THE IMPACT OF PATENT SCOPE: AN EMPIRICAL EXAMINATION OF NEW BIOTECHNOLOGY FIRMS

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Abstract

This analysis examined the impact of patent scope, using a sample of new biotechnology firms. The study was motivated by several recent theoretical analyses which suggest the importance of breadth of patent protection and the limited attention that policy-makers have devoted to the issue. A population of over one hundred biotechnology start-ups, a mixture of private and public firms supported by venture capital firms, was used in the analysis. While the author could not examine the impact of patent scope on public welfare, two dimensions of firm performance were examined: the issuance of public equity, and valuations of these firms. The analyses suggested that patent scope, measured in two alternative ways, had a strong impact on the performance of these firms, and was an economically significant variable.

Introduction*

The optimal breadth of patent protection has been increasingly recognized by economists as an important research topic. Initial theoretical examinations of patenting focused on the determination of optimal length for a grant of intellectual property. But as empirical work has made clear that the protection provided by patents is frequently less than the entire seventeen-year legal life of the awards [e.g., Mansfield, 1984], several theoretical articles have argued that the analytic focus should be on patent breadth, an arena in which patent examiners exercise wide discretion. This

recent theoretical work concerning patent scope was the first motivation for this study. Through a careful examination of a single industry, biotechnology, could patent scope be documented--however imperfectly--to have an impact on firm welfare, a finding which might confirm the importance of this new avenue of theoretical research? The second motivation was the relative disparity in concern about the scope of biotechnology patents between practitioners-who have written at some length on this issue--and the policy community, which has focused on the issues of long patent pendencies and the definition of novelty.

The author was limited in his analysis by the difficulties of measurement. In view of the immaturity of the industry, no attempt was made to estimate the gains to social welfare from innovation, as was undertaken by Trajtenberg in the case of computed tomography [1989]. Rather, the author confined his explorations to the impact of patent scope on firm value, for a subset of the biotechnology industry: venture-backed biotechnology start-ups. While the range of questions which may be asked of this population was limited, the results proved nonetheless provocative.

Previous Literature

Four recent studies are illustrative of theoretical efforts to understand the impact of patent scope. In a pair of recent articles in the *Rand Journal of Economics,* Gilbert and Shapiro and Klemperer examined the trade-off between patent length and breadth, *i.e.,* the proper structure for a patent, holding the overall reward constant. The first two authors consider a setting in which broader patents provide inventors with a greater ability to earn profits, but also increase the social deadweight loss. In this setting, the optimal patent will be very narrow but infinitely-lived [1990]. Klemperer considered an alternative setting, in which consumers facing a patent-holding monopolist can either switch within the product class, or may purchase none of the good at all. In this more complex setting, either narrow-but-long or broad-and-short patents may be optimal [1990]. Finally, two recent working papers, Scotchmer and Green explore a setting in which there are a sequence of innovations, each building on the previous breakthrough, with a variety of licensing and cooperative research arrangements possible between firms [Green and Scotchmer, 19901. Under these assumptions, they can demonstrate that the questions of optimal patent breadth and policies towards technological collaboration are inexorably linked, and that neither can be answered without the other. For instance, Scotchmer demonstrates that when prior collaborative arrangements for R&D are allowed, it is

likely to be optimal to allow broad patent scope; while in their absence, narrow awards are superior [1990].

A different tack is taken by Merges and Nelson in their recent historically-oriented examination of these issues. After reviewing key precedents in a broad spectrum of industries, they argue that the preponderance of evidence suggests that the greatest danger lies in excessively broad patents [1990]. In the bulk of the cases where a few organizations controlled the advancement of a technology, progress has been sluggish. While they do not argue against the need for providing rewards to key breakthroughs through broad patents, they raise questions concerning unnecessarily broad awards. Consequently, they counsel the need for caution in awarding broad patent claims, particularly in science-based industries.

