Putting Technology Transfer in Context: University–Industry Linkages in the United States

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GIST Symposium for University–Industry Linkage

University–Industry Linkages

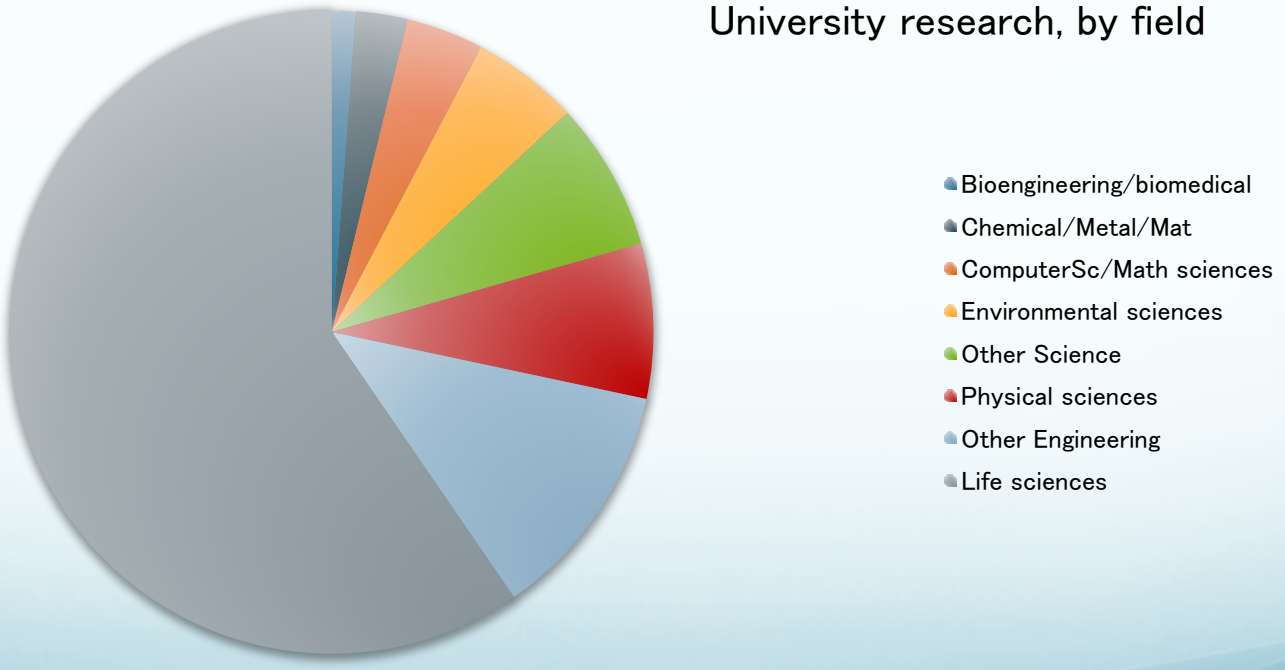
- Substantial policy debate about increasing impact of university research on economic growth
  - Competitiveness agenda (Slaughter and Rhoades, 1996)
- Universities encouraged to engage in technology transfer (patent–license–startup model)
- But, direct transfer of technology to (startup) firms is only one mode of university–industry linkage
- Using prior empirical work, discuss technology transfer in US and broader context of university–industry linkages

Landscape: Research Universities in the US

- No “national” research university (unlike many European or Asian countries),
- About 100 research universities in the US (out of over 3500 colleges and universities in total)
- State universities: University of California at Berkeley, University of Wisconsin, Georgia Institute of Technology
- Private universities: Harvard University, Stanford University, University of Chicago, and Massachusetts Institute of Technology [MIT])
- The top 100 research universities account for about 80% of total federal research funds and the top 10 account for just under 20% of the total

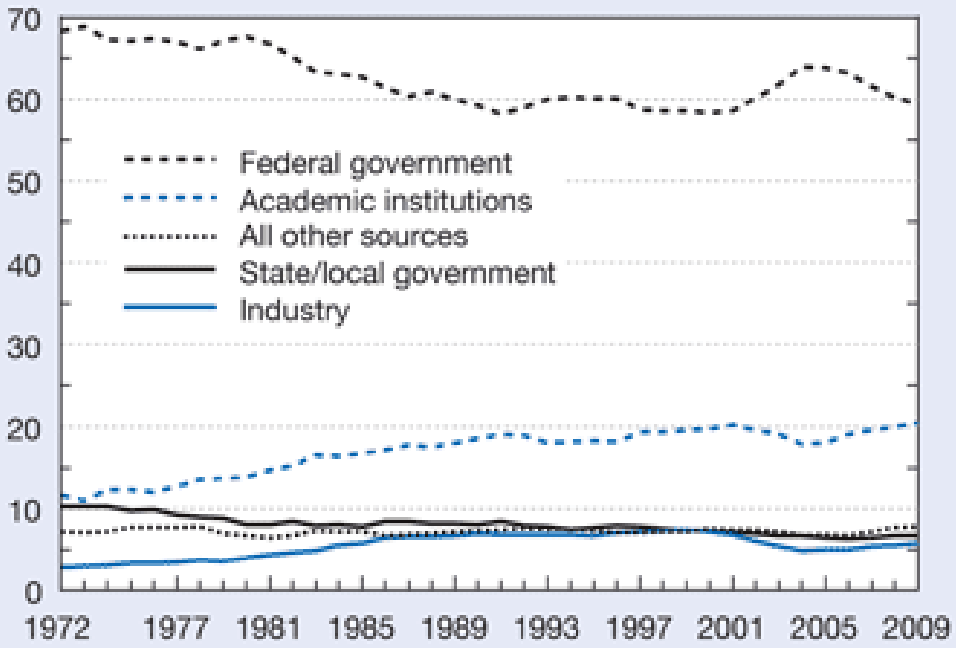
University contribution to R&D, Research, Basic Research

Type of R&D	University share of total
All R&D	14%
All Research	36%
Basic Research	53%



Source: NSF. Science and Engineering Indicators, 2012.

Figure 5-2
Academic R&D expenditures, by source of funding: 1972–2009



NOTE: Science and engineering R&D; non-S&E R&D not included.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Research and Development Expenditures at Universities and Colleges. See appendix table 5-2.

Science and Engineering Indicators 2012

Technology transfer in US

- Bayh-Dole
- Other policies
- Competitiveness agenda
- Trends
  - Industry funding
  - TTOs
  - Patents
  - Licenses
  - Startups

Policy Shifts Encouraging Technology Transfer

- Technology transfer policies predate WWII
  - Morrill Act (1862) creating the land grant colleges, emphasizing agriculture and engineering
  - Hatch Act (1887) funding agriculture experiment stations
  - Technology transfer offices begin in the early 20th C.: Research Corporation 1912; WARF, 1925)
- Yet, the 1980s saw the rise of the "competitiveness agenda" (Slaughter and Rhoades, 1996) and the creation of the New Wave Technology Transfer environment.
- Bayh-Dole Act (1980), created a uniform set of rules that facilitated universities taking title to Federally funded inventions and granting exclusive licenses.
  - The law encouraged universities to commercialize their inventions

Policy Shifts Encouraging Technology Transfer

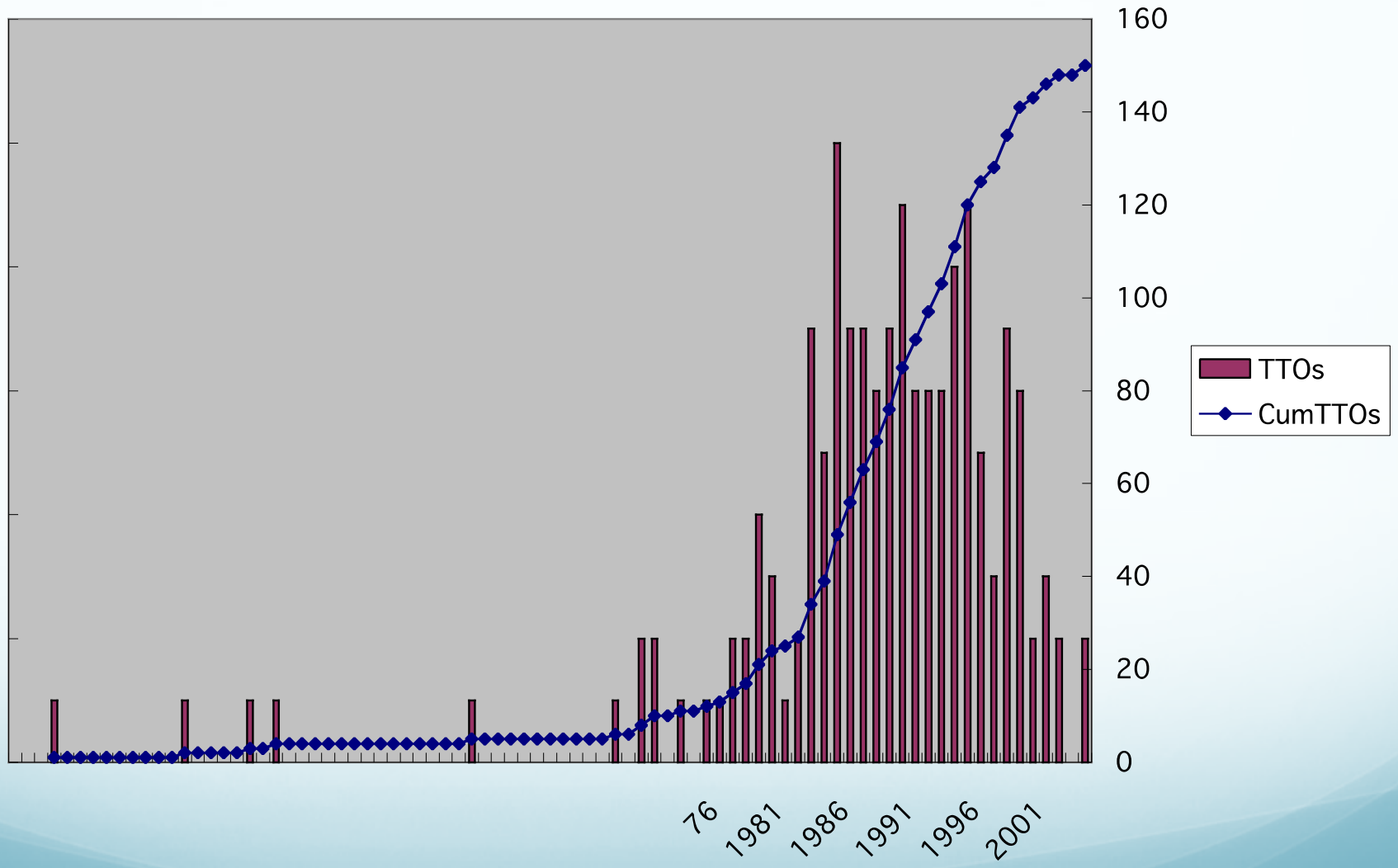
- Several other laws during this period encouraged cooperation between industry and universities/government labs and technology transfer
  - Stevenson Wydler Act and the Federal Technology Transfer Act, allowing creation of CRADAs
  - The National Cooperative Research Act, 1984, encouraged joint research on pre-competitive technology by exempting such consortia (which often included university personnel) from anti-trust prosecution.
  - The Basic Research Tax credit, (1986), gave firms a tax credit for outsourced R&D, encouraging firms to do research contracts with universities.
  - Engineering Research Centers (ERCs) (began in 1985). These centers were located at universities and were funded to encourage applied research and collaboration with industry. NSF has funded about 50 ERCs to date.
  - CREATE Act (2004): collaborative research would not be construed as prior art that would prevent patenting inventions derived from this research, making it much easier to share information between universities and firms without jeopardizing patent rights.

