Patents

Economics, Policy and Measurement

F.M. Scherer

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Introduction

This volume reproduces selected articles I have written on various aspects of the patent system over the course of four decades.

My interest in the patent system came from the conjunction of three forces: a youthful fascination with technology that led me to enter undergraduate studies at the University of Michigan with the intention (abandoned after a year-long course) of majoring in chemistry; my reading of Joseph A. Schumpeter's *Capitalism, Socialism, and Democracy* in Shorey Peterson's economics honors seminar during the spring semester of 1954; and my decision to write on the atomic energy patent laws for the requisite honors thesis.

As the seminar was progressing, the US Congress was debating a new law whose purpose was to move atomic energy from a strictly military endeavor into the commercial realm, with electric power generation as the first of many foreseen applications. Under the US Atomic Energy Act of 1946, private patents in specific nuclear energy areas were prohibited. To encourage the development of a new commercial industry, a new law was being written, which among other things would permit patenting, but the relevant committees were struggling with the question of whether private patents would be subject to compulsory licensing. My paper, 'The Atomic Energy Patent Laws and Economic Progress', analyzed the incentive effects of compulsory licensing provisions, concluding inter alia that they were likely to have their main adverse effect on small firms' R&D investment incentives. The law eventually passed, the Atomic Energy Act of 1954, reserved compulsory licensing for inventions made under government contract and those covering 'special nuclear material' in which the government had a direct interest.

My honors thesis experience must have sensitized me to new developments in the patent field. A triggering event came in the settlements during January 1956 of two major antitrust cases, one requiring AT&T and the other IBM, to license the approximately 9,000 patents in their portfolios, in most instances without receiving royalties in return. There had been earlier compulsory licensing precedents in US antitrust settlements, some surveyed in my senior honors thesis. But the judgments of 1956 were of unusual scope, involving companies pressing the frontiers of technology. In an editorial 27 January 1956, the *Wall Street Journal* warned:

> So it may turn out that these are dangerous victories the Government boasts about. The settlements in these cases indicate a belief that everybody's patents should be everybody else's. But this is a philosophy that strikes at incentive; new ideas and new inventions may be lost. Such Government victories may turn out to be far more costly for the nation than for the companies.

Twenty months later, I was a second-year MBA student at the Harvard Business School, enrolled in the 'Manufacturing' course taught by Georges Doriot. Doriot had been a general responsible for US Army research and development during World War II and in 1957 was president of the first high-technology venture capital firm, American Research and Development Corporation. Among the requirements in his Manufacturing course was that we form groups of around nine students to conduct two hands-on projects in local companies and also to collaborate in writing a so-called 'topic report'. Our group decided for our topic report to address the question of how compulsory patent licensing under antitrust decrees affected R&D investment incentives. The idea was mine, and I was chosen as the project leader. During our Christmas vacation we fanned out to interview 22 companies, many of which had entered compulsory licensing decrees, and we later received mail questionnaires from an additional 69 companies. We also conducted statistical analyses of patenting by a broader universe of US corporations. Our findings were self-published in a monograph, *Patents and the Corporation.*[1] The first edition sold out quickly, so I rewrote parts for a revised second edition, adding new insights I had gleaned from several innovation case studies as a research assistant at the Business School.

What we learned from our interview and survey work was quite contrary to our expectations. The compulsory licensing decrees had for the most part very little adverse impact on the R&D investments of the firms that had experienced them and also of companies that might consider themselves vulnerable in the future. And indeed, the expectation of patent protection seldom played a significant role in the companies' R&D decisions. Rather:[2]

> The survey results showed clearly that competitive exigencies were far more important among established corporations as reasons for research and development than considerations of potential patent protection. Once a company has reached a point where it can regard itself as a going concern, the need to remain on an even plane with, or to surpass, competitors is a far more active incentive to do research and development than the lure of possible exclusive rewards.

Both our interviews and our statistical analysis showed, however, that compulsory licensing decrees did have some negative influence on patenting, the more so, the more directly impacted companies were. The evident reason was that companies were being more selective in applying for new patents and relying more on secrecy, especially for process inventions that were not available to others for physical inspection.

