Markets for technology and the division of innovative labor: A view from the ivory tower

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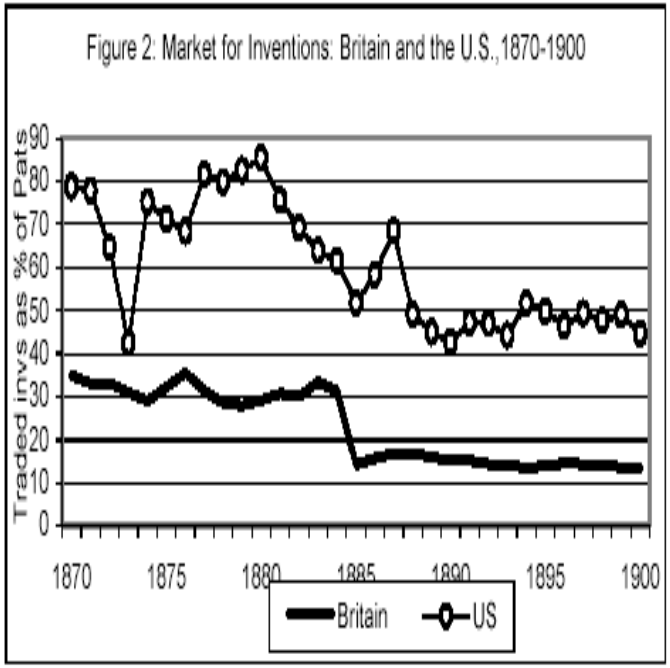
Evolution of Innovation Models

- Early in the 20th century: modern industrial enterprises internalized the R&D function
- End of 20th Century : Greater dependence on outside sources of innovation
  - Licensing
  - alliances
  - “open innovation”
- True? If so, why?

Back to the future?



Notes: The figure shows the ratio of all assignments to patents issued in the U.S.; whereas for Britain, the ratio comprises assignments and licenses relative to patents issued.

The division of innovative labor and markets for technology

Division of labor is limited by the extent of the market

- *Division of innovative labor* is limited by the extent of the *market for technology*
  - Market for technology – licensing, R&D contracts, …

	Existing Technology	**Future Technology or component**
Horizontal (with actual or potential rivals)	Union Carbide licensing Unipol polyethylene technology to Exxon	Sun licensing Java to IBM; R&D joint ventures between Sun and Microsoft.
Vertical (Licensing to non rivals)	Licensing of IP cores in semiconductors; Licensing of lead compounds in pharmaceuticals	Affymax licensing combinatorial technology to pharmaceutical companies; R&D joint ventures;

Estimates of technology licensing in the US, 2002 (IRS + BEA data)

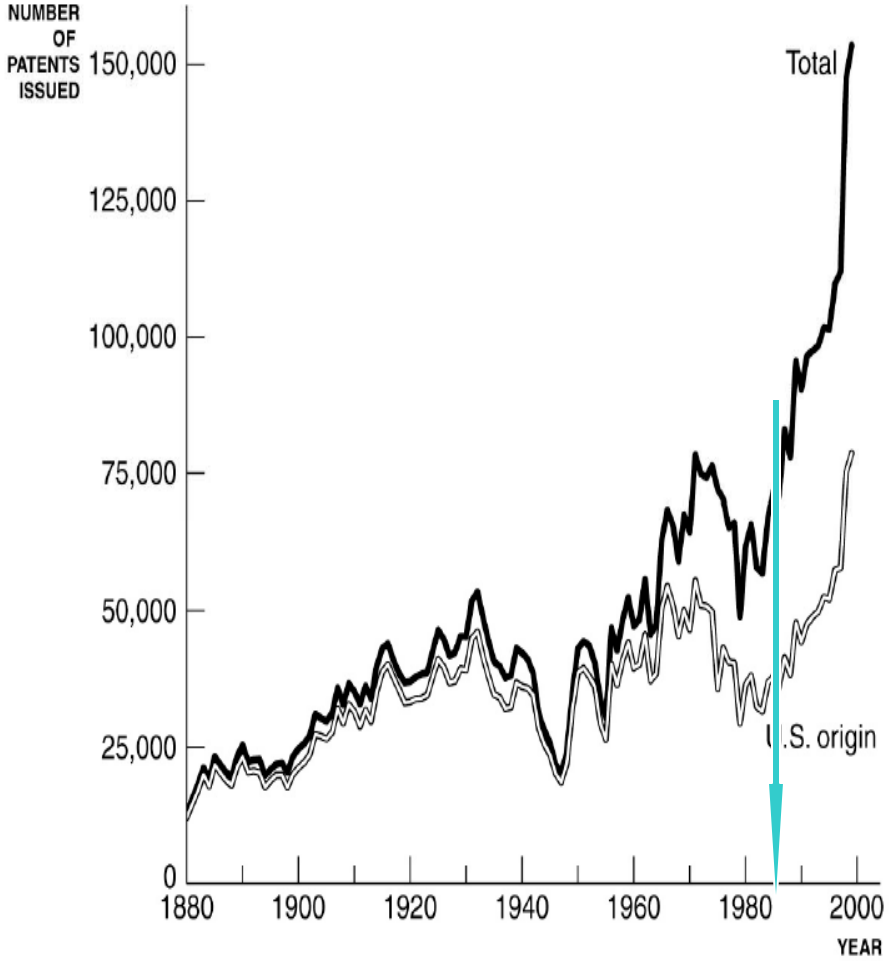
Distribution of IRS Receipts for Types of IP-Licensing Service Commodities across Industry Sectors, 2002, Billions of Dollars