Policy Shifts Encouraging Technology Transfer

- Several key patents also laid the foundation for the growth in commercial activity by universities, especially bio-tech
  - 1980 Diamond v. Chakrabarty Supreme Court decision permitted the patenting of life-forms.
  - 1988, Harvard University OncoMouse patent, extending patentability to higher life-forms (and to a research tool)
  - 1982, CAFC to hear patent appeals
    - Shift to a pro-patent court encouraged universities to patent and encouraged firms to rely on licensed patents as a basis for strategic advantage in the market.
- Financial success of some early patented technologies served as a model
  - Cohen-Boyer patent on recombinant DNA, jointly owned by Stanford and University of California, generated over $250 million in licensing revenue.
  - Note that this patent predated Bayh-Dole.

Technology Transfer Explosion

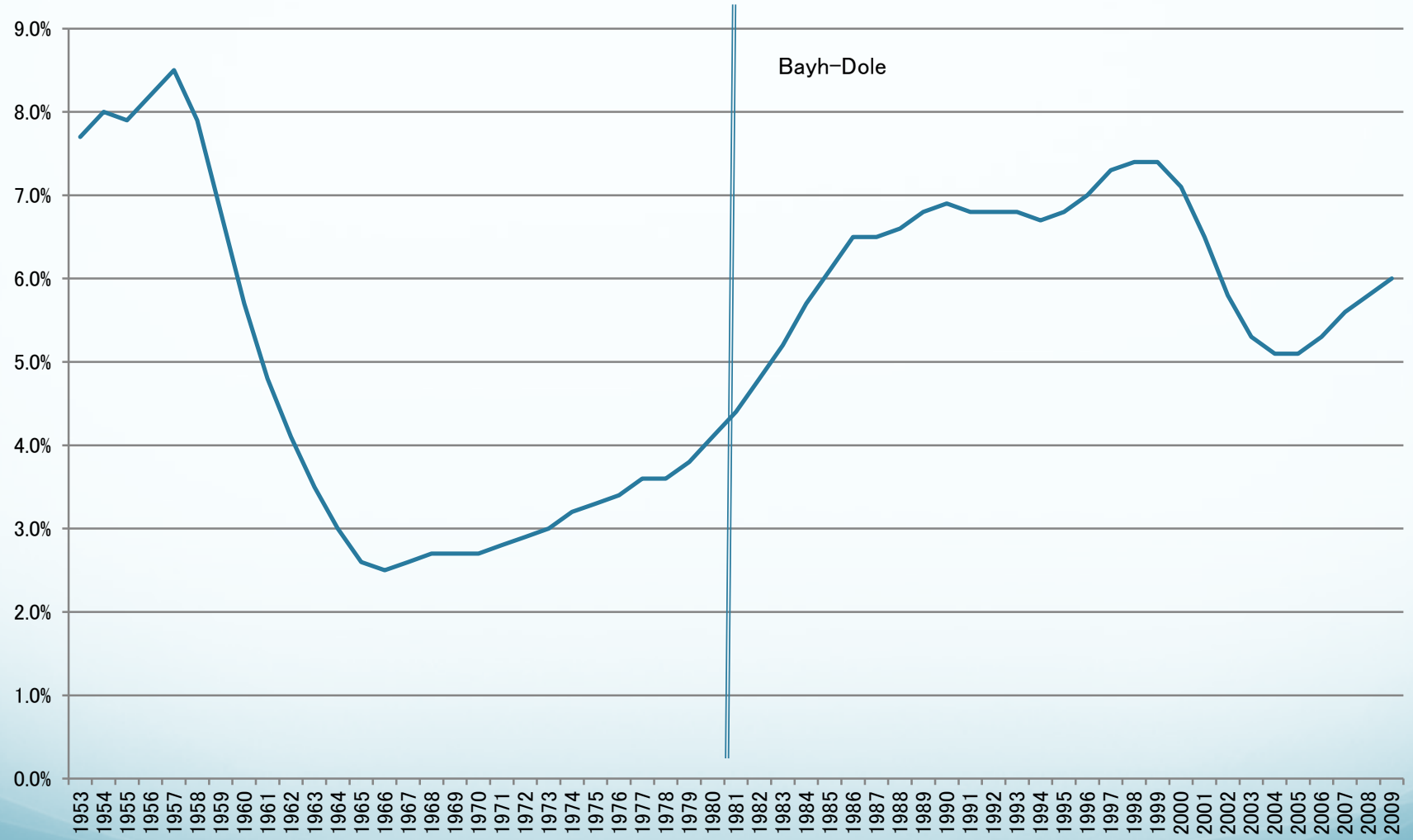
- Result of this policy shift was phase shift in technology transfer activity
- Establishment of TTOs
  - Generally, each university has own TTO (little competition)
  - Expensive to staff and run
- Rapid increase in university patenting
- Growth in licensing revenue
- Increase (?) in industry funding
- However, significant institutional diversity


160
140
120
100
80
60
40
20
0
76
1981
1986
1991
1996
2001
TTOs
CumTTOs

Industry Funding

- Both public and private universities engage in industry-sponsored research, which currently accounts for about 6% of the total university R&D budget
- However, significant variation across universities
- Duke, Ohio State and MIT receiving significant shares (over 10%) of their total research budgets from industry
- Rockefeller and Florida State, on the other hand, receive less than 1% of their funding from industry
- Consulting is also common, and even encouraged, so long as it does not interfere with one's university duties. One day per week is a common norm.

Percent of university research funding from industry, 1953–2008



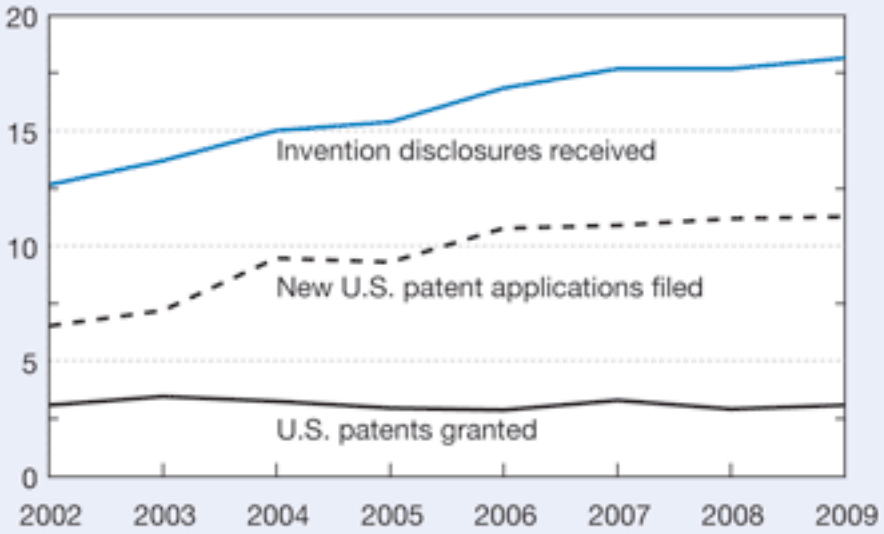
Source: NSF. Science and Engineering Indicators, 2012

Table 2. Percent of Industry Funding, top 5 and bottom 5 research universities, 2009.

Rank	Institution	%Industry
1	Duke University (private)	22.9%
2	SUNY-Albany (public)	22.6%
3	Ohio State University, all campuses (public)	16.8%
4	Purdue University, all campuses (public)	14.8%
5	Massachusetts Institute of Technology (private)	14.0%
96	Case Western Reserve University (private)	1.4%
97	Vanderbilt University (private)	1.4%
98	Yeshiva University (private)	1.0%
99	Rockefeller University (private)	0.8%
100	Florida State University (public)	0.5%

Source: NSF, Science and Engineering Indicators, 2012.

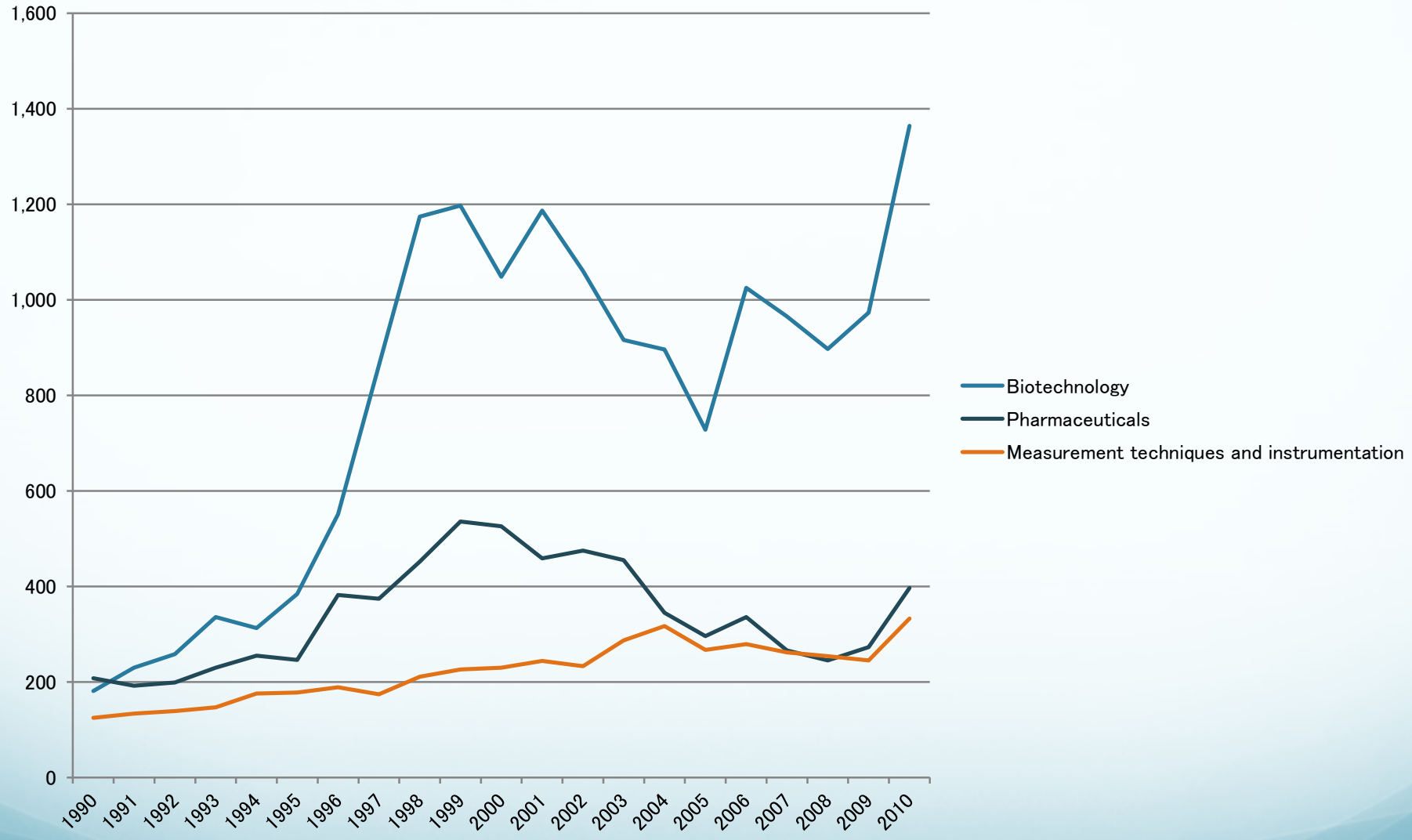
Figure 5-32
U.S. university patenting activities: 2002–2009



SOURCE: Association of University Technology Managers (AUTM), AUTM Licensing Surveys: 2002–2009. See appendix table 5-48.