The findings we reached in *Patents and the Corporation* have since been confirmed and amplified through more sophisticated and wider-ranging surveys conducted at Yale University, Carnegie–Mellon University, the University of Pennsylvania and the University of Cambridge.[3]

Another formative experience underlay the development of my views on how the patent system works in the real world. Between 1966 and 1969, I was principal economic adviser to the Committee on Government Patent Policy (CGPP), a multi-agency task force created to study in depth how the varying disposition of patent rights to inventions made under US government contracts affected contract participation and the diffusion of patented inventions into the commercial sector. The committee's extensive findings were published in a series of volumes by the Harbridge House consulting firm. My direct contributions were made in a series of memoranda, but I summarized what I had learned from the CGPP study and other work in a 1977 monograph, *The Economic Effects of Compulsory Patent Licensing*.[4] That monograph, once virtually inaccessible, has been reprinted in a previous Edward

Elgar Publishing compendium, so no excerpts are presented here.[5] A more succinct summary of my views on how the patent system functions and malfunctions is presented in Article 1 here, which is taken from the second edition of my textbook on industrial organization.[6]

Prior to the 1969 publication of a book by William Nordhaus,[7] most of the theorizing about how the patent system balances incentives for investment in invention against the desire for maximum diffusion of inventions was murkily qualitative. Nordhaus' analysis established a new, more rigorous paradigm. Article 2 reprinted here provides my first (but not final) reaction. It generalizes Nordhaus' special mathematical assumption about the relationship between R&D spending and the extent of invention and shows how, in the more general case, one needs to consider not only the continuous relationship between patent life and the extent of invention, but also whether patent protection makes it possible to satisfy a 'benefits greater than cost' test that might otherwise not be met.

Article 3 is a brief comment on a paper by Edmund Kitch, the originator of the 'prospect theory' of patent rights. In the paper on which I commented, Kitch argues that the Xerox Corporation had no real monopoly power despite its strong patent position. I argue to the contrary, and indeed, observe that Xerox's patent protection was so strong that Xerox represented a rare historical case consistent with Kitch's prospect theory. It should be noted here that the prospect theory proposes, and the Nordhaus theory assumes, quite similar protected positions for a patent holder – a case that, I argue in Article 8 later, implies quite different welfare tradeoffs than does an alternative rent-seeking view of patents. Through my analysis of Xerox's monopoly power I provide hints as to how one derives the demand curve for a market-blocking patent.

Whether or to what extent 'inventions' involving the human genome should receive patent protection has been a controversial policy question in both the United States (which has chosen a relatively tolerant stance) and Europe (which has discouraged gene patents). Article 4 reviews the arguments, first with an overview of patent logic generally and then with a focus on the special features of genome patenting – notably, the key position of startup companies in pushing the technology forward and the strong sequential impact one generation of inventions has on the possibility of making next-stage inventions. It also reports on an empirical survey of the kinds of gene sequence patents issued in the US and the types of firms that received them. It recommends measures to ensure that prior patent positions do not close off subsequent lines of discovery.

During the 1980s, a handful of industries strongly dependent upon patent and copyright protection began intense lobbying efforts to induce third-world nations to emulate the most industrialized nations in the extent of protection they provided to so-called 'intellectual property'. They were led by the pharmaceutical industry, in which patents provide particularly strong and effective protection. Their efforts culminated during the early 1990s in an agreement that for nations to join the newly-created World Trade Organization, they had to provide a high level of patent protection, among other things, for pharmaceutical products, which many less-developed nations had excluded from patentability. As the debate evolved, I grew increasingly concerned that the world's poor nations were being blackmailed to adopt policies that were not in the best interest of their citizens. The question became a major item on my research agenda, leading to a series of papers. Article 5 provides my historical overview of the pharmaceutical patent controversy.

