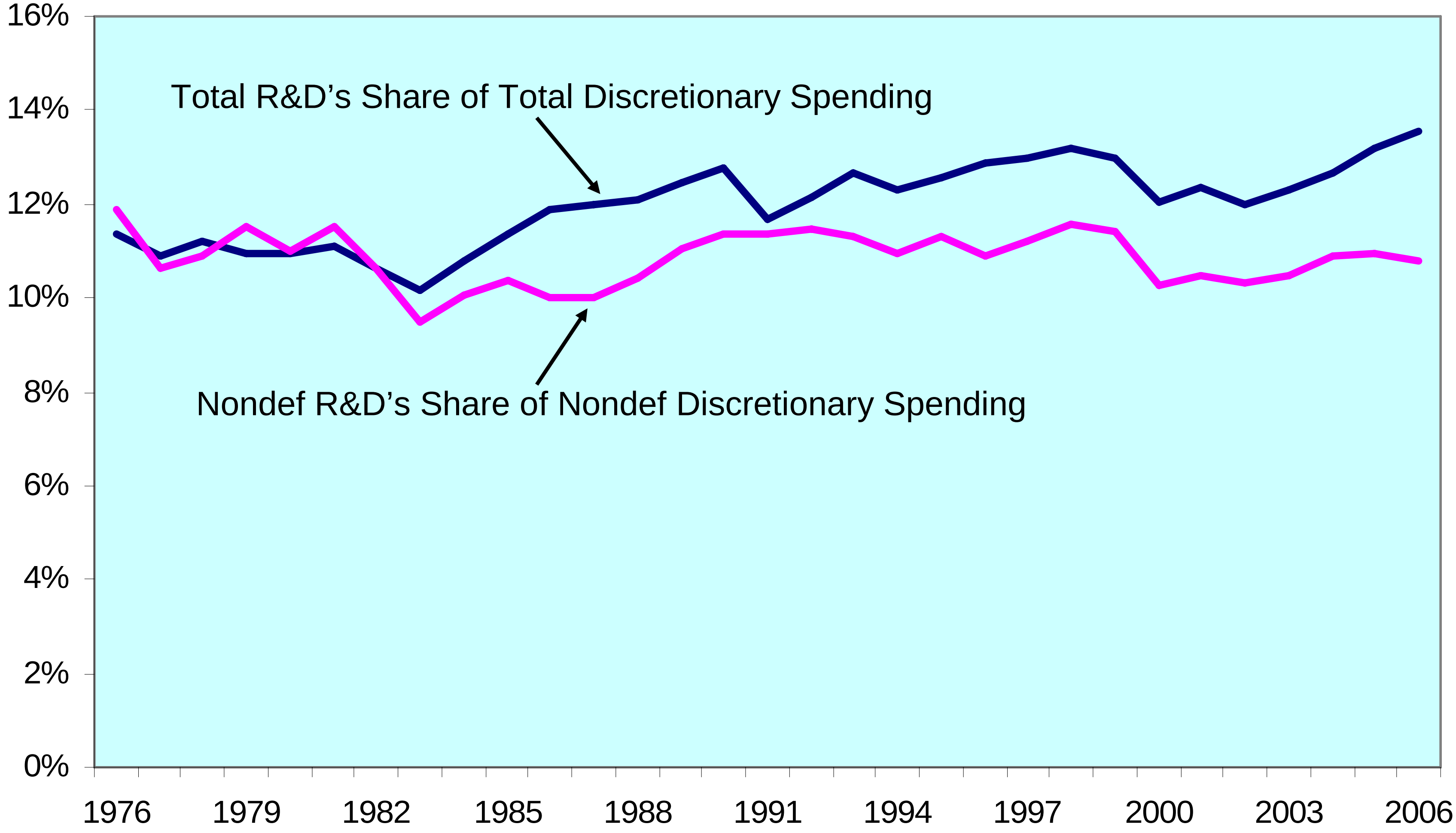
Indicators of Underinvestment



Source: AAAS (http://www.aaas.org/spp/rd/hist06p.pdf)