Sector	**Licensing of Rights to Use IP Protected as Industrial Property**	Licensing of rights to use IP protected by **trademarks**	Licensing of rights to use IP protected by **Copyright**	Licensing of Rights to use a business format under a **franchise**	Payments for rights to use **Natural Resources** and Other intangibles	Total
Manufacturing	**59.5**	9.4	1.0	2.9	-	72.8
Distributive Services	**1.0**	6.9	0.1	5.1	-	13.1
Information	**1.9**	4.9	6.6	0.0	0.1	13.5
Finance and Insurance	**0.2**	0.7	0.0	1.4	0.0	2.4
Professional and Business Services	**3.0**	0.2	1.6	1.5	0.4	6.7
Other Industries	**1.0**	0.7	0.1	4.8	0.8	7.5
Total	**66.6**	22.8	9.4	15.7	1.3	115.9

$30-40Bn for mid 1990s
Arora, Fosfuri, Gambardella, 2001

Carol Robbins, Dept. of Commerce, 2006, tab 7

Growth of patents and MFT coincide after 1980s



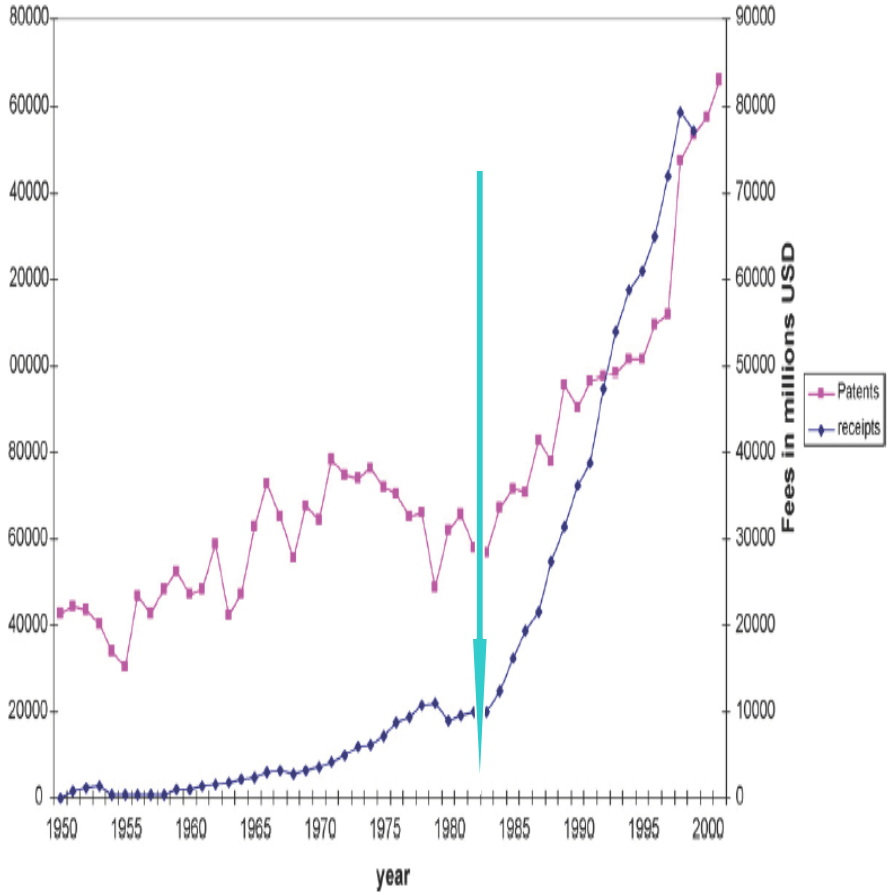


Fig. 2. Growth in non-US held patents and worldwide royalty and license revenues.

Patents and market for technology: Patents promote licensing by small firms

	Small Firm	Large Firm
% increase in licensing propensity	6%	2%
% increase in the propensity to license patented innovations	1%	–3%

Source: Arora and Ceccagnoli, “Patenting and licensing”, 2005

Gambardella, et al., 2007

we find that the most important determinant of patent licensing is firm size.