As Merges and Nelson point out, in few industries today is the question of patent scope as critical as in biotechnology. In an industry where product market competition remains embryonic, and the alternative methods of protection of intellectual property (e.g., learning curve effects, trade secrecy) identified by Levin, *et al*. [1987] remain of limited effectiveness, patents play a critical role. As is dramatically demonstrated by the recent controversies between Genetics Institute and Amgen and between Hybritech and Monoclonal Antibodies, the disposition of a single patent claim can have a major effect on the value of a biotechnology firm.[1] Discussions with entrepreneurs and venture capitalists suggest that in this industry, even a successful patent application with a narrower scope than originally envisioned can lead to reduced access to capital resources for new firms, or even to outright failure. Practitioner discussions of these issues have emphasized the relatively arbitrary nature in which patent scope has been determined by the U.S. Patent Office, with relatively broad claims being awarded to several inventions that many feel to be relatively incremental,[2] while some path-breaking research has been granted relatively limited claims [Biotechnology Research, 1991]. These concerns have been echoed as well in published discussions by members of the patent bar ["American Type," 1990; Goldstein, 1990; "Role," 1990; Winner, 1988].

But these practitioner concerns over patent scope have not figured prominently in the policy analyses concerning intellectual property rights in biotechnology. Instead, two other issues have dominated recent discussions. The first has been the extensive delays in awarding biotechnology patents. A series of congressional hearings and studies by the General Accounting Office have documented both the disproportionately long pendencies of biotechnology patent applications and the

inadequacy of efforts to date by the Patent Office to alleviate these conditions ("House Panel," 1988; "PTO Sets," 1988; USGAO, 1989, 1990].

A second focus of attention has been the definition of what constitutes "novelty" in patents, particularly in the context of the 1985 decision by the Circuit Court of Patent Appeals in a test case, *In re Durden*.[3] While it was in all probability an unintended consequence, the Durden decision has led to a considerable reluctance on the part of patent examiners to grant patents to inventions which apply existing biotechnologies to novel materials--e.g., which use existing processes to develop new products [Wegner, 1988, 1991]. Congressional efforts to repeal the Durden decision (the so-called Boucher bill) have been a second key area of policy interest concerning intellectual property and biotechnology ["Bills," 19911. For instance, in the recent report by the President's Council on Competitiveness, *Report on National Biotechnology Policy,* this was the sole recommendation concerning patent policy [President's Council, 1991].

The Sample

The foundation of the analysis was a proprietary database provided by Venture Economics. The consulting firm, which has monitored the venture capital industry since the mid-1970s, typically obtains its performance information from institutional investors who hold venture capital funds (limited partners). In all, the consulting firm tracked 287 U.S. biotechnology firms which had received at least one round of venture capital. For each firm, information was gathered about critical dates (such as date of formation, initial public offering and termination), as well as all named subsidiaries, joint ventures and spin-offs associated with the firm. Much of the information on firms was provided by Venture Economics, which collects the information through checks of state business registration files and direct contacts with the firms themselves; the rest through the use of a variety of published sources and databases [Lerner, 1991b describes the data collection process].

Information on patenting activity was also gathered, an admittedly imperfect measure of the technological contribution of each firm. One may well ask how closely patents track innovation in the

biotechnology industry. A recent set of analyses by Jaffe, Trajtenberg and others--building in turn on work by Griliches, Scherer and Narin-have demonstrated that patents can be a powerful measure of the innovative output of firms. This is particularly true when the count of patents awarded is augmented by the number of subsequent applications which cite the patent as an intellectual predecessor, a practice known as citation-weighting [Griliches, 1990; Henderson, *et al.,* 1990; Trajtenberg, 1990].

Citations provide one way in which patent examiners delimit the scope of a patent. Each patent application includes one or more claims, which the examiner reviews with an eye to modification and outright deletion. But the scope of the patent is further delineated by citations to previous patents added by the examiner, which indicate the prior art in the area of the new patent. The claim of the citation-weighted analyses is that those patents which receive many subsequent citations--i.e., those whose boundaries see considerable innovative activity-are more important than those which are not so cited, and that citation counts can provide a rough measure of importance. This relationship is especially likely to be true in biotechnology, growing as it does from a scientific base with a tradition of open communication: from its inception, and particularly after the U.S. Supreme Court's 1980 *Diamond v. Chakrabarry* decision, the industry has tended to rely heavily on patents as opposed to trade secrecy to protect discoveries [Bent, *et al.,* 1987; Kenney, 1986; USOTA, 1984]. This is in stark contrast to many high-technology industries, such as semiconductors, where for strategic and practical reasons firms have deemphasized this form of protection [McPherson, 1982]. Furthermore, both large and small U. S. firms have shown an intense desire to protect their intellectual property as quickly as possible, filing preemptive applications which are then split or "continued-in-part" in order to preserve application priority. Thus, all patents assigned to firms and their wholly-owned subsidiaries were tabulated, with joint ventures and spin-offs are counted to the extent that a firm had an interest in the venture. [The procedure is described in detail in Lerner, 1991b].