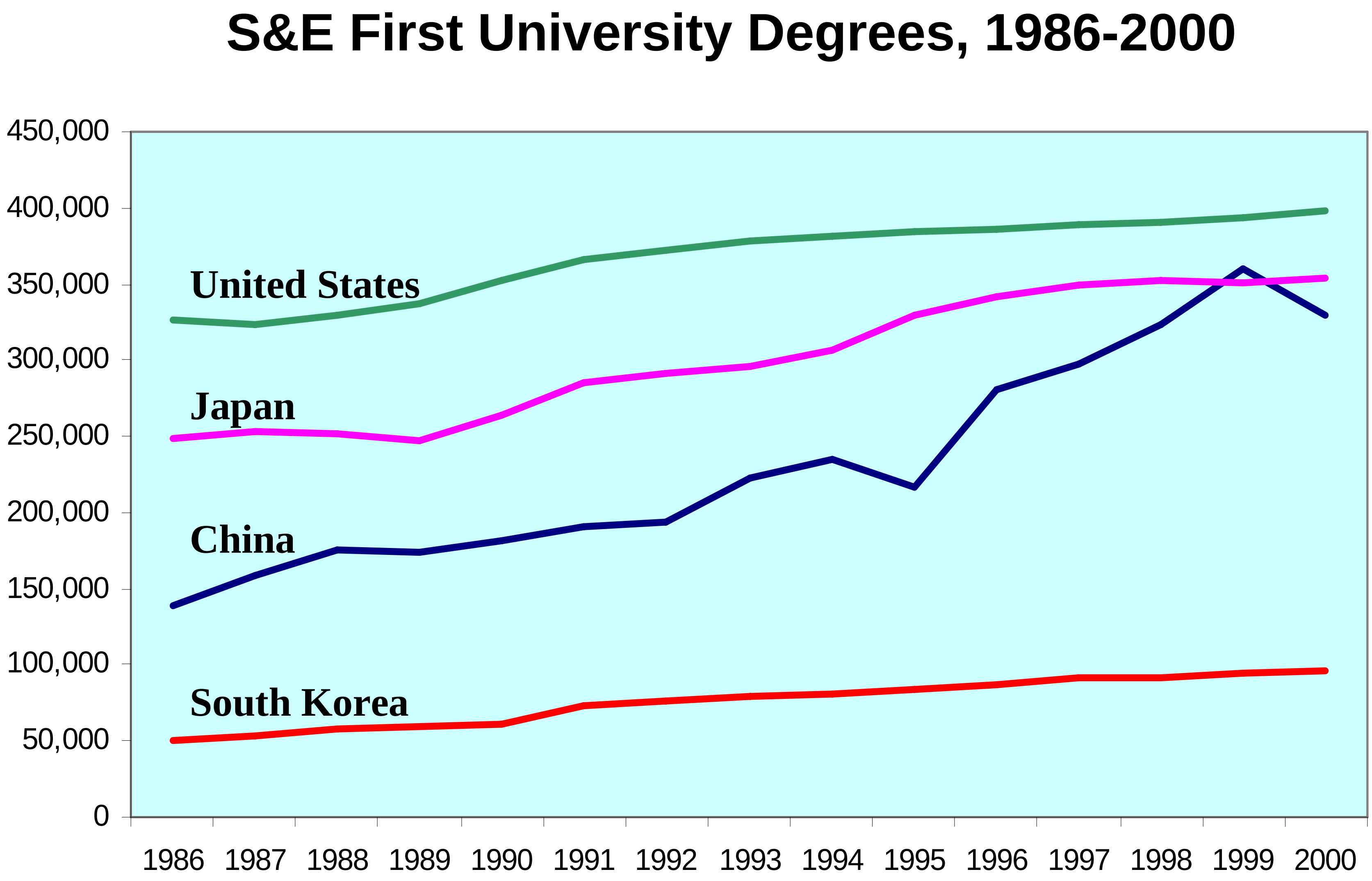
Indicators of Underinvestment

Federal R&D Shares of Federal Discretionary Spending



Source: NSF, Federal Budget FY2006; compiled by AAAS

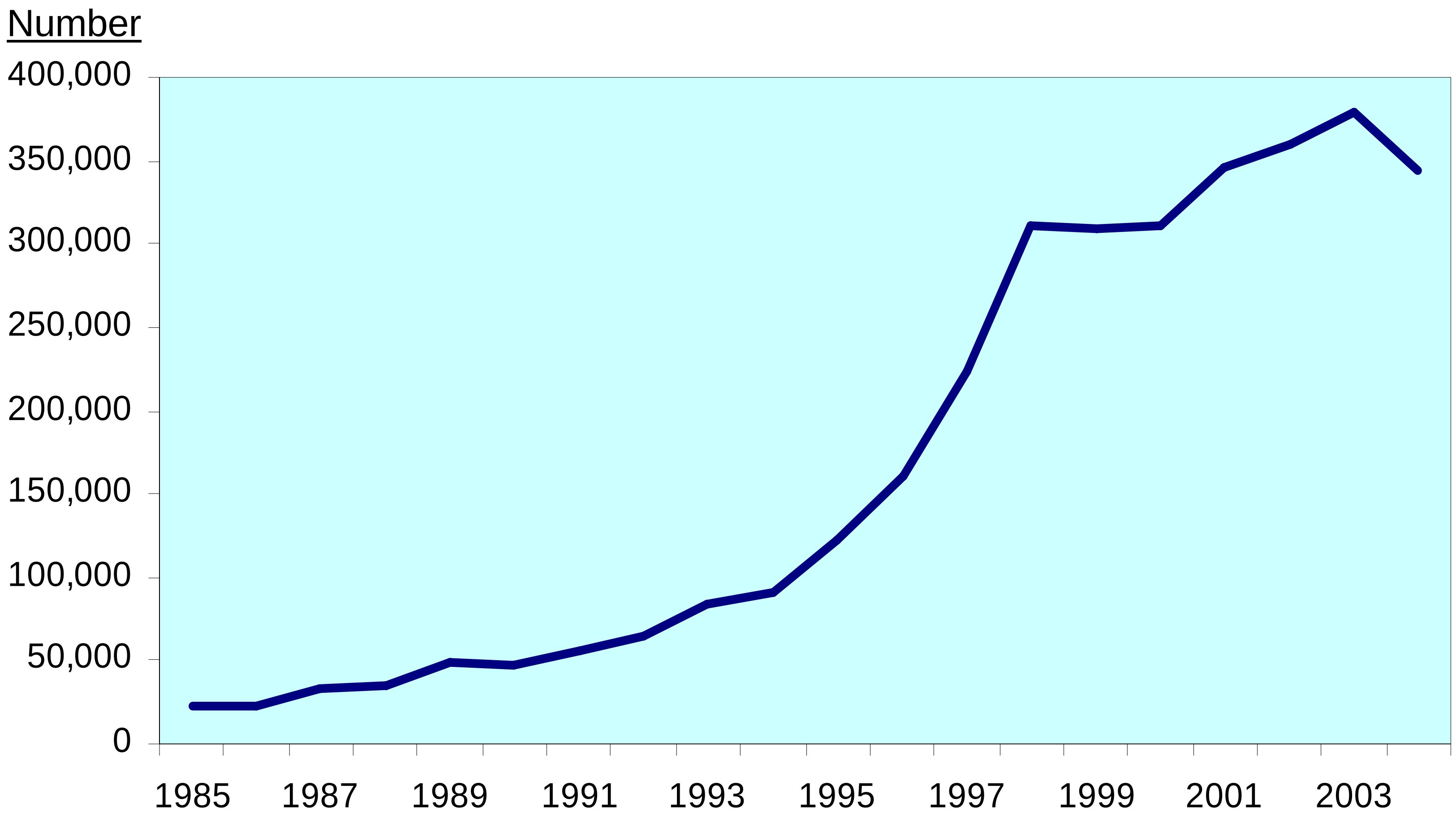
