NBER WORKING PAPER SERIES

PROTECTING THEIR INTELLECTUAL ASSETS: APPROPRIABILITY CONDITIONS AND WHY U.S. MANUFACTURING FIRMS PATENT (OR NOT)

Wesley M. Cohen
Richard R. Nelson
John P. Walsh

Working Paper 7552
http://www.nber.org/papers/w7552

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
February 2000

We wish to thank the following for helpful comments and suggestions: Ashish Arora, Anthony Arundel, John Baldwin, Marco Ceccagnoli, Akira Goto, Shane Greenstein, Dominique Guellec, Bronwyn Hall, Isabelle Kabla, Steven Klepper, Jean Lanjouw, Josh Lerner, Dan Levinthal, Mark Meyers, Ariel Pakes, Cecil Quillen, Mike Scherer, Manuel Trajtenberg, Sidney Winter and participants in the OECD Conference on New Indicators for the Knowledge-Based Economy (Paris) and the International Conference on the Economic and Econometrics of Innovation (Strasbourg). We also wish to acknowledge the influence of the proceedings of the April, 1998 Stanford Conference on Intellectual Property. We also thank Marco Ceccagnoli, Scott Jaspan and Jeff Vitek for research assistance. Finally, we gratefully acknowledge research support from the Alfred P. Sloan Foundation and the Center for Global Partnership. The views expressed herein are those of the authors and not necessarily those of the National Bureau of Economic Research.

Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not)
Wesley M. Cohen, Richard R. Nelson and John P. Walsh
NBER Working Paper No. 7552
February 2000

ABSTRACT

Based on a survey questionnaire administered to 1478 R&D labs in the U.S. manufacturing sector in 1994, we find that firms typically protect the profits due to invention with a range of mechanisms, including patents, secrecy, lead time advantages and the use of complementary marketing and manufacturing capabilities. Of these mechanisms, however, patents tend to be the least emphasized by firms in the majority of manufacturing industries, and secrecy and lead time tend to be emphasized most heavily. A comparison of our results with the earlier survey findings of Levin et al. [1987] suggest that patents may be relied upon somewhat more heavily by larger firms now than in the early 1980s. For the protection of product innovations, secrecy now appears to be much more heavily employed across most industries than previously. Our results on the motives to patent indicate that firms patent for reasons that often extend beyond directly profiting from a patented innovation through either its commercialization or licensing. In addition to the prevention of copying, the most prominent motives for patenting include the prevention of rivals from patenting related inventions (i.e., "patent blocking"), the use of patents in negotiations and the prevention of suits. We find that firms commonly patent for different reasons in "discrete" product industries, such as chemicals, versus "complex" product industries, such as telecommunications equipment or semiconductors. In the former, firms appear to use their patents commonly to block the development of substitutes by rivals, and in the latter, firms are much more likely to use patents to force rivals into negotiations.

Wesley M. Cohen
Professor of Economics and Social Science
Department of Social and Decision Sciences
Carnegie Mellon University
Pittsburgh, PA. 15213
and NBER
wc02@andrew.cmu.edu

Richard R. Nelson
George Blumenthal Professor
International and Public Affairs,
Business and Law
1403 International Affairs
Columbia University
New York, New York 10027
rrn2@columbia.edu

John Walsh
Professor of Sociology
Department of Sociology
University of Illinois at Chicago
Chicago, Illinois 60607
jwalsh@uic.edu

1. Introduction

Industrial R&D is widely seen as a key driver of productivity and economic growth. In 1996, U.S. firms spent almost 120 billion dollars on R&D, in large part because they expected to appropriate a substantial part of the return. Many believe that patent rights are essential to the protection of this return to invention and are consequently a key inducement to R&D.

This belief in the importance of patents and intellectual property protection has underpinned a two-decade trend towards a strengthening of patent protection in the U.S. In 1982, the Court of Appeals for the Federal Circuit was established to make patent protection more uniform and indirectly strengthen it. Since then, patent rates, plaintiff success rates in infringement suits and the number of infringement suits filed have all increased substantially (Kortum and Lerner [1999], Lanjouw and Lerner [1997], Merz and Pace [1994], Administrative Office of the U.S. Courts [1997, Table C-2A]). Since the early 1980's, we have also witnessed an expansion of what can be patented. Diamond vs. Chakrabarty established the patentability of new life forms and the State Street court decision of 1998 has extended patent coverage broadly to business applications of software and financial service products. Since the Bayh-Dole Act of 1980 and subsequent legislation, we have also witnessed an expansion of who can patent, with an extension of eligibility to those conducting research with public funds, including universities and government labs.[1] A similar strengthening and broadening in patent is also underway in Japan and Europe.

Curiously enough, these policy changes have been made despite a forty year legacy of empirical findings in economics that call into question whether patent protection—no less stronger patent protection--advances innovation in a substantial way in most industries. The work of Scherer et al. [1959], Mansfield [1986], Mansfield et al. [1981], and Levin et al. [1987] suggest that patent protection is important in only a few industries, most notably pharmaceuticals.[2] Mansfield's [1986] survey research study sharpened the issue by finding that the absence of patent protection would have had little or no impact on the innovative efforts of a majority of firms in most industries. Again, pharmaceuticals was a clear exception.

If, however, patents were not effective in protecting the returns to innovation in most industries, how did firms profit from their innovations? Scherer et al. [1959] and the subsequent survey research study conducted by Levin, Klevorick, Nelson and Winter [1987] (henceforth referred to as the "Yale" survey) addressed this question. Levin et al.

---

[1] Since waivers had been provided permitting the patenting of publicly supported research before Bayh-Dole, this was not as much of an extension of who can patent as it appeared.

[2] Taylor and Silberston [1973] obtained similar results for the United Kingdom.

[1987] explicitly inquired about the mechanisms in addition to patents that firms could use to appropriate returns from their innovations. These included the exploitation of lead time, moving rapidly down the learning curve, the use of complementary sales and service capabilities and secrecy. The Yale Survey found differences across industries and between product and process innovations in the effectiveness of the appropriability mechanisms employed. Also, often more than one of these mechanisms were judged effective. In most industries, including the most R&D intensive industries (again except drugs), firms did not report patents as one of the important ways in which they profited from their innovations, but reported reliance chiefly upon other mechanisms.

This paper presents results on the nature and strength of appropriability conditions from the Carnegie Mellon Survey (CMS) on Industrial R&D in the U.S. manufacturing sector administered in 1994. The portion of the Carnegie Mellon questionnaire concerned with appropriability conditions builds on the original Yale survey, and attempts to improve upon it with respect to question wording, definition of response scales, and sampling strategy. Aside from reaping the returns from these improvements, there are, however, other substantive reasons for walking over the terrain explored in the Yale survey and related work. First, we are concerned with whether appropriability conditions may have changed over time. Despite a suggestion in the literature that appropriability conditions are stable, enduring drivers of technical advance (cf. Cohen and Levin [1989]), appropriability conditions in the United States may have changed since the original Yale survey with the 1982 creation of the Court of Appeals for the Federal Circuit and the more aggressive enforcement of patent rights noted above. We will compare our findings with the earlier Yale survey to see if these changes in the legal environment have been associated with changes in the reported effectiveness of patents, as well as whether the reported effectiveness of the other appropriability mechanisms have changed. To prefigure our findings, we find that although patents may have increased in importance among large firms, they are still not one of the major mechanisms in most industries when the views of all firms are considered. We also find the importance of secrecy to have increased dramatically since the Yale survey.

The Yale study did not ask why firms apparently patented their inventions even though patents were not effective in protecting those inventions.[3] Thus, while resolving one puzzle, the Yale survey posed another. The question of why firms patent is, however, more than simply an empirical puzzle; it speaks to whether firms use patents in ways that are consistent with the ultimate purpose of patent law, namely to promote technical advance, or, as stated in the U.S. Constitution, "to promote the progress of science and useful arts" (U.S. Constitution, Art. 1, Sectn. 8).[4] In this paper, we explore

---

[3] For example, despite the relative inefficacy of patents outside the chemical industry, Mansfield [1986] found that all twelve of his sample industries patented at least half of their patentable inventions during the 1981-1983 period.

[4] Patents are supposed to do this in two ways. First, by excluding others from exploiting an idea, patents are supposed to confer a legal monopoly over the use of the idea, and thereby generate ex post rents, the expectation of which provide an incentive to invent, and, as some claim, an

why firms patent despite reporting patents to be relatively ineffective (for most industries) in protecting returns to innovation. In brief, we find that firms can profit from patents in ways other than protecting the profits that may directly accrue to the commercialization or sale (i.e., licensing) of a patented innovation. Other reasons for patenting—found to vary by industry--include blocking rivals from patenting related inventions, protection against infringement suits, and using patents in negotiations over technology rights.

In Section 2, we briefly discuss our method of data collection and describe the dataset. Section 3 discusses the effectiveness of different appropriability mechanisms and how that effectiveness has changed over time. Section 4 presents our findings on why firms do and do not patent. Section 5 discusses the implications of our findings.

2. Data and Method

The data come from a survey of R&D managers administered in 1994. The population sampled are all the R&D labs or units located in the U.S. conducting R&D in manufacturing industries as part of a manufacturing firm. The sample was randomly drawn from the eligible labs listed in the Directory of American Research and Technology or belonging to firms listed in Standard and Poor's COMPUSTAT, stratified by 3-digit SIC industry.[5] In our survey, we asked R&D unit or lab managers to answer questions with reference to the "focus industry" of their R&D lab or unit, defined as the principal industry for which the unit was conducting its R&D. We sampled 3240 labs,[6] and received 1478 responses, yielding an unadjusted response rate of 46% and an adjusted response rate of 54%.[7] Our survey data are supplemented with published data on firm sales and employees from COMPUSTAT, Dun and Bradstreet, Moody's, Ward's and similar sources.

---

incentive to commercialize the patented invention as well (Scherer [1980]). Second, patents are also supposed to contribute to the inventive efforts of others by publicly disclosing the details of the protected invention.

[5] We also oversampled Fortune 500 firms.

[6] For each case, we verified the contact information by telephone before mailing the survey. Data were collected from May to December, 1994. We mailed a questionnaire to the contact person at each lab with a cover letter describing the purpose of the research and ensuring confidentiality. Follow-ups were conducted following Dillman's method (Dillman [1978]).

[7] A nonrespondent survey allowed us to determine what percent of nonrespondents were not in our target population. The results showed that 28% of nonrespondents were ineligible for the survey because they either did no manufacturing or did no R&D. Excluding these from our denominator, as well as respondents who should not have been sampled, yields an adjusted response rate of 54% of eligible respondents.

To inform our interpretation of some of our findings, we also supplemented our survey results with interviews of R&D managers and intellectual property officers. We conducted 18 interviews at nine U.S. firms. The interviews typically lasted about one hour, and often included more than one respondent.

For the analysis in this paper, we restricted our sample to firms with at least $5,000,000 in sales or business units of at least 20 people, yielding a sample of 1165 cases. This sample includes firms ranging from less than 25 to over 100,000 employees, with annual sales ranging from less than $1,000,000 to over $60 billion. The median firm has 3309 employees and annual sales of $555 million. The average firm has 22,027 employees and sales of $4.5 billion. The business units range from fewer than 10 employees to over 50,000, with annual sales from zero to over $30 billion. The median business unit has 450 employees and $120 million in sales. The average business unit has 4401 employees and sales of $1.72 billion. The average R&D intensity (R&D dollars divided by total sales) for the firms is 3.35%.

For the purpose of presentation in the tables below, our observations are grouped into 34 ISIC groups which are aggregated at the two or three digit level. For some analyses, we disaggregate our data more finely into 66 industries, defined roughly at the three digit SIC level.[8]

3. Appropriability Mechanisms: Use and Change over Time

In this section, we review our results on the effectiveness of different mechanisms through which firms appropriate the returns to their product and process innovations, including patents, secrecy, lead time, complementary sales and service and complementary manufacturing facilities and know-how.[9]

To measure the effectiveness of appropriability mechanisms, we asked respondents to report the percentage of their product and process innovations for which each appropriability mechanism had been effective in protecting the "firm's competitive advantage from those innovations" during the prior three years. The five response categories were: 1.) less than 10%; 2.) 10% through 40%; 3.) 41% through 60%; 4.) 61% through 90%; and 5.) greater than 90%. This response scale reflects how central a mechanism is to firms' strategies of appropriating rents to their innovations in the sense

[8] Although the level of industry aggregation for the sample is defined as finely as the four digit SIC code level for almost all the observations, we rarely conduct analyses below the three-digit level because we are less confident in the accuracy of our industry assignments below that level.

[9] In addition to this list of mechanisms, our questionnaire also included complexity. Although a feature of products or processes that can indeed affect appropriability, complexity is not, however, something that managers can particularly choose to exploit. In this regard, it differs from the other mechanisms considered and is not featured.

that it reflects both the frequency with which a mechanism is employed and the effectiveness of that mechanism given its use.[10] This response scale offers two advantages over the exclusively subjective measures of mechanism "effectiveness" or "importance" employed in prior studies. It allows us to infer whether appropriability mechanisms are used together, and makes responses more interpretable than exclusively subjective scales.[11] One limitation of this scale, however, is that it may not index the return to using any particular appropriability mechanism due to the skewness in the distribution of the value of innovations. For example, patents or secrecy may effectively protect only ten percent of a firm's innovations, but that ten percent may account for 90% of the value of all of its innovations.

3.1 Relationships among Appropriability Mechanisms

Tables 1 and 2, respectively, provide the mean percentage of product and process innovations (computed on the basis of response category midpoints), by industry, for which each appropriability mechanism was judged to be effective. Reading across the rows indicates that firms in most industries rely upon more than one mechanism to protect their innovations. Table 1 shows that some R&D intensive industries, such as drugs and medical equipment, report relatively high effectiveness scores for every mechanism (except for "other legal"). Most industries tend to report high effectiveness scores for two or more mechanisms. For example, semiconductors, machine tools and aerospace emphasize secrecy and lead time. Autoparts rely heavily on secrecy, lead time and complementary manufacturing capabilities. A small handful of industries report a relatively high score for only one mechanism. For example, the communications equipment computer, steel, and car and truck industries indicate the key mechanism to be lead time. With regard to the protection of new processes, Table 2 reveals a different pattern. Secrecy is commonly the dominant mechanism, as in the chemicals industries, semiconductors and others. Finally, some industries such as electrical equipment score low on all mechansims, suggesting that appropriability is low overall.

The cross-column sums of 200% to 300% in Tables 1 and 2 also suggest that firms at least occasionally rely upon more than one mechanism to protect the same innovation. There are several circumstances in which this may occur. For example, appropriability mechanisms may be linked causally, as when a complementary marketing

[10] Regarding secrecy, most firms typically want to keep most inventions secret at some point in their development. We assume, however, that when asked to estimate the percentage of innovations for which secrecy effectively protects returns, firms would only consider those innovations for which secrecy played a significant role. Responses from the Japanese version of the survey, as well as those from the earlierYale survey support this judgment.

[11] The scale still, however, requires a subjective judgment of when a mechanism is "effective" in protecting an innovation.

capability or a patent confers a lead time advantage.[12] Different mechanisms may also be relied upon at different stages in a given innovation process. Firms may initially rely upon secrecy prior to the commercialization of a new product, but subsequently try to retain competitive advantage through the use of a patent and/or aggressive marketing and lead time. Different mechanisms may even be employed at the same time for a given innovation when an innovation is comprised of separately protectable components or features. Arora [1997], for example, describes how chemical firms will sometimes protect an innovation by applying for one or more patents on different elements of an innovation, while keeping other elements secret.

To explore the ways that appropriability mechanisms tend to be employed together, we conducted a series of factor analyses on our appropriability mechanism effectiveness scores at both the industry and respondent levels.[13] For these analyses, we employ a more disaggregate industry definition than that reflected in Table 1, yielding 66 industries with four or more observations. The factor analysis should suggest whether there are underlying features of industries or of the mechanisms themselves that yield systematic links across selected mechanisms. These features may be associated with the technologies of the manufacturing process or product, the nature of competitive interaction, or differences in the way the policy environment, particularly intellectual property law, may impact different industries.

Presented in Table 3, the results of the analysis suggest three factors.[14] Explaining the preponderance of the variance in the correlation matrix, the first factor is largely comprised of complementary capabilities, including sales and service and manufacturing capabilities, and lead time.[15] The second factor contains the two patent

---

[12] Although we have considered how appropriability mechanisms may be used together, it is also possible that some mechanisms may be employed instead of one another. If one assumes, for example, that a patent fully discloses the key information describing an invention, secrecy is no longer a viable mechanism for appropriation once such a patent is issued (although its use may have been viable up until issuance).

[13] We analyzed the responses to the questions regarding the protection of product and process innovations together since these scores were often highly correlated with one another. These correlations range from .62 (between complementary manufacturing capabilities and know-how in protecting new processes and products) to .74 (between complementary sales and service capabilities in protecting new processes and products).