Science and Engineering Indicators 2012

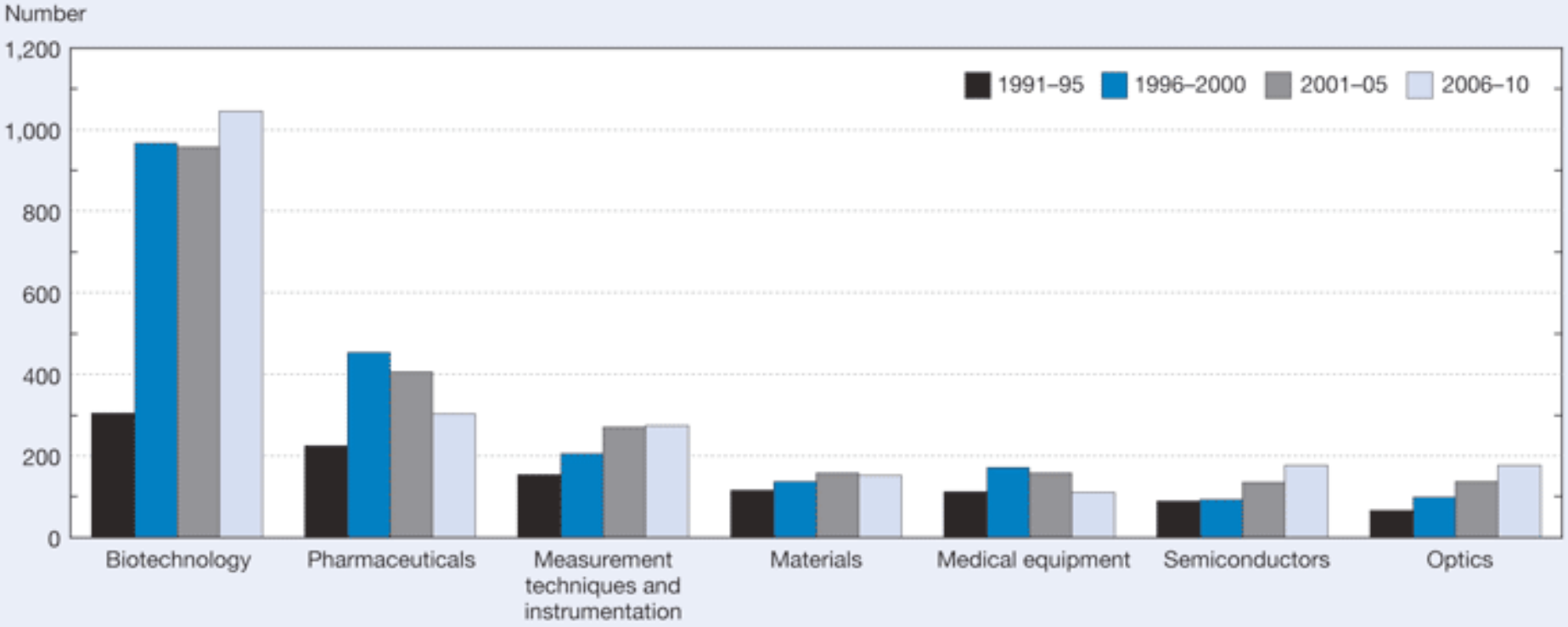
U.S. university patents awarded, by technology area: 1990–2010



Source: NSF. Science and Engineering Indicators

Figure 5-31

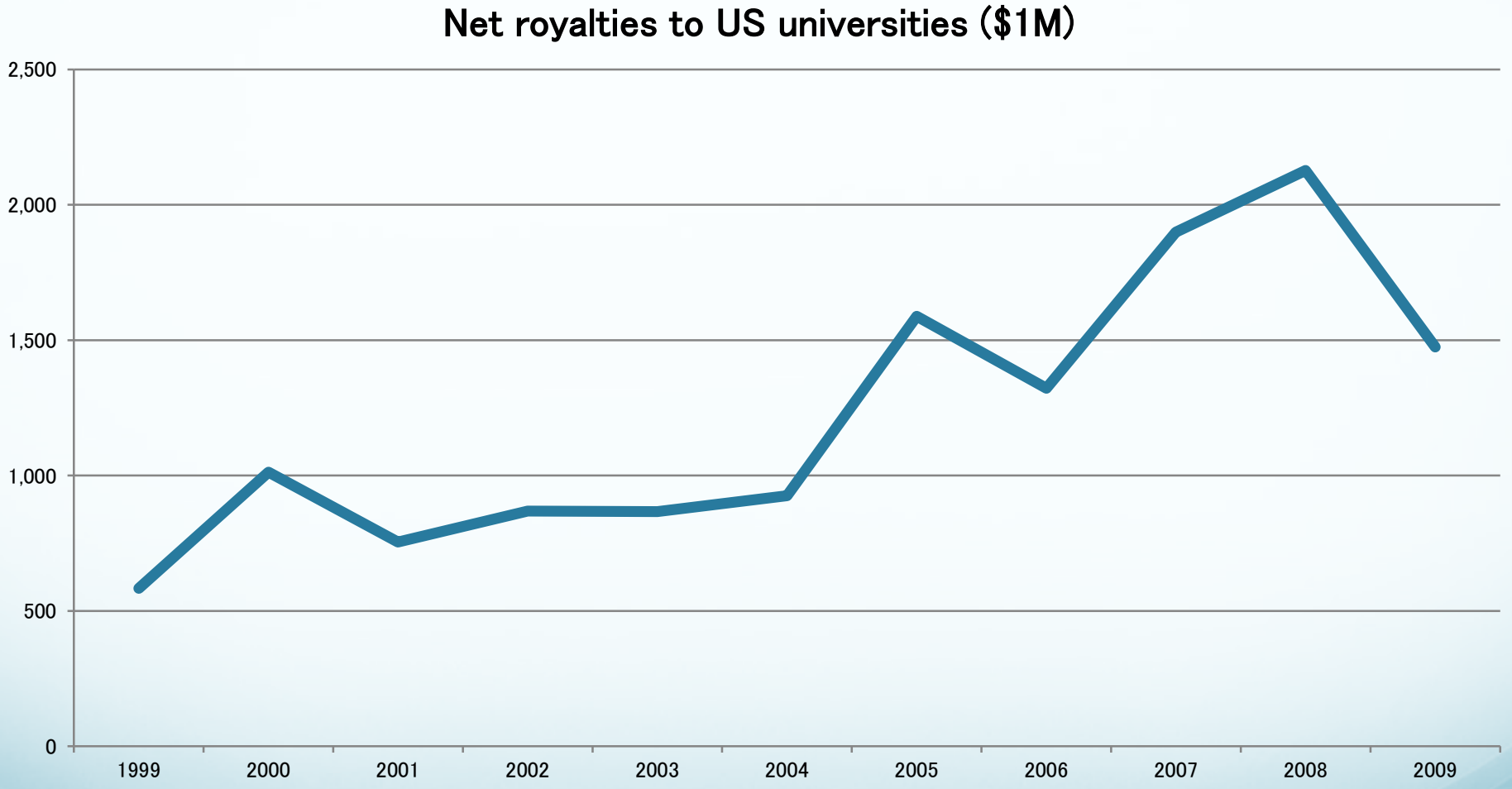
U.S. academic patents, by technology area: Selected 5-year averages, 1991–2010



NOTES: Data include institutions affiliated with academic institutions, such as university and alumni organizations, foundations, and university associations. Universities vary in how patents assigned, e.g., to boards of regents, individual campuses, or entities with or without affiliation with university. The Patent Board™ technology areas constitute an application-oriented classification system that maps the thousands of International Patent Classes (IPCs) at main group level into 1 of 35 technology areas. If patent has more than one IPC, only primary IPC is considered in mapping. Data in figure not comparable to previous versions of the figure due to changes in classification system.

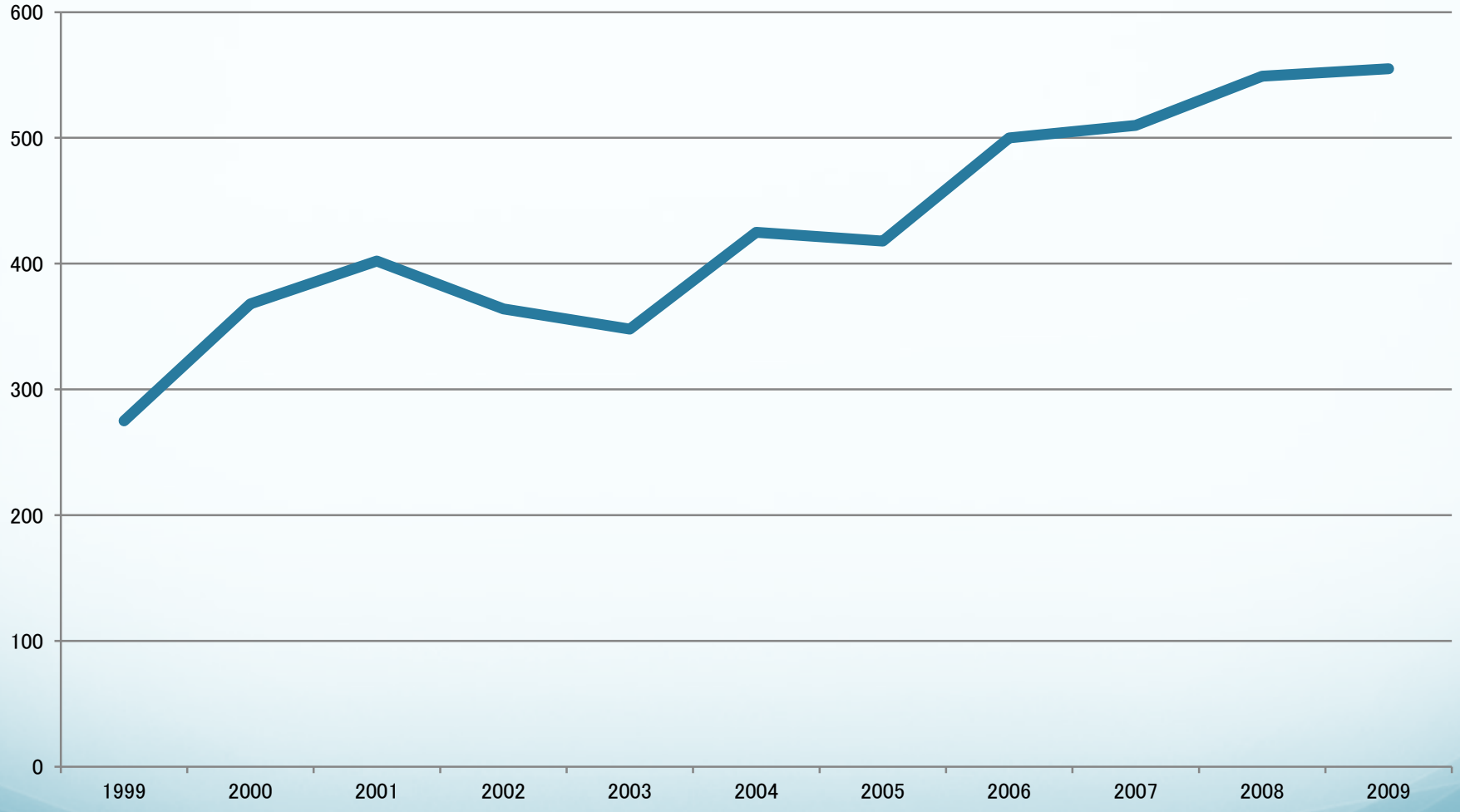
SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from U.S. Patent and Trademark Office (USPTO), Patent Grant Bibliographic Data.