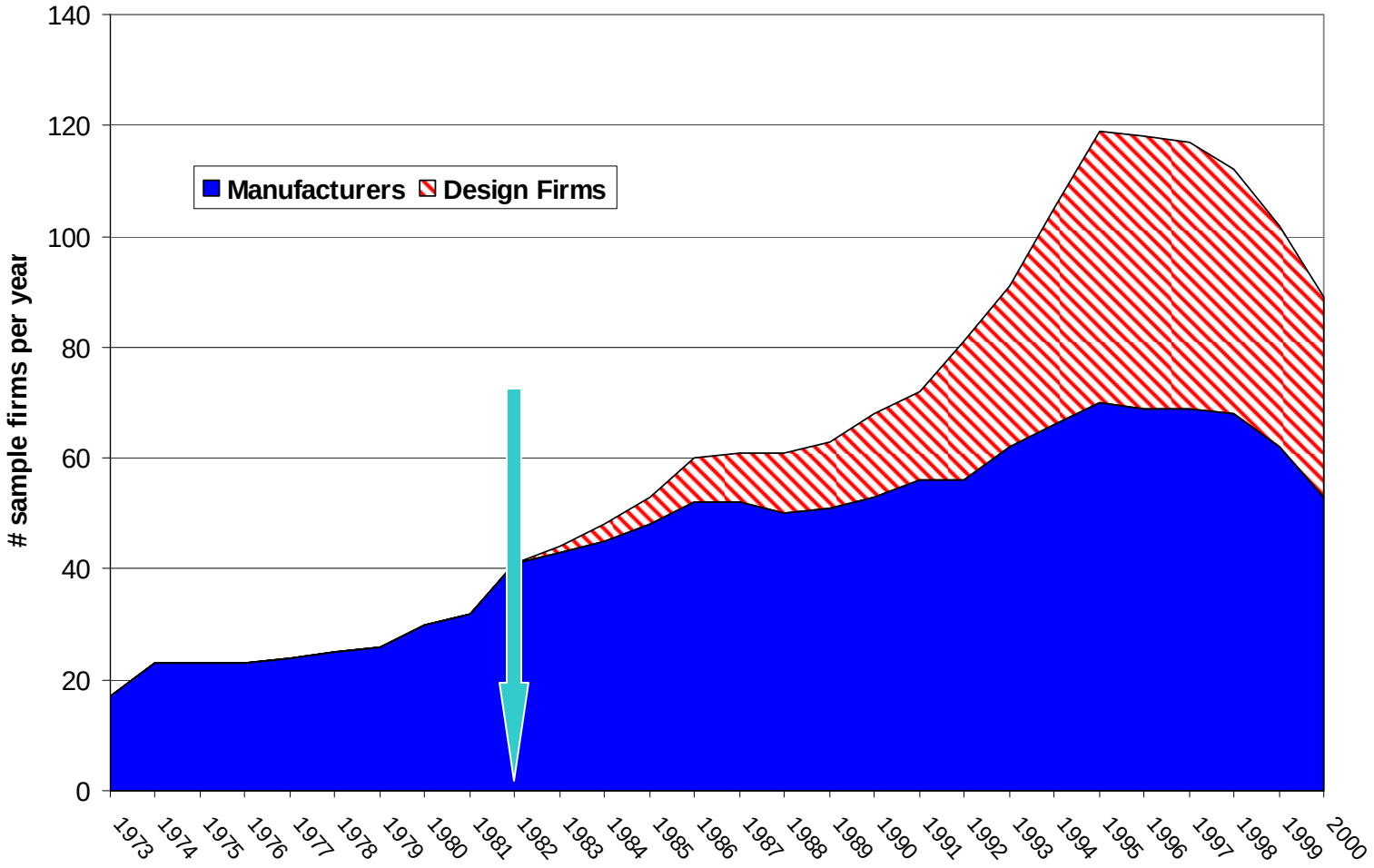
(EU dataset on inventors.)

Patent breadth, value, protection, and other factors suggested by the literature also have an impact, but not as important.

➔ Patents especially important for licensing by small firms.

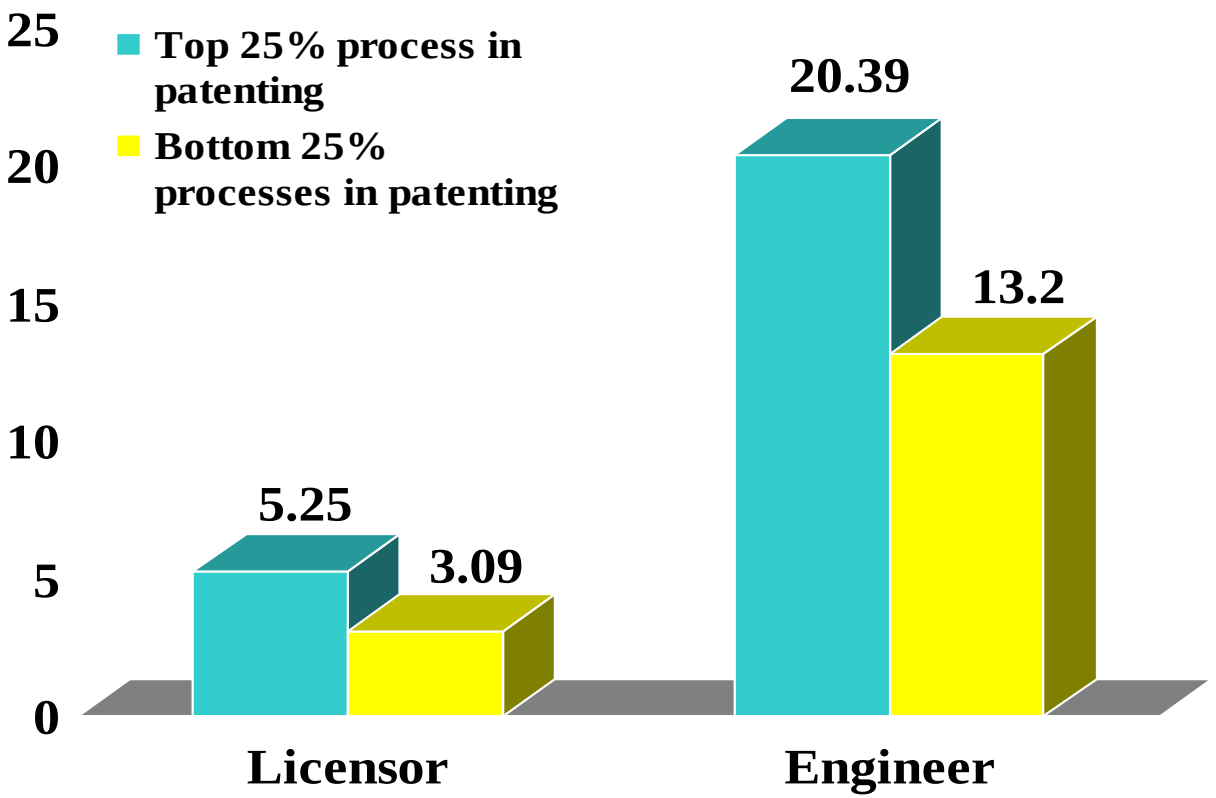
Patents promote entry of specialized design firms in semiconductors