[14] The results presented in Table 3 are computed using a minimum eigenvalue of 1.0 to determine the number of factors and orthogonal (varimax) rotation to determine the loadings. The first factor, with an eigenvalue of 3.56, explains 30% of the variance in the correlation matrix. The second has an eigenvalue of 1.90, explaining 16% of the variance and the third has an eigenvalue of 1.36, explaining 11% of the variance.

[15] The critical role of firms' sales and service and manufacturing capabilities, and the complementarity of these mechanisms with lead time confirm Teece's [1986] argument that the

measures (product and process) as well as other legal mechanisms (which also cross-load with the first factor). The third factor is process and product secrecy.

Although changing the level of aggregation at which industries are defined alters the results of the factor analysis presented in Table 3 somewhat, the pattern in which there is one factor dominated by complementary capabilities and another distinct factor associated with patent protection is robust and consistent with the earlier findings of Levin et al. [1987]. This pattern also holds when the factor analysis is conducted at the respondent as well as the industry level.[16] The most fragile result of the factor analysis is that secrecy does not always constitute its own factor since it occasionally loads with patents or complementary capabilities. [17]

Thus, our findings suggest that firms commonly employ a variety of mechanisms to protect their inventions. The factor analysis also suggests that some of these, notably complementary capabilities and lead time, are so closely tied to one another that they may be collectively viewed as defining a distinct appropriability "strategy." Moreover, given the close link between complementary capabilities and lead time, what we actually have is not five or six distinct mechanisms, but three different "strategies," which include the exploitation of complementary capabilities and lead time, legal mechanisms (notably patents) and secrecy. Also, the close links between the mechanisms used for product and process innovations in an industry suggest that appropriability depends on complementarities between product and process protection for all the mechanisms.[18]

---

private value of an innovation will often depend heavily upon the capabilities of the firm which exploits it.

[16] At the individual level, the first factor (explaining 28% of the variance) consists of complementary sales/service and complementary manufacturing capabilities, other legal mechanisms, and lead time, for product and process (with process lead time cross-loading with secrecy in the second factor). The second factor (explaining 15%) includes process and product secrecy, as well as a cross-loading of process lead time. The last factor (12%) is process and product patents.

[17] One other somewhat fragile result is that, in some of the factor analyses, lead time also partially loads on patenting, suggesting that one role of patents may simply be to slow down competitors, rather than preclude them from imitating altogether.

[18] A caution should be added to our interpretation of our factor analysis. Our finding that firms use a range of appropriability mechanisms does not imply that they are choosing from a menu of possible mechanisms. Rather, the effectiveness (and use) of a particular mechanism is at least partly dictated by the technology itself, the complexity of the product, the nature of the innovation (e.g., secrecy being well-suited for process innovation), the nature of the production process (e.g., complex, capital intensive continuous production may rely heavily on manufacturing capabilities), the nature and intensity of competition within an industry (e.g., the relative importance of price versus being cutting edge), and so on. Future research might

Although suggesting that the effectiveness of these three strategies are independent of one another, the factor analysis does not imply that the strategies are not used together on occasion (i.e. if used together, one might think of their cumulative effect as being additive). Indeed, as Tables 1 and 2 show, they are. For example, no industry relies exclusively on patents. Even pharmaceutical firms emphasize complementary capabilities and being first to market in addition to patents. Also, the fact that patents tend to be used with some other mechanism may partially explain why, although judged to be relatively ineffective, patents are applied for as often as they are; they may simply add sufficient value at the margin when used with other mechanisms.

3.2. Relative Effectiveness of Individual Appropriability Mechanisms

In this subsection, we compare the "effectiveness" of the different appropriability mechanisms on the basis of the percentages of innovations reported to be effectively protected by each. In light of our finding that industries typically employ numerous mechanisms, and often for the same innovation, a finding that one mechanism is effective for a greater percentage of innovations on average within an industry is best interpreted as suggesting that that mechanism is more central to the appropriability strategies for firms overall in that industry, not that other mechanisms are unimportant or do not yield substantial returns.

Summarizing in one bar chart the effectiveness scores for the appropriability mechanisms for product innovations for the aggregate sample, Figure 1 shows that patents are unambiguously the least central of the major appropriability mechanisms overall (significantly below complementary sales/service, $t=6.09$, $p<.0001$), reflecting their subordinate role in the preponderance of industries. Table 1, however, indicates that a handful of industries are distinguished by greater reported patent effectiveness. In medical equipment and drugs, patents are reported to be effective for more than 50% of product innovations, and in special purpose machinery, computers and autoparts, the effectiveness scores range from 40% to 50% of product innovations.[19] Table 1 also indicates, however, that in no industry are patents identified as the most effective appropriability mechanism.

---

fruitfully examine factors that can explain industry and firm differences in appropriability strategies.

[19] In this paper, when reporting industry-level scores and comparisons, we will typically report industries as being "high" or "low" relative to other industries based on some threshold (e.g., more than 50% of innovations, or being above the mean). There is, however, significant intraindustry variance in these scores and it is often not possible to reject the hypothesis that a given industry's score is equal to the next highest scoring industry. The implications of the intraindustry variance of these scores for our ability to precisely rank the more R&D intensive industries in our sample is discussed in detail in Cohen and Walsh [1998].

In our aggregate results displayed in Figure 1, secrecy and lead time are ranked comparably overall as the two most effective appropriability mechanisms for product innovations, with scores at just over 50% for each.[20] These summary evaluations reflect the prominent role of each of the mechanisms across a wide number of industries. Table 1 indicates that secrecy is the top ranked mechanism in 17 industries and lead time is top ranked in 13 industries.[21] At the industry level, we typically observe at least one of the two complementary capabilities (sales and service or manufacturing) ranked close to the top-ranked mechanism.

As presented in Figure 2, the aggregate results for process innovations differ somewhat from those for product innovations. Secrecy is now clearly the most effective mechanisms in aggregate (significantly above complementary manufacturing, $t=6.21$, $p<.0001$), although it is often closely followed in some industries by the use of complementary manufacturing capabilities, the second ranked appropriability mechanism for protecting process innovations.[22] The relatively greater emphasis on secrecy for protecting new processes, consistent with Levin et al.'s [1987] findings, is unsurprising because process innovations are less subject to public scrutiny and thus can be kept secret more readily.[23] Patents are reported to be less effective for process than for product innovations (the product-process difference is significant, $t=15.03$, $p<.0001$), which is also unsurprising since patent infringements are more difficult to detect for process than product innovation given that the former are less public.[24]

---

[20] Even with our large N, we cannot reject the hypothesis that secrecy and lead time are equal ($t=1.55$, $p>.10$). Both lead time and secrecy are significantly greater than complementary manufacturing capabilities ($t=6.84$ and $t=4.52$, respectively, both $p<.0001$).

[21] Secrecy is the most effective mechanism in food, textiles, paper, petroleum, all the chemical industries, rubber and plastics, mineral products, metals, machine tools, electrical equipment, motors and generators, semiconductors, and search and navigation instruments. Lead time appears to play the most important role of all the mechanisms in steel, metal products, general purpose machines, special purpose machines, computers, communications equipment, TV/radio, medical equipment, precision instruments, autoparts, cars and trucks and aerospace.

[22] Complementary manufacturing dominates in a number of industries such as printing/publishing, steel, metal products, general purpose machinery, electronic components, medical equipment, and car/truck. In the aggregate it is significantly above lead time ($t=4.41$, $p<.0001$). Lead time, in turn, is ranked third, significantly above complementary sales and service ($t=8.52$, $p<.0001$).

[23] The absolute score for secrecy does not change between product and process innovations. However, for process innovations, it is significantly higher than all other mechanisms, while for product innovations, secrecy was tied with lead time.

[24] Illustrating this point, one chemical company researcher stated: "If it's [the invention's] a process, and if it's difficult to police, we'll take a second look before patenting."

In light of our finding that patents are relatively ineffective in protecting not only process innovation but product as well, we need to be careful about the meaning of patent "effectiveness." Recall that our questionnaire characterizes effectiveness in terms of the degree to which respondents believe that patents protect the firm's competitive advantage due to the patented inventions. Our initial piloting of the questionnaire suggests that respondents interpreted the notion of competive advantage due to the patented innovation as referring to returns realized via either the commercialization or licensing of the patented inventions, not whether patents generate profit more generally in other less direct or conventional ways.[25]

3.3. Changes in the Importance of Patents and Other Appropriability Mechanisms

An initial—and superficial—comparison of the full sample CMS results with those of Levin et al. [1987] suggest that the relative effectiveness of patents has declined. While patents are the last ranked mechanism for protecting process innovations in both surveys, they were ranked last in the protection of product innovations in the CMS from having been ranked ahead of secrecy in the earlier Yale survey. This continued low relative standing of patents is surprising in light of the recent pro-patent changes in the courts and in the adjudication of infringement suits noted above. The availability of the data from the earlier Yale survey, which was administered in 1983—felicitously timed with the patent court reforms of the early 1980s—provides the basis for a more careful, though still limited, intertemporal comparison of effectiveness of patents, as well as that of other appropriability mechanisms.

To compare the CMS and Yale survey, we need to account for differences in response scales and in the firms and industries sampled. To accommodate differences in response scales as well as possible, we compare the relative effectiveness rankings of the different mechanisms rather than absolute scores.[26] Regarding the firm samples, while

[25] In follow-on interviews to our survey, Hall and Ham [1999] also found that semiconductor firms narrowly interpreted our survey question regarding patent effectiveness to mean whether patents protected the profits due to the commercialization or licensing of the patented inventions, not whether patents were profitable in some other general way.

[26] The Yale survey employed a seven-point Likert scale providing subjective measures of the effectiveness of each appropriability mechanism in "capturing and protecting the competitive advantages of new or improved..." products or production processes. In contrast, the Carnegie Mellon survey asked respondents to estimate, for the prior three years, the percentage of innovations for which they considered each mechanism to be effective in protecting the firm's "competitive advantage from those innovations." Some of the mechanisms considered also differed somewhat between the two surveys. The Yale survey did not include product or process complexity, "other legal mechanisms" or complementary manufacturing capabilities as possible mechanisms. The Yale survey also included mechanisms that were not included in the Carnegie Mellon Survey, notably "moving quickly down the learning curve," and "patents to

the Yale survey sampled only publicly traded manufacturing firms which tend to be large relative to the population of all firms, the CMS sampled from a much broader firm size distribution in the manufacturing sector. To probe the sensitivity of our findings to the different firm size distributions, we correlated the CMS effectiveness scores for all appropriability mechanisms with firm and business unit size (controlling for industry effects). The only statistically significant correlation coefficients greater than .11 were those between the effectiveness of product patents and, respectively, the logs of firm size ($r=.14$, $p<.01$) and business unit size ($r=.22$, $p<.0001$), suggesting that the comparative findings for patent effectiveness may be affected by differences in the underlying firm size distributions. Accordingly, to make our sample more comparable to that of the Yale survey, we dropped from the CMS sample all firms with sales of less than half a billion dollars, and then recomputed the appropriability effectiveness scores. To control for differences in the sampled industries, we also redefined the CMS industries to conform to the industry definitions originally used in the Yale survey. We then identified 33 identically defined industries with at least four observations in each sample (using the truncated large firm sample from the CMS).[27] We then compare both the aggregate results between the two surveys, as well as the results for the 33 "comparison" industries. Tables 4 and 5 give the industry-level results for the 33 industries using the Yale definitions and the large-firm CMS sample.

Making the firm size distributions of the two samples more comparable modestly revises our impression that the relative effectiveness of patents has not changed or may have even declined. We now observe an increase in reported patent effectiveness between the mid 1980s and 1990s, at least in some industries. The aggregate results for the truncated, large-firm CMS sample presented in Figures 3 and 4 show the overall mean effectiveness score for product and process patents to be almost indistinguishable from the score for complementary sales/service ($t=0.17$ and $t=0.15$, respectively, $p>.85$) and close to that of complementary manufacturing for product patents as well ($t=1.07$, $p>.25$). However, the top mechanisms (secrecy and lead time for product, secrecy and manufacturing capabilities for process) continue to garner substantially higher scores (the comparisons are all significant at least at $p<.001$). We also find that, among large firms, patents have the highest effectiveness scores in a number of industries, including drugs, toilet preparations, gum and wood chemicals, pipes/valves, oil field machinery, switchgear, and autoparts. In addition, (while not the top mechanism) patents have average scores of at least 50% in organic chemicals, fibers, turbines/generators, motors/industrial controls, and medical equipment. Another comparison between the two surveys is provided by Tables 4 and 5 which present the appropriability mechanism rankings across the two surveys for the 33 identically defined industries. In the 1983 Yale survey, product patents were ranked first or second in seven industries. In the CMS, they

---

secure royalty income." Thus, we should be cautious when comparing results across the two surveys.

[27] By imposing a cutoff of four observations, we lose a good number of the 128 industries represented in the Yale survey due to its smaller sample size.

were ranked first or second twelve times. With regard to the protection of process innovation, Tables 4 and 5 show no appreciable change. Patents were ranked first or second in six industries in both surveys.

Thus, although first mover advantages and complementary sales and service capabilities ranked well ahead of patents in the Yale survey, and secrecy and first mover advantages well ahead of patents in the CMS, our results suggest that between 1983 and 1994 patents may have come to occupy a more central role in large firms' efforts to protect their product innovations in a growing number of industries. While patents are still not the dominant mechanism in most industries for protecting product innovations, it now appears that they can be counted among the major mechanisms of appropriation in a more sizeable minority of industries.

The sharpest difference between the findings of the two surveys--and one which is robust to differences in the firm size distributions of the two samples--concerns the role of secrecy in protecting product innovations. Between the Yale and Carnegie Mellon surveys, secrecy vaulted from being judged the least effective major mechanism to being judged the most, along with lead time. Tables 4 and 5 show that for the 33 comparison industries, secrecy never ranked either first or second in the Yale survey for the protection of product innovations. In contrast, in our survey, secrecy ranks first or second in 24 of the 33 industries, ahead of even lead time which ranked first or second in 18 of the 33 industries. For the protection of process innovations, secrecy is also ranked higher in the Carnegie Mellon Survey than in the earlier Yale survey. In the Yale survey, secrecy ranked first or second for protecting process innovations in 12 of the 33 industries, while in the CMS, it is ranked first or second in 31 industries, far ahead of any other mechanism.

We do not know what is driving the apparent growth in the importance of secrecy as an appropriability mechanism, nor do we possess data on changes over time in the ways in which secrecy policies may be manifest (e.g., nondisclosure agreements, strictures on publication, noncompete clauses in employment contracts, etc.). Additional corroborating evidence suggests, however, that the result is not an artifact of differences between the Yale and Carnegie Mellon surveys' response scales and question wording and order. First, the result is consistent with another comparative finding between the two surveys (discussed below), namely that concern over information disclosure has become more prominent as a reason not to patent since the 1983 Yale survey. Second, a 1995 National Science Foundation pilot survey of 236 firms inquiring about the importance of patents, design registration, secrecy, complexity and lead time, and employing a subjective Likert response scale resembling that of the original Yale questionnaire, found secrecy to be ranked just behind lead time, and much more important than patents in protecting the returns to product innovation. Although limited in industry coverage, these results were close to what we found, and differed from the original Yale results in which patents clearly dominated secrecy.[28] Finally, Lerner's

---

[28] Regarding a possible effect of question wording and order, an identical set of questions to those employed in the CMS were included in a questionnaire administered in Japan at

[1994] results are also consistent with our findings when he finds, for a sample of 530 firms, trade secret disputes to be commonplace, representing 43% of the intellectual property litigation in his sample.

4. Strengths and Weaknesses of Patents

In this section, we address two questions. First, we examinine why firms decide not to patent innovations, partly to learn why they report patents to be relatively ineffective in the preponderance of industries. Second, we examine the motives for patenting to gain some insight into whether the patenting practices of firms may, under some circumstances, broadly depart from the purpose of patent law to promote technical advance. We also wish to understand whether there is a disjuncture between firms' perceptions of patent effectiveness and their patenting behavior as the literature suggests and, if so, why.

4.1 Reasons Not to Patent

In our survey, we asked firms to report which reasons contributed to the decision not to apply for a patent on the most recent invention which they decided not to patent. The reasons for not applying for a patent considered in our survey include: 1. difficulty in demonstrating the novelty of an invention; 2. the amount of information disclosed in a patent application; 3. the cost of applying; 4. the cost of defending a patent in court; 5. the ease of legally inventing around a patent. Figure 5 indicates the percentage of respondents indicating whether a particular reason figured into their decision not to patent.[29] Figure 6 indicates the percentage of respondents reporting whether a given reason is the most important reason not to patent.