The Analysis

Two issues needed to be resolved before beginning the analysis: the definition of patent scope and determination of the unit of analysis. The best way to measure patent scope might thought to be through subjective assessments. With the help of one or more molecular biologists, the breadth of claims granted in

each patent could be assessed. The author's concern about such an analysis was that it would be inexorably shaped by the developments in biotechnology since 1984: rather than measuring which patents proved to be broad in view of the subsequent evolution of the discipline, the author wanted to examine the breadth of claims in view of the state of knowledge in 1984.

Instead, the author employed a proxy, the number of subclasses into which the patent was assigned at the time of the award. Patent examiners assigned each patent to one or more patent subclasses, using both the U.S. and International Patent Classification (IPC) schemes. The examiners have a strong incentive to carefully classify these patents, because they use these classifications to search the prior state-of-the-art before making patent awards. These classifications are updated to reflect the changing knowledge base, very frequently in the case of the U.S. scheme, every few years for the international system.

The author employed the highly-nested international scheme as a proxy for patent scope. The number of distinct international patent classes to which the firm was assigned was employed, using the third tier of detail: i.e., a patent assigned to classes C12M 1/12, C12N 1/14 and C12N 9/60 would be counted as falling into two distinct classes [WIPO, 1989]. (The first four categories of this classification scheme are nested, with each level of detail being a subset of the larger category. This is in contrast to the U.S. system, where subclass of 435/40 is a subset of 435/39, which is in turn a subclass of 435/34, but 435/41 is not [USDOC/PTO, 1991].)

The analysis focused on the firm level, examining the impact of varying patent scope on the relative success of new biotechnology firms. The author employed in his analysis all firms in the Venture Economics sample which were in business as independent, privately-held entities at the end of 1984. This date was selected because it was a relatively quiet period, after the surge of new firm creation and initial public offerings which characterized the years 1981-83, but before the lesser-but-similar boom of 1986-87. Furthermore, it was sufficiently long ago that virtually patent applications from then were already awarded. Consequently, truncation biases of the sort analyzed by Trajtenberg [1990] and discussed by the author elsewhere [1991b] were of little concern here, unlike samples from later years. In all, 121 firms in the sample met this criterion.

The first dependent variable employed was each firm's market value. Unfortunately, a value can

be assigned to a firm only in the cases where the company has made a public stock offering, been liquidated, or (in some cases) been acquired. In many, but not all, cases where private companies have been acquired, estimates of the size of the transactions could be obtained from analyst reports and the trade press, and then suitably corrected for inflation. But for many of the smaller acquisitions (particularly between private firms), as well as for the companies which remain in business but are still privately held, no value estimates were readily available. These firms were not included in this analysis.[4]

An alternative analysis employed a qualitative dependent variable. Several such choice variables might be suggested: for instance, whether the firm has survived to the present day or not. In actuality, however, survival is not unambiguously good. A venture capitalist may profit considerably more from the sale of a company than from a surviving company which struggles along with little success. The distribution of venture capital returns, however, is highly skewed. A small share of firms account for the bulk of these profits, and these outlying cases almost all involve companies which make public stock offerings [Khoylian, 1988; Sahlman and Stevenson, 1989]. Thus, the dependent variable in the second analysis indicated whether the firm reached the generally best outcome, a public stock offering .[5]

Thus, the specification--while not strongly grounded in a theoretical model--attempted to assess the importance of patent scope. For the going public analysis, a probit regression was employed,

IPO? = α +(Control Variables) β +(Scope Variable) γ.

In the other analysis, an ordinary least squares regression was run,

In(Value) = α +(Control Variables) β + (Scope Variable) γ,

with the logarithm of the appropriate control variables also employed.

The first set of independent variables related to the scope of the firm's patents. Both the average and maximum number of three-digit IPC subclasses in patents awarded by or in process at the end of 1984 were computed for each firm {ScopeAvg, ScopeMax}. These measures, as discussed above, were intended to serve as alternative proxies for the scope of each firm's patent awards, and were used in separate regressions.