One argument advanced by the patent proponents is that the grant of patent rights would stimulate greater inventive effort within nations offering patents for the first time. That such a tendency would exist can hardly be denied, but how strong would the behavioral change be? On this there was little relevant evidence. Fortuitously, a natural experiment occurred in Italy, which in 1978 began granting pharmaceutical product patents after a long period of denying them. During the period of denial the world's leading generic drug supply industry took root in Italy. Fortunately, a Harvard undergraduate student, Sandy Weisburst, had the ability to read Italian and took an interest in the question as a senior thesis topic. Article 6 summarizes the results of his research. In the first decade after Italy began awarding pharmaceutical product patents, drug R&D and the marketing of new drug products scarcely increased relative to world trends, but Italy's balance of trade from generic drug exports dropped sharply. The experiment revealed that making the transition to high-technology product innovation is clearly not assured simply through a change in patent policies. To my dismay, the publishers of the journal in which our joint article appeared changed the designated order of authors; Weisburst should be considered the senior author.[8]

With the inclusion of the TRIPS (trade-related aspects of intellectual property rights) articles in the World Trade Organization treaty, how those provisions would be interpreted became a priority question, especially in view of the AIDS pandemic escalating in the third world. Article 7 is distilled from a longer paper commissioned by the World Health Organization and circulated at the WHO–WTO Høsbjør, Norway, conference in April 2001. It was written with Jayashree Watal, who served previously as a member of the Indian delegation at the WTO treaty talks. We attempted to extend the frontiers in several controversial areas. We reviewed the logic of patent protection for pharmaceutical products and examined how compulsory licensing, authorized under two articles of the TRIPS agreement, might work. Our analysis identified a lacuna – that production under compulsory license was required to be preponderantly for home consumption, but small, least-developed nations were unlikely to have the domestic capability to produce their own generic drugs under compulsory license. That lacuna was remedied through mutual agreement in August 2003 in preparation for the (otherwise unsuccessful) Cancun Round of trade negotiations. We also showed, as several other economists had done earlier, that when pharmaceutical manufacturers enjoy patent protection in all the world's nations, the best pricing strategy would be for them to engage in Ramsey-type price discrimination, charging relatively high prices in the richest nations and low prices in the poorest nations. From an analysis of AIDS anti-retroviral drug pricing in 15 nations for the years 1995–9, we found only a weak tendency toward such pricing. We identified reasons why and proposed changes to encourage the optimal policy. In fact, the price front broke in 2001, triggered by offers from Indian generic drug producers, who were not yet bound by first-world patent laws, and encouraged by the consensus reached at Høsbjør. Thus, in the years that followed, anti-retrovirals were available to third-world nations at prices much lower than in the first world. The final section of the article explores a loophole in US tax law to show how under certain conditions pharmaceutical makers can actually increase their after-tax profits by giving away drugs to charitable health-care organizations.

During the approximately eight years I struggled with the problems posed under TRIPS for the supply of pharmaceuticals to low-income nations, it was clear that a theory of optimal patent protection richer than the one originated by William Nordhaus was needed. Article 8 is the fruit of that struggle. It combines a generalization of the Nordhaus invention inducement theory with a rigorous approach to measuring the benefits of various patent regimes in rich and poor nations, assuming the Ramsey pricing recommended in Article 7. It adds a component that is seldom utilized in economists' benefit–cost analyses, but which I considered vital to addressing the value-laden question of third- vs first-world equity in patent questions – weighting benefits by the ratio of the marginal utility of income for poor consumers relative to the marginal utility for rich consumers. It shows that for plausible values of that ratio, global welfare is higher if low-income nations are not required to provide strong patent protection on pharmaceutical products invented in the first world. An important distinction is made between what might, given Article 3, be called the Nordhaus–Kitch prospect view of invention inducement mechanisms and rent-seeking models, which differ by assuming that R&D outlays rise to exhaust discounted quasi-rent potentials. The case for third-world free-riding on first-world inventions is shown to be stronger in the rent-seeking case, which, empirical evidence suggests, appears to reflect real-world tendencies more closely.

Patents are of interest to economists not only because of their incentive role in stimulating technological innovation, but also because they provide a potential lever for the difficult task of measuring the rate and direction of inventive activity. During the 1960s Jacob Schmookler and I collaborated in extending the art of using patent statistics as instruments of measurement.[9] Articles 9 through 17 stemmed from that collaboration, at first directly and then, after Schmookler's untimely death in 1967, by inspiration.