Our results in Figure 5 show that ease of inventing around is the most cited reason (significantly above novelty, $t=5.10$, $p<.0001$) and information disclosure, along with lack of novelty, also score high.[30] Figure 6 shows that the percentage of respondents reporting concerns over disclosure and "inventing around" as their most important

---

approximately the same time as the CMS. Japanese respondents rated secrecy as the least effective of the major appropriability mechanisms and rated patents as among the most effective (Cohen, Goto, Walsh, Nagata and Nelson [1999]). Although the differences in these results may reflect cultural or other cross-national differences, the result for Japan suggests that question wording or order did not somehow bias the results toward secrecy.

[29] To save space in the questionnaire, we did not distinguish between process and product innovations for this question. We did, however, draw this distinction when we considered the reasons to patent.

[30] Novelty is significantly above disclosure ($t=3.43$, $p<.001$) and disclosure, in turn, is significantly above application cost ($t=4.64$, $p<.0001$).

reasons not to patent are almost equal (t=0.13, p>.85).[31] We interpret these results as suggesting that the key reasons why patents provide limited protection are that they can be invented around and disclose critical information.[32] Disclosure is presumably of particular concern when a patent can be invented around.[33]

Over ten years prior to the CMS, the Yale survey also inquired about the reasons why firms did not patent, casting their question in terms of the "limitations on the effectiveness of patents." Levin et al. [1987] also found that an important "limitation on the effectiveness" of patents was that competitors could legally invent around them. In their aggregate results, no other limitation, including "patentability" (resembling our demonstration of novelty) or concern over information disclosure were comparably scored for either product or process innovations. Thus, concern over information disclosure appears to have grown since the Yale survey, which is consistent with the increased emphasis on secrecy reported above.[34]

In addition to our aggregate results, we observe within-industry relationships between reasons not to patent and firm size. Consistent with Lerner's [1995] finding that the costs of patent litigation dissuade smaller firms from patenting, the Kendall Tau correlation coefficient between the log of overall firm size and whether the respondent indicated cost of defending a patent in court as a reason for not applying for a patent, controlling for industry effects, is -.18 and significant at the .01 confidence level. The analogous correlation with the cost of applying for a patent is -.11, which is also significant at the .01 level.[35] These findings may suggest that larger firms are better able to spread the fixed costs of applying for and defending patents over greater levels of

---

[31] One chemical company executive voiced particular concern over disclosure, for example, when he stated, "Will a patent teach our competitors and give the shop away?"

[32] An industry by industry analysis shows the same qualitative pattern.

[33] For the most important reason not to patent an invention, both disclosure and inventing around are significantly below novelty (p<.01), which is not surprising given the novelty requirement for receiving a patent. The fact, however, that a sizable number of respondents (24%) rank disclosure as the <u>most</u> important reason, even above novelty, is striking.

[34] None of the reasons found to be prominent as reasons not to patent, namely demonstration of novelty, concern over information disclosure or ease of legally inventing around the patent, proved to be correlated with size. Thus, the key difference regarding the importance of information disclosure between the Yale and Carnegie Mellon survey findings appear to be robust to differences in the underlying firm size distributions.

[35] These aggregate results are qualitatively confirmed in the correlations for the seventeen industries with more than 8 observations, where 15 of the seventeen correlations between size and defense cost are negative, and, of these 15, eight are significant at the .10 confidence level, and 16 of the seventeen between size and application cost are negative and, of these 16, five are significant.

output, which may in turn explain the positive relationship noted above between reported patent effectiveness and firm size.

4.2 Why Patent?

Patenting activity is considerable and has grown substantially since the early 1980's in the U.S. The total number of U.S. patent grants has increased 78% to 101,419 between 1983 and 1995, and for U.S. corporations alone it has increased 72% to 44,035 (National Science Board [1998, p. A-373]). Our CMS data indicate that approximately 70% of R&D performers applied for at least one patent in the 1991-1994 period. Respondents also claim to apply for patents on 49% of their product innovations and 31% of their process innovations.[36]

Patenting therefore is high by historical standards and the majority of new products are patented. Are patent propensities inconsistent, however, with firms' evaluations of the effectiveness of patents as the literature has suggested? To address this question, we estimate a simple logit model in which we regress a log transform of our industry (R&D-weighted) average propensities to apply for patents for product and process innovations, respectively, against the (R&D weighted) average industry patent effectiveness scores. Recall that our effectiveness measures reflect each respondent's evaluation of the percentage of product or process innovations for which patents or other mechanisms are effective in protecting the "competitive advantage" from those innovations. Patent application propensity is the percentage of innovations for which patents are sought.

The results for the regressions which includes only our measure of patent effectiveness on the right hand side are presented in Table 6 for product innovations and Table 7 for process innovations. We observe R-squared's of .45 and .11 for product and process patent propensity, respectively, and both coefficient estimates are significant at

---

[36] However, there are large differences in the propensity to patent across industries. As presented in the appendix in Table A1, for product innovations, several industries apply for patents for more than two thirds of their innovations, including chemicals (nec), drugs, mineral products, and medical equipment. In contrast, there are also many industries that applied for patents on fewer than 15% of their product innovations, including food, textiles, glass, steel and other metals. For process innovations, the higher patenting (i.e., greater than 40%) industries include paper, petroleum, chemicals (nec), drugs, mineral products, and communication equipment. Lower patenting industries (i.e., less than 10%) include textiles, glass, steel, special purpose machines, machine tools, motors/generators, electronic components, and TV/radio. The computations for this table drop those observations where the sum of the share of process and product innovations equals 100% because in such cases, it is likely that the respondents misconstrued the question to mean that the numbers should sum to 100%, which was not correct. We also assigned those respondents who had applied for no patents in the prior three years a value of zero on propensity of patent. Finally, responses are weighted by size of R&D budget.

the .01 level. Since the argument suggesting an inconsistency between reported patent ineffectiveness and patenting behavior has to do with the effectiveness of patents *relative* to other mechanisms, and the fact (established above) that the use of patents and other mechanisms are not mutually exclusive (and may even be complementary), we estimate a second simple specification where the effectiveness scores for the other mechanisms are also included. Also presented in Tables 6 and 7, the R-squared's increase to .54 for product patent propensity and .27 for process patent propensity. Evaluated at the sample means, the coefficient estimates from the simple bivariate regressions imply that for a one percent increase in the percentage of innovations for which patents are reported to confer effective protection, the share of product and process innovations for which the firm applies for patents increases by 0.96 and 0.47 percent, respectively, with little change when the other mechanism scores are included.

While our results reflect a strong link between reported patent effectiveness and patenting behavior, the R-squared's as well as the significant, positive intercept terms in the logit regressions also suggest that our measure of the effectiveness of patents has limited explanatory power in explaining the observed propensities to patent, particularly for process innovations. If respondents are judging the effectiveness of patents in terms of their protection of the returns realized through the commercialization or licensing of patented inventions (which, per above, is what we believe), then the limited explanatory power of patent effectiveness could reflect uses of patents that generate profits, but not directly from the commercialization or sale of the patented inventions. To shed light on this and other possibilities, we now turn to our examination of the reasons firms patent.

In our survey, we asked respondents to indicate which of a list of reasons motivated their most recent decisions to apply for a patent for a product and process innovation, respectively. The reasons for patenting considered in our survey include the prevention of copying, the prevention of other firm's attempts to patent a related invention (which we call "patent blocking"), the earning of licensing revenue, use to strengthen the firm's position in negotiations with other firms (as in cross-licensing agreements), the prevention of infringement suits, use as a measure of internal performance of a firms' technologists, and the enhancement of the firm's reputation.

Figures 7 and 8 provide the aggregate results on respondents' reasons for applying for their most recent product or process patents, respectively. Figure 7 shows that in the aggregate, the motive of blocking rival patents on related innovations, indicated by 82% of the respondents, is second ($p<.0001$) only to prevention of copying (96%) as a motive for patenting.[37] Figure 8 shows similar results for process patents, where the prevention of copying is indicated by 78% of respondents and patent blocking, again the second most important reason (significantly below copying but significantly above prevention of

[37] In a couple of industries, namely miscellaneous chemicals and steel, blocking was named as a reason more often than the prevention of copying and in drugs, mineral products, concrete/cement, machine tools, communications equipment and medical equipment, blocking was named by almost as many respondents as the prevention of copying (i.e., within 5%).

suits, p<.0001), is indicated by 64%.[38] In the aggregate, the prevention of suits occupies third place as a reason for patenting, with 59% and 47% of respondents reporting it as a reason for product and process patenting respectively.[39] These are followed by use in negotiations and the use of patents to "enhance reputation." Other than using patents to measure internal performance, using patents to earn licensing revenue is the least important reason for applying for patents, reported as a reason for patenting products and processes by only 28% and 23% of respondents, respectively.[40] Consistent with the findings of Levin et al. [1987], this result suggests that only a minority of respondents expect to sell their protected knowledge in disembodied form.[41] After weighting our aggregate results by the number of respondent patent applications, the numbers change appreciably only for prevention of suits and use in negotiations, which increase to 74% and 58%, respectively, for product patents and to 63% and 49%, respectively, for process patents, suggesting that those firms that patent the most are disproportionately concerned about prevention of suits and the use of patents in negotiations.[42]

The legal and qualitative literature as well as our interviews suggest that the reasons firms patent may differ across industries and technologies (cf. Warshofsky [1994]). To probe for differences in the motives for patenting across industries, we exploit a distinction drawn by Levin et al. [1987], Merges and Nelson [1990], Kusonoki,

---

[38] Blocking is again indicated by a greater percentage of respondents than the prevention of copying in miscellaneous chemicals and steel, and the two reasons are tied in six industries, including textiles, petroleum refining, rubber/plastic products, mineral products, concrete and cement and machine tools.

[39] Both scores are significantly above use in negotiations (p<.0001).

[40] Both scores are significantly below the next highest use (negotiations for product patents, reputation for process patents, p<.0001).

[41] One qualification to this inference is our finding that almost half of our respondents patent products and over a third patent processes to enhance the firm's reputation. While a sizable fraction of these may reflect a vanity component, some of these respondents may be signaling an intention to use their patents as the basis for approaching the capital markets or for selling the firm outright. Supporting that such a concern motivates some patenting, we find negative correlations between the likelihood of a respondent reporting this motive for patenting and firm and business unit size, which is consistent with the assumption that smaller firms would more typically use patents in this way.

[42]One common theme regarding the prevention of suits that emerged from the interviews was that firms use patents to allow themselves to be able to use their own technologies; that is, without being sued. Firms also reported using publications in the same way (so called, "defensive publication") when they feel that a patent will be ineffective. By publishing parts of an invention (and keeping other parts secret), the firm can keep its freedom to commercialize a product without risk of another firm patenting it. A communications equipment manufacturer's executive stated, "If you don't think you can get the patent, but you are afraid someone else might get it, you publicly publish it, so that our idea doesn't get turned around on us."

Nonaka and Nagata [1998] and Kash and Kingston [2000] between "complex" versus "discrete" or simple technologies. For our purpose, the key difference between a complex and a discrete technology is whether a new, commercializable product or process is comprised of numerous separately patentable elements versus relatively few. New drugs or chemicals typically are comprised of a relatively discrete number of patentable elements. In contrast, electronic products tend to be comprised of a larger number--often hundreds--of patentable elements and, hence, may be characterized as complex. Although the difference between complex versus simple technologies is typically driven by the technology and physical character of a product, patent policy itself may also play a role. For example, the recent ruling that gene fragements are separately patentable suggests that the commercialization of a single biotechnology drug product may now require rights over numerous patents.

In complex product industries, firms often do not have proprietary control over all the essential complementary components of at least some of the technologies they are developing.[43] Firms hold rights over technologies that others need, and vice-versa, creating a condition of mutual dependence that fosters extensive cross-licensing. One communications equipment manufacturer's executive stated: "Mostly, your patents are used in horse trading. You come together and say, 'Here's our portfolio.' In our industry, things all build on each other. We all overlap on each other's patents. Eventually we come to some agreement: 'You can use ours and we can use yours.'"

To test for differences in the uses of patents between complex and discrete product industries, we created a dummy variable, COMPLEX, equal to "1" for complex product industries and "0" for discrete product industries.[44] We then conduct a series of comparisons to see if the use of patents differs systematically as expected between complex and discrete product industries. We begin by looking at the use of patents in negotiations. We find that the average for complex product industries is 54.9% of respondents claiming that use in negotiations is an important reason to patent, while in discrete product industries, only 40.6% use patents in this way ($z=3.79$, $p<.001$).[45] We

[43] An exception was Hewlett-Packard Co.'s almost impenetrable protection of its inkjet printer introduced in 1988. It held some 50 patents covering the technology of how ink flowed through the printer head alone (Yoder [1994]).

[44] Lacking strong priors, we use the following assignment. Industries with ISIC codes less than 2900 (e.g., food, textiles, chemicals, drugs, metals and metal products) were coded as "discrete" and those with ISIC codes of 2900 or above (e.g., machinery, computers, electrical equipment, electronic components, instruments, and transportation equipment) were coded as "complex". We excluded ISIC3600 (other manufacturing). This coding scheme is similar to Kusonoki, et al. [1998], who label these categories "material" and "system" industries. In their analyses, they excluded food, steel and metal products on the grounds that these were difficult to classify. We have included these as "discrete", in part based on the ISIC classifications. However, we suspect there is substantial heterogeneity within these groups of industries. Such heterogeneity is likely to bias the results toward zero (providing a conservative test of group differences).

[45] Based on Wilcoxon rank-sum test.

can see in Table 8 that the preponderance of the sixteen industries in which fifty percent or more of the respondents report patenting for use in negotiations are complex product industries, including the electronics (computers, semiconductors, electronic components, communications equipment, TV/radio) industries, instruments (including medical equipment) and transportation (auto/truck, autoparts, aerospace).[46]

Among the industries with more than fifty percent reporting use of patents for negotiations, there is only a small handful of "discrete" product (i.e., products comprised of a relatively small number of patentable elements) industries, including drugs, steel and metal products. The presence of drugs suggests that when patents are used for negotiations, those negotiations may not only apply to cross-licensing (despite the explicit mention of cross-licensing in the survey question), but to licensing revenue as well. Accordingly, to compute the column labeled "Cross-licensing" in Table 10, we remove from the respondents who report using their patent for "negotiations" those who also report using it for licensing revenues. This provides a conservative estimate of industries which patent with a particular view toward cross-licensing. We also weight responses by the number of patent applications.[47] Drugs, steel and metal products now drop below forty percent, while semiconductors, medical equipment, instruments and autos are above.[48] Comparing the two industry groups (and weighting cases by number of patent applications), we find that, on average, 54.8% of those in "complex" product industries used patents for "Cross-licensing," while only 10.3% of those in "discrete" product industries used patents in this way (χ^2[1 d.f.]=4129.8, p<.0001).[49]

---

[46] The differences for process innovations are much smaller (39.0% for complex v. 35.6% for discrete, Wilcoxon z=0.875, p>.38). As shown in Table 9, electronics and transportation industries (though not instruments) again score relatively high for process patents. In general, we are less certain about our predictions for process patents, because it is more difficult to know (without extensive knowledge of each industry) about the nature of the manufacturing process, and, in turn, whether commercializable process innovations are likely to be "discrete" or "complex."

[47] A few industries change in unexpected ways when we weight. However, because this analysis is sensitive to outliers, one large firm answering in other than the predicted way can substantially change the average. Thus, while particular industries may be classed as "high cross licensing" or not depending on weighting, exclusions of outliers, etc., the grouping of industries is fairly robust, with complex-product industries tending to score high and "discrete-product" industries scoring low.

[48] For process patents, cross-licensing is also high (greater than 40%) in at least some of the electronics and transportation industries (see Table 11). Again, per footnote 46 above, we are less certain about our predictions for process patents.

[49] These averages (and those in the following paragraphs on reasons to patent) are estimated using a weighted logistic regression. We use logistic regression (with COMPLEX as the predictor) to account for the dichotomous character of the variables. We weight cases by number of patent applications to better reflect the use of the "average" patent (since some respondents

In addition to noting important cross-industry differences with regard to cross-licensing, we observe important differences with regard to the use of patenting for licensing revenue. There are only ten industries in which 40% or more of the respondents report licensing revenue as a motive for patenting. These are printing/publishing, petroleum products, drugs, steel, metal products, motors/generators, semiconductors, communication equipment, TV/radio, and aerospace. Once we weight these responses by patent applications, these results are largely reinforced with two important exceptions. Semiconductors now drops substantially below average, while computers are now substantially above, suggesting that licensing revenue is a greater concern for less patent-intensive firms in semiconductors, but a concern for the more patent-intensive firms in computers. Overall, we find that discrete product industries make greater use of product patents for licensing (37.5% for discrete versus 28.8% for complex, χ^2[1 d.f.]=194.8, p<.0001).[50] More generally, use of patents for licensing revenue in complex product industries such as computers, semiconductors and telecommunications as well as discrete product industries suggests that while there may be broad differences in the uses of patents across industries, there are cross-firm differences within industries reflecting heterogeneity in the features, goals and capabilities of firms.[51]

As noted above, our results show that the prevention of rivals from patenting related inventions, which we call patent preemption or blocking, to be the most pervasive motive for patenting after the prevention of copying. To understand this result and how this motive may vary across industries, it is useful to consider that the notion of "related inventions" has two different meanings. Inventions may be related whether they are

account for many more patents than others). For process patents, the results are similar (44.4% versus 11.5%, χ^2[1 d.f.]=2618.5, p<.0001). For the unweighted regressions the results are weaker, but still significant (p<.0001) for product patents (though no longer significant for process patents).