Indicators of Underinvestment



Source: National Science Foundation

Indicators of Underinvestment

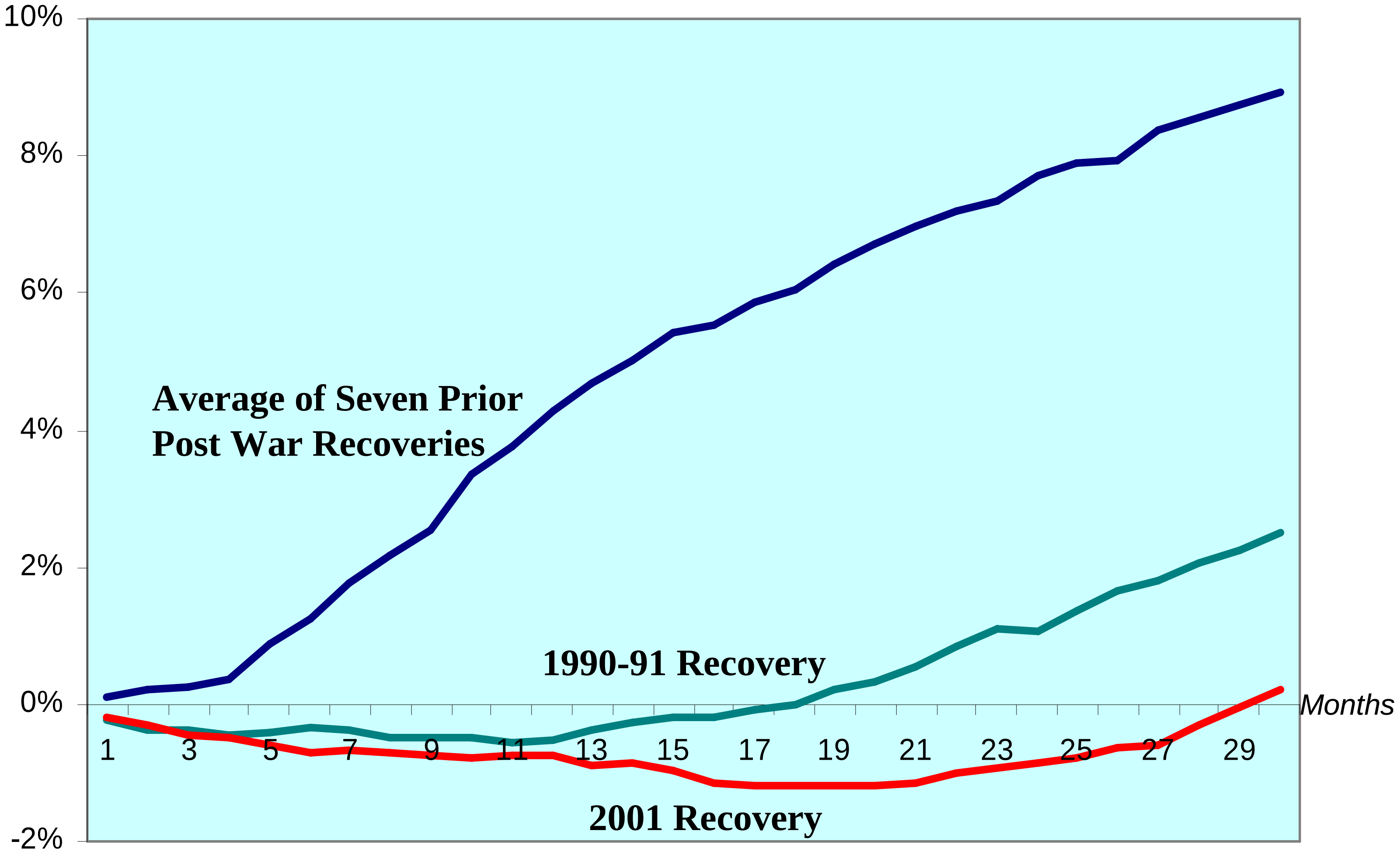
References to Scientific Publications in U.S. Patents