U.S. semiconductor mfg. and design firms, by year
(Ziedonis, 2003, “The Enforcement of Patent Rights in the United States”)



Patents promote entry of specialized tech suppliers in chemicals

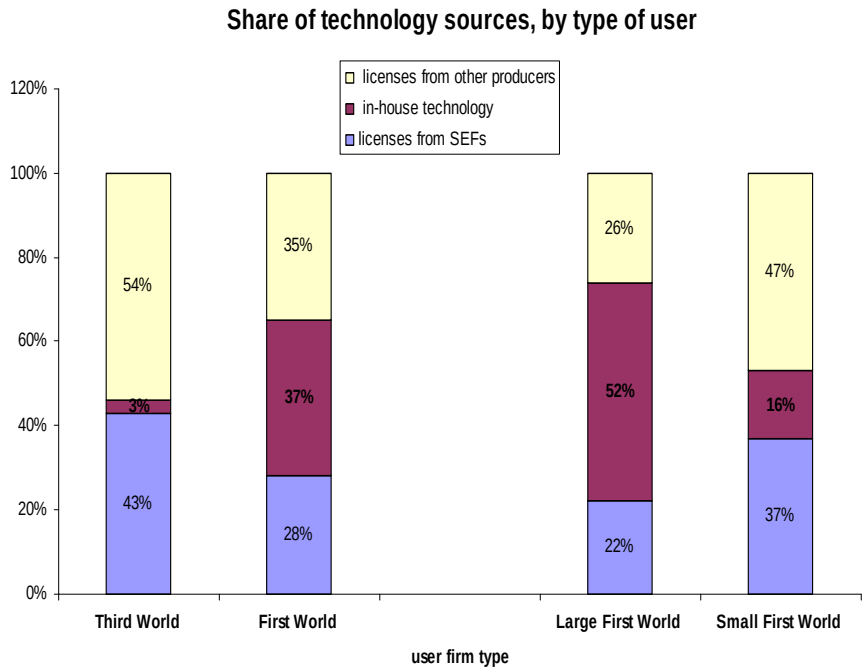
Average # of Specialized Engineering Firms by process category, 139 process technologies (1980-90)



Source: Arora, Fosfuri & Gambardella, “The division of inventive labor”, 2003

Implications of markets for technology

Markets for technology diffuse technology, encourage entry and product market competition



Source: Arora and Gambardella, 1998
Data: All chemical plants, 1980-90

Share in World exports of chemicals, 1899-1993, by country of origin

	USA	Britain	Germany[1]	Other W. Europe[2]	Japan	Other
1899	14.2	19.6	35.0	13.1	0.4	4.2
1913	11.2	20.0	40.2	13.1	1.0	0.3
1929	18.1	17.5	30.9	15.3	1.8	0.4
1937	16.9	16.0	31.6	19.4	3.0	0.3
1950[1]	34.6	17.9	10.4	20.5	0.8	0.5
1959	27.4	15.0	20.2	21.1	3.1	0.2
1993	13.0	5.2	12.7	13.1	13.0	33.4

Source: Table 2 in Eichengreen, in Arora, Landau, and Rosenberg (eds), 1998

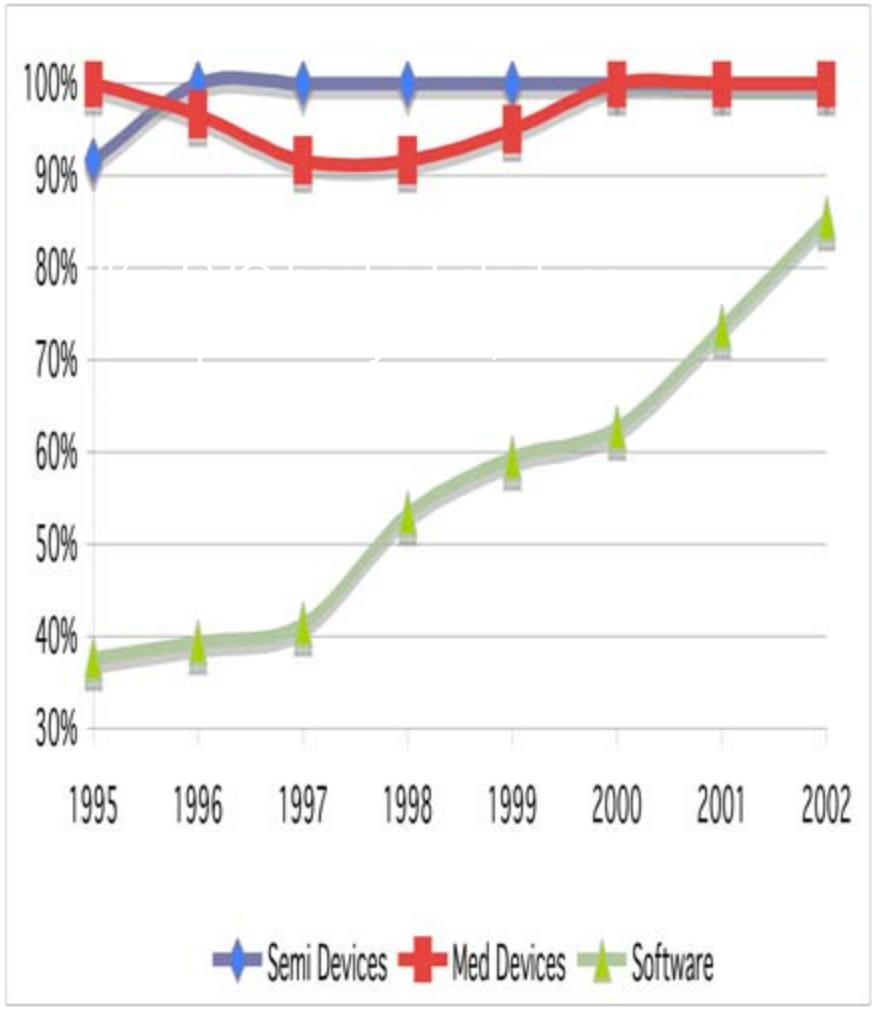
Information security software: non-producer patents, licensing, entry and exit are correlated