Science and Engineering Indicators 2012



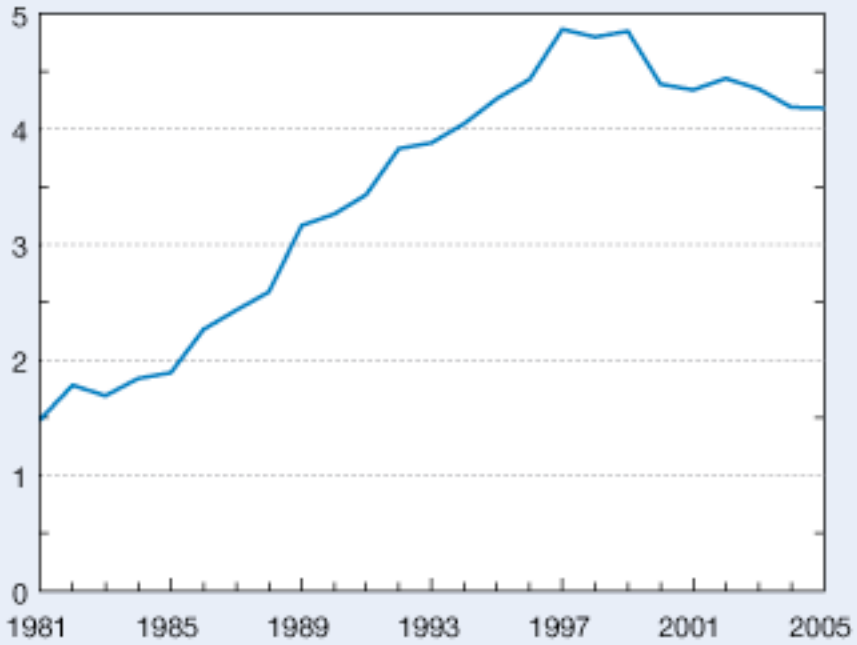
Source: NSF. Science and Engineering Indicators, 2012 (from AUTM data)

University-based startup companies formed



Source: NSF. Science and Engineering Indicators, 2012 (from AUTM data)

Figure 5-36
U.S. academic share of patenting by U.S. private and nonprofit sectors: 1981–2005



NOTES: Patents issued by U.S. Patent and Trademark Office (USPTO) to U.S. universities and corporations. U.S. private and nonprofit sectors include U.S. corporations (issued bulk of patents in this category), nonprofits, small businesses, and educational institutions.

SOURCES: USPTO, Technology Assessment and Forecast Report: U.S. Colleges and Universities, Utility Patent Grants, 1969–2005 (2007); and National Science Foundation, Division of Science Resources Statistics, special tabulations.

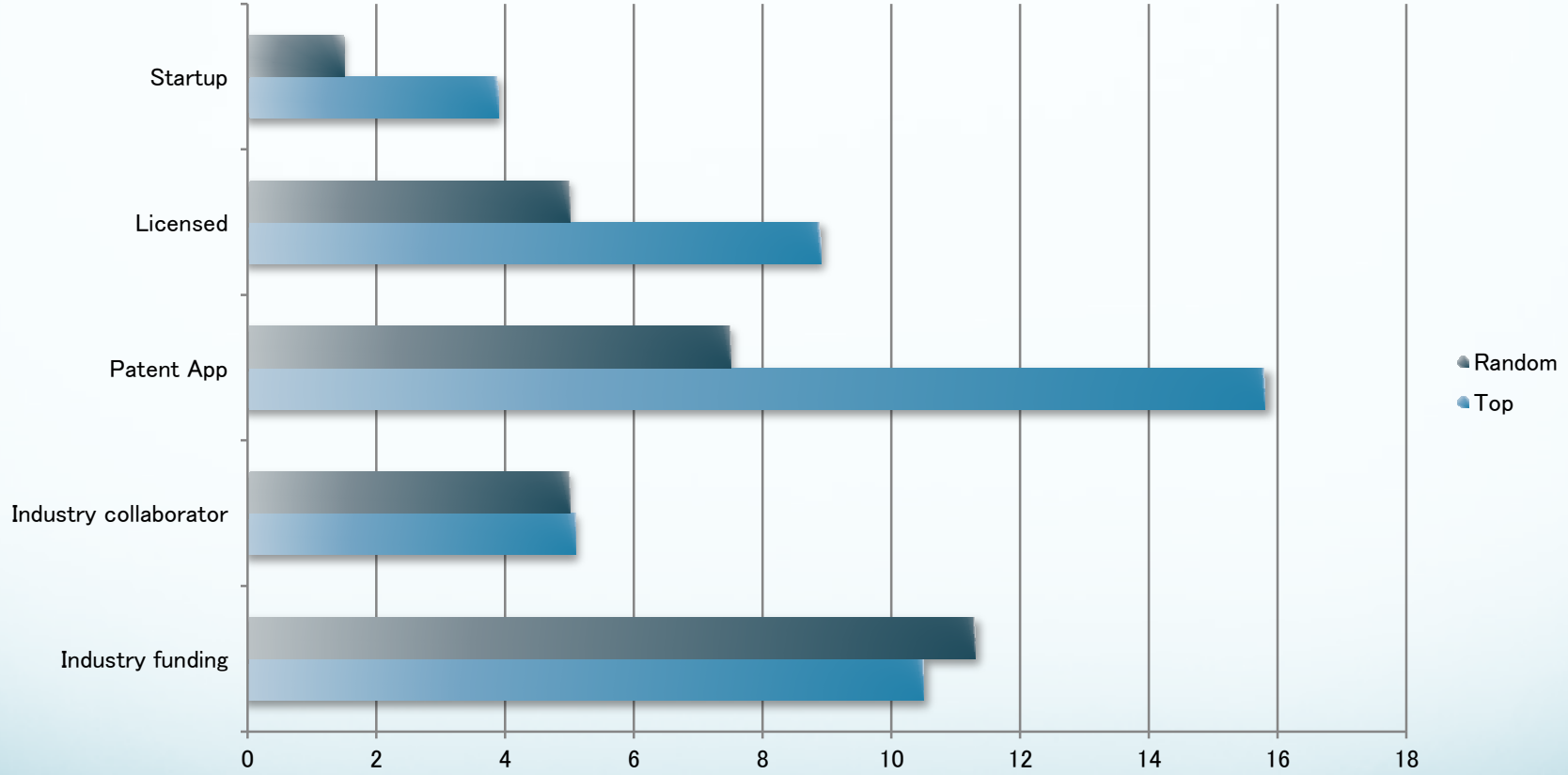
Science and Engineering Indicators 2008

Note: Now stabilized at 4.2–4.7% for about a decade (SEI, 2012)

Forms of commercial activity

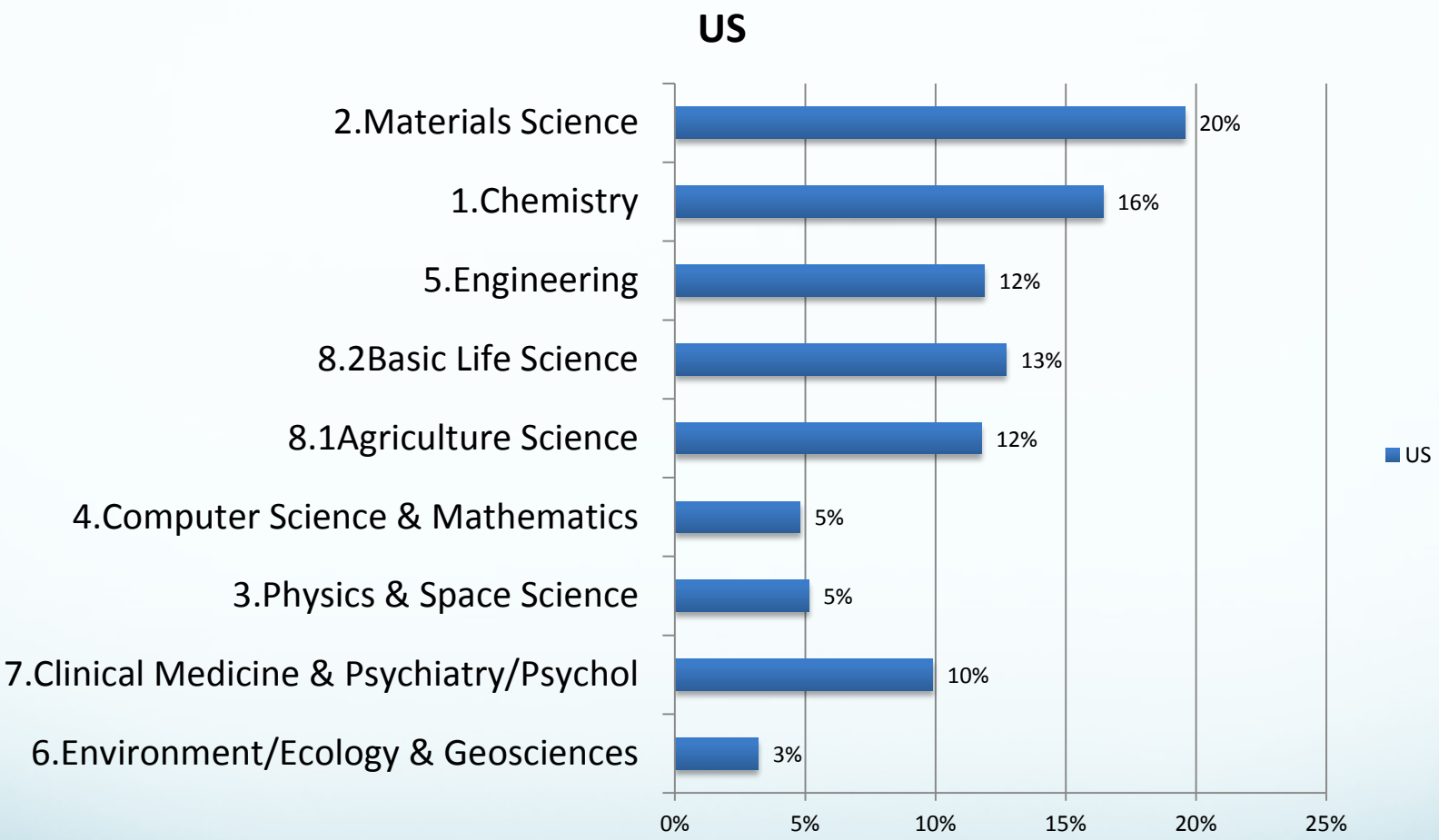
- UI linkages (Scientist survey)
  - Industry funding
  - Industry collaborator
  - Patent
  - License
  - Startup
- By field

Commercial Activity, US Projects, Top 1% and Random Papers (%Yes)