Source: Francis Narin, Research & Equity Markets

Indicators of Underinvestment

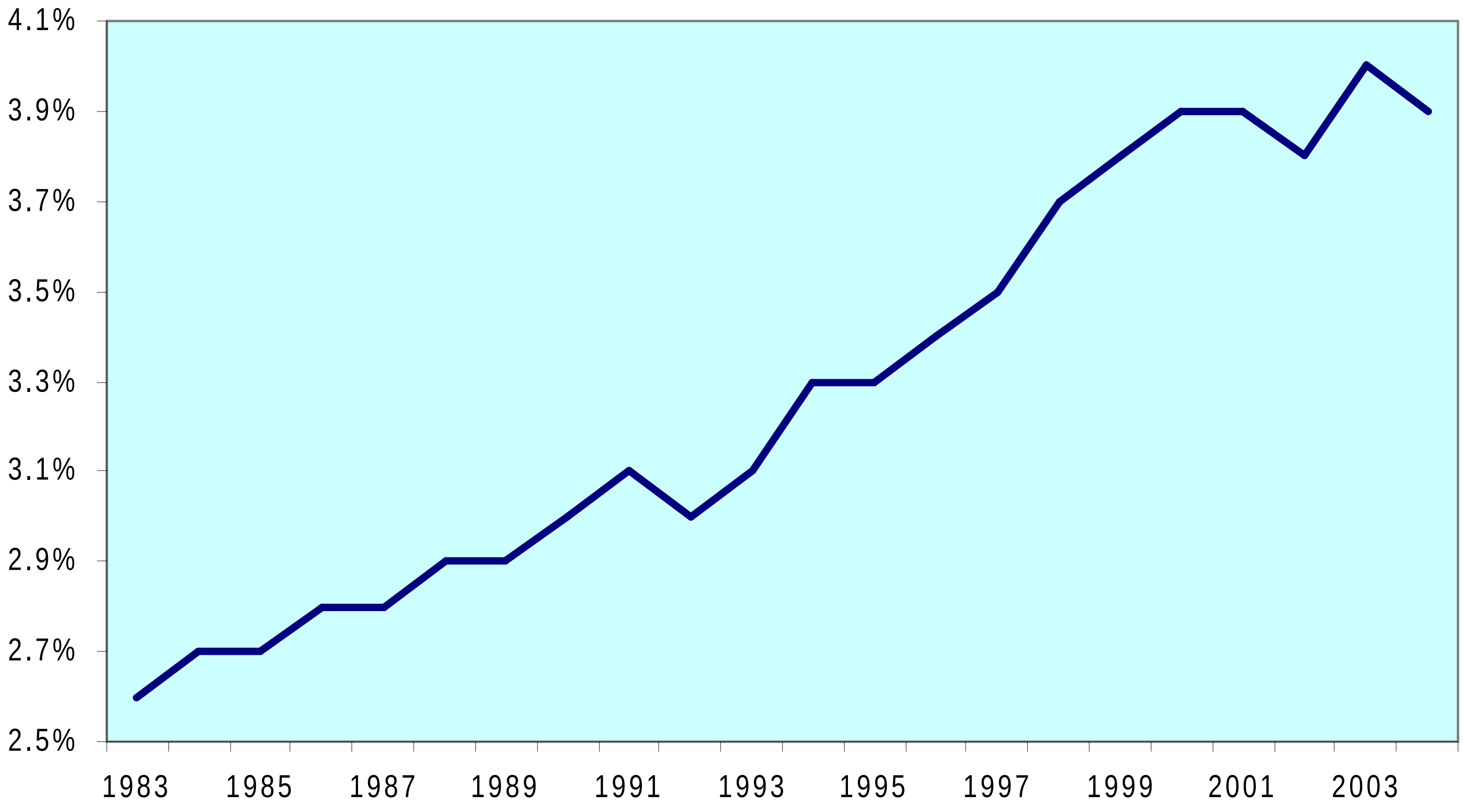
Non-Farm Private Sector Employment Growth in Post World War II Business Recoveries: Percent Change from Recession Trough