Several control variables were used as well. These included type of firm--dummy variables were constructed for animal- and agricultural-related firms {AAR}, contract biotechnology research services {BRS}, human diagnostics {HD}, human therapeutics {HT} and industrial biotechnology {IB}-total

venture capital received through December 31, 1984 {VenCap}, and the age of the firm on this date {Age}, each of which might be expected to affect the probability of a firm making a initial public offering and its value. In addition, the author concerned lest he confuse the impact of patent scope with that of the firm's patent activity as a whole. Consequently, the author added two measures of patenting activity as control variables: a dummy variable measured if the firm had received or had in process any successful patent applications by this date, and the count of these awards {PatAny, PatCount}.

The author, concerned with the possibility that the measure of patent scope might be correlated with significant omitted variables, employed in supplemental regressions two additional sets of variables. The first set related to the background of the individuals who founded the company: might, for instance, broader patent scope be associated with research close to the frontiers of science emerging from university laboratories? For the many of the companies in the sample, information about the founders was available from the initial public offering prospecti and/or two surveys conducted by the North Carolina Biotechnology Center [survey methodology is described in Dibner, 1987]. Among the variables employed were dummies indicating whether founders had backgrounds in academia, other biotechnology start-ups, major corporations with related lines-of-business, venture capital or other financial services, and legal or consulting services {UnivBack, SUBack, CorpBack, VCBack, LawBack}; as well as if the firm was an arranged spin-off from another entity {SpinOff}.

A final set of variables examined--for all firms which had received one round of venture capital by the end of 1984--the presence or absence of key types of initial investor. These were identified through an earlier study by the author which examined the degree of underpricing and extent of underwriting fees in initial public offerings by biotechnology firms [Lerner, 1991a]. These reputation-shaping investors included venture capital funds specializing in biotechnology, funds affiliated with corporations with related lines-of-business, funds affiliated with financial institutions such as insurance companies and banks, venture capitalists in the same metropolitan region as the firm who might be able to provide particularly effective oversight, venture capitalists exclusively from regions other than California and the Northeast, especially old or large venture funds,[6] and individual investors or "angels" {BioVC, CorpVC, FinVC, MSAVC, RegionVC, OIdVC, LargeVC, Angel}. In addition, the

number of initial investors was employed {InvestNo}. Tables I and II summarize the dependent and independent variables.

TABLE I: DESCRIPTION OF VARIABLES IN PATENT SCOPE REGRESSIONS

Variable	Description
IPO?	Dummy set to 1 if firm made initial public offering through 1990.
Value	Value of firm in September 1990, if publicly traded, or at termination (inflation-adjusted using GNP deflator) (millions of dollars).
Age	Age of firm on December 31, 1984
AAR	Dummy set to 1 if firm focused on agricultural- or animal- related biotechnology
BRS	Dummy set to 1 if firm focused on biotechnology research services.
HD	Dummy set to 1 if firm focused on human diagnostics.
HT	Dummy set to 1 if firm focused on human therapeutics.
IB	Dummy set to 1 if firm focused on industrial biotechnology.
VenCap	Total venture capital ($ thousands) received through December 31, 1984.
PatAny	Dummy set to 1 if firm awarded or had in process any patents by December 31, 1984.
PatCount	Number of patents awarded to firm or in process by December 31, 1984.
ScopeMax	Maximum number of distinct international patent classes (at third level of detail) in patents awarded to firm or in process by December 31, 1984.
ScopeAvg	Average number of distinct international patent classes (at third level of detail) in patents awarded to firm or in process by December 31, 1984.
UnivBack	Dummy set to 1 if a firm founder had a background in academia.
CorpBack	Dummy set to 1 if a firm founder had a background in a corporation with a related line-of-business.
SUBack	Dummy set to 1 if a firm founder had a background in a new biotechnology firm.
VCBack	Dummy set to 1 if a firm founder had a background in venture capital or other financial services.
LawBack	Dummy set to 1 if a firm founder had a background in law or consulting.
Spinoff	Dummy set to 1 if the firm was spun off from an established entity.
BioVC	Dummy set to 1 if initial investors included a biotechnology venture fund.
CorpVC	Dummy set to 1 if initial investors included a venture fund of a related corporation.
OldVC	Dummy set to 1 if initial investors included a venture fund with 15 years' experience.
LargeVC	Dummy set to 1 if initial investors included a venture fund over $125 million ('88$'s)
MSAVC	Dummy set to 1 if initial investors included a venture fund with offices in same urban area as firm's headquarters.
InvestNo	Number of initial investors in firm.
FinVC	Dummy set to 1 if initial investors included a financial-affiliated venture fund.
RegionVC	Dummy set to 1 if initial investors included exclusively regional venture funds.
Angel	Dummy set to 1 if initial investors included an individual angel.