I had already used patent data for *Patents and the Corporation* to measure statistically how compulsory licensing affected corporate patenting. Further exploratory work was carried out in an econometrics paper for Hendrik Houthakker at Harvard in 1962. The first project on which I embarked as a new assistant professor at Princeton in 1963 was to compile what at the time was considered a large database on patenting and, to a more limited extent, R&D employment by 448 large American manufacturing corporations. Article 9 attempted a definitive test of various structural hypotheses derived from the work of Joseph A. Schumpeter, notably, that large corporations provide more fertile soil for research, development and technological innovation than small firms, and that innovative activity is more intense in industries dominated by only a few firms (that is, tight oligopolies) than in atomistically structured industries. The analysis supported for the most part a rejection of the Schumpeterian hypotheses, recognizing to be sure possible exceptions, given the substantial diversity of industrial circumstances. I presented the results inter alia in September 1965 at a conference in Fontainebleau, France, where French finance minister (later president) Valery Giscard d'Estaing and others, persuaded by Schumpeterian theorizing, argued that Europeans could best catch up to the US juggernaut technologically by creating large national 'champion' enterprises dominating the industries they occupied. I argued then (joined by several other Americans attending the conference) that they were mistaken. The hindsight of 40 years and numerous European industrial policy failures supports my skepticism much more than their optimism.

In Article 10, I extended the 448-company database to analyze how inventive activity, measured by patents, affected corporations' sales growth and profitability. This was one of those hypotheses everyone knew to be true, but which had at the time very little systematic statistical support. The results confirmed the hypotheses, but showed also that the business cycle had an important confounding influence. The linkages I found have been confirmed in numerous subsequent studies.

In our occasional meetings during the 1960s, Jacob Schmookler and I debated whether technological changes were triggered more by 'demand-pull' influences or advances in the science and technology base, which I named 'technology-push' inducements. In Chapter VIII of *Invention and Economic Growth*, Schmookler proposed an ingenious synthesis of the contending hypotheses: technological advances were responsive to the pull of demand, but the industrial locus from which the advances originated followed patterns of specialization, with industries enjoying the richest science and technology bases contributing a disproportionate share of advances, which they sold across industry boundaries to meet less well-endowed industries' demands. He conceptualized this idea as a kind of input–output matrix, but did not live long enough to implement the concept empirically. Having worked during the mid-1970s at the US Federal Trade Commission to collect an extraordinarily detailed set of data, including R&D expenditure data, broken down by narrowly-defined line of business, I took up the challenge in the late 1970s where Schmookler left off. To advance toward the goal, I had a team of four unusually bright Northwestern University students analyze 15,112 US invention patents obtained by 443 corporations, ascertaining from the printed specifications for each patent and information on company product lines by geographic location the industry in which the invention originated as well as the industry(ies) expected to derive benefit from the invention. The patent data were then linked to R&D data in the Federal Trade Commission files. Article 11 provides the main descriptive result of this grueling data collection effort. It shows rich flows of technology from originating industries to using industries and reveals inter alia why agriculture, mining and many service industries have enjoyed rapid rates of productivity growth even though they performed at the time (and most still do perform) very little research and development. The productivity consequences were analyzed more fully in separate articles not reprinted here.[10]

Article 12 makes further use of the industry-linked patent data to retest for a much broader array of industries. Schmookler's finding that inventive activity, measured by patents assigned to the industries using the inventions, was responsive to the pull of demand. Schmookler's basic hypothesis is confirmed, although not as strongly as in *Invention and Economic Growth*, and less so for industrial materials inventions than for the capital goods inventions his original analysis emphasized. One of the most striking results came from distinguishing between capital goods inventions made within the industry using them and those made by other industries and sold in inter-industry transactions. The correlation with demand variables was if anything stronger for the inter-industry transactions than for inventions made in response to demand within the inventing firm's own sphere of operation. Markets for technology transmit their incentive signals remarkably well!