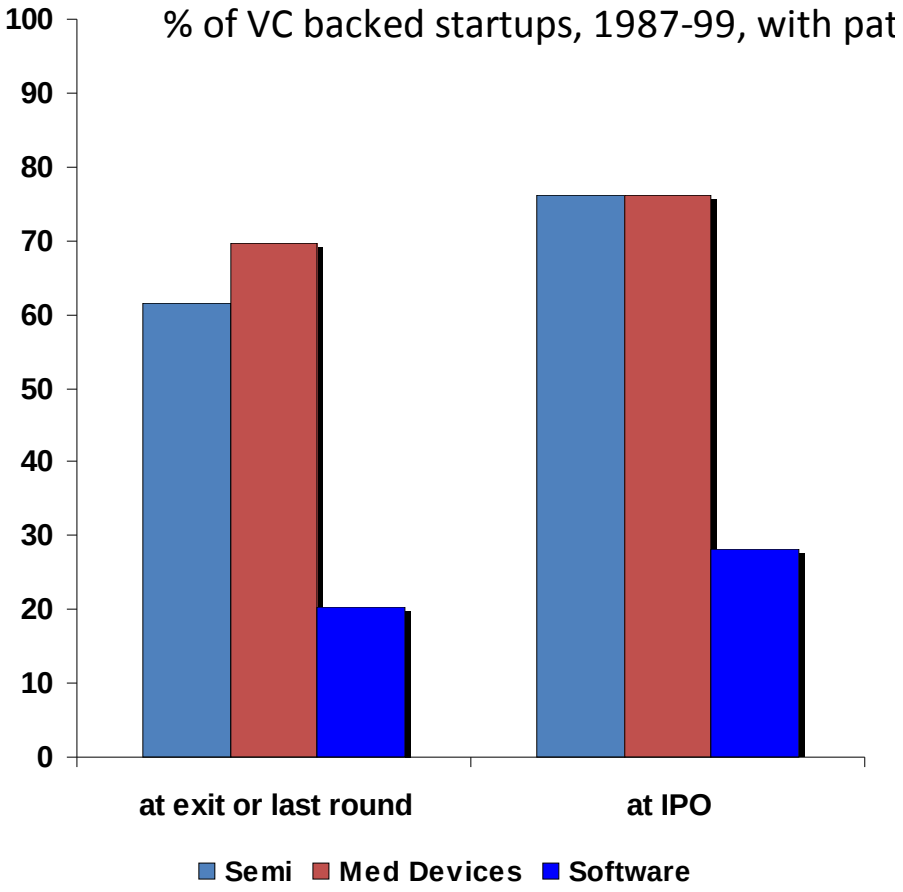
	Avg # of security patents at entry	Avg. share of non-prod. patents	Specialized licensors (max over time)	Licensing deals (incl. to users) / producer	% entrants with licensed tech
Encryption based markets	**12.85 (8.75)**	**0.73**	**17**	**0.69 (0.01)**	**65**
Other markets	**2.69 (11.35)**	**0.27**	**0**	**0.26 (0.02)**	**13**

	Entry	Prop. of exits before 2004
Encryption based markets	216	0.27 (0.03)
Other markets	127	0.22 (0.04)

- Encryption markets
  - More patent intensive (Giarratana, 2004)
    - 2/3rds of all security patents are encryption patents
  - Functioning market for technology (Gambardella and Giarratana, 2007

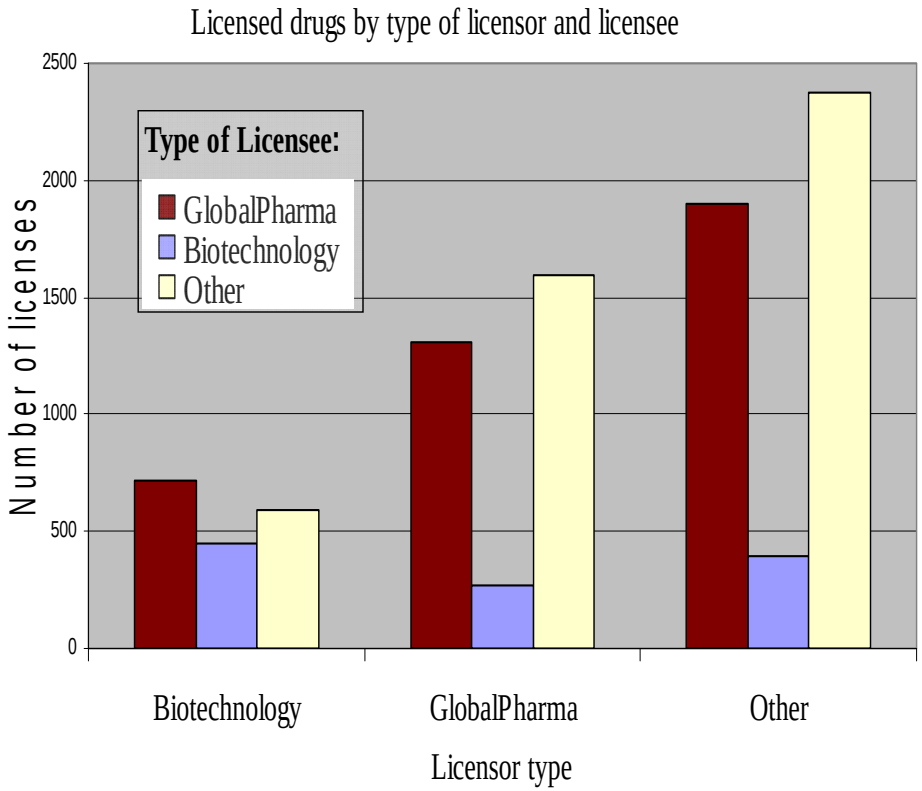
Successful startups in semi-conductors, med devices and even software rely on patents





