

## The Nature Of The Market For Technology In Biopharmaceuticals

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### Markets for technology (I)

On the one side: Increasing importance:

- a) Rise of specialized tech. producers
- b) Outsourcing of tech. activities

On the other side: economic and OT literature:

Factors that *limit* the creation of markets for technology:

1. Increasing returns
2. The production of technology is marked by economies of scale and fixed sunk costs
3. Historically, technology has not been characterized by an extensive division of labor

Explanations

- Cognitive reasons (knowledge as information, knowledge as tacit knowledge)
- Transaction costs

### Markets for Technology

Increasing Importance: Explanations

Cognitive and Contractual Determinants

A) General and Abstract Knowledge

B) GPTs, Market Size, Division of Innovative Labor

An Industry of specialized technology suppliers can then specialize in the production of General Purpose Upstream Technologies, without having to invest in the knowledge and economic assets that are necessary to operate in the operation market. (Life sciences as an extreme case: uncertainty, development costs, time horizon)

## Introduction and Motivation

### Tragedy of anticommons and/or comparative advantage of different types of firms in division of (innovative) labor

Literature on organization and division of labor among firms suggests that:

a) Small firms (biotech firms) are relatively more efficient at research and large firms are relatively better at development and commercialization. (e.g., Levinthal and March – exploration versus exploitation; Arrow 1983).

*Strong version – absolute advantage, not just comparative advantage*

b) Small firms better able to (or more willing to) engage in riskier projects (Arrow 1983; Holmstrom, 1989)

c) Biotech differs from traditional drug discovery in that there is a lower incidence of “false positives”. Implication – losers are discarded earlier in the innovation process. (Can be seen as a special case of a )

## Introduction and Motivation

Literature on market for technology and technology licensing suggests that:

a) Licensor’s superior information about technology can lead to a “lemon’s problem” – inferior projects offered for licensing while better projects retained for in-house development (e.g., Pisano, 1997)

b) More generally, integrating discovery with development is more efficient (e.g., Teece, Chandler, ...)

## Data Set & Sample

1. **Dataset** (PHID at EPRIS) – Biopharma R&D, collaboration and market.

a) 11418 R&D projects initiated between 1989 and 1999 by 427 pharma, 1226 biotech, and 613 univs and non-profits.

b.) Project characteristics – ATC4 class, pharmacological activity, therapeutic targets, originator firm, developer, stage of clinical, country.

2. **ATC** characterized on a 1-5 Likert type scale (by pharmacologists) in terms of in terms of “morbidity”, “multiplicity of causes”, “acuteness”, “remedies”, “rarity”.

3. **Sample**: All terminated projects that at least reached Clinical I, by US firm in US and European firm (EU + Norway and Switzerland) in Europe.

a) Exclude projects where product licensed out by incumbent pharma.

b) Total of 2078 projects.

c) *All results conditional on termination.*

1. **Reported results**: Only for US (~900 obs). Largely unchanged if add European data.

2. **Definitions**:

a) **Biotech Firm**: Firms founded after 1976 (excl JV between incumbent pharma).

b) **Success**: Clear Clinical III.

**Sample descriptive statistics**

	US Sample	European sample
Originator		
Pharma	37.6%	87.4%
Biotech	56.8%	11.5%
Universities	5.6%	1.2%
% licensed	7.5%	2.1%
Biotech	4.8%	1.7%
Universities	2.7%	0.4%
% successful	9.5%	11.0%
No. of Obs.	965	776

*Biotech firms:  
Lower morbidity;  
Less common (rarer diseases);  
Fewer remedies.*

**Success: Biotech versus Pharma  
Probit Estimates.  
Dependent Variable = 1 if Success.**

Parameter	Estimate	Std. Error
Constant	-2.67	1.07
Morbidity	0.02	0.10
Common	-0.21	0.16
Causes	0.46**	0.11
Remedies	0.33**	0.14
Chronic	-0.50**	0.20
Biotech Firm Dum	0.12	0.13
Obs (Positive Obs)	910 (78)	
Log Lik	-251.1	