Sources: BLS for employment data; NBER for recession trough dates

Indicators of Underinvestment

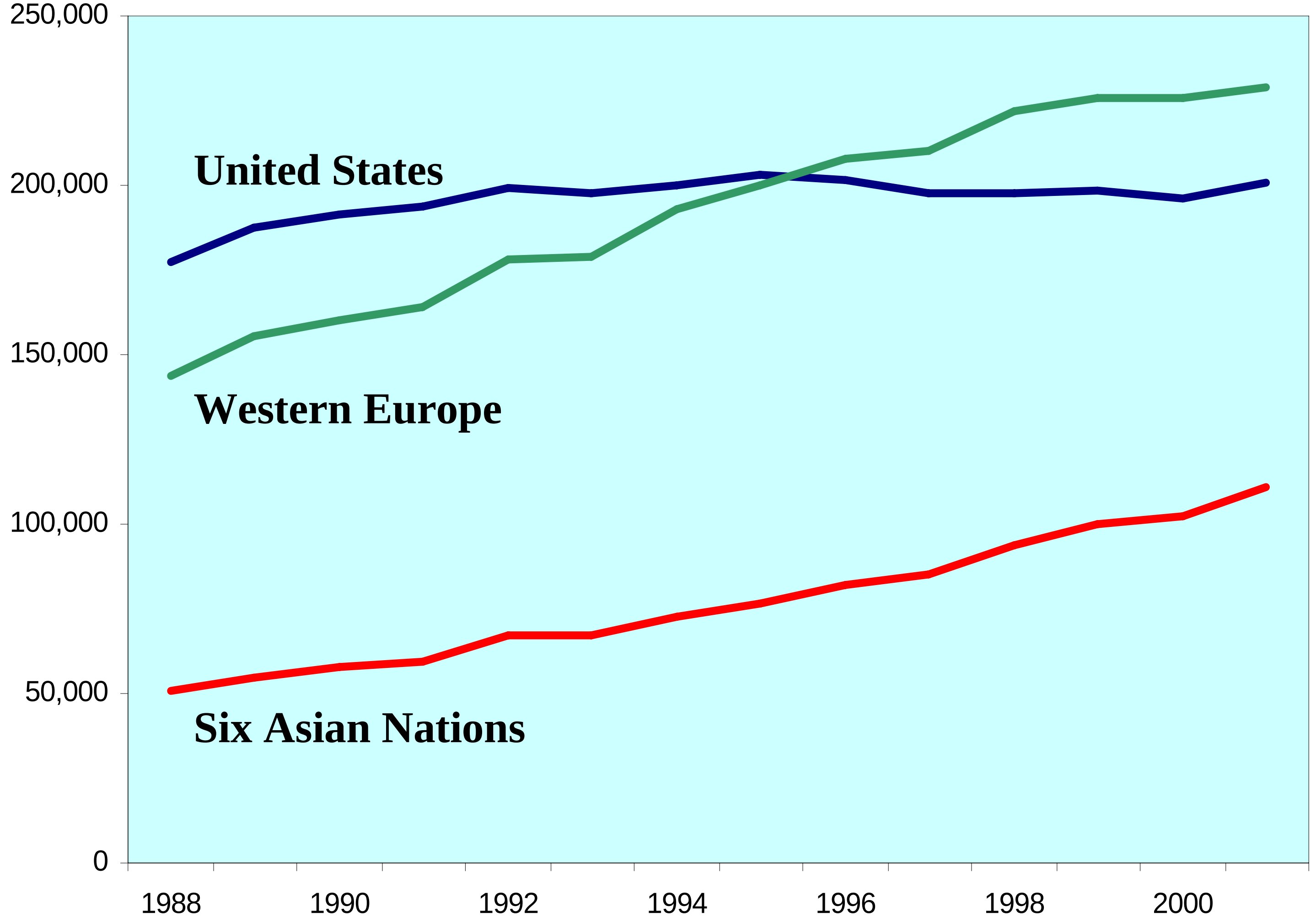
Science and Technology Employment as a Percent of Total Employment, 1950–2004