Source: David Hsu and Rosemary Ziedonis, 2008

The market for technology in bio-pharma is significant

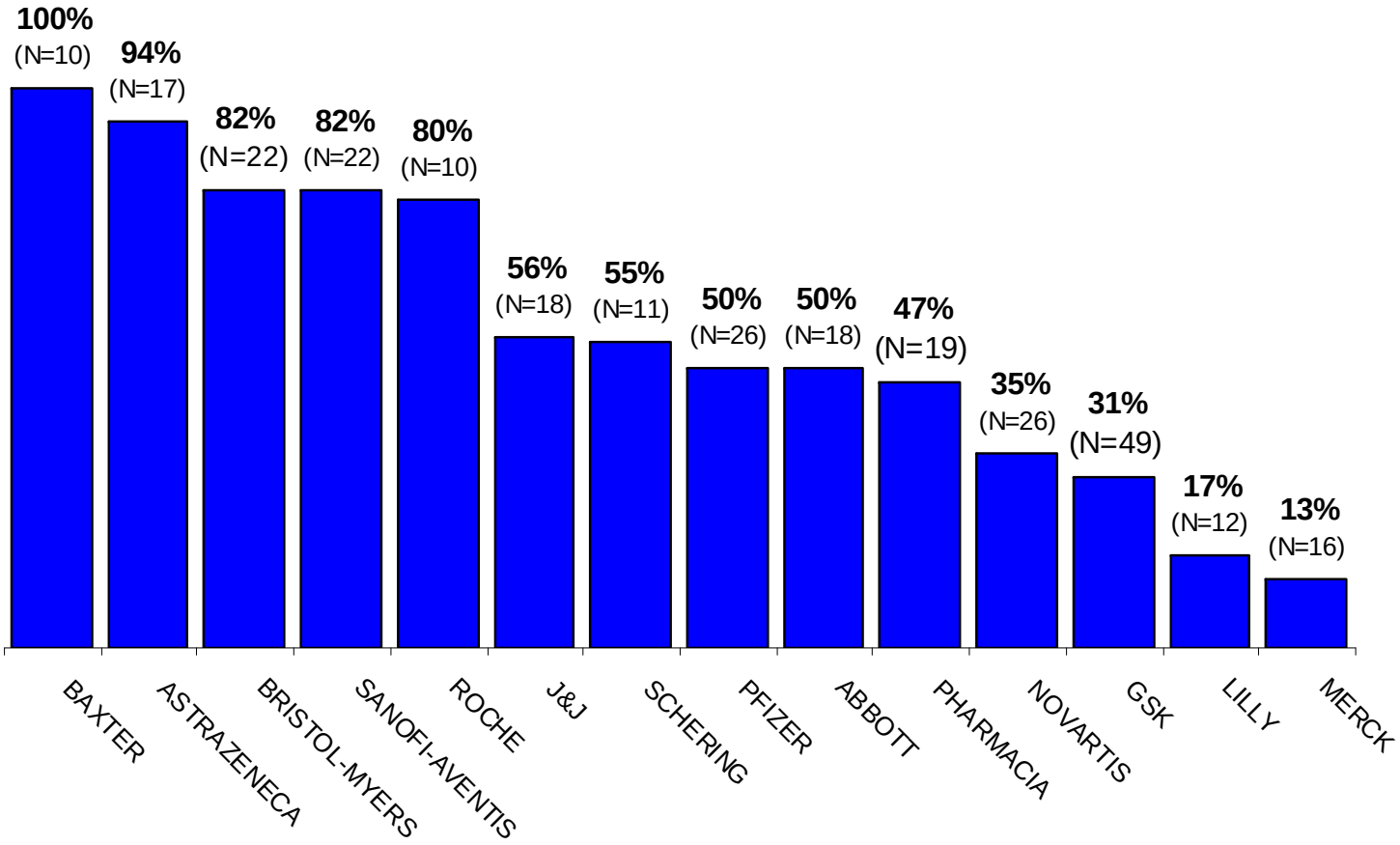


- Market for technology is not confined to biotechs licensing to pharma
- Significant licensing amongst pharma firms as well.

Source: Alcacer and Gittelman, 2008

Pharma firms rely extensively on outside knowledge for their products.