TABLE II: SUMMARY STATISTICS FOR PATENT SCOPE REGRESSIONS

Variable	Mean	Stan. Dev	Minimum	Maximum
IPO?	0.33	0.47	0	1
Value	50.87	98.03	0	508.91
Age	3.31	2.63	0.16	16.50
AAR	0.24	0.43	0	1
BRS	0.03	0.18	0	1
HD	0.21	0.41	0	1
HT	0.24	0.43	0	1
IB	0.12	0.33	0	1
VenCap	4398.7	6312.6	0	30154.2
PatAny	0.34	0.48	0	1
PatCount	0.91	1.84	0	10.5
ScopeMax	0.60	1.04	0	5
ScopeAvg	0.51	0.81	0	3
UnivBack	0.64	0.48	0	1
CorpBack	0.24	0.43	0	1
SUBack	0.29	0.46	0	1
VCBack	0.22	0.42	0	1
LawBack	0.22	0.42	0	1
Spinoff	0.03	0.18	0	1
BioVC	0.14	0.35	0	1
CorpVC	0.11	0.32	0	1
OldVC	0.28	0.45	0	1
LargeVC	0.22	0.42	0	1
MSAVC	0.28	0.45	0	1
InvestNo	2.64	2.28	0	16
FinVC	0.17	0.41	0	1
RegionVC	0.25	0.44	0	1
Angel	0.10	0.30	0	1

Tables III and IV present the results of the probit analysis of firms which did or did not make initial public offerings; Tables V and VI examine the firms' valuations.[7] Each table uses one of two scope measurements, either the maximum or the average patent scope awarded to the firm in this period. The author attempted alternative regressions, first using the scope and control variables alone; then adding the variables concerning the background of the founders and the reputation of the financial intermediaries together and separately. (Variables with insufficient observations were dropped from the regressions reported below. Furthermore, it was not possible to estimate the probit equation with the entire set of variables.)

While the results reported below cannot test the impact of patent scope on social welfare, they do suggest that this variable has a real economic impact. Whether average and maximal patent scope is employed, the variable proves to be consistently positive in sign and generally significant. In fact, it is

quite interesting to compare the impact of the proxy for patent scope with that of the number of patents awarded. For instance, in the basic regression of firm value (Table VI, column 1) a 10% increase in average patent scope leads to a 4 % climb in firm value, while a comparable increase in the number of patents awarded leads to a 3 % boost (with considerably less confidence that the effect is statistically different from zero).

Nor does the positive sign associated with patent scope appear to stem from the omission of other variables which significantly affect firm value and the probability of making an initial public offering. Fearful that the significance of patent scope might be driven by omitted variable bias, the author added the reputation and background variables. In these cases, there was no major shift in the significance of the patent scope variable, though there was some variation reflecting the changes in sample size and composition.

In addition to the consistent patterns associated with patent scope, several other patterns emerged from Tables III through VI:

- the positive impact on firm value and the decision to go public associated with the amount of venture capital funding, a result which is not surprising.
- the positive impact (in virtually all the regressions) of support from a corporate-affiliated venture capital fund, which may reflect the benefits of close corporate ties more generally.
- the positive impact on the decision to go public of the presence of a founder with a background in venture capital, but the insignificant impact of this factor on firm value.
- the negative impact on firm value and the decision to go public associated with having been supported entirely in the initial financing round by venture capitalists from other than the Northeast and California.

Many of the signs of the coefficients associated with other variables in these regressions are variable, reflecting the limited number of degrees of freedom and the changes in sample size. Under these circumstances, the strength and persistence of the positive impact of broader patent scope are all the more surprising.

TABLE III: PROBIT ANALYSIS OF PUBLIC OFFERING, USING MAXIMUM SCOPE

Dependent Variable: IPO?

