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Rolling Equilibriums at the Pre-Commons Frontier:
Identifying Patently Efficient Royalties for Complex Products

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ABSTRACT

Patent pricing problems have roiled industry in recent years. The biggest challenge is splintered in-licensing of thousands of patents for a single behemoth product. The universal fog in allocating royalties creates license pseudo-anti-commons, where willing parties have conflicting expectations. The resulting social costs and transfer inefficiencies are widely mistaken for the effects of real anti-commons.

I formulate a pricing solution here. It begins by viewing patents as a rippling pre-commons—a perimeter of private property between public domain and unknown technical terrain. I show that the momentum of the perimeter's point migrations provides a ready basis for comparing and differentiating closely related patent value, and that a portfolio of patent rights has a progressive equilibrium of value. Thus, a patent's claim significance can be amplified in proportion to its art's market diffusion to derive an objective comparative figure of merit for utilitarian impact, which allows rational profit splitting.

This new framework is the first to address the full spectrum of objective patent valuation factors, and does so in a rational, efficient, reproducible, and fact-sensitive way.

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I. INTRODUCTION: A PERFECT STORM IN PROGRESS

Software developers have a full menu of contract pricing methods based on labor costs.[1,2] These include fixed price, cost plus, fixed rate, and management surcharges. The prices may further be adjusted based on code length, work duration, degree of complexity, inflation, and turnaround speed. Yet unless there is a profit-sharing partnership, developer pricing is unrelated to the utilitarian value of the product. Imagine, then, the confusion that results when accountants must determine not the cost but the value of using certain tools and paradigms in software development. Further, imagine that hundreds of different tools and paradigms are employed in a single development project, and that some tool values are not assessed before billions of lines of code are finished for the ultimate product. Then, consider IBM's or Microsoft's plight in licensing such rights from hundreds of parties for a behemoth software product. If all licensor hopes were met, royalties would siphon away the entire revenue stream, yet no

[1] Personal communication (March 2008) from Frank R. Denton, Jr. (Lt. Col., USAF, ret.), a former project manager and budget analyst for the U.S. Air Force and Secretary of Defense as well as for Comsat, Contel, and General Scientific defense contracts.

[2] For a concise document on use of several variants for pricing developmental software, see standards (in English) established under Taiwan's Government Procurement Act, Art. 22, para. 2 (promulgated on May 17, 1999, amended on Dec. 1, 2002), at Articles 12-20 of the *Regulations for Selection and Fee Calculation of Information Services Providers Entrusted by Entities*, available at http://www.pcc.gov.tw/upload/article/ed34.pdf (last visited July 9, 2008).

one can identify fair relative pricing. The conditions are ripe for a perfect storm of delays, disputes, and social costs.

That scenario is not hypothetical, yet surprisingly to date the scholarship and public debate on patent licensing logjams has overlooked the effect of pricing dilemmas on transfer efficiencies for invention rights. For instance, a recently published book on the need to reform the U.S. patent system explores virtually every aspect of patents, including an entire chapter discussing what they are worth to their owners, but says nothing about the fog in pricing.[3] Meanwhile, courts continue to struggle with the long-prevailing *Georgia-Pacific* test for assessing infringement damages, yielding notoriously unpredictable results.[4] Congress has been skeptical about judicial efficiency in this area, but a bill on infringement damages that passed the U.S. House of Representatives in 2007 continued to focus on qualitative factors instead of the missing mechanics for pricing.[5] There is indeed a perfect storm of discontent, but it cannot be calmed by trimming rights or imposing merely qualitative rules unless we eliminate patents altogether.

In this paper, I provide and explain a pricing approach that can resolve the problem of splintered licensing. In the sections that follow, Part I sets the stage by discussing the commons and anti-commons as they apply to patents, and shows that the pricing bottleneck is a pseudo-anti-commons. I explain that the aggregate migration of rights (due to constant technology capture and patent term expiration) provides an analytically useful physical analogy to enable value comparisons within a large portfolio of such rights. Part II briefly surveys the landscape of historical patent valuation methods, with their respective pros and cons, and explains why a real options method represents the best choice. This section then explains that patent metrics have a poor track record as value indicators primarily because they overlook many operational points at which commercialization commonly breaks down. By contrast, my method describes already-realized invention value, and is applied when commercialization has been successful or is nearly complete. I use simple metrics to amplify patent claim contributions (weightiness) in proportion to growth of their technical field's importance (velocity), deriving an objective figure of merit (momentum) for utilitarian impact. This allows rapid differentiation of value within the equilibrium of change embodied in a rights portfolio, enabling rational royalty splits for private ordering and judicial remedies. Part III reviews some shortcomings of the *Georgia-Pacific* infringement damages rule, but discusses how features of the new algorithm, when fitted with my prior-published patent pricing algorithm based on real options, uniquely satisfies all *Georgia-Pacific*

[3] *See* JAMES BESSEN & MICHAEL L. MEURER, PATENT FAILURE: HOW JUDGES, BUREAUCRATS AND LAWYERS PUT INNOVATORS AT RISK 79-80, 189-91 (2008) [hereinafter Bessen & Meurer]. The authors mount copious quantities of economic data as evidence for their proposition that the patent system has gone so far awry that it is a failure for which reformation is long overdue. Chapter 5 (pp. 95-119) discusses what patents are worth to their owners. Among symptoms cited as problematic are perceived patent thickets especially for software inventions.

[4] *See* Trell v. Marlee Elecs. Corp., 912 F.2d 1443, 1447 (Fed. Cir. 1990) ("[T]he actual calculation of the royalty . . . involv[es] more the talents of a conjurer than those of a judge.").