Percent of new drugs with more than 50% of patent attached to the drug being not held by the commercializing firm, for companies with >10 NDAs --> 1989-2004



Source: Ceccagnoli, Graham, Higgins, Lee; 2008

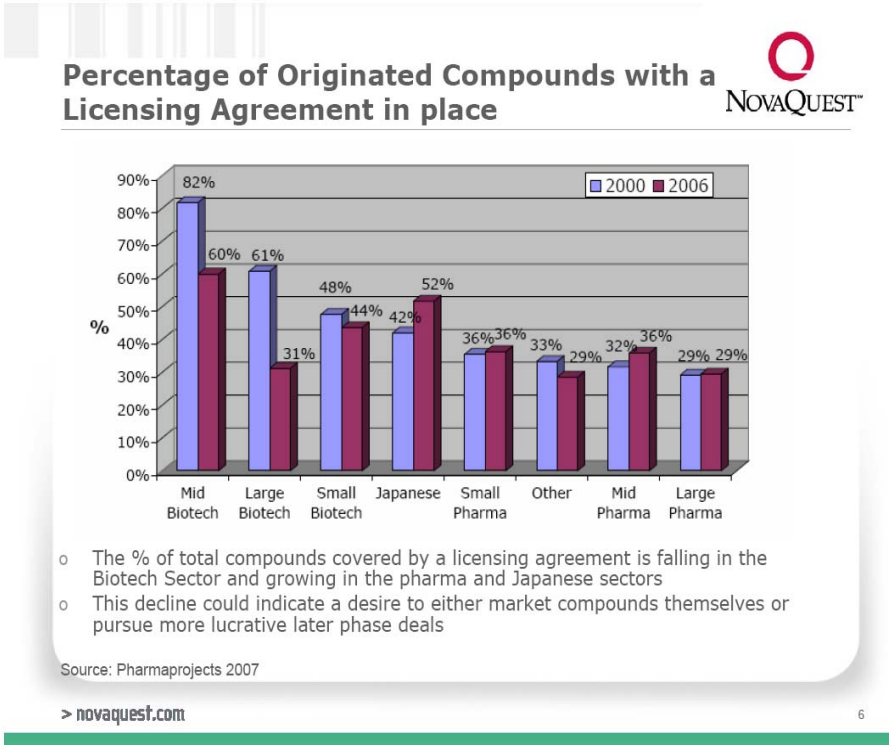
Markets for technology and their discontents

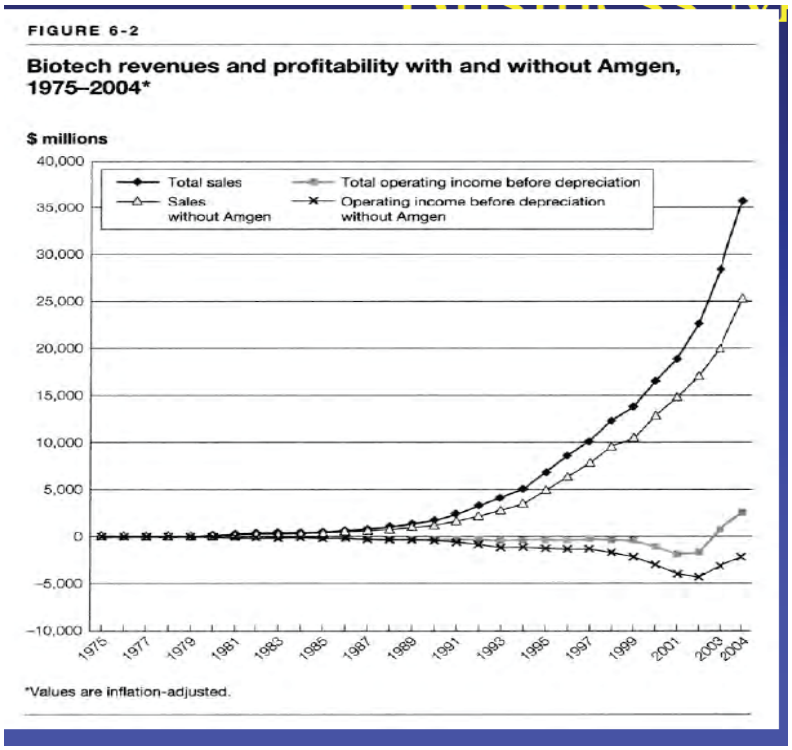
Whither bio-pharma?

Patenting and academic research?

Anti-commons?

Science as a business in biopharma





Source: Gary Pisano, *The Business of Science*, 2006)

- Problem may be *insufficient* division of innovative labor
- Biotechs, esp mid sized and larger, are moving away from the division of innovative labor.
  - more likely than before to develop drugs in-house instead of outlicensing.

Foundational patents: university patents may be as guilty as others in blocking research

Table 4-2 Principal Assignees of Patents by Category

	Total Patents	Top Assignees
Genes and Gene Regulatory Sequences	6,145	*U. California (158)* Pioneer Inc. (150) Ludwig Inst. (72) Monsanto (72) Chiron Corp. (71) *General Hosp. (71)*
SNPs and Haplotypes	1,482	Pioneer (183) Dekalb Genetics (107) Stine Seed Farm (48) *U. California (39)* *John Hopkins (25)*
Gene Expression Profiling	7,428	*U. California (215)* Incyte (170) Affymetrix (117) Gen-Probe (100) **DHHS (96)**
Protein Structure	39	Abbott Labs (3) Connaught Labs (3) *U. California (3)* *U. Alberta (3)*
Protein-protein interactions	6,964	Genentech (181) *U. California (178)* **DHHS (84)** Chiron (82) Immunex (78)
Modified Animals	652	*U. California (26)* *General Hosp. (11)* Pharming BV (10)
Software	60	Abgenix Inc. (9) Millennium (8) Rosetta (4)
Algorithms	91	Pioneer Hi-Bred (3) Cytokinetics (42) All others (2 or 1)
Databases	1,466	Affymetrix (108) *U. California (45)* Agilent Tech. (34) Nanogen (22) Sequenom (18)
EGF	765	Sugen (23) Genentech (16) *U. California (12)* **DHHS (12)** *Yale (11)*
CTLA4	63	Bristol-Myers Squibb (20) *Dana Farber (6)* Repligen (4) Genetics Inst. Inc. (3) Pfizer (3)
NF-kB	94	*U. California (7)* Bristol-Myers Squibb (6) Tularik (5) Ariad (3) *Dalhousie Univ. (3)*