Source: National Science Board, *Science & Engineering Indicators - 2006*

Indicators of Underinvestment

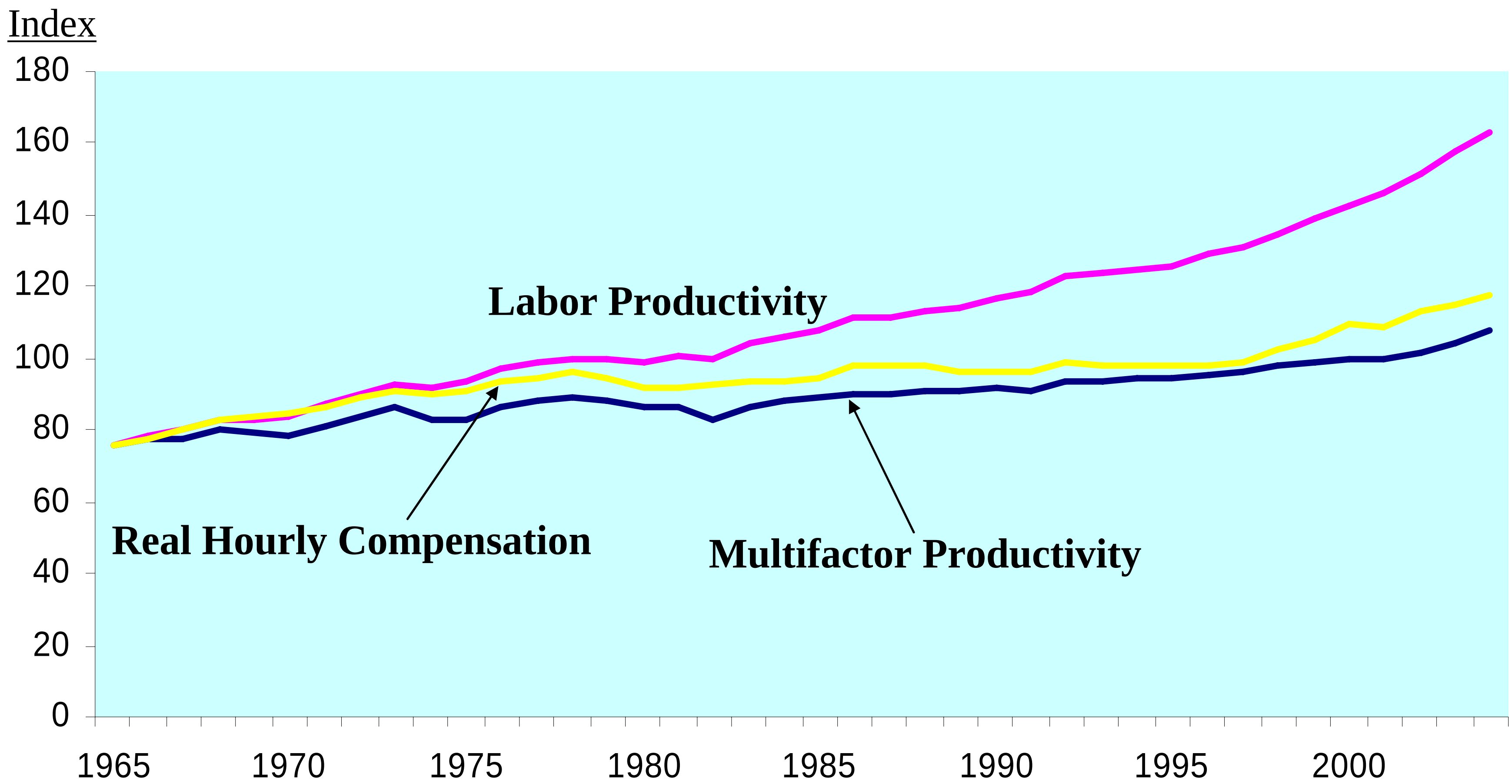
S&E Articles Published, 1988–2001



Source: National Science Foundation. The six Asian nations are Japan, South Korea, Taiwan, India, China, and Singapore.

Indicators of Underinvestment

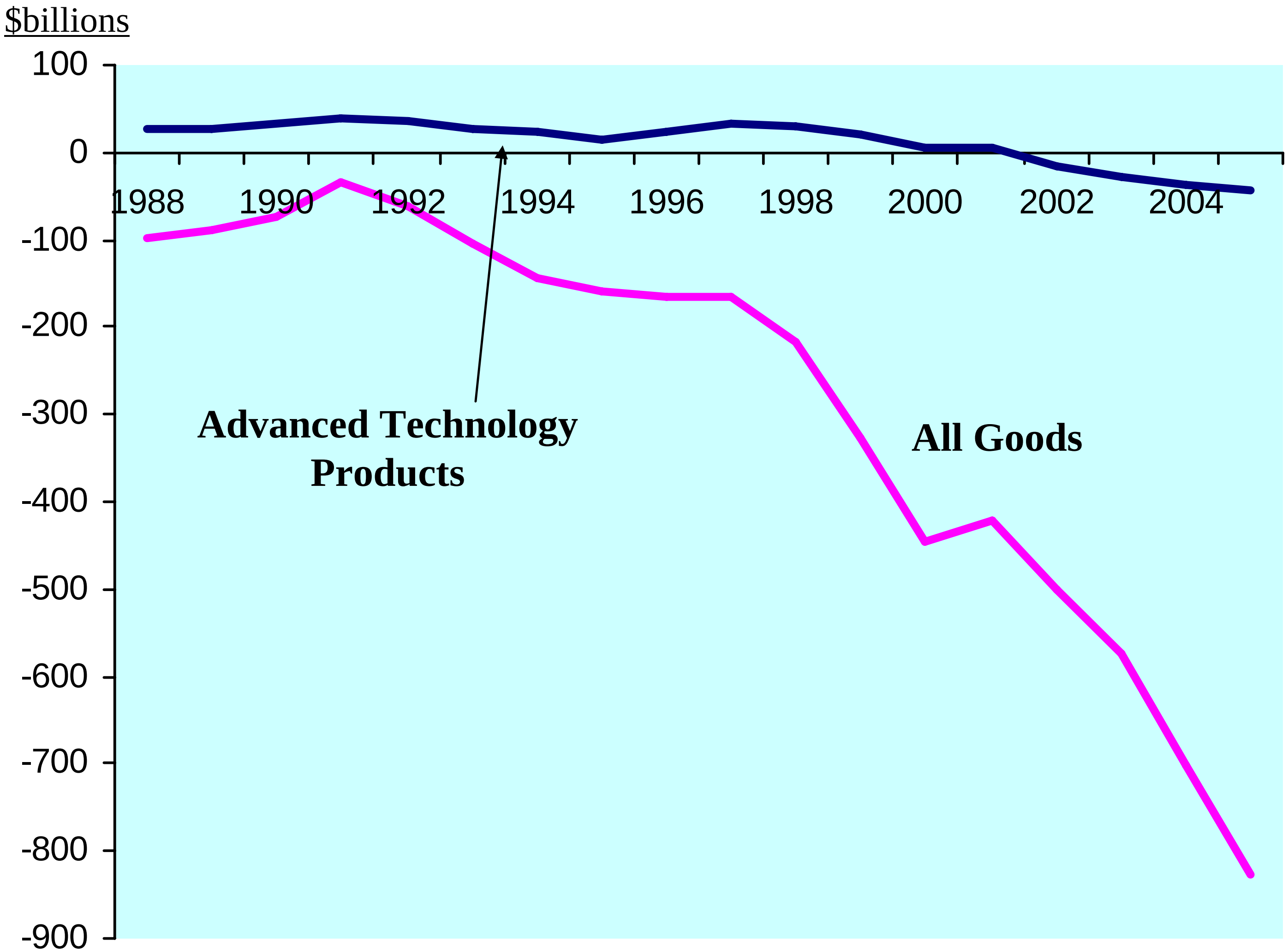
Trends in Productivity and Income
Non-Farm Business Sector, 1965-2004