	Basic Regression		+Background		+Reputation	
Variable	**Coeff.**	**t-stat.**	**Coeff.**	**t-stat.**	**Coeff.**	**t-stat.**
Age	**0.04**	**0.69**	**-0.40**	**0.93**	**-0.11**	**1.11**
AAR	**-0.08**	**0.17**	**1.43**	**0.79**	**0.22**	**0.39**
HD	**0.14**	**0.31**	**0.91**	**0.67**	**-0.28**	**0.46**
HT	**0.14**	**0.31**	**1.83**	**1.16**	**0.05**	**0.08**
IB	**0.18**	**0.35**	**4.06**	**1.81**	**0.46**	**0.65**
VenCap	**0.0001**	**2.24**	**0.0002**	**1.49**	**0.0001**	**2.66**
PatAny	**-1.28**	**1.87**	**-5.96**	**2.12**	**-1.00**	**1.30**
PatCount	**0.05**	**0.34**	**1.34**	**1.67**	**-0.14**	**0.86**
ScopeMax	**0.65**	**2.14**	**2.66**	**2.53**	**0.89**	**2.45**
UnivBack			**0.89**	**0.95**		
CorpBack			**1.79**	**1.62**		
SUBack			**1.89**	**1.72**		
VCBack			**3.99**	**2.65**		
SpinOff			**-3.02**	**1.35**		
BioVC					**-0.49**	**0.85**
CorpVC					**1.61**	**2.73**
OldVC					**-0.58**	**1.29**
LargeVC					**-0.47**	**1.03**
MSAVC					**-0.36**	**0.83**
InvestNo					**0.12**	**1.31**
FinVC					**0.68**	**1.38**
RegionVC					**-0.77**	**1.62**
Angel					**-0.99**	**1.47**
Constant	**-0.81**	**1.92**	**-3.93**	**2.23**	**-0.51**	**0.80**
# Observations	**103**		**45**		**87**	
Log Likelihood	**-59.03**		**-12.34**		**-41.09**	
X^2 -statistic	**17.56**		**36.60**		**34.24**	

TABLE IV: PROBIT ANALYSIS OF PUBLIC OFFERING, USING AVERAGE SCOPE

Dependent Variable: IPO?

	Basic Regression		+Background		+Reputation	
Variable	**Coeff.**	**t-stat.**	**Coeff.**	**t-stat.**	**Coeff.**	**t-stat.**
Age	**0.04**	**0.74**	**-0.18**	**0.63**	**-0.11**	**1.08**
AAR	**-0.04**	**0.08**	**1.18**	**0.79**	**0.23**	**0.41**
HD	**0.22**	**0.47**	**0.76**	**0.63**	**-0.16**	**0.27**
HT	**0.23**	**0.51**	**1.36**	**1.08**	**0.16**	**0.28**
IB	**0.26**	**0.51**	**2.87**	**1.68**	**0.57**	**0.82**
VenCap	**0.0001**	**2.27**	**0.0001**	**0.93**	**0.0001**	**2.72**
PatAny	**-1.34**	**1.84**	**-3.03**	**1.64**	**-1.04**	**1.24**
PatCount	**0.13**	**0.98**	**0.76**	**1.41**	**-0.01**	**0.05**
ScopeMax	**0.65**	**1.82**	**1.71**	**2.20**	**0.85**	**1.97**
UnivBack			**0.78**	**0.96**		
CorpBack			**1.39**	**1.62**		
SUBack			**1.03**	**1.24**		
VCBack			**2.93**	**2.89**		
SpinOff			**-1.79**	**0.99**		
BioVC					**-0.40**	**0.71**
CorpVC					**1.48**	**2.64**
OldVC					**-0.53**	**1.20**
LargeVC					**-0.57**	**1.26**
MSAVC					**-0.35**	**0.84**
InvestNo					**0.12**	**1.30**
FinVC					**0.67**	**1.39**
RegionVC					**-0.65**	**1.39**
Angel					**-0.85**	**1.30**
Constant	**-0.88**	**2.06**	**-3.03**	**2.21**	**-0.61**	**0.96**
# Observations	**103**		**45**		**87**	
Log Likelihood	**-59.89**		**-15.59**		**-42.56**	
X^2 -statistic	**15.86**		**30.12**		**31.31**	

TABLE V: OLS ANALYSIS OF FIRM VALUE, USING MAXIMUM SCOPE

Dependent Variable: *log (***Value)**

	Basic Regression		+Background		+Reputation		+Back. +Reput.	
Variable	**Coeff.**	**t-stat.**	**Coeff.**	**t-stat.**	**Coeff.**	**t-stat.**	**Coeff.**	**t-stat**
Age	**0.05**	**0.59**	**-0.03**	**0.17**	**0.25**	**1.32**	**0.28**	**0.96**