[50] For process patents, the results are even weaker (32.9% for discrete versus 28.4% for complex, χ^2[1 d.f.]=53.5, p<.0001). If we use the unweighted scores, the results are no longer significant for either product or process.

[51] Our interviews also suggest that licensing revenue is becoming more important recently, at least for some firms, with firms becoming more aware of the potential payoff to staking intellectual property claims and enforcing those claims through lawsuits. Reflecting this change in attitudes, one respondent stated, "Patents are a business in itself. They generate licensing opportunities." Consistent with Hall and Ham's interview findings for the semiconductor industry, the respondents point to high profile lawsuits, such as the Texas Instruments' semiconductor lawsuits or the "epochmaking" Polaroid v. Kodak case as important triggers for this change in attitude toward the role of patents. Reflecting the notion that firms may be embracing more aggressive intellectual property policies than a decade ago, two consultants, Rivette and Kline [2000] just published a volume admonishing firms to better exploit their intellectual property policy and "unlock the hidden value of patents."

substitutes or complements, and the intent associated with "blocking" may turn on this distinction. Consider industries or technologies where the patenting of substitute inventions (i.e., inventions that resemble one another functionally) is possible. In this setting, firms wishing to protect some patented core invention may patent substitutes to foreclose that possibility to rivals, building what is sometimes called a "patent fence." Those substitutes may represent improvements upon the original product or not, and the firm may have no intent of commercializing those inventions. For example, in the 1940's du Pont patented over 200 substitutes for Nylon to protect its core invention (Hounshell and Smith [1988]). Turner [1998] documents the case of the "Fan" patent where Du Pont patented an improvement on its already commercialized color proofing process for photographic film in order to prevent its preemption in the marketplace.

Inventions may also be related to one another if they are economic complements when, to create a single commercializable product, numerous separately patentable inventions need to be combined, which is commonly the case in complex product industries. In such settings, holding a patent on one of these elements can block the acquisition of exclusive property rights over the commercializable invention as a whole.

Blocking patents may be used either to extract licensing revenue or to force inclusion in cross-licensing negotiations. In the former instance, a patent holder with no intent of commercializing the complex product may want to extract some share of the rents via licensing, as illustrated by Texas Instrument's efforts to secure licensing revenues from Japanese and subsequently American semiconductor manufacturers during the 1980's and 1990's. Alternatively, because no one firm can move ahead on developing and commercializing new technology without access to rival technology, incumbents can use their patents as bargaining chips either to compel their inclusion in cross-licensing or at least secure the freedom to move ahead on similar technological efforts without being sued. We call this use of patents "block to play" because, by compelling either access to rival technology or at least protecting against suits by incumbents, it facilitates a firm's participation in a broad domain of technological activity.

Our discussion of the two forms of patent blocking suggests that there may be different motives associated with blocking between discrete and complex product industries. In discrete product industries, such as chemicals, we would expect firms that report blocking as a motive do so with a view toward creating a patent fence. While, as noted above, patent fences may be created where patents are strong, we would expect the practice to be more common when the patented core invention is more susceptible to substitution. Under such circumstances, it would seem unlikely that a firm could use either a "core invention" patent or one of the patents surrounding the core invention to generate licensing revenue or to strengthen its position in negotiations. Thus, we expect the preponderance of respondents who report blocking as a motive for patenting in discrete product industries to report no intention of using that patent for negotiations or licensing. The column labeled "Fences" in Table 10 shows patent application-weighted percentages of respondents by industry who report blocking as a motive, but not the motives of use in negotiations or licensing.[52] Use of patents to build such "fences" is, as conjectured, much more common in discrete product industries (45.0%) than in complex product industries (10.6%) (χ^2[1 d.f.]=2973.7, p<.0001).[53]

In contrast to the motives for patenting observed in discrete product industries, our discussion of the uses of blocking in complex product industries suggests that firms should commonly use the same patent for blocking and to strengthen their positions in cross-licensing negotiations. The column labeled "Player" in Table 10 shows, by industry, the percent of respondents who report using a patent for blocking and for negotiations, but not to secure licensing revenue.[54] Comparing this "Player" variable across the types of industries, we find that "complex" product industries score substantially higher than do "discrete" product industries (44.7% versus 10.1%, χ^2[1 d.f.]=2847.5, p<.0001). For process patents the results are similar (30.3% versus 9.8%,χ^2[1 d.f.]=1131.9, p<.0001). For the unweighted regressions, the results are substantially weaker (26.2% versus 18.5% for product, p<.05, 17.1% versus 14.9% for process, p>.45), suggesting that this "player" strategy is much more prominent among the firms with larger patent portfolios.

Thus, we observe three uses of patents that appear to differ across industries. First, in discrete product industries such as drugs where patents are effective, patents afford sufficient protection on individual inventions to confer monopoly rents via either the commercialization of an invention by the firm itself or via licensing. In the majority of discrete product industries where patents are weaker, firms are more likely to use patents for blocking by creating patent fences that impede the development of competing

---

[52] The industries where the percent of such respondents exceed 50%, and often substantially, indeed include all the chemical industries (except drugs), textiles, paper, rubber/plastic products, mineral products and electrical equipment. For process patents, we find chemicals (except drugs) again scoring substantially above average, along with food, textiles, and paper (see Table 11). The absence of the drug industry from this list further suggests that in discrete product industries where patents are effective in preventing substitution and provide a strong basis for licensing, firms do not build patent fences as commonly as otherwise.

[53] For process innovations, the results are similar (43.8% versus 14.3%, χ^2[1 d.f.]=2152.4, p<.0001). For the unweighted regressions, the results are weaker, but still significant (p<.01).

[54] We impose the latter restriction to focus conservatively on those industries where cross-licensing is most important. The numbers in the "Player" column in these two tables are low because excluding licensing revenue as a motive excludes some firms that patent to maintain player status and license, and, per Tables 8 and 9, licensing revenue is also an important reason to patent in many complex product industries (e.g. semiconductors, TV/radio, and aerospace). As expected, the percentages are relatively high for complex product industries such as electronics (except computers), instruments, machinery and machine tools industries and autoparts. For process patents, we add printing/publishing and metals and drop special purpose machines (see Table 11).

alternatives and are less likely to use them for negotiations. Finally, in complex product industries, while patents are also used for licensing revenue, the larger, more patent intensive firms are more likely to use them to strengthen their positions as players in cross-licensing negotiations. Tables 10 and 11 also show that not all industries divide neatly into these uses; it is invariably a matter of degree, with heterogeneity manifest within all industries. Industries where the uses are particularly diverse include instruments, medical equipment and communications equipment.

If firms use patents in different ways within industries, are there systematic features to these intraindustry differences? To consider this possibility, we focus specifically on whether there are any relationships within industries between motives for patenting and the size of firms or their business units, or the firm's patent intensity. On the basis of Kendall Tau correlation coefficients and controlling for industry effects (for the seventeen industries with at least 8 observations), of all the reasons to patent product innovations, only the motive of patenting "to enhance the reputation of the firm or its employees" is significantly (at .01 confidence level) correlated with size, measured as either the log of firm sales ($r = -.11$), or the log of business unit employees ($r = -.16$). Suggesting that smaller firms are more likely to report this motive, this negative correlation coefficient can be rationalized by the need of smaller firms' in some high technology industries to hold patents in order to acquire financing or alliance partners (Smith-Doerr, Owen-Smith, Koput and Powell [forthcoming]). We also observe significant positive correlations between the number of respondents' patent applications and two motives for patenting, namely to strengthen your bargaining position in negotiations and to prevent infringement suits; the correlation coefficients for these two relationships are .16 and .15, respectively for product innovations (and stronger for the motives for patenting process innovations). Thus, as suggested above, it appears that, within industries, firms that patent the most tend to be more concerned with negotiations and the prevention of suits.

5. Discussion

U.S. patent policy has changed markedly since the Yale survey was administered in the early 1980's. First, in 1982, the Court of Appeals for the Federal Circuit's was established. Since that time, the judiciary's posture on patent law has become more pro-patent as reflected in increased plaintiff success rates in infringement suits. Administrative changes to diminish patent pendency periods have also been implemented with a view toward strengthening patents. Has there, however, been any significant increase in the reported effectiveness of patents? Overall, our findings suggest that patents are still not the major mechanism for appropriating returns to innovations in most industries. Instead, we find that the key appropriability mechanisms in most industries are secrecy, lead time and complementary capabilities (see Figures 1 and 2). In fact, the major change compared to the "pre-reform" Yale survey is the rise in the reported importance of secrecy. Of all the appropriability mechanisms, however, secrecy lends itself the least to R&D spillovers. Since R&D spillovers are a key source of productivity growth (Griliches [1992]), further research is warranted on the causes and possible impacts of this result.

The most we can say about the impact of policy changes on the effectiveness of patents is that, when we look at the responses of the large firms comparable to those surveyed by Levin et al. [1987], some industries have witnessed perhaps a modest increase in reported effectiveness, suggesting that patents may now be playing a more central role in the appropriability strategies of larger firms. Our results also suggest that the costs associated with patents, particularly their defense, disproportionately dissuades small firms from availing themselves of patent protection.[55] Thus, the standing of patents against other means of appropriation has not changed substantially. Even among large firms, these other mechanisms continue to dominate in firms' appropriability strategies in the majority of industries. This modest change in the status of patents suggests either that the institutional changes in the patent system are not as substantial as one might believe, or that enduring features of technologies and industries may constrain any increase in patent effectiveness that is achievable through changes in policy and judicial practice.

Consistent with prior claims, our results suggest that there is also a good deal of patenting that is not readily explained by the relative effectiveness of patents as a device for protecting the profits due to specific inventions. Our interviews and survey results on the reasons why firms patent suggest an explanation, namely that there are common uses of patents that stand apart from the function of protecting the profits directly associated with either the licensing or commercialization of the patented invention.

One broader use of patents observed particularly in chemical (apart from drugs) and other discrete product industries is their combination to build patent fences around some patented core invention. Such fence building involves the patenting, though not licensing (nor necessarily even commercializing), of variants and other inventions that might substitute for the core innovation in order to preempt rivals from introducing competing innovations.[56] Firms do not, however, build such patent fences because individual patents effectively prevent imitation or substitution, but because they do not.

A second common use of patents which also goes beyond the licensing or commercialization of the patented invention is observed in complex product industries such as electronics. This is patenting to become or remain a major competitor (i.e., "player") in an industry, often via the amassing of large portfolios. The fact that the same patents are often used for both blocking and negotiations in such industries suggests that

[55] Conceivably, the legal costs associated with patents may loom larger for smaller firms due to lower levels of output over which to spread the associated fixed legal costs.

[56] Similarly, firms may use blocking patents to make it costly for other firms to conduct R&D in a broad technological domain, recalling Liebenau's description of the German chemical firms in the 1890 to 1930 period when they used patents "to build walls around whole research areas." (cited in Arora [1997]).

firms patent not only to protect their own technology, but to hold their rivals hostage by controlling technology that they need. The threatened sanction is often less the expectation of exclusion pending the resolution of a lawsuit, but the more certain and immediate economic harm due to the legal action alone. The ransom demanded by the firm is either formal access to rival technology realized through liberal cross-licensing, or at least the ability to do work similar to that of its rivals without being sued. In this fashion, patents confer the reciprocal access to one another's technologies which enables firms to steadily improve and expand their product lines and processes--something which firms must do to be major competitors in complex product industries subject to rapid technological change. By conferring nonexclusive access to a market in such settings,[57] patents are less an instrument for appropriating rents directly from the firm's own patented inventions (via their commercialization or licensing), and more an instrument for appropriating a share of the oligopolistic rents accruing to the new technologies of all incumbents. How big a share, however, will often be affected by the size and quality of a firm's patent portfolio which affects the terms of trade between rival technologies and its own.[58]

The threat, often implicit, of infringement suits and countersuits underpins almost all the uses of patents, whether to force participation in cross-licensing negotiations in complex product industries, to build patent fences in discrete product industries, or to protect the ability to license or commercialize a new technology in the drug and other industries. Since patents themselves are the best countermeasure to the threat of litigation,[59] it is not surprising, therefore, that we observe the prevention of suits to be one

[57] Under conditions of uncertainty with regard to the success of a firm's own R&D and that of rivals, the goals of establishing an exclusive right versus a nonexclusive right over an innovation via blocking patents are not necessarily inconsistent. Indeed, firms may conceivably begin with a strategy of aggressively blocking with the hope of establishing an exclusive right, and if that strategy fails, they are then in a position to at least secure nonexclusive access.

[58]While a number of interviewees in the electronics industry reported that cross-licensing negotiations often culminated in royalty-free cross-licensing, one did note that now it was more typical for money to change hands: "You make comparisons of patent portfolios [interviewee measures spaces with fingers, one twice the other]. You recognize the difference. Even THAT gap might create multiple millions of dollars in payments from the weaker company to the stronger. To cancel out the gap, you have to pay. You have 10 good patents, I have 15, you owe for the 5 good patents. Ten or 15 years ago, the two companies would negotiate a royalty free cross-license patent peace. But, given the huge size of the business, even a small, delta, gap creates multimillions of dollars in value."

[59] An attorney for the now-acquired computer manufacturer, DEC, stated, "Our patents can be a sword or a shield." (Coy [1993]). Affirming this observation on the basis of extensive interviews of semiconductor firms, von Hippel [1988] observed that, threatened by an infringement suit, a firm will typically send "a pound or two" of copies of patents germane to the business of the potential plaintiff and suggest that it is they who are the real infringers, culminating in cross-licensing (p. 53).

of the most important uses of patents across all industries, notwithstanding the nature of the technology. What is interesting is that patents appear to be used as the basis for either threatening or defending against litigation independent of whether they are considered to be effective in their more conventional applications. This suggests that patents can be used either defensively or offensively even if they are weak or untested. They need only confer the right to sue and thus impose the costs of litigation and possible injunctive relief on rivals. But presumably the effectiveness of patents in such litigation-intensive strategies depends upon the firm's ability to support the requisite legal talent, as suggested by our findings that smaller firms are disproportionately dissuaded from applying for patents due to the costs of their defense and disproportionately report patents to be ineffective. The broad issue posed, however, by the pervasive defensive use of patents is whether the social value of patenting is substantially reduced "because it requires all to assume the overhead of defensive patenting" (von Hippel [1988, p. 53]).

Do any of these insights into the reasons for patenting allow us to say anything about the surge in patent rates observed since the early 1980's? When combined with more qualitative insights drawn from our interviews and other research, we believe they do.[60] First, we suspect that the use of patents in litigation-intensive strategies has increased over time. Although our data cannot show that either the prevention of or the prospective filing of suits have increased as motives for patenting during the recent past, such an inference is supported by both anecdotal evidence (e.g., Warshofsky [1994], Kash and Kingston [2000]) and the fact that patent infringement cases have more than doubled since the early 1980's (Korman [1998]). Our own data also show that the most patent intensive firms in complex product industries are patenting with a view toward blocking rivals to strengthen their positions in cross-licensing negotiations. Suggested by Hall and Ham's [1999] as well as our own interviews, patent portfolio races have accelerated as firms have felt increasingly compelled to apply for patents because they need to protect themselves from being blocked or believe that they need a strong portfolio to force rivals to cede access to their technologies on more favorable terms. The notion that a noncooperative strategic interaction of this sort could lead to an accelerating patenting rate is consistent with the fact that it is now firms in complex product industries, notably electronics, that are patenting the most in the U.S. Of the ten firms receiving the most patents in 1998, nine are in the electronics industries.