*Bottom Line: Biotechs not markedly better in this sample*

**Success: Biotech (licensed and in-house) versus Pharma  
Probit Estimates.  
Dependent Variable = 1 if Success.**

Parameter	Estimate	Std. Error
Constant	-2.80**	1.11
Morbidity	0.02	0.10
Common	0.17	0.17
Causes	0.49**	0.12
Remedies	0.32**	0.15
Chronic	-0.50**	0.21
Biotech * License	1.47**	0.22
Biotech*(1-License)	-0.14	0.14
Obs (Positive Obs)	910 (78)	
Log Likelihood	-223.1	

*Bottom Line: No evidence of "lemons problem"*

**Prob of Success, Licensed and in-house, By Stage of Clinicals**

Stage	Probability	Std Error
Clinical I Licensed in Clinical I	22.0%	3.8
Internally developed	6.5	0.9
Clinical II Licensed in Clinical II	72.7	
Internally developed & passed clinical I	13.4	26.5 3.1
Clinical III Licensed in Clinical III	73.3	
Internally developed & passed clinical II	12.7	41.5 4.2

**Bottom Line:**

1. At any stage, a molecule licensed in at that stage has a higher probability of passing that stage than in-house compound.
2. Licensed compounds are not significantly different in nature (e.g., morbidity, chronic etc.) from non-licensed

**Differences in pure development capability: licensed compounds only**  
**Probit Estimates: Dependent Variable = 1 if success**

Parameter	Estimate	Std. Error
Constant	3.67	3.91
Morbidity	-0.61	0.35
Common	-0.36	0.42
Causes	-0.36	0.47
Remedies	0.60	0.42
Chronic	-1.30**	0.63
Pharma Dummy	0.58*	0.35
Obs (Positive Obs)	71 (29)	
Log Likelihood	-36.24	

*Bottom Line: Even after controlling for origin, incumbent pharma have a higher success rate. Size and sig. of coefficient increases if drop controls. Suggests Pharma have a comparative advantage in development.*

**Stage Of Failure By Type Of Firm**  
**Only Clinical III projects. Only non-licensed projects**  
**Probit estimates: Dependent Variable = 1 if success.**

Parameter	Estimate	Std. Error
Constant	-0.47	2.12
Morbidity	0.06	0.17
Common	-0.13	0.34
Causes	0.33	0.21
Remedies	0.20	0.28
Chronic	-1.30**	0.40
Biotech Dummy	0.69**	0.24
Obs (Positive Obs)	131 (56)	
Log Likelihood	-82.23	

*Bottom Line: Biotech projects fail earlier. Conditional of reaching clinical III, biotechs have significantly higher success. Implication: True rate of success likely higher for biotech firms. Sample biased because select only terminated projects.*

### **Findings and tentative conclusions**

1. Licensed compounds have substantially higher probability of success.
2. Biotech firms have greater probability (likely!!) to originate successful drugs.
3. Biotechs have a higher share of failures early.
4. Pharma have an edge in development which partially compensates for apparent lower probability of originating successful drugs.

### **Possible Implications**

1. No “lemons” problem in market for technology
2. Biotechs have higher development costs for later clinical (e.g., higher cost of capital; poor links with hospitals and physicians) – but should also imply lower probability of early failure.
3. Biotechs have lower false positives in early clinicals.
4. Pharma have lower false negatives in early clinicals.
5. Biotechs have a superior distribution of projects from which to draw — (but should imply lower probability of early failure)

### **Tentative Conclusion (Working Hypotheses)**

Biotechs have lower false positives and a superior distribution of projects and higher development costs compared with pharma firms. Possibly as well, pharma firms have lower false negatives.

There is no lemons problem in the technology market. The greater success of licensed drugs is due both to the greater selectivity imposed by royalty and milestone payments and superior distribution of projects available to biotechs.

## Markets for technology in therapeutics (II)

### Increasing importance:

Systems of exchange relationships in domain characterized by structural breakthroughs in underlying knowledge bases.