The linked patent and R&D data were used again in Article 13 to determine differences in industries' 'propensity to patent', which I defined as differences in the number of patents received per million dollars of R&D expenditures. Fairly wide differences are observed – from 0.45 patents per million dollars in motor vehicles to 3.20 patents in stone, clay and glass products. Various qualitative and quantitative hypotheses explaining the reasons for these differences are explored. The data are also used to achieve new insights into the Schumpeterian firm size hypotheses tested earlier in Article 9. At the individual line of business level, the probability that at least one patent will be obtained rises nonlinearly, the higher R&D outlays are. Counts of the number of patents received per line of business rise most often proportionately with R&D outlays, and next most frequently with a diminishing returns tendency. Again, the Schumpeterian firm size hypotheses are not supported.[11]

Linking 15,112 patents to the lines of business that originated them and then tracing their effects through a chain of inter-industry sales was a prodigiously labor-intensive operation. The question nagged at me, was there an easier way? Article 14 revisits the topic, constructing a matrix of inter-industry technology flows under the assumption that inventions are traced more easily to the industries in which they originate, after which they can be flowed out to using industries in rough proportion to the patterns of inter-industry sales recorded in input–output matrices periodically published by the US Department of Commerce (and by other governments' statistical agencies). The answer is, similar results can be obtained, although there are some differences, and difficult methodological questions must be resolved and new data classifications must be undertaken to do the job satisfactorily. Because it is generally similar to the matrix included with Article 11, the detailed inter-industry technology flows matrix originally published with Article 14 is omitted in the version reprinted here.

In using patents to measure the amount, origins and uses of inventive activity, one is well-advised to be sensitive to the limitations of one's yardstick. Articles 15 to 17 reflect this concern.

Rather than constructing a matrix of technology flows through the laborious examination of individual patents, as my team did for Article 11, it was suggested during the early 1980s that a concordance from US Patent Office classes to industries, devised by Patent and Trademark Office staff, be employed. At an early stage of our linking project we attempted to use patent classifications, but found them ill-suited to the task, since many emphasize generic technological characteristics (for example, 'article dispensing', 'furnaces' and 'measuring and testing') that might be conceived or used in any industry. To illustrate this point more generally, a selection of 100 patents from our sample of 15,112 was linked to industries through the Patent Office concordance and, alternatively, through our reading of patent specifications and information on the products manufactured in establishments where the inventors worked. Disagreement rates of up to 49 percent, mostly attributable to problems in the Patent Office concordance, were reported in Article 15. My experience since then suggests that the International Patent Classification is more useful than the US classification for industry linkings, since it is organized mainly by industries rather than narrow technological features. Even then, it is hard to tell for inventions sold across industry lines whether an origin industry or a using industry has been identified.

In my research during the early 1960s for Article 9, I happened upon a small sample for which George Washington University researchers had identified through survey methods the profitability of individual patents. I also attended a seminar at which Benoit Mandelbrot discussed the extraordinary statistical properties of highly skew distributions of the Pareto form, that is, with a few outlying extreme values. When Pareto α coefficients are below 1.0, such distributions are characterized by asymptotically infinite means and variances. A crude test with the George Washington University data suggested that the profitability distribution might be Pareto with α less than 0.5, leading me to conclude that 'patent statistics are likely to measure run-of-the-mill industrial inventive output much more accurately than they reflect the occasional strategic inventions which open up new markets and new technologies'. Those inventions, I continued, must remain the domain of economic historians.

This worry remained latent for a quarter century until an opportunity arose during the late 1990s to take advantage, with the collaboration of Dietmar Harhoff, of data generated during 1977, the last year in which patent protection could be obtained in Germany only through domestic patents without the complication of newly-authorized Europatents. We selected what were likely to be the most valuable patents as those running to full term because their holders had paid annual renewal fees totalling DM16,075 (about $7,500 at 1986 exchange rates). We then sought to ascertain through telephone and face-to-face interviews with patent holders the economic value of each such patent. A smaller parallel sample was drawn for the US. Using these peculiarly rich data, we found in Article 16 that the distribution was indeed highly skew, as expected, but that it was more likely to conform to a tolerably well-behaved log normal form rather than the Pareto form. We also found that patent value estimates made using our direct methods were several hundred times higher than those derived by other scholars through inferences based only upon patent renewal rates. The main reason for the difference is that renewal rate studies assume that through non-renewal the patent holder forgoes only the right to exclude others from using the invention but does not surrender its own right to use the invention, whereas our counter-factual question assumed that the patent holder would surrender the right to use its own invention. With our US patent sample we were able to estimate that the aggregate profitability of the selected inventions exceeded the total amount spent on research and development by the patent-holding companies in 1976, the most likely year of invention.