Source: Bureau of Labor Statistics

Indicators of Underinvestment

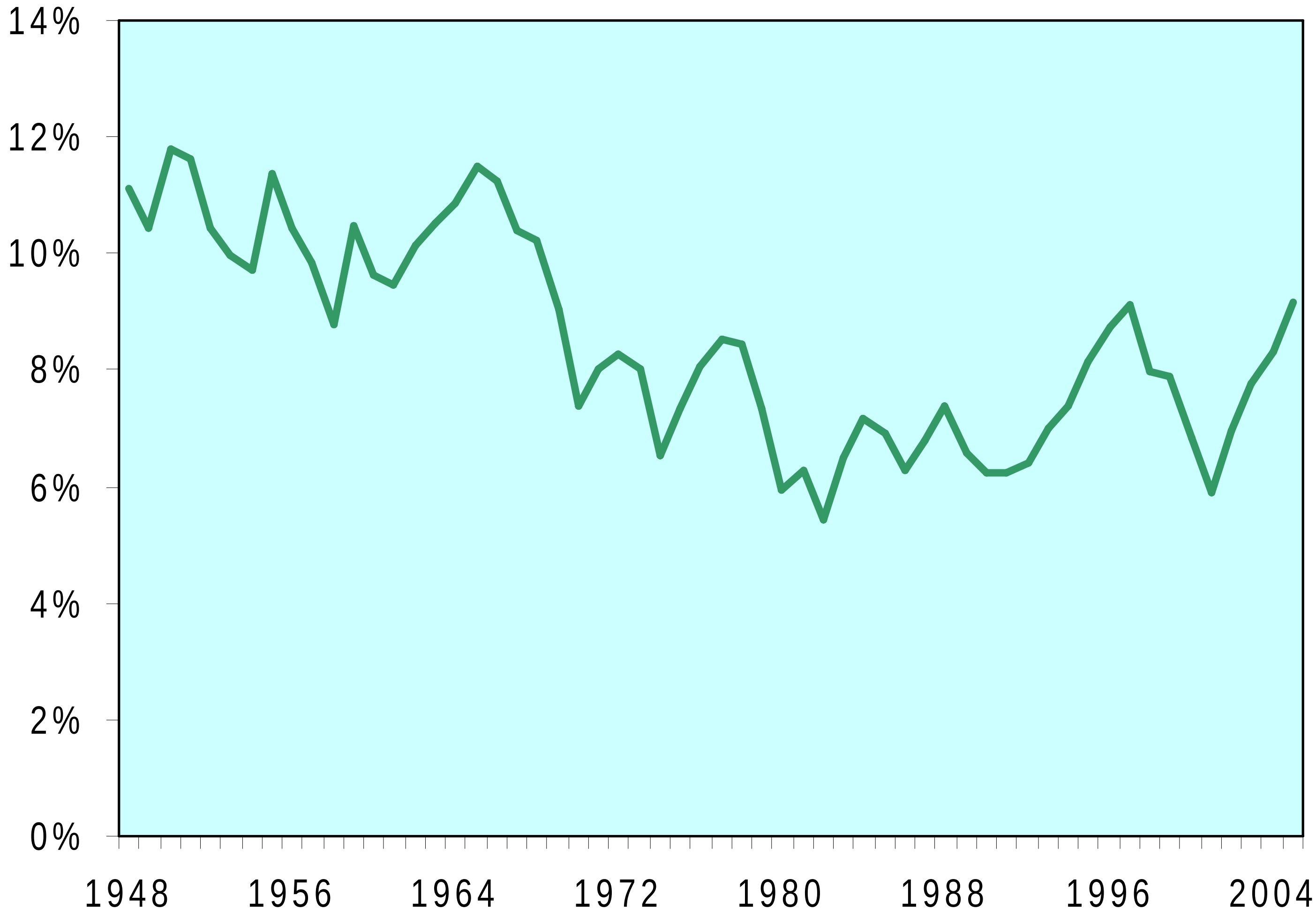
U.S. Trade Balances for High-Tech Products and All Goods 1988-2005 (in $billions)



Source: Census Bureau, Foreign Trade Division

Indicators of Underinvestment

Ratio of Domestic Corporate Profits Before Taxes to GDP, 1948-2005



Source: Bureau of Economic Analysis. Domestic profits exclude receipts by all U.S. corporations and persons of dividends from foreign corporations, U.S. corporations' share of reinvested earnings of their incorporated foreign affiliates, and earnings of unincorporated foreign affiliates net of corresponding payments.

Magnitude of Underinvestment

Recent Retrospective Economic Impact Studies: Outputs and Outcomes of NIST Laboratory Research			
Industry/Project	**Output**	**Outcomes**	**Measure**
Chemicals: Standards for sulfur in fossil fuels (2000)	• Measurement methods • Reference materials	• Increase R&D Efficiency • Increase productivity • Reduce transaction costs	IRR: 1,056% BCR: 113 NPV: $409M
Semiconductors: Josephson volt standard (2001)	• Measurement methods • Reference materials	• Increase R&D efficiency • Enable new markets	IRR: 877% BCR: 5 NPV: $42M
Communications: Data encryption standard (2001)	• Standard (DES) • Conformance test methods	• Accelerate new markets • Increase R&D efficiency	IRR: 270% BCR: 58–145 NPV: $345M–$1.2B
Communications: Role-based access control (2001)	• Generic technology • Reference models	• Enable new markets • Increase R&D efficiency	IRR: 29–44% BCR: 43–99 NPV: $59–138M
Energy: Gas mixture standard for regulatory compliance (2002)	• Standard (NTRM)	• Increase productivity • Reduce transaction costs	IRR: 221–228% BCR: 21–27 NPV: $49–63M
Manufacturing: Product design data standard (2002)	• Standard (STEP) • Conformance test methods/facilities	• Increase R&D efficiency • Reduce transaction costs	IRR: 32% BCR: 8 NPV: $180M

IRR=Internal (Social) Rate of Return, BCR=Benefit-Cost Ratio and NPV=Net Present Value.