Note: The assignee is the company or organization assigned ownership on the original patent. Through consolidations, mergers and acquisitions, and other transactions, ownership may change. Private organizations, foundations, and hospitals are distinguished from commercial entities by *italics*. Government entities are indicated by **bold** typeface.

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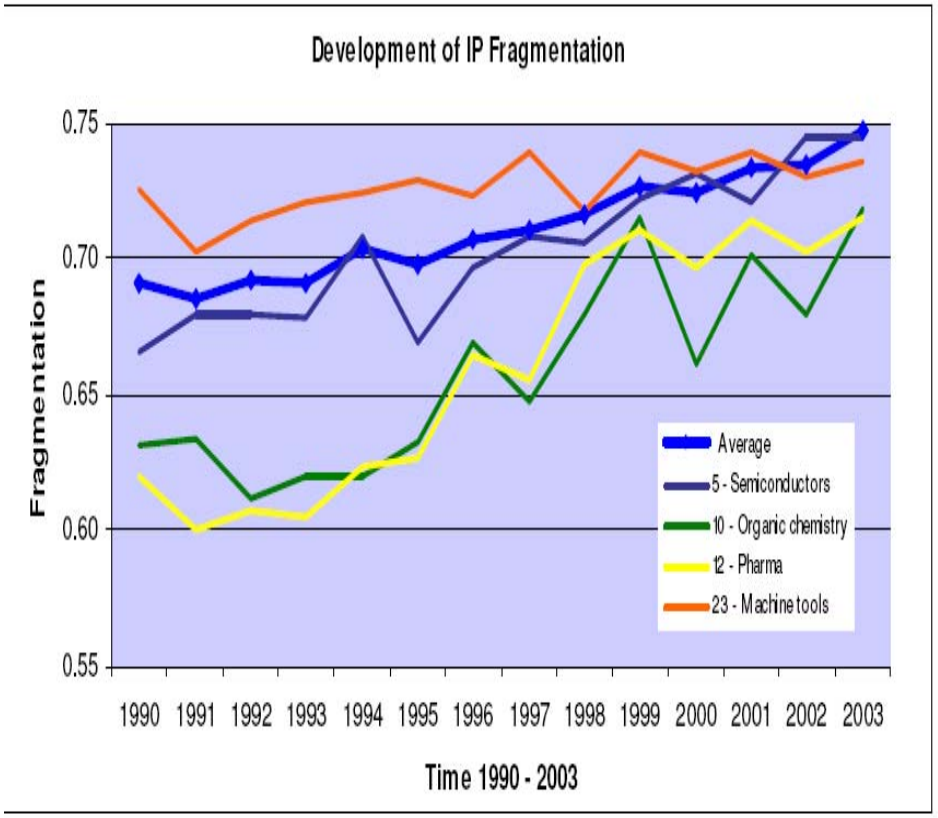
Source: National Academy of Sciences, 2005

"WE HAVE MET THE ENEMY AND HE IS US"

Thickets and patent fragmentation



Source: Cockburn, MacGarvie and Mueller, 2008

- Patent landscape becoming more complex
- Substantial litigation costs (and perhaps rising) (e.g., Lanjouw and Schankerman, 2003)
- Potential for harm exists – limited evidence as yet.

Anti-commons: An uncommon tragedy?

- Heller and Eisenberg, Murray and Stern, v. Walsh and Co.
- If scientists are dissuaded from research because they will not be able to patent the findings, this is not evidence of anti-commons; this is evidence that the profit oriented research is shaped by profit opportunities.
- Clinical research in America, which is inextricably mixed up with “for-fee” clinical practice.
- Here anti-commons may be a problem since diagnostic tests more efficiently done as a battery

The owners of this Chongqing "nail house" refused to leave it, thwarting plans for a shopping mall.
en.wikipedia.org/wiki/Tragedy_of_the_anticommons

Only 32 out of 381 respondents (8%) ... conducted research in the prior two years using ... knowledge covered by someone else’s patent. ... No one reported abandoning a line of research. *Thus, of 381 academic scientists, even including the 10% who claimed to be doing drug development or related downstream work, none were stopped by the existence of third party patents*.

(Walsh, Cho and Cohen, 2005)

- Only those scientists intending to patent were affected by existence of patents
- Problems in sharing may lie elsewhere, e.g., in materials transfer
  - exacerbated by legal concerns

Patents as potential roadblocks

- Bad patents create problems.
- Bad patents in the hands of players with short term strategies create bigger problems – BUT

- Patent policy must not discriminate against business models based on licensing.
- In a knowledge based economy, prejudices in favor of material production is simply a prejudice. SO

- Investing in improving the quality of patents is a good idea.
- Getting the USPTO to recognize that its mission is not to serve inventors but to serve society.