There is any distinctive feature of markets for technology, which can make them different from “conventional” markets?

### Implications:

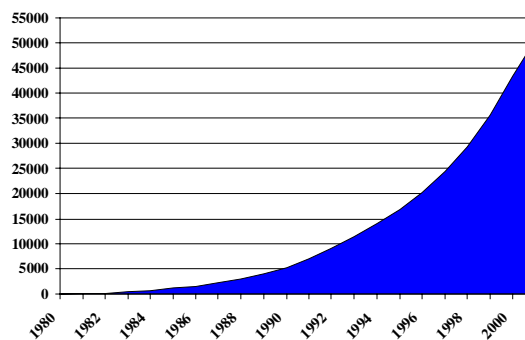
The economic functions they perform (Fuel of Interest and Power of Genius);

The analytical strategies they call for

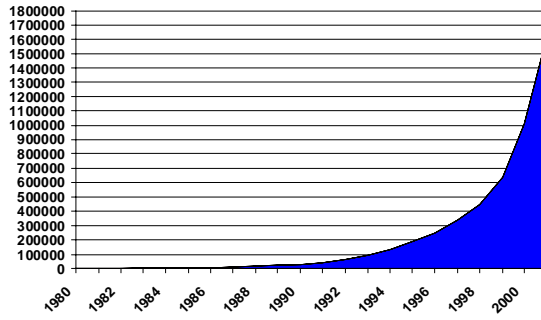
## Markets for technology (II)

- Salient features of Problem Spaces and Decompositions should be used as explanatory constructs in the analysis of the structural evolution of the market for technology
- Molecularization; Proliferation of plausible targets for therapeutic intervention; Structure/Function at different levels of organization of the human organism; Natural functions, Artificial functions # from Chemistry and Mechanical Engineering
- Types (Originators, Developers) Roles (GPT vs. Cospecialization); Technological background of the agreements (discovery and development technologies)
  - (1) Agreements and Technological Dynamics  $\Rightarrow$  Patents and the possibility of writing contracts for new potential therapeutic solutions; (2) GPT: Non exclusive licensing agreements (multiple developers and access to the tools; multiple areas; different types of firms)

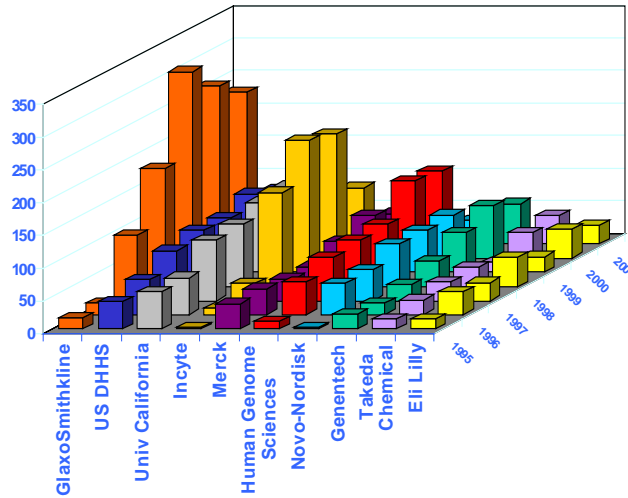
## Growth of patents (1981-2001)



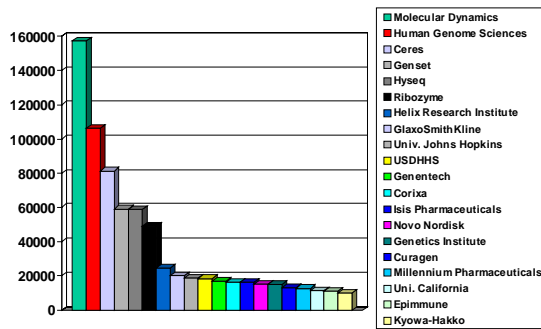
Growth of sequences  
(1981-2001)



Patenting Activity (1995-2001)



Top 20 Sequencers  
(November 2001)



### Top 20 Patentees (November 2001)