AAR	**0.61**	**0.89**	**-0.10**	**0.10**	**1.41**	**1.77**	**-1.97**	**1.23**
BRS	**1.81**	**1.22**	**-0.52**	**0.34**	**3.72**	**2.24**	**-1.44**	**0.58**
HD	**1.60**	**2.14**	**-0.44**	**0.46**	**2.76**	**3.27**	**-0.15**	**0.10**
HT	**0.63**	**0.92**	**0.13**	**0.13**	**1.19**	**1.56**	**-0.87**	**0.56**
IB	**1.30**	**1.57**	**-0.51**	**0.46**	**3.08**	**2.53**	**1.24**	**0.71**
*log(***VenCap)**	**0.26**	**3.86**	**0.18**	**2.11**	**0.45**	**3.99**	**-0.01**	**0.04**
PatAny	**0.22**	**0.26**	**-0.31**	**0.38**	**0.42**	**0.41**	**-1.83**	**1.27**
*log (***PatCount)**	**-0.04**	**0.06**	**-0.19**	**0.31**	**-0.62**	**0.84**	**-0.16**	**0.19**
ScopeMax	**0.43**	**1.30**	**0.38**	**1.30**	**0.40**	**1.26**	**0.71**	**2.00**
UnivBack			**0.15**	**0.29**			**-1.04**	**1.27**
CorpBack			**-0.77**	**1.55**			**-1.46**	**2.32**
SUBack			**0.69**	**1.24**			**-0.62**	**0.68**
VCBack			**-0.52**	**0.98**			**0.42**	**0.64**
LawBack			**-0.52**	**0.94**			**1.27**	**1.24**
SpinOff			**-0.42**	**0.32**				
BioVC					**-1.31**	**1.50**	**-0.46**	**0.36**
CorpVC					**1.14**	**1.79**	**1.91**	**2.09**
OldVC					**1.48**	**2.47**	**0.85**	**0.90**
LargeVC					**-0.59**	**1.00**	**1.13**	**1.41**
MSAVC					**0.17**	**0.31**	**-0.72**	**0.86**
InvestNo					**0.02**	**0.15**	**0.01**	**0.06**
FinVC					**-1.19**	**1.56**	**-2.92**	**2.33**
RegionVC					**-1.56**	**2.74**	**0.58**	**0.56**
Angel					**-0.39**	**0.54**	**1.51**	**1.75**
Constant	**-0.33**	**0.45**	**2.63**	**2.37**	**-2.79**	**2.27**	**4.92**	**2.03**
# Observations	**5**		**37**		**45**		**33**	
R^2	**0.54**		**0.62**		**0.71**		**0.77**	
$\acute{R}^2$	**0.43**		**0.32**		**0.49**		**0.06**	
F-statistic	**4.96**		**2.07**		**3.19**		**1.09**	

TABLE VI: OLS ANALYSIS OF FIRM VALUE, USING AVERAGE SCOPE

Dependent Variable: *log (***Value)**

	Basic Regression		**+Background**		**+Reputation**		**+Back. +Reput.**	
Variable	**Coeff.**	**t-stat.**	**Coeff.**	**t-stat.**	**Coeff.**	**t-stat.**	**Coeff.**	**t-stat**
Age	**0.05**	**0.65**	**-0.05**	**0.28**	**0.25**	**1.38**	**0.25**	**0.79**
AAR	**0.67**	**0.99**	**0.09**	**0.09**	**1.44**	**1.85**	**-1.62**	**0.96**
BRS	**1.86**	**1.27**	**-0.32**	**0.21**	**3.61**	**2.24**	**-1.05**	**0.39**
HD	**1.67**	**2.28**	**-0.22**	**0.23**	**2.79**	**3.42**	**0.33**	**0.21**
HT	**0.63**	**0.96**	**0.33**	**0.34**	**1.16**	**1.58**	**-0.46**	**0.29**
IB	**1.46**	**1.79**	**-0.17**	**0.16**	**3.42**	**2.88**	**2.18**	**1.09**
*log(***VenCap)**	**0.25**	**3.86**	**0.17**	**2.04**	**0.44**	**4.02**	**0.01**	**0.06**