What could have set off the growing use of patents for both defensive and offensive uses, as well as the accelerating patent portfolio races observed in the complex product industries? The court reforms of the early 1980's may have set the stage. As suggested by Cohen et al. [1998] and Hall and Ham [1999], the demonstration effects of the Polaroid vs. Kodak settlement and a number of very visible, successful suits in electronics suggested the utility of both defensive patenting, as well as that of more aggressive strategies entailing the use of patent portfolios to garner licensing revenue. Moreover, the more recent example of IBM's success with aggressive licensing strategies

[60] See Kortum and Lerner [1999] for a more comprehensive consideration of the possible causes of the patent surge. Their conclusion, which is consistent with ours, is that the major change is one of management practice, but one might wonder why management practice has changed.

has reinforced this trend. These demonstrations of the offensive and defensive utility of patenting may have also interacted with the greater technological competition observed both nationally and internationally since 1980, which may in turn have induced firms to value intellectual property more highly. This competition could also account for the greater use of secrecy as well as patents since the use of either of these appropriability mechanisms can be increased at lower cost and more quickly than that of other mechanisms such as lead time or the exploitation of complementary capabilities.[61]

Do our findings regarding firms' reasons to patent suggest any public policy concerns? In particular, to return to a question posed above, do these motives suggest that patents may be used in ways that may undermine the ultimate purpose of patent law to advance technology? Some of the more pervasive motives that we have identified raise concerns. For example, the building of patent fences can be carried to the extreme noted by Scherer [1980] and others to the point of creating "patent thickets" that foster broader monopolies than anticipated by patent policy which in turn impede entry and the innovation that may accompany it. Patent fences may have a similar effect when they are developed to the point of walling off entire technology domains (Arora [1997]). Moreover, patent fences may not only preclude innovations that substitute for some core innovation but also inventions that may improve upon the original invention (cf. Turner [1998]), particularly in industries where technology advances cumulatively.

In complex product industries where both noncooperative strategic patenting appears to be accelerating and patenting for cross-licensing is common, other policy concerns are raised. First, we suspect that the patent portfolio races observed in these industries reflect excessive patenting from a social welfare perspective (as would typify a Prisoners' Dilemma-like situation), and are thus raising the cost of innovation unduly.[62] Moreover, some share of the patenting in these industries may provide little offsetting social welfare benefit by inducing R&D to begin with. As our data suggest, most firms in complex product industries do not consider patents, but first mover advantages, secrecy and the exploitation of complementary capabilities as the key means of protecting their inventions.

---

[61] One communications equipment manufacturer confirmed that it is not costly to implement secrecy strategies, suggesting, "One advantage of secrecy is it is cheap." Another communications equipment executive explicitly tied together the growth in his firm's patenting with a greater emphasis on secrecy when he stated: "Our patent portfolio has increased. Patents are more important than they were before. We are beginning to recognize that. But, at the same time, secrecy awareness has increased even more. We are becoming more cognizant of the value of keeping things like process secret."

[62] See also Kash and Kingston [2000] for a similar conclusion based on more qualitative evidence.

Another policy concern in complex industries is, if access to competitor technology is essential to being a viable competitor (i.e., "player"), and only incumbents holding significant patent portfolios can achieve such access, then patenting can again become a vehicle for impeding entry and the innovation that often accompanies it.[63] Unlike the patent thicket case, here the barrier does not protect one firm but a group of oligopolistic incumbents. An offsetting advantage of such entry restrictions is implied, however, by the arguments of Merges and Nelson [1990], Scotchmer [1991] and Heller and Eisenberg [1998] who suggest that as the number of firms holding separately patented pieces of the same commercializable technology becomes too large, commercialization may fail due either to a stacking of licensing fees or a breakdown in negotiations arising from asymmetric subjective valuations of patent rights and associated transactions costs. Thus, by limiting entry, patent portfolio races may actually help prevent such breakdowns in negotiations over intellectual property. Patent portfolio races may offer yet another offsetting social benefit. Such races induce firms to disclose more of their inventions because failure to do so (through patents) creates the risk of being excluded from the industry or even from use of one's own inventions. This greater disclosure increases the extent to which rivals can build on each other's R&D, presumably accelerating the pace of innovation.[64] This effect is also enhanced by the more liberal cross-licensing that typifies the player strategy.[65]

Our data do not show the degree to which patent portfolio races distort the nature of R&D incentives or lead to socially wasteful outcomes, or whether such portfolio races or patent thickets actually block entry. Nor do they indicate whether fee stacking or the breakdown of negotiations in complex technology industries have ever undermined the commercialization of innovation. The data do suggest, however, that the potential for such outcomes may be more pervasive than previously thought. They also show that

---

[63] Indeed, our interviews suggest that the cross-licensing practices observed in complex product industries would tend to discriminate against less patent-rich entrants. Respondents noted that firms are reluctant to sell their technology, but are willing to trade it only to firms that have valuable technology (intellectual property) to use as currency.

Another issue is the effect of patenting on the kind of R&D firms will undertake in the numerous instances where firms are patenting largely for defensive purposes, or simply to increase the sizes of their patent portfolios. For example, would the latter strategy induce firms to pursue more incremental innovation than otherwise?

[64] The prominence of fear of disclosure as a reason to avoid patenting an invention suggests that respondents see this risk to patenting. And yet, we see they still feel compelled to patent the bulk of their innovations in complex product industries to maintain their player status.

[65] The use of patents as bargaining chips to gain access to rival's technologies also suggests that patents can be transformed from being primarily a mechanism for appropriation into a vehicle for enhancing the firm's technological opportunities. Firms with large patent portfolios can gain access to the accumulated knowledge of a large number of other firms, and by forcing liberal cross-licensing agreements, enhance the available technological opportunities.

patents are used in substantially different ways across different technologies, suggesting that policy and court decisions affecting the breadth of claims, applicable nonobviousness standards, likelihood of being upheld in court and other features of patents will likely have different impacts on invention and competition in different industries.

REFERENCES

Administrative Office of the U.S. Courts (1997), Judicial Business of the United States Courts, Washington, D.C.

Arora, A. (1997), "Patents, licensing, and market structure in chemicals," *Research Policy*, 26: 391-403.

Cohen, W.M., Goto, A., Nagata, A., Nelson, R.R. and Walsh, J. (1998), "R&D spillovers, patents and the incentives to innovate in Japan and the United States", Carnegie Mellon University, working paper.

Cohen, W.M. and Levin, R.C., (1989) "Empirical Studies of Innovation and Market Structure," in R. Schmalensee and R. Willig, ed., *Handbook of Industrial Organization,* Amsterdam: North Holland.

Cohen, W.M., Nelson, R.R. and Walsh, J. (1997) "Appropriability conditions and why firms patent and why they do not in the U.S. manufacturing sector," Carnegie Mellon University, working paper.

Wesley M. Cohen and John Walsh, "R&D Spillovers, Appropriability and R&D Intensity:
a Survey Based Approach," Carnegie Mellon University, June, 1998.

Coy, Peter (1993) " The global patent race picks up," *Business Week*, Aug. 9, 1993, p. 57.

Dillman, D.A. (1978) *Mail and Telephone Surveys: The Total Design Method*, New York: Wiley-Interscience.

Griliches, Z. (1992) "The Search for R&D Spillovers," Scandinavian Journal of Economics, Vol 94, No. 3, Supplement, pp. 529-547.

Hall, B. and Ham, R.M. (1998) "The patent paradox revisited: Firm strategy and patenting in the U.S. semiconductor industry," NBER Conference on Patent System and Innovation, Jan. 8, 9, Santa Barbara, 1999, Working Paper.

Heller, M. and Eisenberg, R. (1998) "Can Patents Deter Innovation? The Anticommons in Biomedical Research", *Science*, Vol 28, May 1st, pp.698-701.

Hounshell, D.A. and Smith, J.K. (1988) *Science and Corporate Strategy,* Cambridge: Cambridge University Press.

Kash, D.E. and Kingston, W. (2000), "Patents in a World of Complex Technologies," mimeo, George Mason University.

Korman, R. (1998) "Lo! Here come the technology patents. Lo! Here come the lawsuits." New York Times, December 27, 1998, BU:4.

Kortum, S. and Lerner, J. (1999) "What is behind the recent surge in patenting?," *Research Policy,* 28:1-22.

Kusonaki, K., Nonaka, I., and A. Nagata. (1998) "Organizational capabilities in product development of Japanese firms." *Organization Science* 9:699-718.

Lanjouw, J.O. and Lerner, J. (1997) 'The enforcement of intellectual property rights: A survey of the empirical literature,' NBER, Working Paper 6296.

Lerner, J. (1994a) "Patenting in the shadow of competitors", *Journal of Law and Economics,* 38: 463-496.

Lerner, J. (1994b) 'The importance of trade secrecy,' Harvard Business School, Division of Research, working paper 95-043,

Levin, R., Klevorick, A., Nelson, R.R., and Winter, S.G. (1987) "Appropriating the returns from industrial R&D", *Brookings Papers on Economic Activity*, 783-820.

Mansfield, E. (1986) "Patents and innovation: An empirical study," *Management Science*, 32:173-181.

Mansfield, E., Schwartz, M. and Wagner, S. (1981) "Imitation costs and patents: An empirical study," *Economic Journal*, 91:907-918.

Merges, R.P. and Nelson, R.R. (1990) "On the Complex Economics of Patent Scope", *Columbia Law Review*, 90: 839-916.

Merz, J. and Pace, R. (1994) "Trends in patent litigation: the apparent influence of strengthened patents attributable to the Court of Appeals for the Federal Circuit", *Journal of the Patent and Trademark Office Society,* v. 76.

National Science Board (1998) *Science and Engineering Indicators 1998,* Washington, D.C.: U.S. Government Printing Office.

Rivette, K.G. and Kline, D. (2000) *Rembrandts in the Attic: Unlocking the Hidden Value of Patents,* Boston: Harvard Business School Press.

Scherer, F.M. (1980) Industrial Market Structure and Economic Performance, Chicago: Rand McNally.

Scherer, F.M., et al. (1959) *Patents and the Corporation.* 2nd edn. Boston, privately published.

Scotchmer, S. (1991), "Standing on the shoulders of giants: cumulative research and patent law," *Journal of Economic Perspectives,* Vol. 5, pp. 29-41.

Smith-Doerr, Laurel, Jason Owen-Smith, Kenneth W. Koput and Walter W. Powell. Forthcoming, "Networks and knowledge production: collaboration and patenting in biotechnology." Pp 331-349 (Ch. 20) in R. Leenders and S. Gabbay, eds., *Corporate and Social Capital*, New York: Kluwer Academic Publishers

Taylor, C.T. and Silberston, Z.A. (1973) *The Economic Impact Of The Patent System: A Study Of The British Experience*. Cambridge:Cambridge University Press.

Teece, D.J. (1986) "Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy," *Research Policy*, Vol 15, pp. 286-305.

Turner, Julie S. [1998] "The nonmanufacturing patent owner: Toward a Theory of Efficient Infringement," *California Law Review*, Vol. 86, No. 1.

von Hippel, Eric [1988], *The Sources of Innovation*, New York: Oxford University Press.

Warshofsky, F. (1994) *The Patent Wars,* New York: John Wiley and Sons.

Yoder, S.K. (1994) "How H-P used tactics of the Japanese to beat them at their game," *Wall Street Journal,* Sept. 8, 1994, pp. 1, A9.

TABLE 1

Effectiveness of Appropriability Mechanisms for Product Innovations:
Mean Percentage of Product Innovations for which Mechanism Considered Effective[1]

Industry	N	Secrecy	Patents	Other Legal	Lead Time	Complementary Sales/Svc	Complementary Mfg.
		Mean percentage of innovations					
1500:Food	89	58.54	18.26	21.18	53.37	39.83	51.18
1700:Textiles	23	63.70	20.00	25.87	58.26	55.22	58.26
2100:Paper	31	55.00	36.94	26.45	47.10	40.00	39.84
2200:Printing/Publishing	12	32.50	12.08	21.67	48.33	66.25	60.42
2320:Petroleum	15	62.00	33.33	6.33	48.67	40.33	35.67
2400:Chemicals, nec	65	52.77	37.46	21.62	48.62	44.92	41.31
2411:Basic Chemicals	35	48.00	38.86	11.57	38.29	45.86	44.71
2413:Plastic Resins	27	55.93	32.96	18.15	38.33	44.63	46.11
2423:Drugs	49	53.57	50.20	20.82	50.10	33.37	49.39
2429:Miscellaneous Chemicals	29	70.69	39.66	25.52	55.52	55.17	48.97
2500:Rubber/Plastic	35	56.86	32.71	10.14	40.86	34.29	37.71
2600:Mineral Products	18	46.11	21.11	12.22	39.72	37.78	40.00
2610:Glass	6	46.67	30.83	11.67	50.00	62.50	70.00
2695:Concrete, Cement, Lime	10	45.00	30.00	17.50	38.00	45.50	40.00
2700:Metal, nec	6	65.83	20.00	5.00	50.83	58.33	61.67
2710:Steel	10	37.00	22.00	11.50	61.50	34.50	42.00
2800:Metal Products	44	43.07	39.43	18.18	48.18	37.05	40.11
2910:General Purpose Machinery, nec	74	49.19	38.78	20.88	52.23	41.15	43.65
2920:Special Purpose Machinery, nec	64	45.08	48.83	23.05	59.69	46.33	51.09
2922:Machine Tools	10	61.50	36.00	9.00	61.00	43.00	34.50
3010:Computers	25	44.20	41.00	27.20	61.40	40.20	38.00
3100:Electrical Equipment	22	39.09	34.55	15.00	33.41	32.27	31.82
3110:Motor/Generator	22	50.91	25.23	19.09	48.86	47.27	45.23
3210:Electronic Components	26	34.04	21.35	20.19	45.58	50.00	51.15
3211:Semiconductors and Related Equipment	18	60.00	26.67	22.50	53.33	42.22	47.50
3220:Communications Equipment	34	47.21	25.74	20.15	65.59	42.06	41.18
3230:TV/Radio	8	50.00	38.75	35.63	53.75	24.38	38.75
3311:Medical Equipment	67	50.97	54.70	29.03	58.06	52.31	49.25
3312:Precision Instruments	35	47.29	25.86	20.86	54.14	49.57	45.57
3314:Search/Navigational Equipment	38	48.95	28.68	24.08	46.84	32.89	40.53
3410:Car/Truck	9	42.22	38.89	19.44	65.56	41.67	42.22
3430:Autoparts	30	50.83	44.35	15.65	64.35	44.84	53.06
3530:Aerospace	48	55.10	32.92	16.15	58.02	34.58	46.88
3600:Other Manufacturing	84	49.29	33.81	26.61	63.51	42.56	45.30
ALL	1118	51.00	34.83	20.71	52.76	42.74	45.61
	(s.e.)	(0.96)	(0.94)	(0.73)	(0.92)	(0.91)	(0.88)

[1] Response categories were: less than 10%, 10-40%, 41-60%, 61-90%, and greater than 90%. Means were computed using category midpoints.

TABLE 2

Effectiveness of Appropriability Mechanisms for Process Innovations:
Mean Percentage of Process Innovations for which Mechanism Considered Effective[1]

Industry	N	Secrecy	Patents	Other Legal	Lead Time	Complementary Sales/Svc	Complementary Mfg.
		Mean percentage of innovation					
1500:Food	89	55.84	16.40	15.00	41.91	29.78	46.52
1700:Textiles	23	60.65	25.22	24.35	48.70	44.35	53.91
2100:Paper	31	58.87	27.58	19.35	34.52	20.65	34.03
2200:Printing/Publishing	11	20.45	8.64	10.91	33.64	50.91	63.64
2320:Petroleum	15	57.33	36.67	6.33	32.00	27.67	31.33
2400:Chemicals, nec	63	53.65	20.40	12.86	27.14	28.41	42.30
2411:Basic Chemicals	35	58.43	29.71	11.71	25.71	26.71	40.14
2413:Plastic Resins	27	62.96	21.30	7.22	23.70	25.19	34.26
2423:Drugs	48	68.13	36.15	16.04	35.52	25.21	44.17
2429:Miscellaneous Chemicals	28	76.25	27.32	15.71	33.93	40.36	54.46
2500:Rubber/Plastic	35	59.14	19.86	11.43	35.86	23.00	37.43
2600:Mineral Products	18	48.89	23.33	11.11	28.61	27.50	46.94
2610:Glass	6	58.33	30.83	18.33	31.67	42.50	50.00
2695:Concrete, Cement, Lime	10	54.00	18.50	15.50	26.50	31.50	33.50
2700:Metal, nec	6	65.83	31.67	12.50	66.67	46.67	50.00
2710:Steel	10	41.00	15.50	11.50	42.00	25.00	42.00
2800:Metal Products	42	46.19	22.50	15.36	39.05	35.36	47.38
2910:General Purpose Machinery, nec	69	37.54	23.62	16.30	34.86	28.33	40.00
2920:Special Purpose Machinery, nec	63	41.83	28.57	16.03	44.92	35.48	41.27
2922:Machine Tools	10	48.00	18.00	9.50	43.00	34.00	39.00
3010:Computers	20	42.50	30.25	16.75	39.75	23.50	35.50
3100:Electrical Equipment	22	31.59	19.09	6.82	19.09	11.82	18.86
3110:Motor/Generator	21	42.62	22.14	17.86	44.52	31.67	39.29
3210:Electronic Components	26	46.54	15.19	15.00	42.69	42.31	55.77
3211:Semiconductors and Related Equipment	18	57.50	23.33	8.33	47.78	32.22	42.50
3220:Communications Equipment	33	35.30	14.70	13.94	43.03	33.64	40.61
3230:TV/Radio	8	47.50	18.75	18.75	38.75	32.50	46.88
3311:Medical Equipment	66	49.24	34.02	22.27	45.15	32.12	49.55
3312:Precision Instruments	31	43.55	16.77	15.81	35.48	32.74	40.81
3314:Search/Navigational Equipment	37	43.65	13.24	16.35	39.05	31.89	42.97
3410:Car/Truck	9	34.44	21.67	17.22	34.44	26.67	41.11
3430:Autoparts	31	56.45	24.35	15.16	50.16	36.94	55.97
3530:Aerospace	47	49.26	21.38	13.30	42.23	28.40	44.89
3600:Other Manufacturing	79	51.65	23.42	20.76	44.56	31.39	38.29
ALL	1087	50.59	23.30	15.39	38.43	30.73	43.00
	(s.e.)	(1.03)	(0.83)	(0.63)	(0.96)	(0.88)	(0.95)

[1] Response categories were: less than 10%, 10-40%, 41-60%, 61-90%, and greater than 90%. Means were computed using category midpoints.