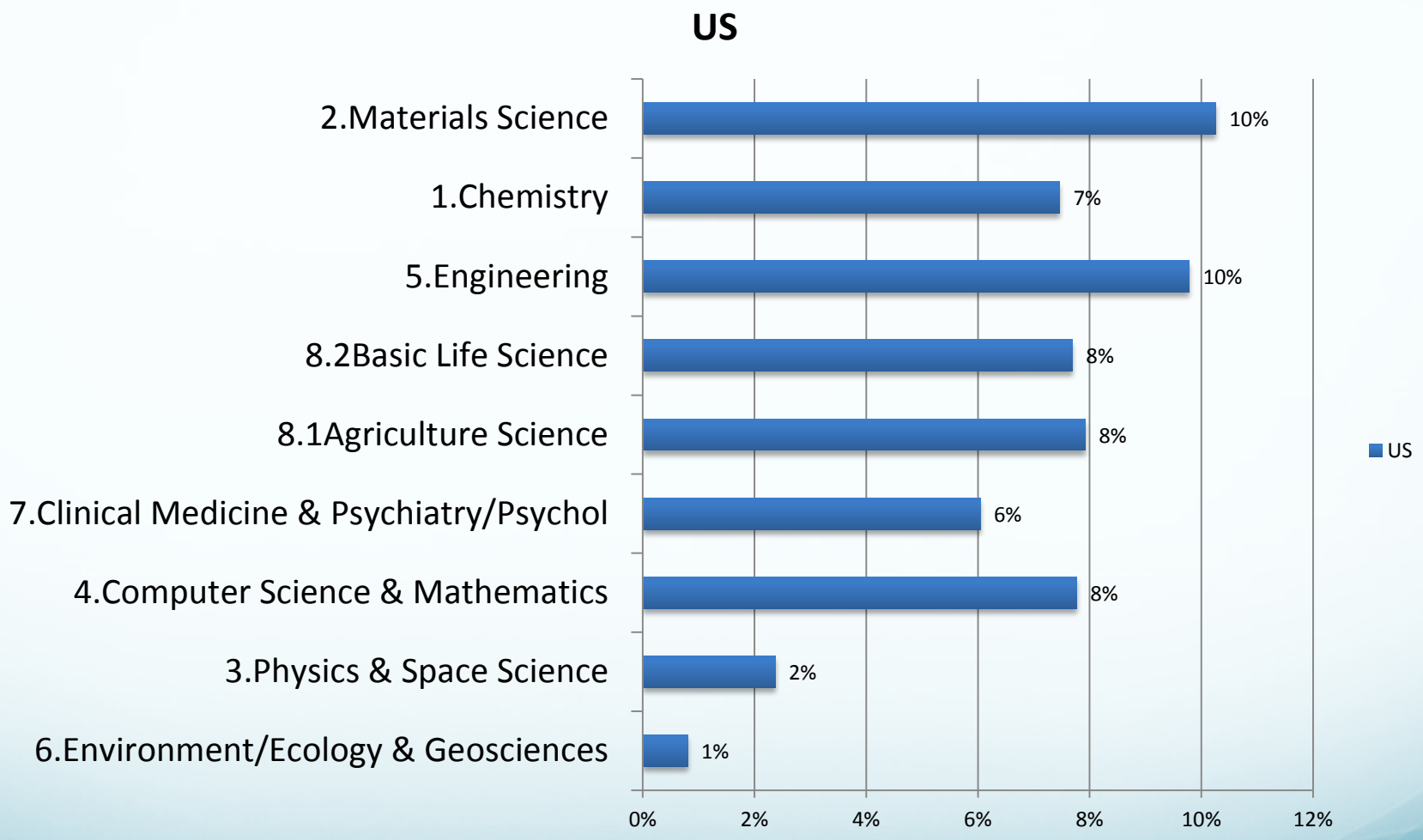
Source: Walsh et al. 2012

Patents, US, by field



Source: Walsh et al. 2012

Licensed, US, by field

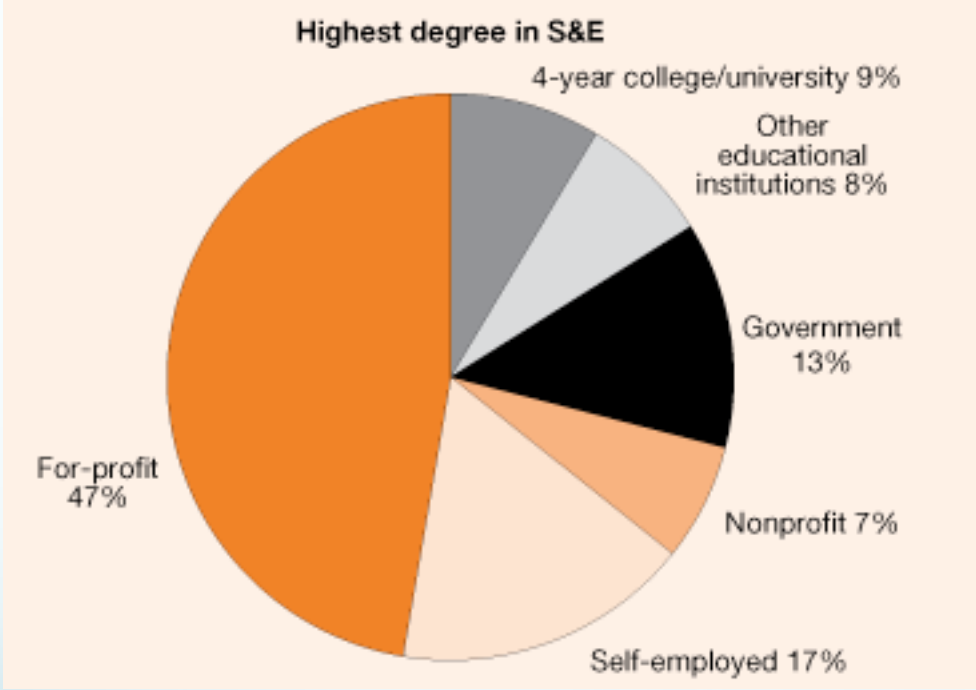


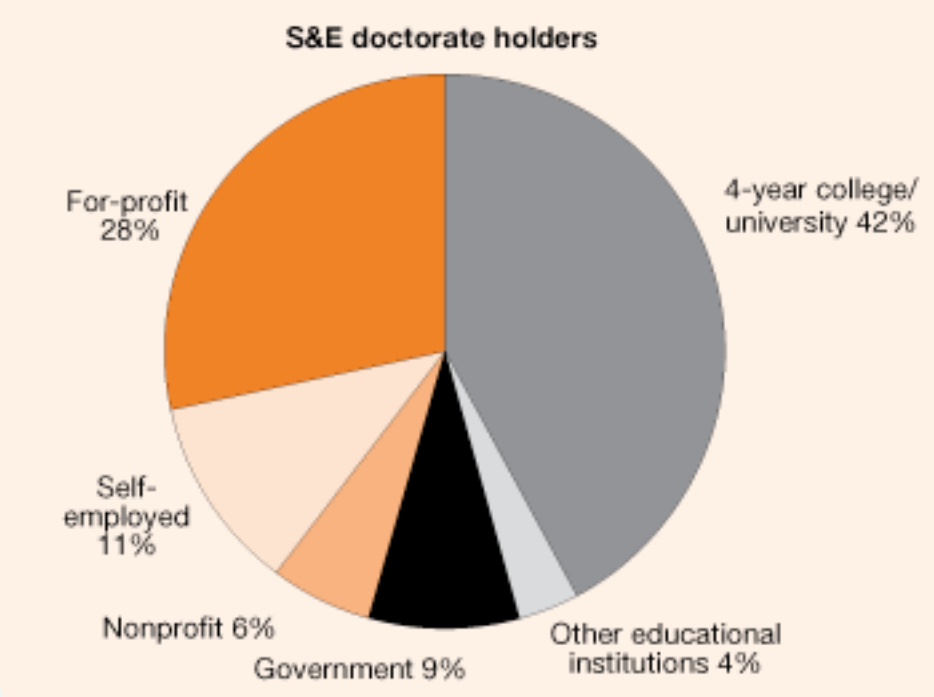
Source: Walsh et al. 2012

Broader context

- University patents as percent of all patents
  - Produce 14% of US R&D (SEI, 2012)
  - But only 4% of domestic patents (SEI, 2012)
- Trained personnel
  - Doctorates in industry

Employment sector for individuals whose highest degree is in S&E and for S&E doctorate holders, 2006



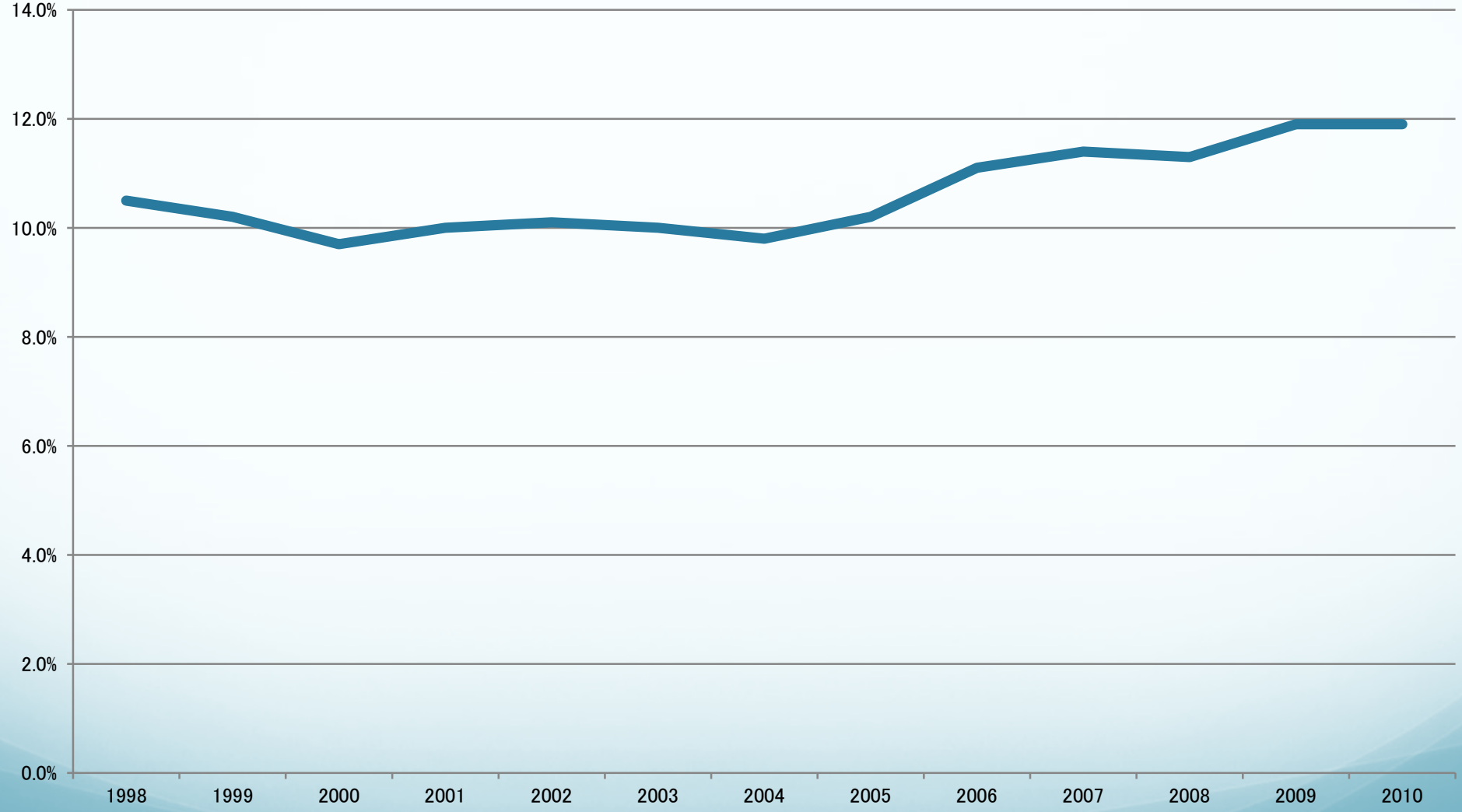


SOURCE: NSF. Science and Engineering Indicators, 2010

Broader context

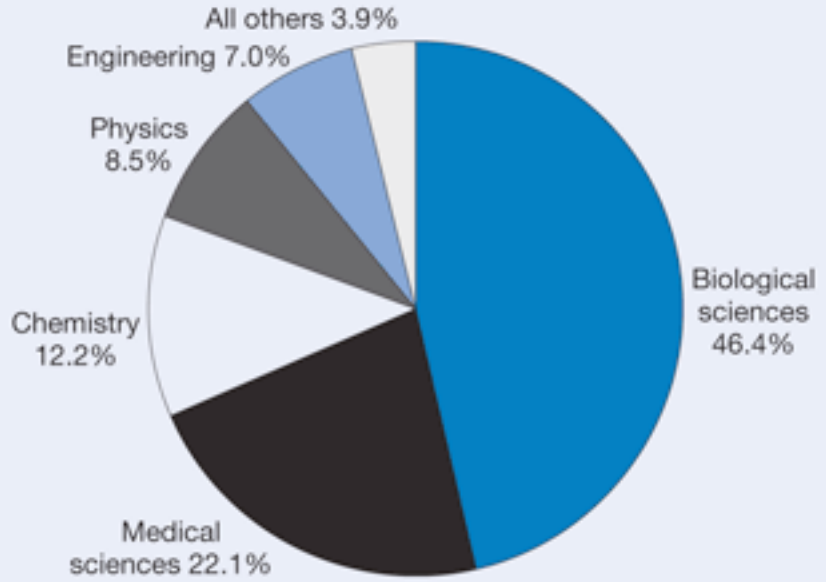
- Publications as key channel
  - Publishing much more common than patenting (cf Agrawal and Henderson, 2002)
- U-I co-publication as one major direct channel
  - In 2010, 66.5% of industry papers had a university co-author (up from 57% 10 years before) (SEI, 2012)
- Patents citing S&T literature
  - Big growth in prior period (Narin, et al. 1997).
  - But, now stabilized
- Surveys of impact of university research

Percent of US Patents Citing S&E Lit



Source: NSF. Science and Engineering Indicators, 2012

Figure 5-33
Citations of U.S. S&E articles in U.S. patents, by selected S&E article field: 2010