Article 17 carries our analysis of the patent value data further. In it, we discovered that the most valuable patents tended to be cited most frequently in subsequently issued patents. Patents not renewed to full term were in turn cited less frequently on average than those for which renewal fees were paid over the maximum patent life of 18 years. A richer analysis of the German data (not reprinted here) uncovered additional ascertainable correlates of patent value.[12] Notably, those German patents that were targeted for and survived external 'opposition' proceedings proved to be especially valuable.

The implications of highly skew payoff distributions are profound. Basically, the law of large numbers works poorly, or with extreme Pareto distributions, not at all.

This means that portfolio strategies lose their effectiveness in ensuring that if one invests in a large enough number of projects, returns on investment will converge toward stable averages.[13] Article 18 carries the findings from our skewness research in new, more speculative directions. Is it possible that skewness – that is, the fact that relatively few investments yield most of the returns – is actually a positive motivating force, rather than a factor discouraging investment through risk aversion? The selection provides a theoretical explanation why those who take high-technology plunges might be skewness lovers, advancing complementary evidence from the analysis of horse race betting. Further investigation of the behavioral implications is very much to be desired.

Notes

1. The authors, listed in approximate order of their contributions to the book, were F.M. Scherer, Sigmund Herzstein, Alex W. Dreyfoos, William G. Whitney, Otto J. Bachmann, Cyril P. Pesek, Charles J. Scott, Thomas G. Kelly and James J. Galvin; 1958, *Patents and the Corporation: a Report on Industrial Technology under Changing Public Policy*, Boston, MA.
2. Ibid., p. 149 of the revised edition.
3. See Richard C. Levin et al., 'Appropriating the Returns from Industrial Research and Development', *Brookings Papers on Economic Activity* 3, 1987, 783–820; Wesley M. Cohen, 'Patents and Appropriation: Concerns and Evidence', *Journal of Technology Transfer*, **30**, January 2005, 57–71; Edwin Mansfield, 'Patents and Innovation: An Empirical Study', *Management Science*, **32**, 1986, 173–81; and C.T. Taylor and Z. Aubrey Silberston, *The Economic Impact of the Patent System: A Study of the British Experience*, Cambridge: Cambridge University Press, 1973. An important anticipatory publication was Arnold Plant, 'The Economic Theory Concerning Patents for Inventions', *Economica*, **1** new series , February 1934, pp. 30–51.
4. New York University Graduate School of Business Administration Monograph Series in Finance and Economics, 1977.
5. Ruth Towse and Rudi Holzlhauer, *The Economics of Intellectual Property*, International Library of Critical Writings in Economics, Cheltenham, UK and Northampton, MA, USA: Edward Elgar, 2002, vol. II, pp. 315–400.
6. In the third edition, the chapter on patents was combined with other material and is therefore not used here.
7. *Invention, Growth, and Welfare: A Theoretical Treatment of Technological Change*, Cambridge, MA: MIT Press, 1969.
8. After serving a term as a Supreme Court clerk, Weisburst is now an associate with the Mayer, Brown, Rowe and Maw law firm.
9. Schmookler's magnum opus was *Invention and Economic Growth*, Cambridge, MA: Harvard University Press, 1966.
10. F.M. Scherer, 'Inter-Industry Technology Flows and Productivity Growth', *Review of Economics and Statistics*, **64**, November 1982, 627–34; and 'R&D and Declining Productivity Growth', *American Economic Review*, **73**, May 1983, 215–18.
11. For additional results, see F.M. Scherer, 'Technological Change and the Modern Corporation', in Betty Bock et al. (eds), *The Impact of the Modern Corporation*, New York: Columbia University Press, 1984, 286–93.
12. Dietmar Harhoff, F.M. Scherer and Katrin Vopel, 'Citations, Family Size, Opposition and the Value of Patent Rights', *Research Policy*, **32**, 2003, 1343–63.
13. See F.M. Scherer and Dietmar Harhoff, 'Technology Policy for a World of Skew-Distributed Outcomes', *Research Policy*, **29**, 2000, 559–66.

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PART IV THE ROAD AHEAD

PART I

ECONOMIC ANALYSIS AND POLICY