TABLE 3

Factor Analysis of Industry Mean Scores on Appropriability Mechanisms for Product and Process Innovations
(N=66)

Mechanism	Factor 1 Capabilities/First Mover	Factor 2 Patents	Factor 3 Secrecy
Complementary Sales/Svc. (Pro	**0.813**	-0.108	0.120
Complementary Mfg. (Product)	**0.781**	-0.014	0.194
Complementary Sales/Svc. (Pro	**0.753**	0.055	0.035
Complementary Mfg. (Process)	**0.677**	0.025	0.160
First Mover (Product)	**0.604**	0.322	-0.086
First Mover (Process)	**0.602**	0.232	0.084
Other Legal (Process)	**0.580**	**0.528**	0.000
Patent (Process)	-0.012	**0.760**	0.241
Patent (Product)	-0.050	**0.678**	0.049
Other Legal (Product)	**0.402**	**0.620**	-0.092
Secrecy (Process)	0.058	0.149	**0.797**
Secrecy (Product)	0.189	0.014	**0.749**
Variance Explained	29.7%	15.8%	11.3%

TABLE 4

Effectiveness Rankings of Appropriability Mechanisms in the 1983 Yale Survey for the 33 Comparison Industries

Mechanism	Number of Industries Ranking Mechanism as:			
	1st	2nd	3rd	4th
Product Innovation				
Patents	4	3	17	9
Secrecy	0	0	11	22
Lead Time	14	14	5	0
Sales & Service	16	16	1	0
Process Innovation				
Patents	2	4	3	24
Secrecy	2	10	19	2
Lead Time	26	5	2	0
Sales & Service	4	16	7	6

TABLE 5

Effectiveness Rankings of Appropriability Mechanisms in the 1994 Carnegie Mellon Survey for the 33 Comparison Industries

Mechanism	Number of Industries Ranking Mechanism as:				
	1st	2nd	3rd	4th	5th
Product Innovation					
Secrecy	13	11	2	5	2
Patents	7	5	7	4	10
Lead Time	10	8	6	7	2
Sales & Service	4	4	7	10	8
Manufacturing	3	3	14	7	6
Process Innovation					
Secrecy	21	10	1	1	0
Patents	1	5	3	8	16
Lead Time	3	7	16	4	3
Sales & Service	0	0	3	19	11
Manufacturing	10	12	10	1	0

Table 6 - PRODUCT INNOVATIONS
Dependent Variable: Log-odds-ratio of the propensity to patent product innovations

Variable	Specification I Estimate	Specification I St. Error	Specification II Estimate	Specification II St. Error
Intercept	-2.414 ***	0.251	-1.004 *	0.571
Patent	0.043 ***	0.006	0.044 ***	0.007
Secrecy			-0.005	0.007
First Mover			-0.015 *	0.009
Complementary Sales/Service			-0.009	0.009
Complementary Manufacturing			0.004	0.011
Product Complexity			-0.004	0.007
R^2	0.45		0.54	
N. of Industries	61		61	

Table 7 - PROCESS INNOVATIONS
Dependent Variable: Log-odds-ratio of the propensity to patent process innovations

Variable	Specification I Estimate	Specification I St. Error	Specification II Estimate	Specification II St. Error
Intercept	-2.792 ***	0.364	-2.061 ***	0.579
Patent	0.033 ***	0.012	0.034 ***	0.013
Secrecy			-0.001	0.009
First Mover			-0.006	0.012
Complementary Sales/Service			-0.038 ***	0.014
Complementary Manufacturing			0.012	0.014
Product Complexity			0.006	0.013
R^2	0.11		0.27	
N. of Industries	61		61	

NOTES:
*1) *: Significant at 10%;**: Significant at 5%; ***: Significant at 1%.*

TABLE 8

Reasons to Patent Product Innovations: Percent of Respondents by Reason

Industry	N[1]	Measure Perf.	Licensing Revenue	For Use in Negots.	Prevent Suits	Prevent Copying	Blocking	Enhance Reputation
		Percentage of Industry Respondents						
1500:Food	45	4.44	15.56	33.33	46.67	93.33	73.33	28.89
1700:Textiles	10	20.00	20.00	40.00	80.00	100.00	90.00	60.00
2100:Paper	22	9.09	27.27	40.91	40.91	100.00	90.91	27.27
2200:Printing/Publishing	5	0.00	40.00	40.00	40.00	80.00	60.00	60.00
2320:Petroleum	10	10.00	60.00	60.00	80.00	100.00	90.00	60.00
2400:Chemicals, nec	44	4.55	36.36	34.09	56.82	100.00	86.36	43.18
2411:Basic Chemicals	25	0.00	12.50	29.17	33.33	100.00	87.50	45.83
2413:Plastic Resins	21	4.76	23.81	28.57	47.62	100.00	85.71	38.10
2423:Drugs	36	13.89	44.44	61.11	66.67	100.00	97.22	69.44
2429:Miscellaneous Chemicals	21	9.52	19.05	47.62	38.10	95.24	100.00	47.62
2500:Rubber/Plastic	23	0.00	26.09	30.43	65.22	100.00	78.26	47.83
2600:Mineral Products	7	14.29	28.57	42.86	71.43	85.71	85.71	57.14
2695:Concrete, Cement, Lime	5	40.00	20.00	40.00	80.00	100.00	100.00	80.00
2700:Metal, nec	4	0.00	25.00	25.00	25.00	75.00	25.00	0.00
2710:Steel	6	16.67	50.00	83.33	83.33	83.33	100.00	50.00
2800:Metal Products	35	5.71	42.86	37.14	57.14	97.14	82.86	51.43
2910:General Purpose Machinery, nec	54	7.41	12.96	33.33	50.00	98.15	79.63	55.56
2920:Special Purpose Machinery, nec	59	1.69	20.34	40.68	54.24	94.92	72.88	45.76
2922:Machine Tools	8	12.50	12.50	50.00	62.50	100.00	100.00	50.00
3010:Computers	20	0.00	30.00	80.00	90.00	85.00	65.00	40.00
3100:Electrical Equipment	14	0.00	14.29	42.86	57.14	92.86	78.57	21.43
3110:Motor/Generator	9	11.11	44.44	55.56	55.56	100.00	77.78	22.22
3210:Electronic Components	12	0.00	33.33	58.33	75.00	91.67	75.00	50.00
3211:Semiconductors and Related Equipment	12	0.00	41.67	66.67	66.67	91.67	75.00	33.33
3220:Communications Equipment	19	10.53	47.37	78.95	73.68	84.21	78.95	63.16
3230:TV/Radio	5	20.00	100.00	100.00	100.00	100.00	80.00	80.00
3311:Medical Equipment	60	5.00	21.67	58.33	65.00	95.00	93.33	56.67
3312:Precision Instruments	22	0.00	4.55	54.55	63.64	95.45	81.82	54.55
3314:Search/Navigational Equipment	31	3.23	38.71	58.06	45.16	90.32	74.19	51.61
3410:Car/Truck	8	25.00	37.50	75.00	62.50	100.00	37.50	50.00
3430:Autoparts	23	4.35	17.39	65.22	78.26	95.65	82.61	56.52
3530:Aerospace	37	5.41	56.76	59.46	67.57	97.30	70.27	45.95
3600:Other Manufacturing	53	3.77	22.64	35.85	56.60	98.11	86.79	43.40
ALL	765	5.75	28.27	47.38	58.77	95.81	81.81	47.91
	(s.e.)	(0.84)	(1.63)	(1.81)	(1.78)	(0.73)	(1.40)	(1.81)

[1] All industries with fewer than four observations deleted.

TABLE 9

Reasons to Patent Process Innovations: Percent of Respondents by Reason

Industry	N[1]	Measure Perf.	Licensing Revenue	For Use in Negots.	Prevent Suits	Prevent Copying	Blocking	Enhance Reputation
		Percentage of Industry Respondents						
1500:Food	44	4.55	18.18	34.09	43.18	84.09	70.45	25.00
1700:Textiles	7	14.29	28.57	42.86	85.71	100.00	100.00	42.86
2100:Paper	23	4.35	34.78	47.83	39.13	86.96	78.26	17.39
2200:Printing/Publishing	4	0.00	25.00	50.00	25.00	75.00	50.00	50.00
2320:Petroleum	10	0.00	60.00	70.00	70.00	80.00	80.00	50.00
2400:Chemicals, nec	39	5.13	23.08	17.95	48.72	78.95	55.26	23.68
2411:Basic Chemicals	25	0.00	16.00	24.00	36.00	96.00	88.00	44.00
2413:Plastic Resins	18	5.56	22.22	22.22	33.33	94.44	88.89	44.44
2423:Drugs	33	18.18	33.33	48.48	54.55	87.88	81.82	54.55
2429:Miscellaneous Chemicals	19	5.26	21.05	31.58	36.84	68.42	73.68	36.84
2500:Rubber/Plastic	17	0.00	12.50	25.00	56.25	75.00	75.00	31.25
2600:Mineral Products	6	0.00	16.67	33.33	83.33	100.00	100.00	50.00
2695:Concrete, Cement, Lime	5	40.00	40.00	20.00	60.00	80.00	80.00	60.00
2700:Metal, nec	4	0.00	25.00	75.00	50.00	100.00	75.00	50.00
2710:Steel	6	16.67	50.00	50.00	50.00	50.00	66.67	16.67
2800:Metal Products	32	3.13	28.13	40.63	37.50	68.75	50.00	37.50
2910:General Purpose Machinery, nec	42	2.38	14.29	26.19	30.95	61.90	40.48	30.95
2920:Special Purpose Machinery, nec	52	0.00	19.23	30.77	38.46	71.15	53.85	34.62
2922:Machine Tools	8	12.50	12.50	37.50	50.00	62.50	62.50	12.50
3010:Computers	17	0.00	35.29	70.59	88.24	70.59	58.82	23.53
3100:Electrical Equipment	14	0.00	7.14	7.14	14.29	50.00	35.71	7.14
3110:Motor/Generator	6	16.67	33.33	33.33	66.67	83.33	66.67	16.67
3210:Electronic Components	12	0.00	25.00	41.67	41.67	83.33	58.33	33.33
3211:Semiconductors and Related Equipment	12	0.00	41.67	50.00	58.33	91.67	58.33	25.00
3220:Communications Equipment	17	5.88	23.53	52.94	52.94	76.47	52.94	35.29
3230:TV/Radio	4	25.00	100.00	100.00	100.00	100.00	75.00	50.00
3311:Medical Equipment	54	5.56	14.81	38.89	46.30	79.63	68.52	38.89
3312:Precision Instruments	16	6.25	6.25	31.25	50.00	68.75	62.50	31.25
3314:Search/Navigational Equipment	24	4.17	20.83	37.50	37.50	62.50	58.33	29.17
3410:Car/Truck	8	25.00	25.00	62.50	50.00	87.50	37.50	37.50
3430:Autoparts	21	0.00	5.00	45.00	50.00	70.00	60.00	45.00
3530:Aerospace	35	8.57	50.00	44.12	52.94	82.35	58.82	35.29
3600:Other Manufacturing	40	2.50	12.50	30.00	50.00	82.50	60.00	35.00
ALL	674	5.04	23.25	36.96	46.50	77.61	63.58	34.03
	(s.e.)	(0.84)	(1.63)	(1.86)	(1.93)	(1.61)	(1.86)	(1.83)

[1] All industries with fewer than four observations deleted.

TABLE 10

Patenting Strategies: Product Patents

Industry	N	Cross Licensing	Fences	Player
		Weighted percentage of industry respondents		
1500:Food	45	38.45	47.81	36.84
1700:Textiles	10	4.67	92.52	4.67
2100:Paper	22	20.75	67.07	20.75
2200:Printing/Publishing	5	30.43	21.74	30.43
2320:Petroleum	10	0.86	0.50	0.86
2400:Chemicals, nec	44	4.09	53.77	4.09
2411:Basic Chemicals	24	14.57	64.57	14.57
2413:Plastic Resins	21	2.83	53.72	2.83
2423:Drugs	36	8.29	22.81	8.29
2429:Miscellaneous Chemicals	21	15.44	78.80	15.44
2500:Rubber/Plastic	23	5.43	79.35	4.89
2600:Mineral Products	7	2.63	97.37	0.00
2695:Concrete, Cement, Lime	5	28.57	39.68	28.57
2700:Metal, nec	4	0.00	47.62	0.00
2710:Steel	6	17.86	11.90	17.86
2800:Metal Products	35	7.38	30.63	7.38
2910:General Purpose Machinery, nec	54	82.31	7.78	82.31
2920:Special Purpose Machinery, nec	59	61.90	21.88	57.55
2922:Machine Tools	8	80.00	12.86	80.00
3010:Computers	20	14.43	0.00	4.18
3100:Electrical Equipment	14	20.96	52.10	19.76
3110:Motor/Generator	9	4.94	2.47	4.94
3210:Electronic Components	12	46.92	8.46	44.62
3211:Semiconductors and Related Equipment	12	56.49	1.81	56.49
3220:Communications Equipment	19	34.50	3.79	34.50
3230:TV/Radio	5	0.00	0.00	0.00
3311:Medical Equipment	60	63.81	25.46	58.41
3312:Precision Instruments	22	54.59	38.78	49.49
3314:Search/Navigational Equipment	31	70.13	9.37	69.49
3410:Car/Truck	8	98.09	0.53	0.00
3430:Autoparts	23	68.72	10.34	67.52
3530:Aerospace	37	11.62	16.39	9.02
3600:Other Manufacturing	53	24.15	47.21	23.61
ALL	764	33.51	27.59	28.24
	(s.e.)	(1.71)	(1.62)	(1.63)

TABLE 11

Patenting Strategies: Process Patents

Industry	N	Cross Licensing	Fences	Player
		Weighted percentage of industry respondents		
1500:Food	44	8.25	75.99	6.63
1700:Textiles	7	2.43	57.28	2.43
2100:Paper	23	25.50	53.15	15.51
2200:Printing/Publishing	4	45.45	0.00	45.45
2320:Petroleum	10	20.04	0.00	20.04
2400:Chemicals, nec	39	3.51	58.39	2.08
2411:Basic Chemicals	25	10.83	79.43	7.38
2413:Plastic Resins	18	1.21	61.79	1.21
2423:Drugs	33	8.73	27.38	7.58
2429:Miscellaneous Chemicals	19	15.00	39.30	15.00
2500:Rubber/Plastic	16	5.56	83.33	5.56
2600:Mineral Products	6	0.00	100.00	0.00
2695:Concrete, Cement, Lime	5	0.00	66.67	0.00
2700:Metal, nec	4	65.00	5.00	65.00
2710:Steel	6	14.29	11.90	14.29
2800:Metal Products	32	18.97	16.48	18.20
2910:General Purpose Machinery, nec	42	54.12	29.76	54.12
2920:Special Purpose Machinery, nec	52	61.26	14.62	3.42
2922:Machine Tools	8	51.43	7.14	51.43
3010:Computers	17	4.58	2.08	3.33
3100:Electrical Equipment	14	0.00	25.75	0.00
3110:Motor/Generator	6	19.61	9.80	19.61
3210:Electronic Components	12	46.92	6.15	30.77
3211:Semiconductors and Related Equipment	12	51.60	2.09	51.60
3220:Communications Equipment	17	32.03	3.60	31.33
3230:TV/Radio	4	0.00	0.00	0.00
3311:Medical Equipment	54	48.05	23.65	42.24
3312:Precision Instruments	16	36.00	26.86	36.00
3314:Search/Navigational Equipment	24	52.62	11.19	52.62
3410:Car/Truck	8	98.09	0.53	0.00
3430:Autoparts	20	57.23	17.81	56.20
3530:Aerospace	34	6.09	16.99	3.42
3600:Other Manufacturing	40	23.93	38.22	21.93
ALL	671	28.05	29.16	20.24
	(s.e.)	(1.74)	(1.76)	(1.55)