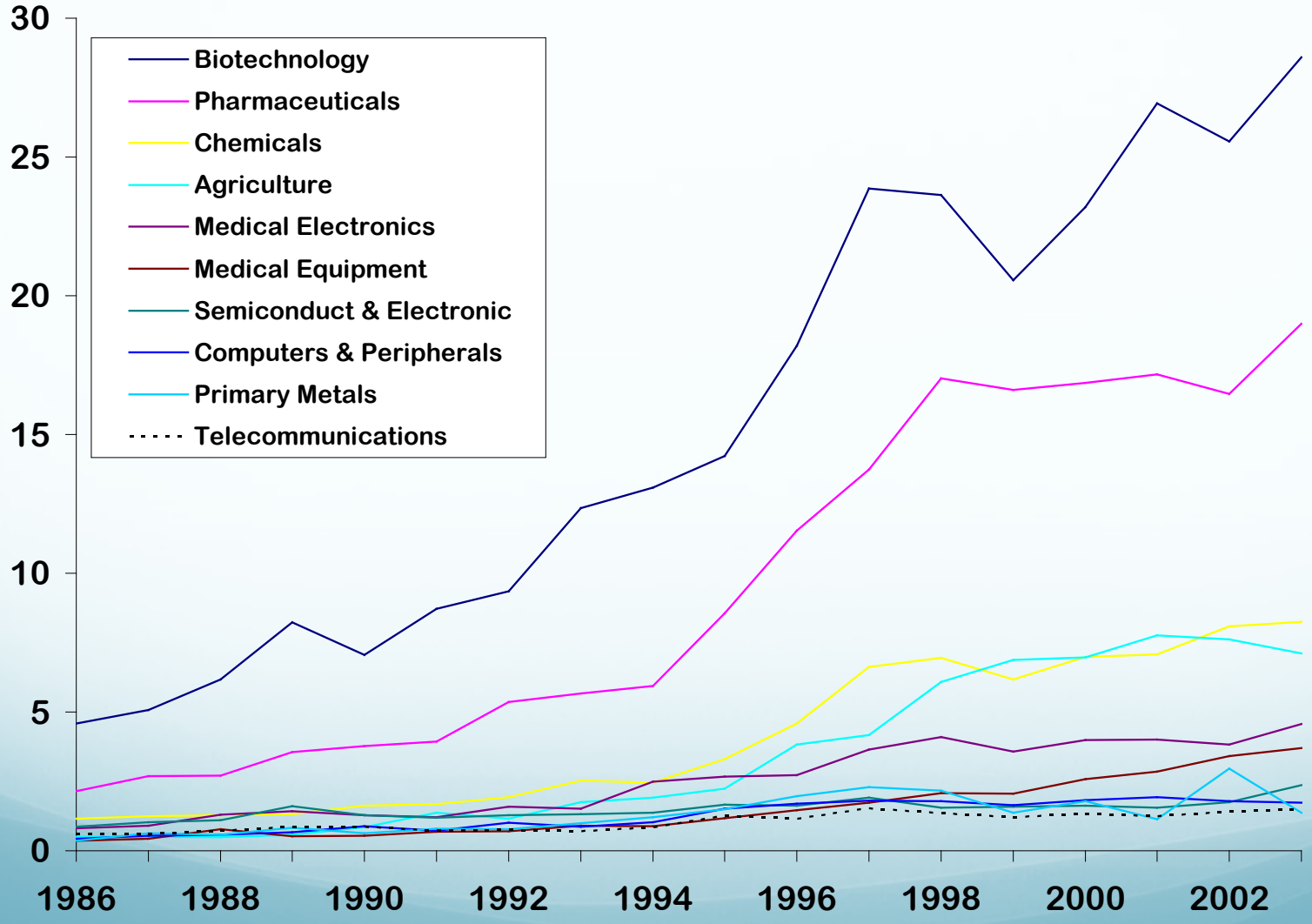


NOTES: Citations are references to S&E articles in journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Citation counts based on a 6-year window with 5-year lag, e.g., citations for 2010 are references in U.S. patents issued in 2010 to articles published in 2000–05.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from U.S. Patent and Trademark Office (USPTO), Patent Grant Bibliographic Data, and Thomson Reuters, SCI and SSCI, http://www.thomsonreuters.com/products_services/ science/. See appendix table 5-50.

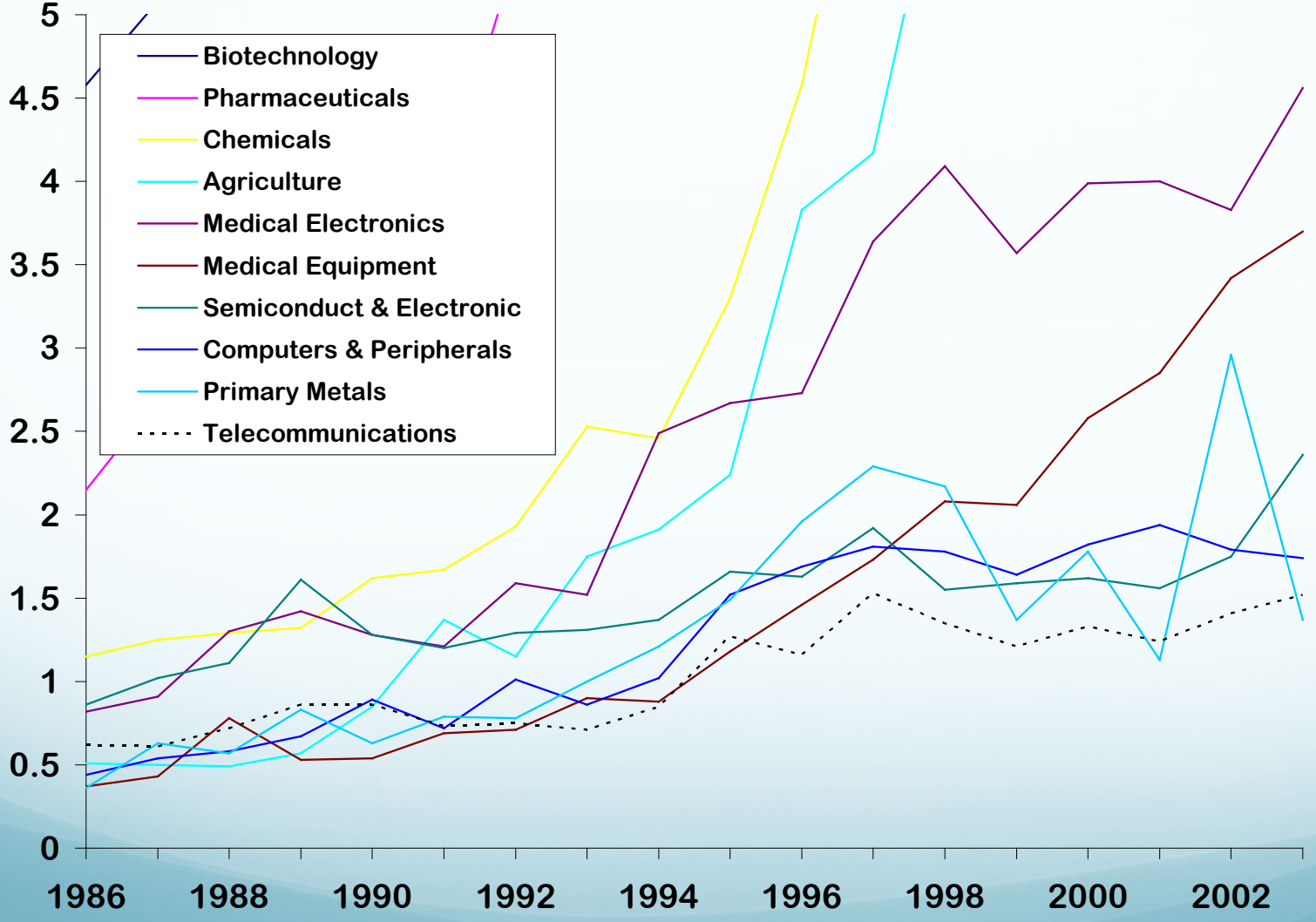
Science and Engineering Indicators 2012

Number of references from patents to papers on US company patents, 1986-2003



Source: CHI Research, Inc.

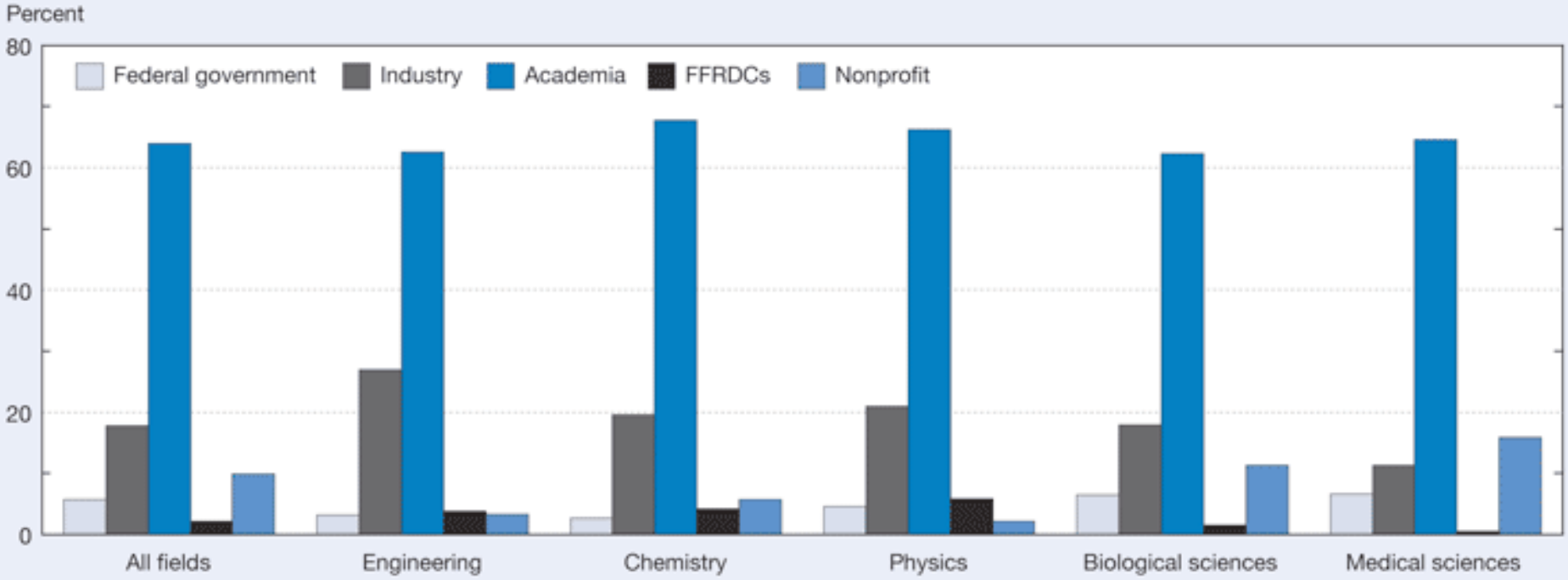
Number of references from patents to papers on US company patents, 1986-2003



Source: CHI Research, Inc.