Studies available at http://www.nist.gov/public_affairs/budget.htm

Magnitude of Underinvestment

Focus of Study	Infrastructure Studied	Industries Covered	Estimated Annual Costs of Inadequate Infrastructure
Interoperability costs (1999)	• Product design data exchange	• Automotive supply chain	$1 billion
Deregulation (2000)	• Metering • Systems monitoring/control	• Electric utilities	$3.1–$6.5 billion
Software testing (2002)	• All stages of the testing cycle	• Transportation equipment • Financial services • Extrapolation to entire U.S.	$1.8 billion $3.3 billion $60 billion
Interoperability costs (2004)	• Business data exchange: production scheduling, inventory management, procurement, and distribution/marketing	• Automotive supply chain • Electronics supply chain	$5 billon $3.9 billion
Interoperability costs (2004)	• Business data exchange: design & engineering, construction, and operations & maintenance	• Construction/building systems management	$15.8 billion
Medical testing (2004)	• Quality of measurement assurance	• Laboratories (calcium)	$0.06–$0.199 billion

Magnitude of Underinvestment

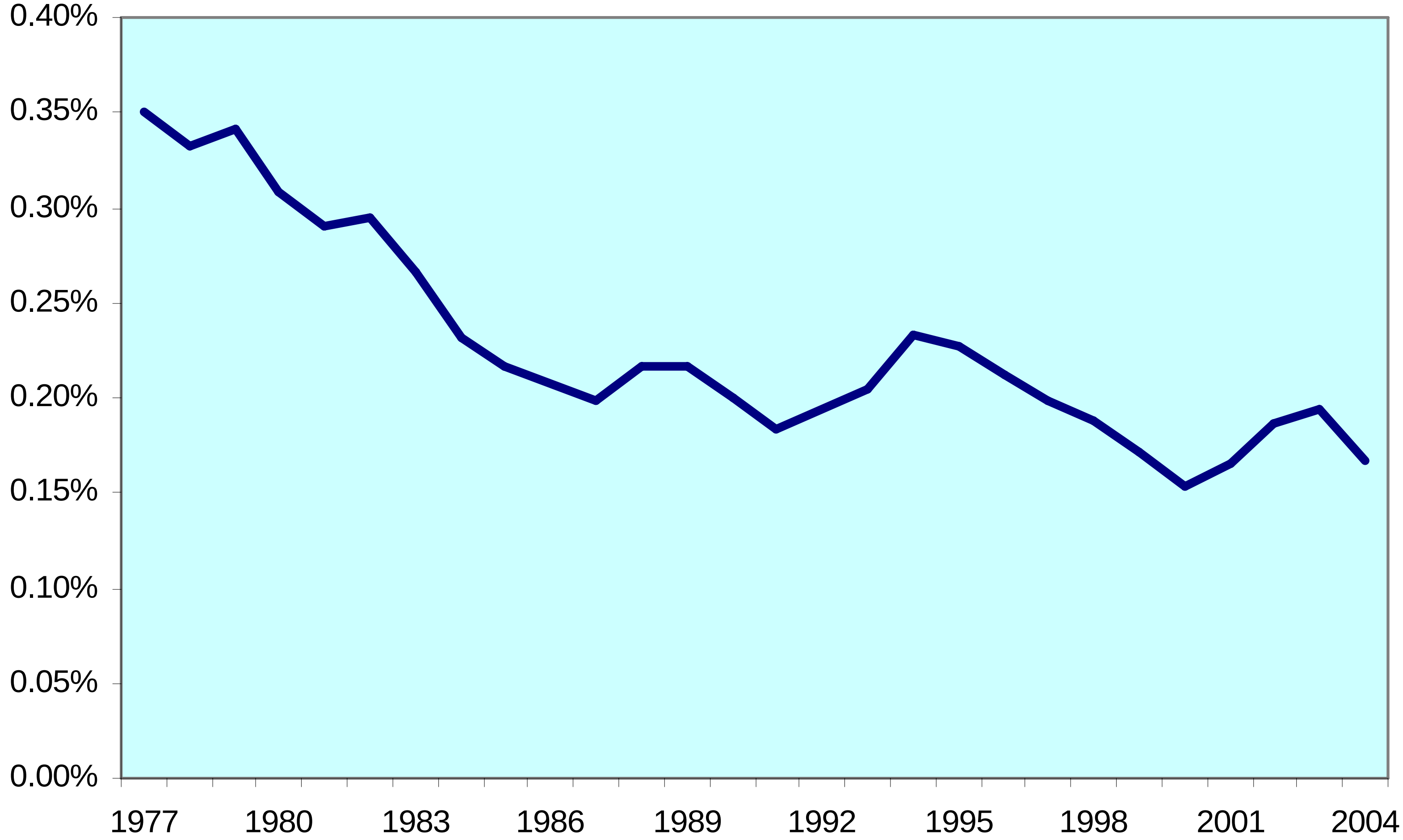
Costs of Inadequate
Software Testing Infrastructure

Industry Coverage	Annual Cost	Potential Economic Benefits
Transportation Equipment and Financial Services	$5.18 B	$2.10 B
U.S. Economy	$59.5 B	$22.2 B

Source: RTI International, *The Economic Impacts of Inadequate Infrastructure for Software Testing* (NIST Planning Report 02-3)

Magnitude of Underinvestment

Ratio of NIST Laboratory Funding to Industry-Funded R&D: 1977-2004



Source: National Science Foundation; NIST Budget Office