Figure 1
Effectiveness of Appropriability Mechanisms for Product Innovations

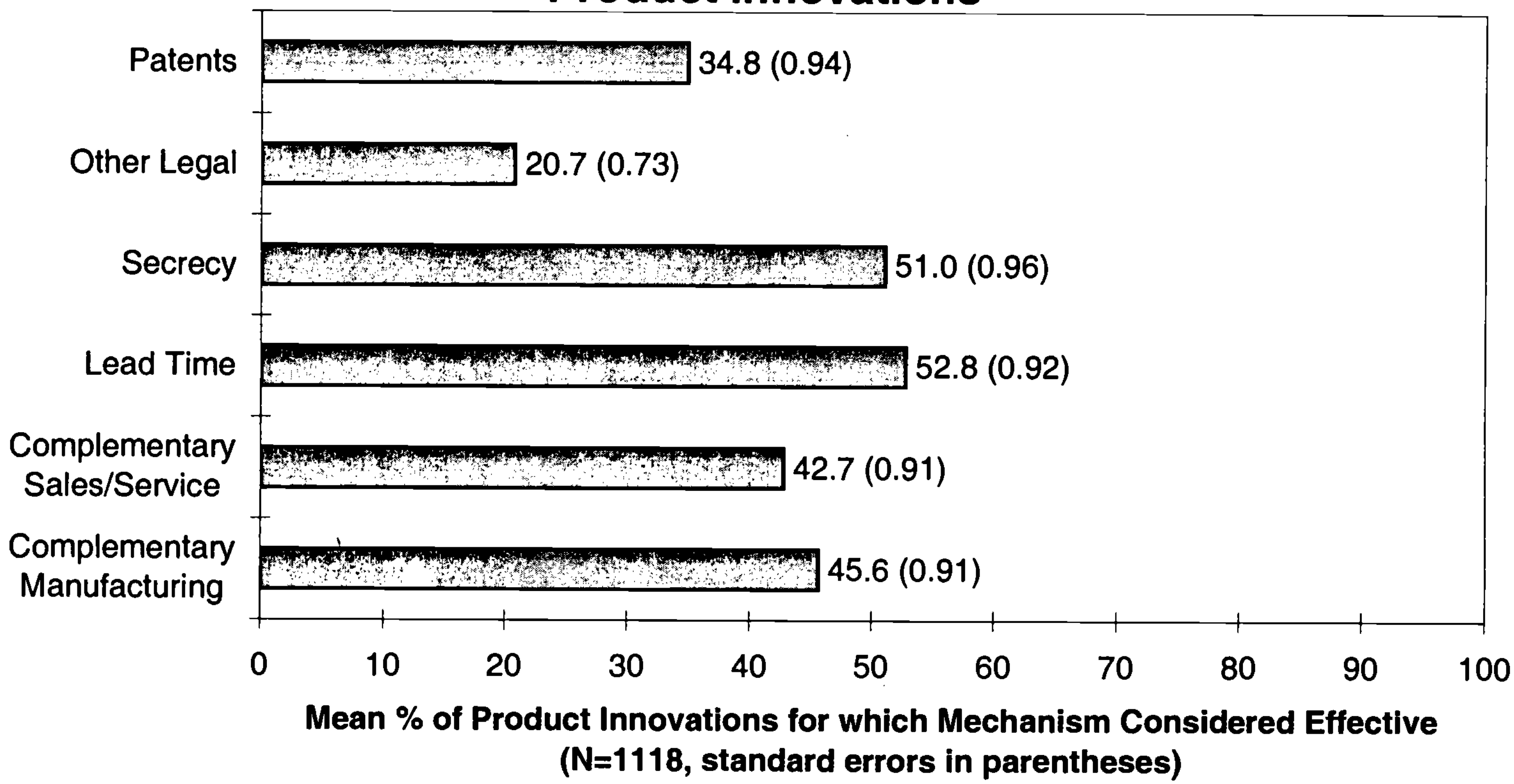

Figure 2
Effectiveness of Appropriability Mechanisms for Process Innovations

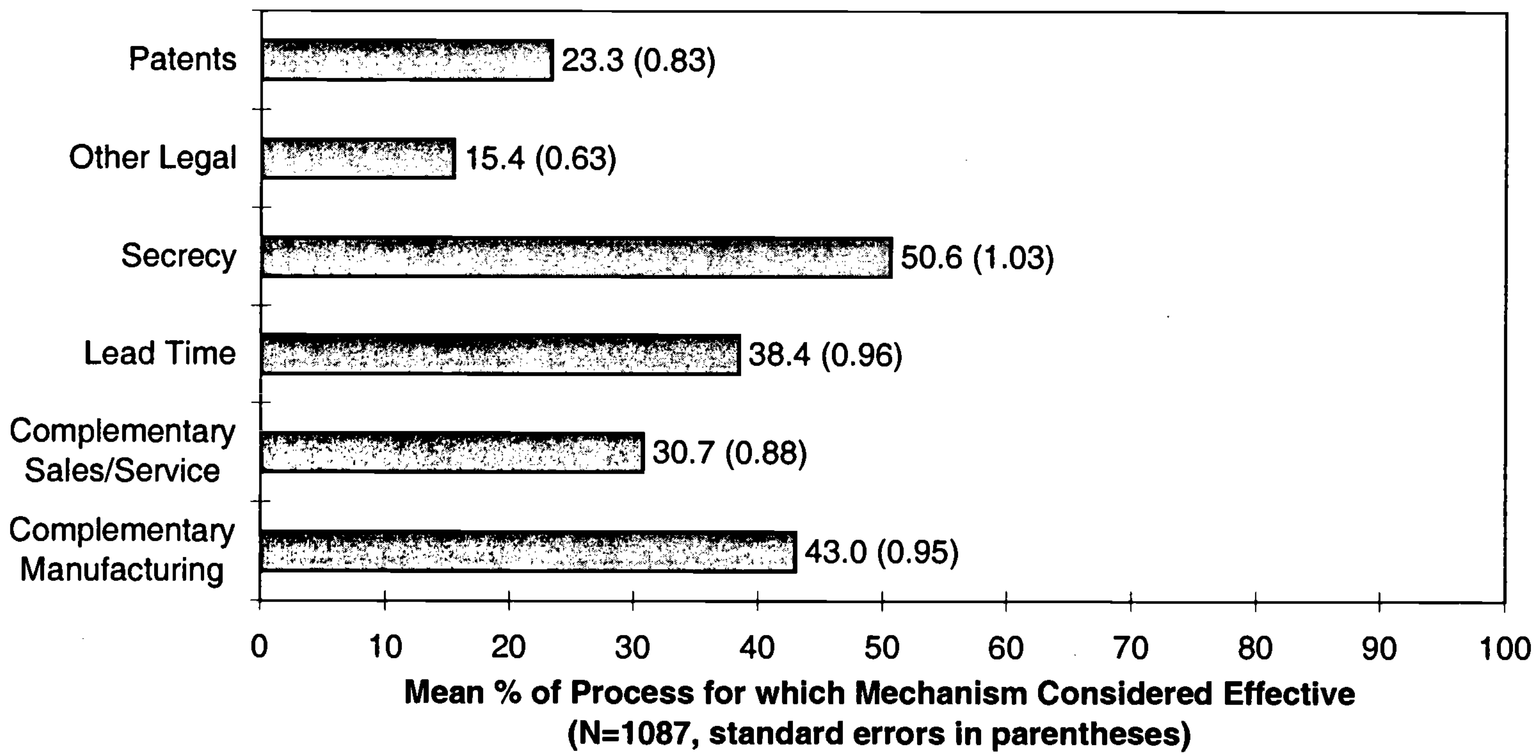

Figure 3
Effectiveness of Appropriability Mechanisms for Product Innovations for Large Firm Subsample

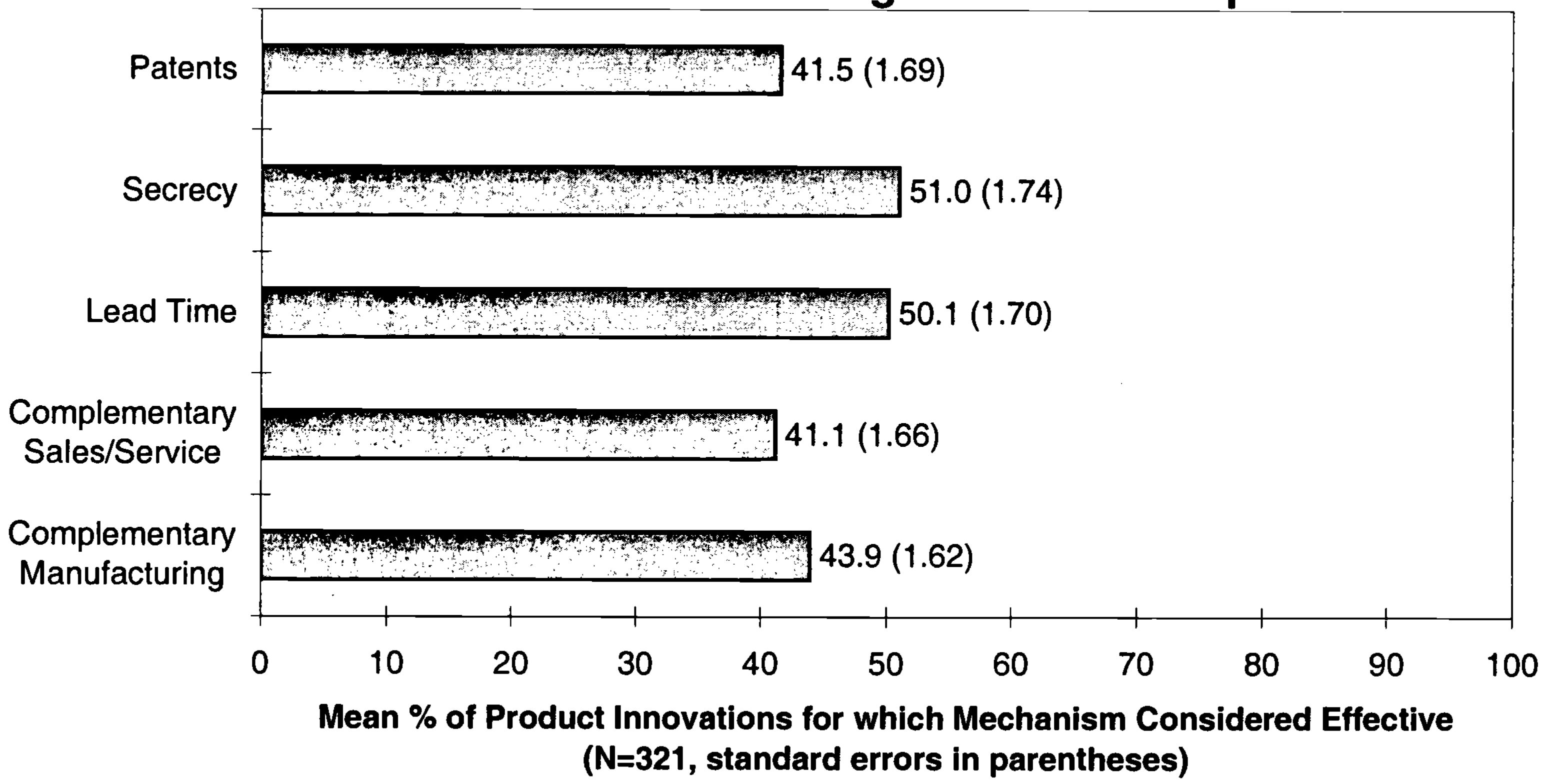

Figure 4
Effectiveness of Appropriability Mechanisms for Process Innovations for Large Firm Subsample