Primarily (though not exclusively) to academic publications

Figure 5-34
Citations of U.S. S&E articles in U.S. patents, by selected S&E field and article author sector: 2010



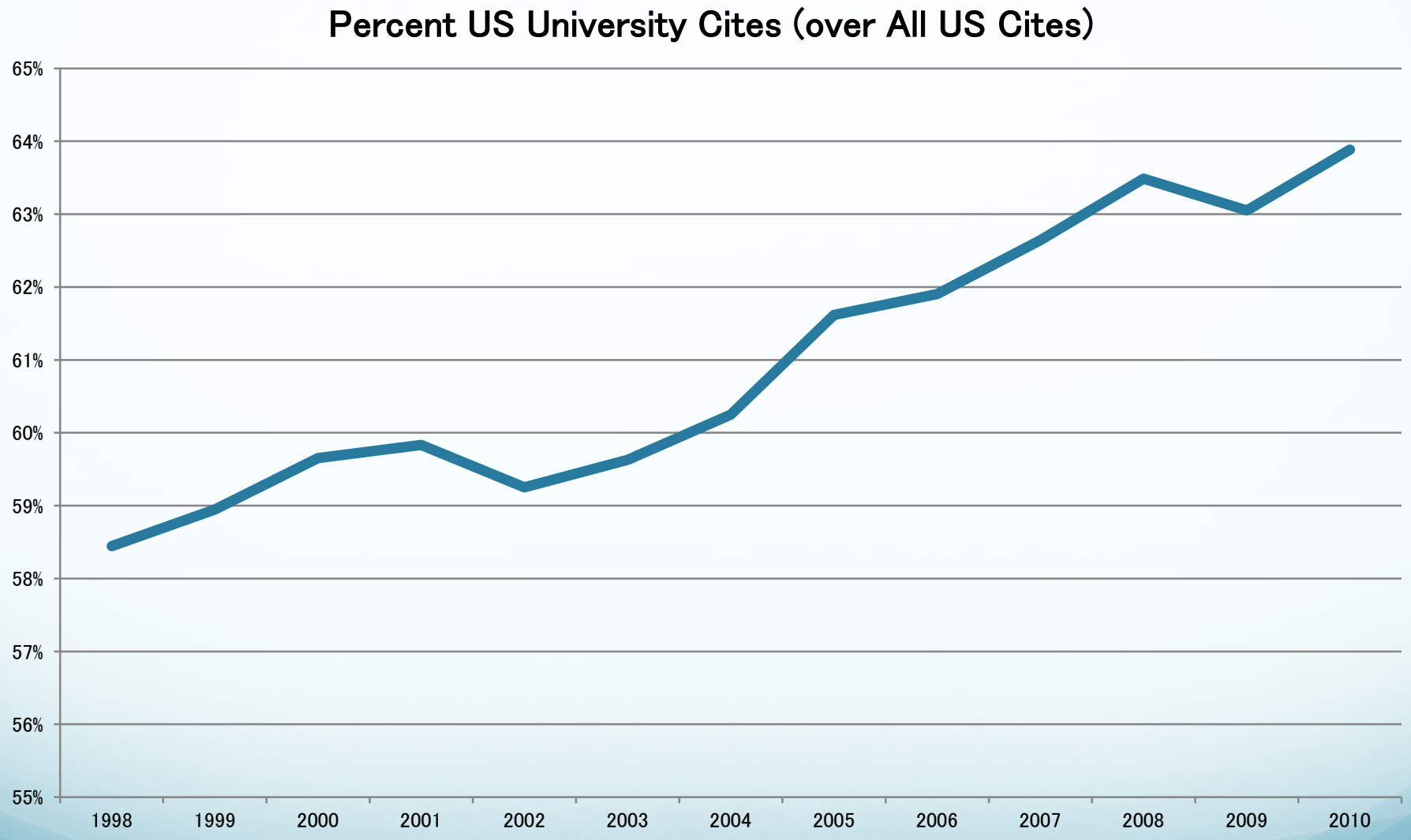
FFRDC = federally funded research and development center

NOTES: Citations are references to U.S. S&E articles in journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). Citations on fractional-count basis, i.e., for cited articles with collaborating institutions from more than one sector, each sector receives fractional credit on basis of proportion of its participating institutions. Citation counts based on a 6-year window with 5-year lag, e.g., citations for 2010 are references in U.S. patents issued in 2010 to articles published in 2000–05. Detail may not add to total because of rounding.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, and The Patent Board™, special tabulations (2011) from U.S. Patent and Trademark Office (USPTO), Patent Grant Bibliographic Data, and Thomson Reuters, SCI and SSCI, http://www.thomsonreuters.com/products_services/science/.

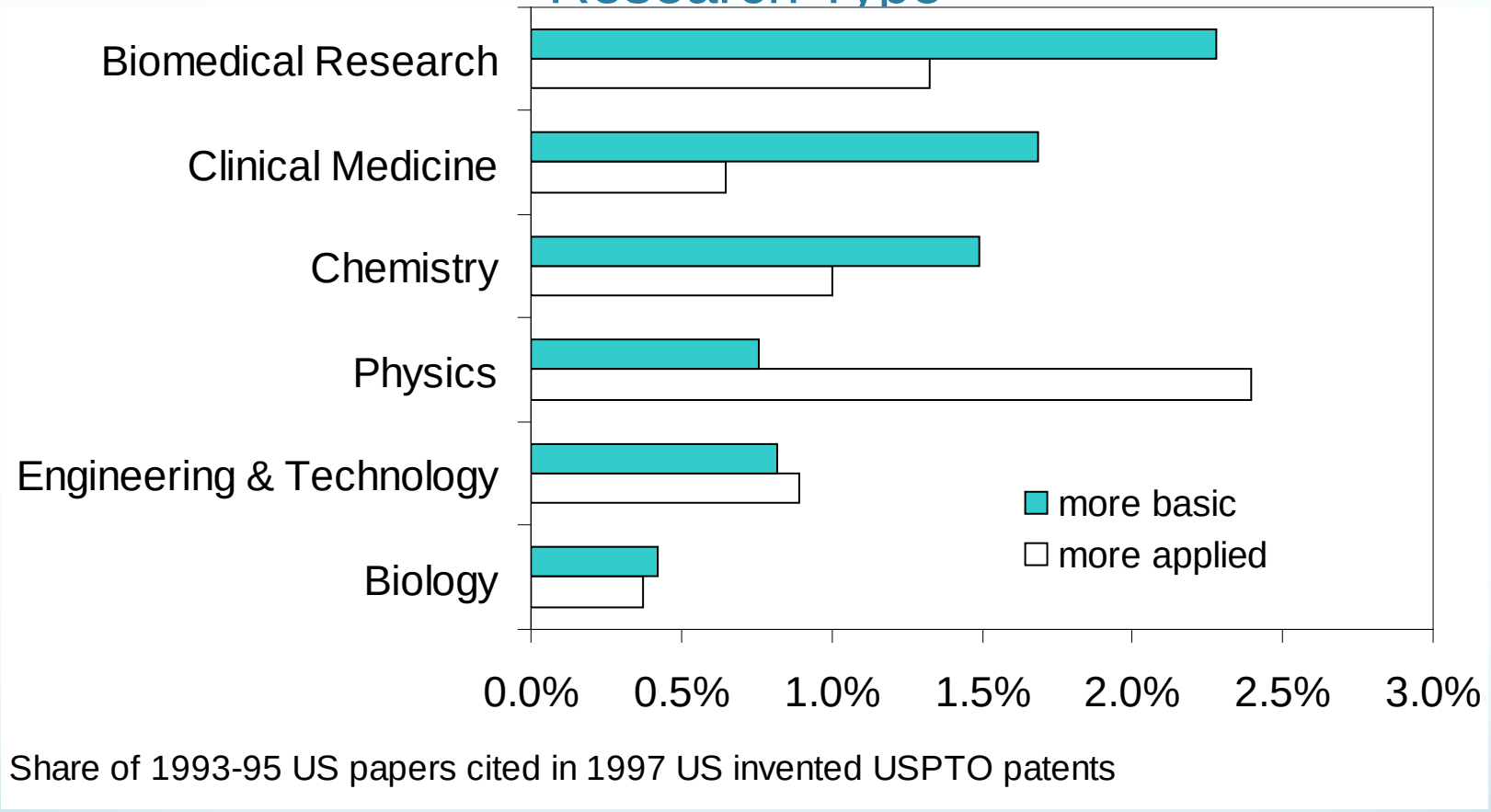
Science and Engineering Indicators 2012

Growing importance of university publications in US patent citations
(Percent of cites to S&E lit that are to universities)



Source: NSF. Science and Engineering Indicators, 2012

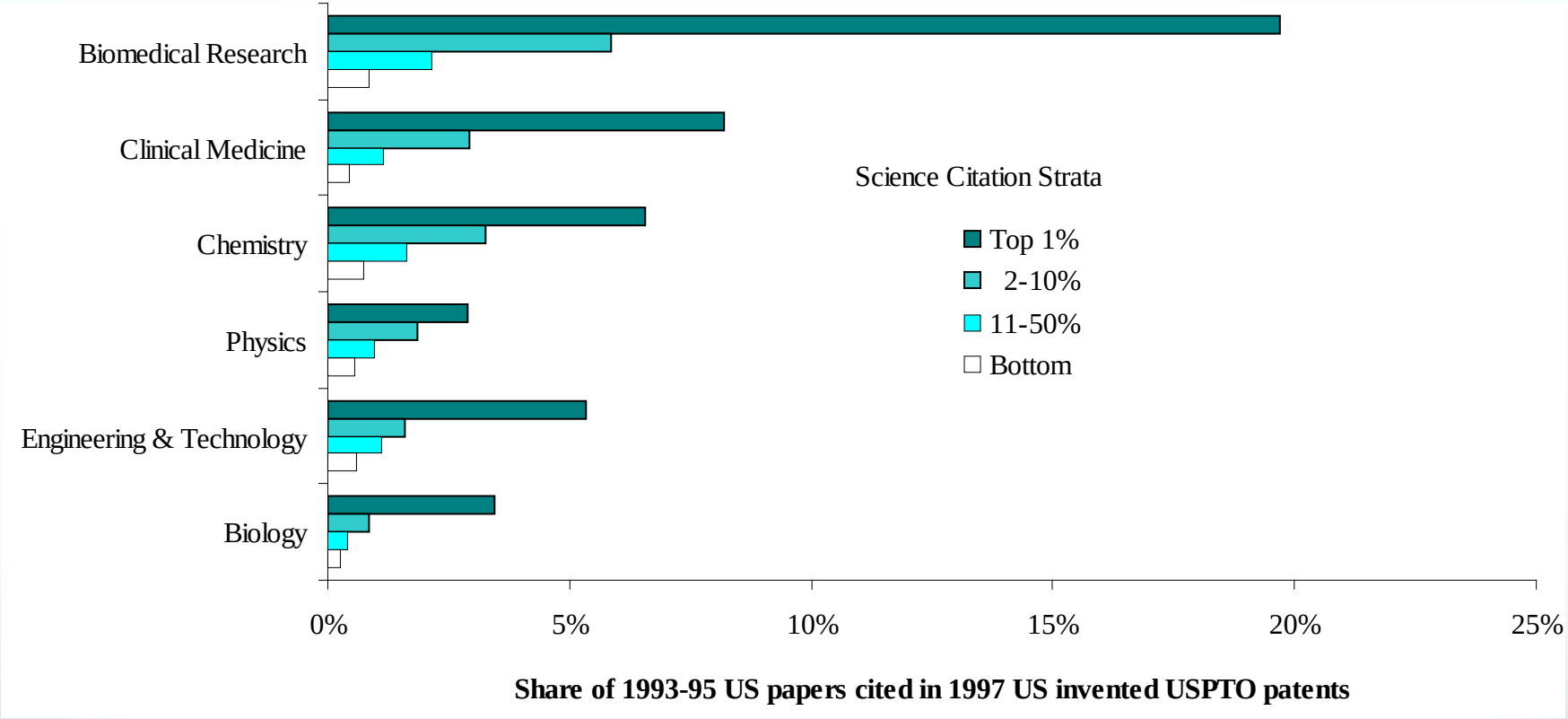
Percentage of Papers Cited in Patents by Field and by Research Type