PatAny	**-0.71**	**0.68**	**-0.71**	**0.68**	**-0.46**	**0.39**	**-2.46**	**1.34**
*log (***PatCount)**	**0.35**	**0.60**	**0.24**	**0.48**	**-0.32**	**0.48**	**0.44**	**0.52**
ScopeMax	**0.82**	**1.72**	**0.42**	**0.97**	**0.81**	**1.79**	**0.88**	**1.56**
UnivBack			**0.15**	**0.32**			**-0.97**	**1.10**
CorpBack			**-0.75**	**1.48**			**-1.30**	**1.93**
SUBack			**0.59**	**1.06**			**-0.73**	**0.73**
VCBack			**-0.53**	**0.98**			**0.37**	**0.52**
LawBack			**-0.50**	**0.88**			**1.23**	**1.11**
SpinOff			**-0.51**	**0.38**				
BioVC					**-1.34**	**1.59**	**-0.50**	**0.36**
CorpVC					**1.13**	**1.84**	**-1.75**	**1.80**
OldVC					**1.44**	**2.47**	**0.85**	**0.90**
LargeVC					**-0.70**	**1.22**	**0.80**	**0.95**
MSAVC					**0.22**	**0.42**	**-0.62**	**0.70**
InvestNo					**0.05**	**0.38**	**0.07**	**0.43**
FinVC					**-1.27**	**1.71**	**-3.08**	**2.23**
RegionVC					**-1.51**	**2.75**	**0.57**	**0.51**
Angel					**-0.50**	**0.72**	**1.32**	**1.43**
Constant	**-0.33**	**0.45**	**2.63**	**2.37**	**-2.79**	**2.27**	**4.92**	**2.03**
# Observations	**53**		**37**		**45**		**33**	
R^2	**0.55**		**0.61**		**0.72**		**0.73**	
$\acute{R}^2$	**0.45**		**0.30**		**0.52**		**-0.08**	
F-statistic	**5.22**		**1.96**		**3.47**		**0.90**	

Conclusion

As has been repeatedly cautioned in this discussion, the analysis could only examine whether patent scope affects the development and value of new biotechnology firms, not social welfare as a whole. But the key finding of this examination--that patent scope, measured in two alternative ways, does appear to have a significant impact on the eventual outcome of these firms-suggested some more speculative considerations.

One point emphasized in writings by venture capitalists with experience in the biotechnology industry [e.g., Johnston and Edwards, 1987], as well as the formal modeling by the author [Lerner, 1991c], is the considerable advantage provided by the flexibility and the lack of bureaucracy which typify new biotechnology firms. While their efforts may be ultimately independently duplicated by larger firms, or alternatively acquired or licensed by these larger entities, it is difficult to argue that new firms did not contribute in large part to the early U.S. lead in commercial biotechnology. To the author, the significant impact of patent scope on these firms suggested that the issue of the breadth of protection of intellectual property deserved more serious attention than it has received to date.

Footnotes

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[1]*Amgen, Inc. v. Chugai Pharmaceutical Co, Ltd., 706 F. Supp. 94, 110, 9 U.S.P.Q.2d (BNA) 1833, 1846 (D.* Mass. 1989), 927 F.2d 1200 (Fed. Cir. 1991); *Hybritech, Inc. v. Monoclonal Antibodies, Inc.,* 623 F. Supp. 1344, 1353, 227 U.S.P.Q. (BNA) 215, 221 (N.D. Cal. 1985), rev'd, 802 F.2d 1367, 231 U.S.P.Q. (BNA) 81 (Fed. Cir. 1986), cert. denied, 480 U.S. 947 (1987).

[2] An example is Genentech's patent on the expression of recombinant proteins (US Patent 4704362), which built on earlier patents by researchers at Stanford University and non-patented work at other universities [Merges and Nelson, 1990].

[3]763 F.2d 1406, 226 U.S.P.Q. 359 (Fed. Cir. 1985).

[4]It was unclear what, if any, selection biases were associated with omitting these firms from the sample.

[5]One possible objection, examined in a companion paper [Lerner, 1991a], is that firms may go public not because they are of high quality, but because they can signal they are of high quality. That analysis, using a "hidden" measure of patent activity, concludes that it is the highest quality firms which make public offerings.

[6]An "old" venture capital fund was defined as one with at least fifteen years of experience at the time of the initial investment; a "large" fund as one with at least $125 million dollars under management at the time in 1988 dollars, adjusted using "Griliches-Hall" index of the cost of performing research and development.

[7]The results are robust to changes in the specifications: when the original variables are employed in the valuation analysis, or the logarithms of the independent variables in the probit analysis, the t-statistics for the scope variables remain positive and at approximately the same level of significance.

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