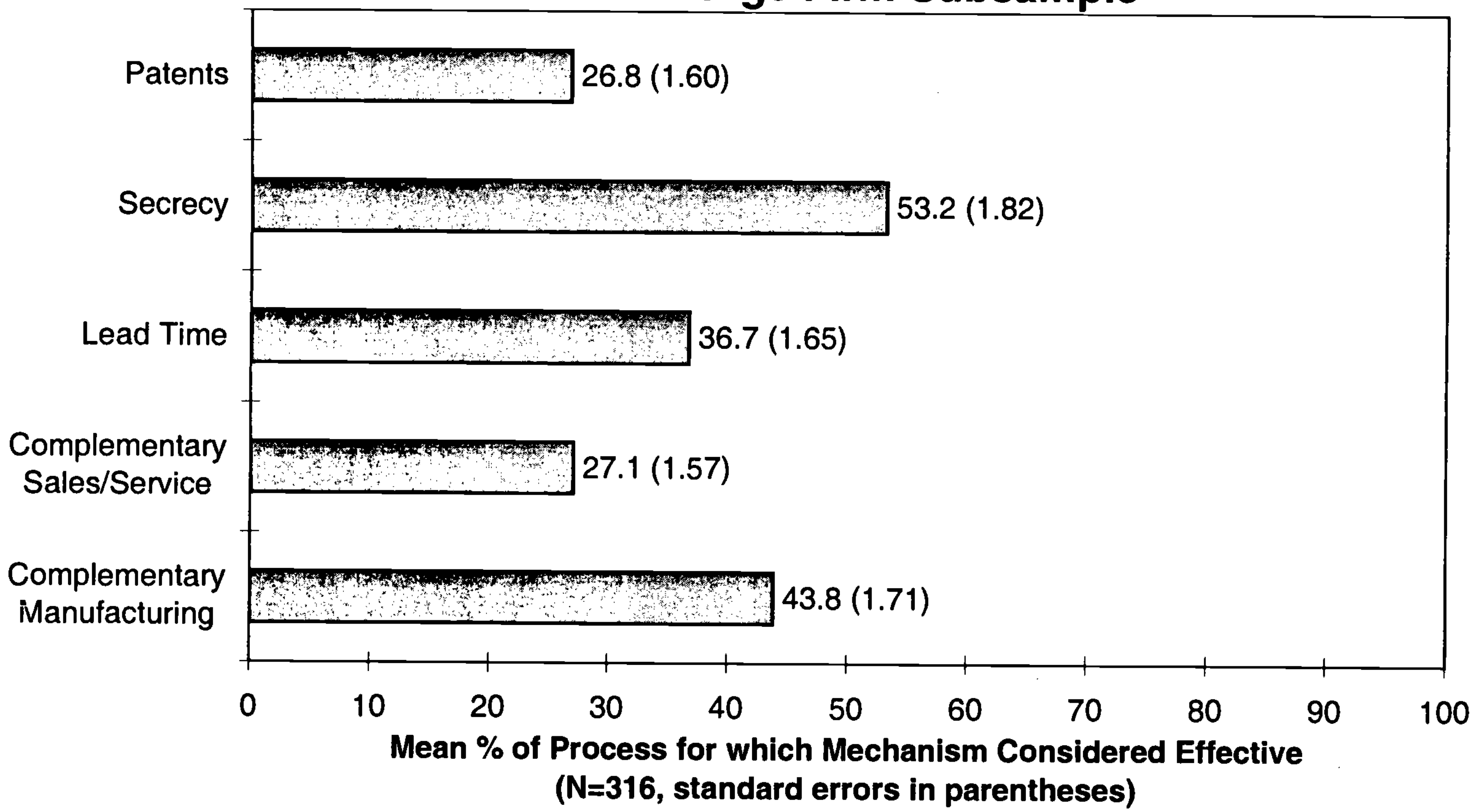

Figure 5
For Unpatented Innovations, Reasons Not to Patent

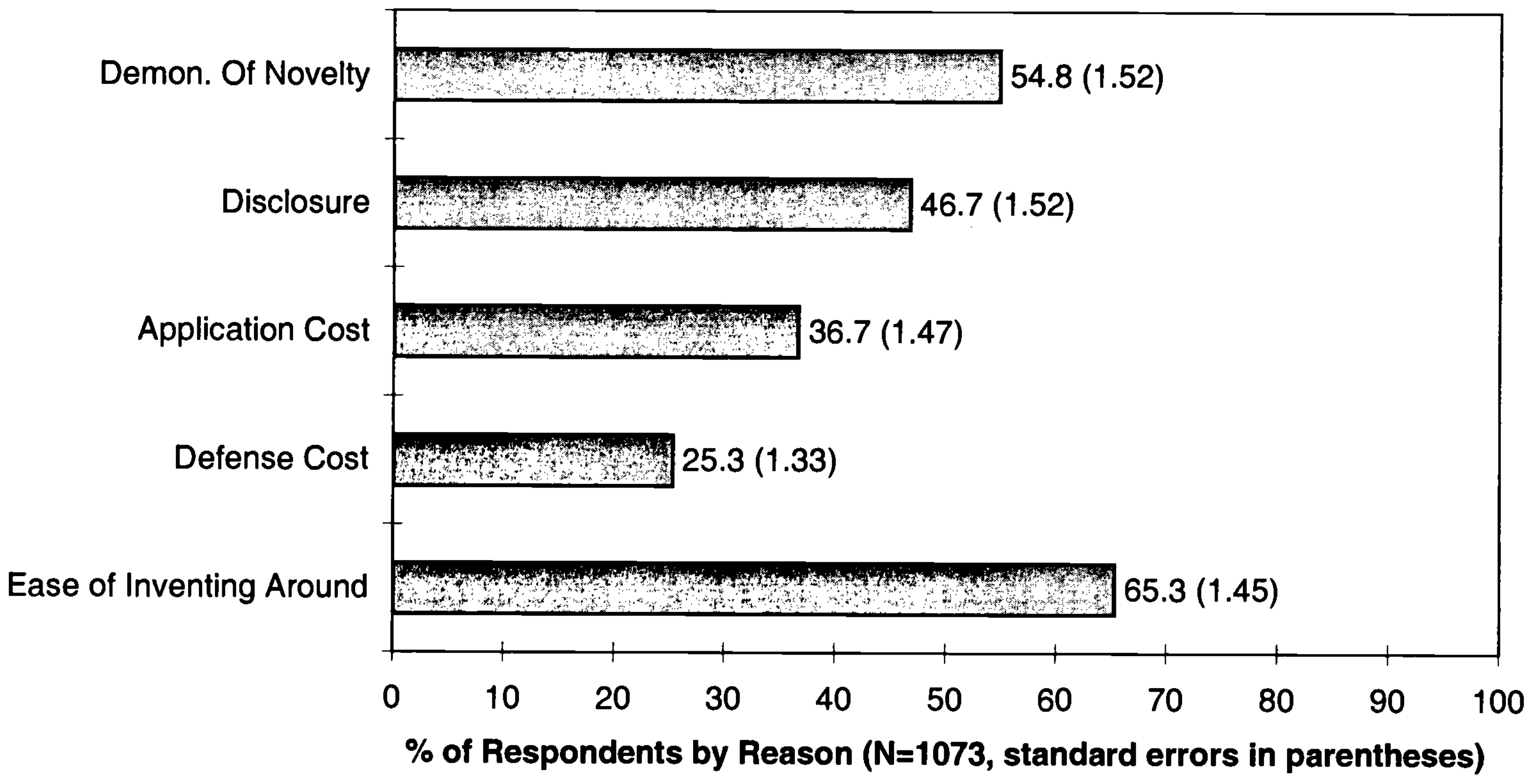

Figure 6
For Unpatented Innovations, Most Important Reasons Not to Patent

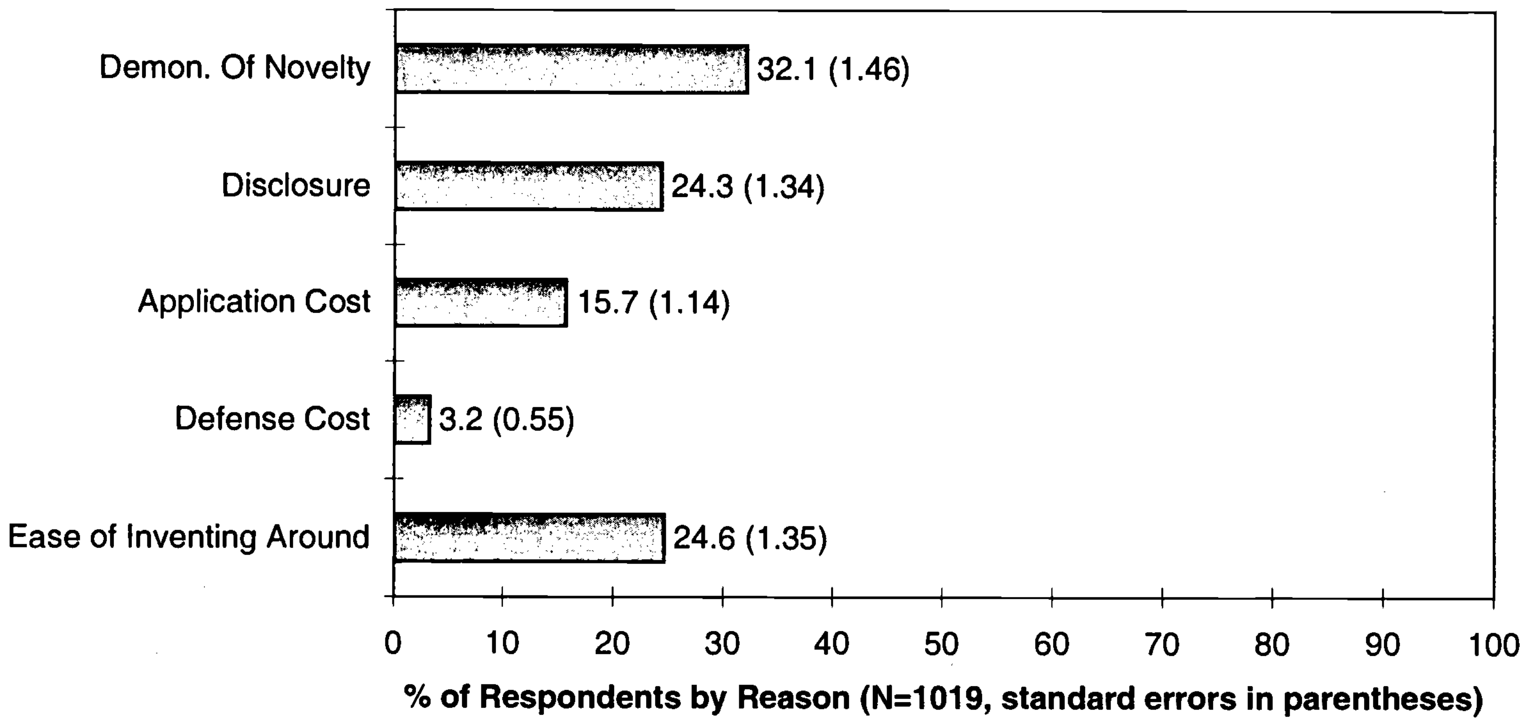

Figure 7
Reasons to Patent Product Innovations

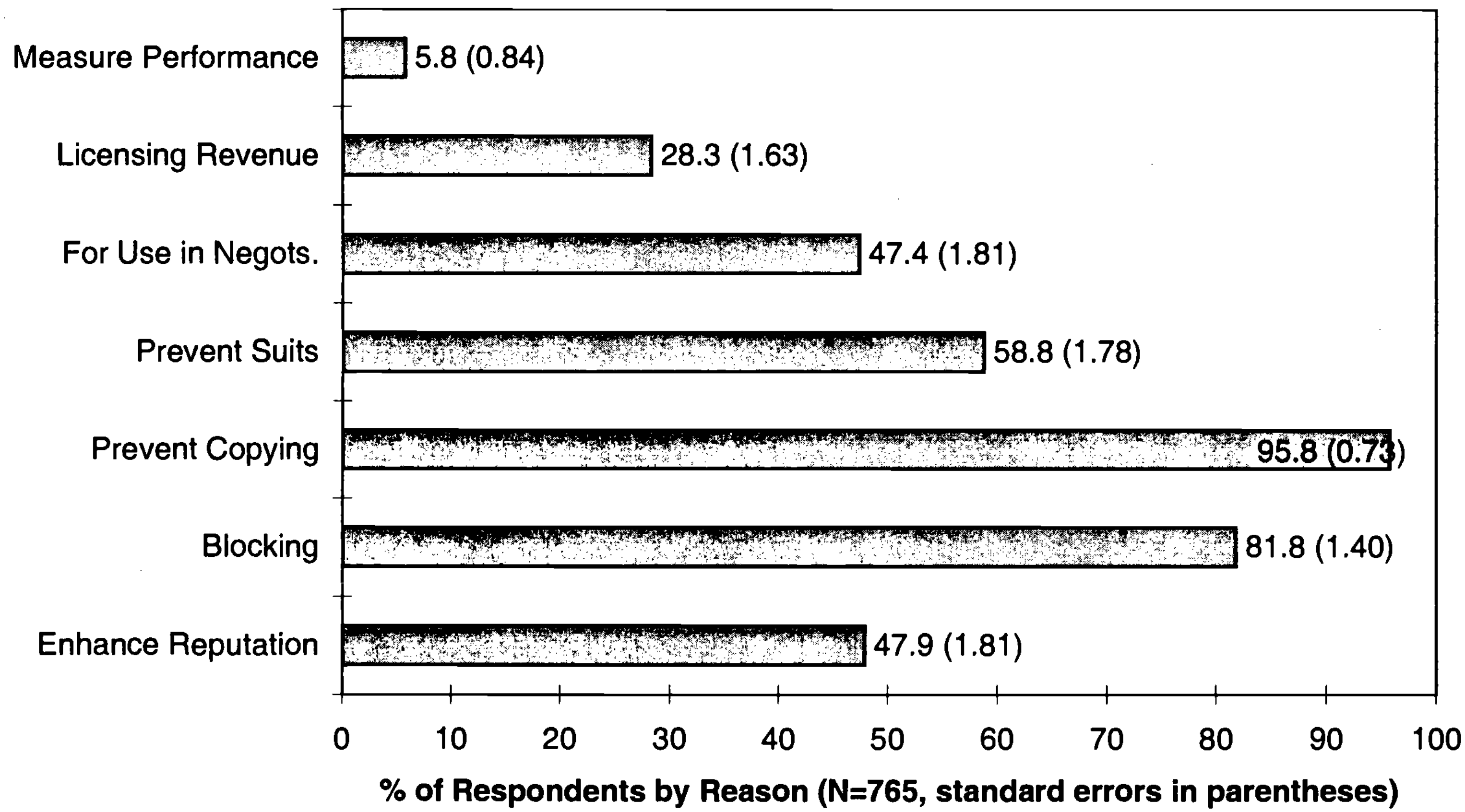

Figure 8
Reasons to Patent Process Innovations

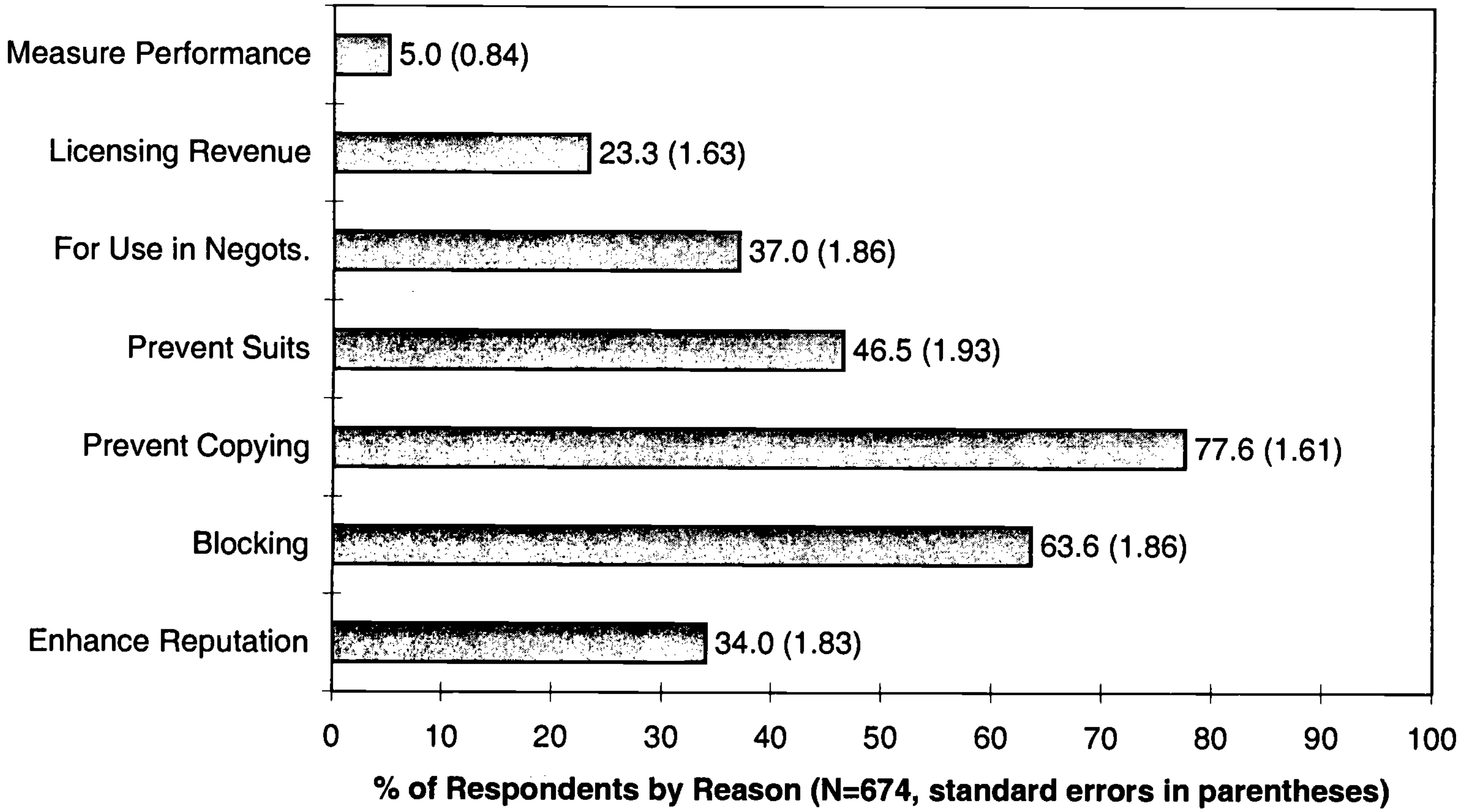

TABLE A1

Patenting Activity by Industry: In the Last Three Years, Percent of R&D Units Applying for Patents and Percent of Product and Process Innovations

Industry	N	% Applying	N	Mean[1] % Product	N	Mean[1] % Process
1500:Food	87	52.87	78.00	14.64	74.00	15.21
1700:Textiles	23	43.48	21.00	9.49	18.00	6.79
2100:Paper	31	77.42	23.00	59.19	20.00	47.99
2200:Printing/Publishing	12	41.67	12.00	44.37	12.00	19.96
2320:Petroleum	15	73.33	12.00	37.74	10.00	62.28
2400:Chemicals, nec	64	68.75	50.00	68.90	44.00	61.49
2411:Basic Chemicals	35	77.14	26.00	51.28	23.00	26.38
2413:Plastic Resins	25	76.00	20.00	24.39	20.00	35.17
2423:Drugs	49	73.47	35.00	95.50	29.00	41.85
2429:Miscellaneous Chemicals	29	72.41	21.00	57.74	16.00	15.75
2500:Rubber/Plastic	34	64.71	29.00	39.80	26.00	20.09
2600:Mineral Products	18	38.89	16.00	79.25	17.00	53.76
2610:Glass	6	50.00	6.00	5.83	4.00	2.16
2695:Concrete, Cement, Lime	10	50.00	8.00	42.11	8.00	23.80
2700:Metal, nec	7	71.43	5.00	2.97	4.00	37.38
2710:Steel	11	54.55	7.00	4.46	7.00	2.68
2800:Metal Products	44	77.27	35.00	48.78	28.00	26.55
2910:General Purpose Machinery, nec	74	74.32	60.00	45.50	49.00	27.65
2920:Special Purpose Machinery, nec	63	92.06	47.00	38.51	38.00	9.84
2922:Machine Tools	11	72.73	9.00	29.07	8.00	3.38
3010:Computers	25	80.00	19.00	38.82	16.00	26.10
3100:Electrical Equipment	21	61.90	18.00	59.16	17.00	18.65
3110:Motor/Generator	22	40.91	21.00	29.20	17.00	3.14
3210:Electronic Components	26	46.15	23.00	34.15	20.00	8.46
3211:Semiconductors and Related Equipment	17	64.71	14.00	48.51	12.00	20.60
3220:Communications Equipment	32	59.38	29.00	59.58	25.00	48.20
3230:TV/Radio	8	62.50	7.00	60.93	6.00	0.00
3311:Medical Equipment	66	89.39	51.00	66.80	42.00	31.16
3312:Precision Instruments	33	69.70	27.00	40.01	24.00	23.04
3314:Search/Navigational Equipment	37	86.49	32.00	50.24	24.00	24.43
3410:Car/Truck	9	88.89	8.00	48.63	5.00	19.62
3430:Autoparts	31	77.42	26.00	53.13	19.00	16.12
3530:Aerospace	49	77.55	42.00	50.81	37.00	35.66
3600:Other Manufacturing	85	64.71	72.00	37.05	62.00	17.22
ALL	1109	69.79	909.00	49.12	781.00	31.43

[1] Dropped respondents where sum of % Product and % Process = 100, suggesting respondent misunderstood question.