Share of 1993-95 US papers cited in 1997 US invented USPTO patents

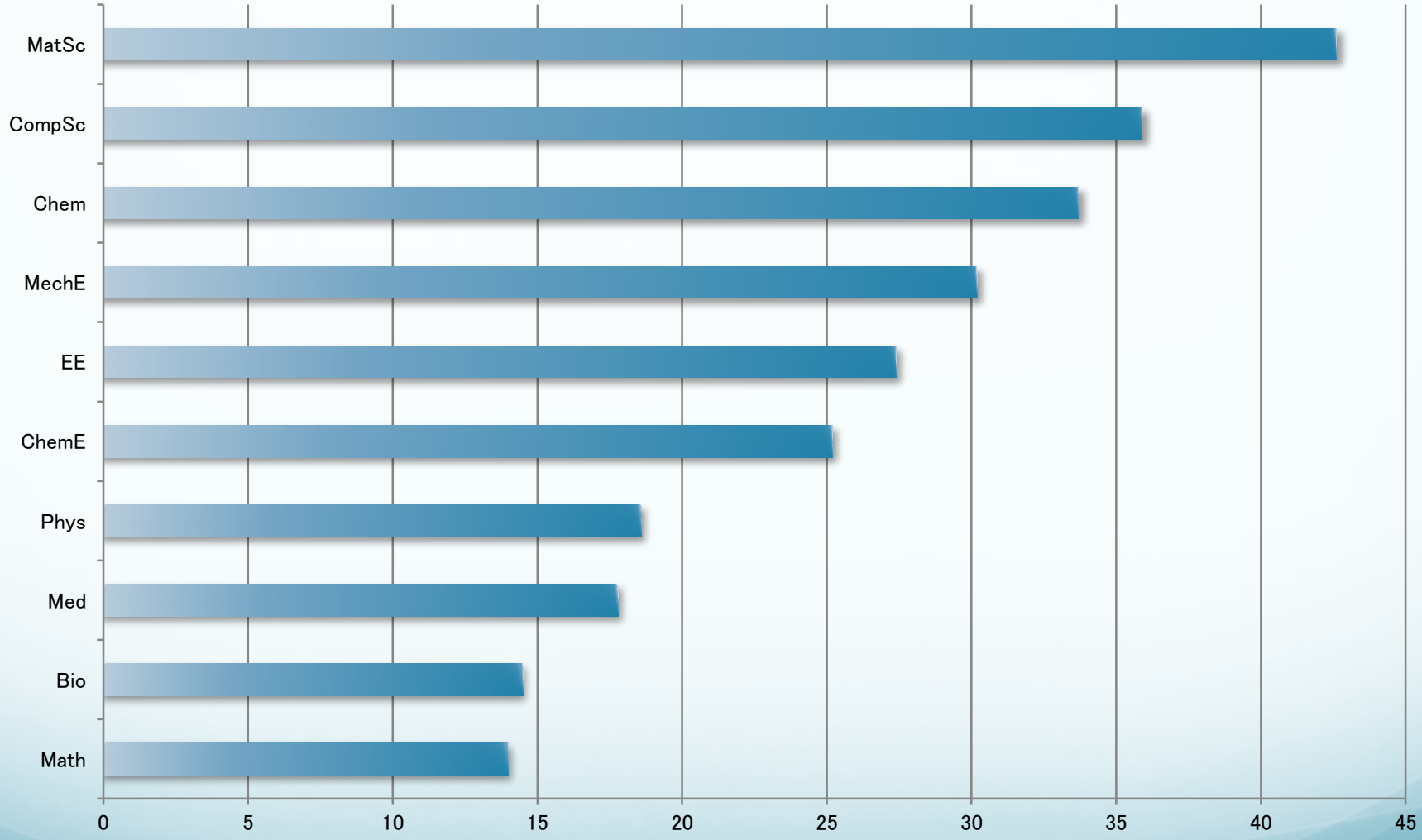
Source: CHI Research, Inc.

Highly Cited Papers are Much More Likely to be Cited in Patents



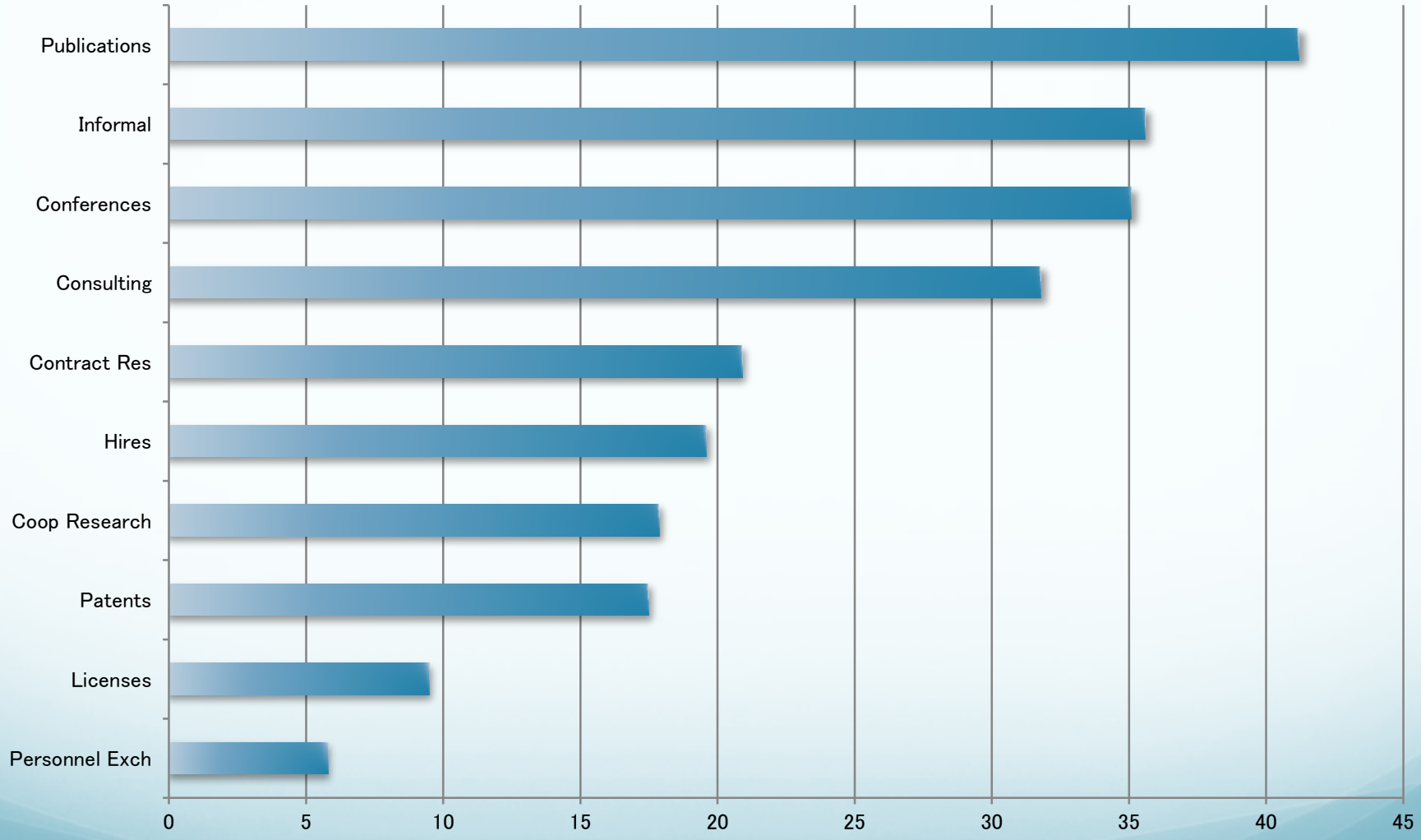
Source: CHI Research, Inc.

Percent of R&D managers reporting public research in each field as important for their firm's R&D



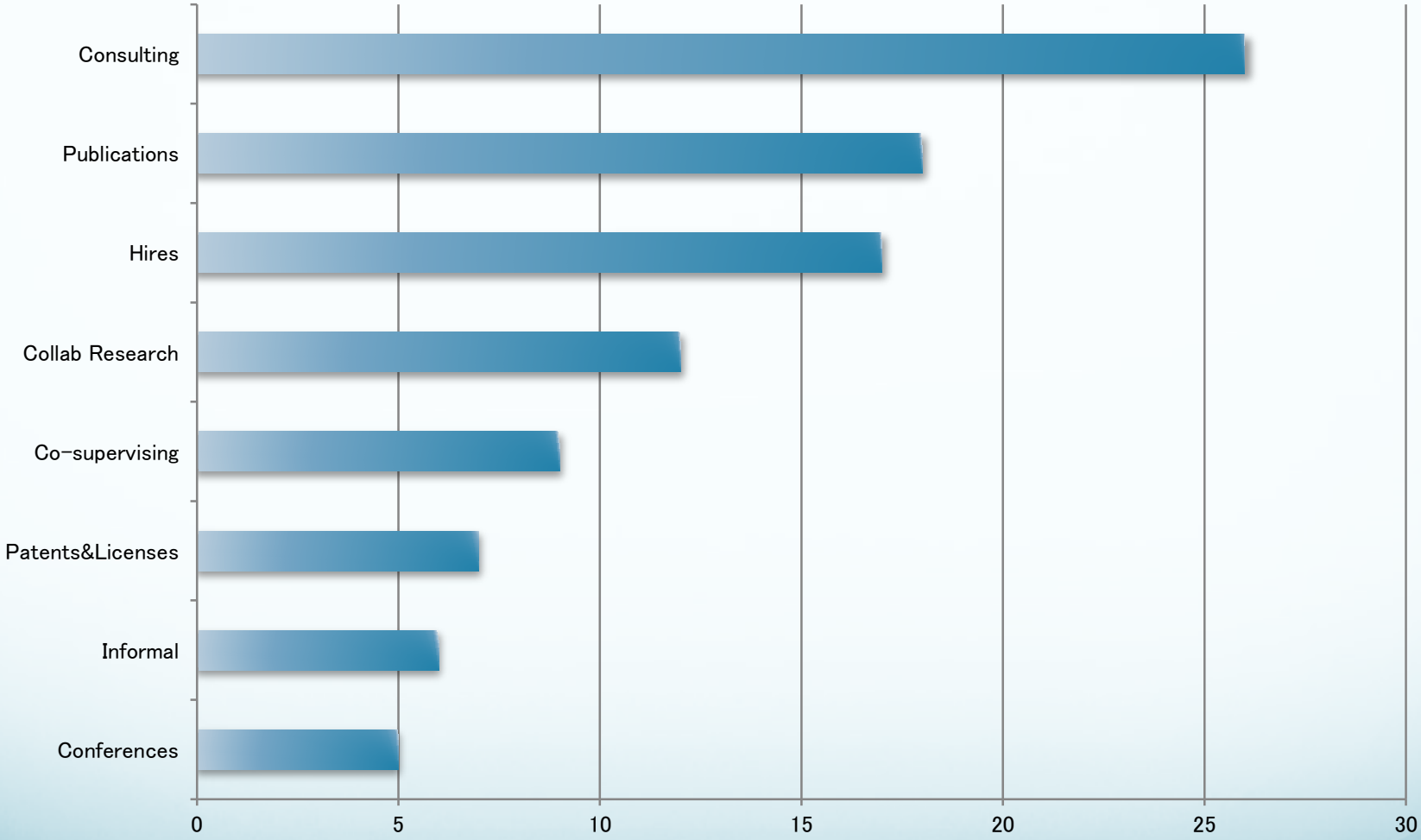
Source: Cohen, Nelson, Walsh. 2002. Management Science.

Percent of R&D Managers Reporting Channels as Important for Accessing University Research



Source: Cohen, Nelson, Walsh. 2002. Management Science.

Estimated share of each channel for influencing industry research, MIT Faculty



Source: Agrawal and Henderson. 2002. Management Science.

What does science contribute?

- Cohen et al. (2002) [US]:
  - Research findings (29%)
  - Instruments & techniques (22%)
  - Prototypes (8%)

- Gibbons & Johnston (1974) [UK]
  - Properties, composition, characteristics of materials or components
  - Theories, laws, general principles
  - Existence of specialist facilities/services
  - Location of information
  - Test procedure and techniques
  - Design-based information
  - Knowledge of equipment or materials with particular properties
  - Operating principles or rules, specs, technical limits

List ordered descending by academic contribution

Conclusions: Transfer of knowledge from universities to firms

- Push for universities to be more engaged in technology transfer
  - Transfer seems to be increasing over time
- Direct tech–transfer model is only (small) subset
- Often indirect (through publication and training)
- Varies by industry
  - Especially direct in pharma & biotech
- Varies by academic research field
  - Materials, chemistry, engineering relatively high