[5] *See* H.R. REP. NO. 110-1908, available at http://thomas.loc.gov/cgi-bin/bdquery/z?d110:H.R.1908 (last visited July 12, 2008) (passed September 7, 2007). Its corresponding bill S. 1145 remained in committee. The House version as passed would have added new requirements for infringement damages analysis in 35 U.S.C. 284(b).

requirements and does so with unprecedented precision and justifiability. This qualifies the new model for immediate judicial adoption, even under existing case law. Part IV discusses the method's further implications.

II. CALMING A STORMY THEATER OF THE COMMONS

Much effort has been invested judicially, theoretically, and commercially to seek paths by which many competing prerequisite interests may be satisfied before a technology is commercialized. In particular, logjams of converging monopolies have attracted comment. One proposed solution would sharply limit abstractions in claims, thereby narrowing their scope and interpretation.[6] Another would provide expedited or more expert review of questions on patent validity and infringement.[7] Still another would sharply raise patent renewal (i.e., maintenance) fees to compel inventors to abandon patents on less profitable inventions.[8] A more sweeping option is general compulsory licensing under a statutory scheme as provided by many foreign nations to enable use of further improved third-party inventions.[9] However, compulsory schemes assume that patent pricing has efficient mechanisms, whereas I will show here that it does not. Thus compulsory licensing would only tend to add to the turmoil. I find that an understanding of the shifting frontier in the relationship between monopolies and the public domain sheds more light. The theory of the commons and its relationship to the anti-commons illustrate the commercial context and elements of this model.

A. Setting the Stage: The Commons and Its Tragedies

It will be recalled that rural villages historically had public green areas—commons—that were often a few centrally located acres. In principle, the local government could regulate use of a commons, but in many cases locals were free to graze their livestock there as they pleased. In modern times, governments have created an intangible equivalent to a commons, namely the public domain from which intellectual property rights cannot be privately (re)captured by a patent or private ordering.[10] Yet commons—and by extension public domain—have a recognized disadvantage that bears discussion in order to set the stage for subsequent sections.

Because of the unrestricted use, medieval village commons were overgrazed.[11]

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[6] *See e.g.*, Bessen & Meurer, *supra* note 3, at 239-41.

[7] *Id.* at 241-42.

[8] *Id.* at 247-48.

[9] *See, e.g.*, ANTHONY D'AMATO & DORIS ESTELLE LONG, EDS., INT'L INTELL. PROP. ANTHOLOGY, 310-17 (1996).

[10] *See, e.g.*, Eileen Kane, *Patent Ineligibility: Maintaining a Scientific Public Domain*, 80 ST. JOHN'S L. REV. 519 (2006), available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=833564 (regarding unpatentable subject matter); s*ee also* North American Container, Inc. v. Plastipak Packaging, Inc., 415 F.3d 1335 (Fed. Cir. 2005) (barring the grant of reissue patent claims that recapture subject matter surrendered during prosecution to obtain the original patent); *cf.* U.S.P.T.O., MANUAL OF PATENT EXAMINING PROCEDURE § 1412.02 (2008) [hereinafter MPEP].

[11] WILLIAM FORSTER LLOYD, TWO LECTURES ON THE CHECKS TO POPULATION (Oxford University Press, 1833).

Hardin famously rationalized this on the basis of asymmetric division of positive and negative utility. On the positive side, each herder received all proceeds from each additional animal that can be supported by access to the commons; on the negative side, the pasture was slightly degraded by each additional animal.[12] As a result, each rational herder reached the same conclusions concerning self-interest, so overgrazing and damage to the commons were inevitable. Hardin called this the tragedy of the commons due to the "remorseless working of things."

Hardin's observations were nothing new: the economic incentives and disincentives had been recognized from ancient times.[13] His greater contribution was in deriving prescriptive implications, and not merely by restating the problem in antiseptic, utilitarian algebra. He noted that the tragedy embodies a category of problems that can be addressed effectively only by modification of human values (for instance, "quality of life") as opposed to purely technical solutions. Then, he showed that the concept has surprising power and adaptability to illuminate the basis and remedies for overuses caused by human population growth, whether they involve natural or non-natural resources. Hardin proposed fencing and policing vulnerable common resources by deliberate means, because self-interested individuals are not guided by conscience alone.

B. Anti-Commons as Phantom

Heller identified an opposite to the commons—an anti-commons—that represents a tragedy at the other extreme.[14] There the property of interest is not publicly owned, yet no one can use it practically. For a contrast with the commons, imagine a square mile of prime pasture divided into 1000 different parcels of varying size, shape and terrain, with each parcel owned by a different party and only a few parcels adjacent to a public road or path. In order for parcels distant from public access to be grazed lawfully, permission must be obtained to move livestock across the land of at least a dozen other owners. Parcel non-uniformity makes pricing comparisons difficult for the private right-of-way. Some owners may be hard to contact. And some may be reluctant to negotiate. But the value of grazing just one of the 1000 parcels is not enormous because each can support only a few animals. Thus, even though title is clear and the land may be good, without ancillary rights the outlying landlocked lots may be useless or even go abandoned (i.e. transaction costs and or opportunity costs are too high).[15] This lack of practical utility is

[12] Garrett Hardin, *The Tragedy of the Commons*, 162 SCIENCE 1243, 1244 (1968).

[13] THUCYDIDES (ca. 460 B.C.-ca. 395 B.C.), HISTORY OF THE PELOPONNESIAN WAR, Book I, Sec. 141, (Richard Crawley trans., 1910). "[T]hey devote a very small fraction of time to the consideration of any public object, . . . each fancies that no harm will come to his neglect, . . . and so, by the same notion being entertained by all separately, the common cause imperceptibly decays." BENJAMIN JOWETT, THE POLITICS OF ARISTOTLE: TRANSLATED INTO ENGLISH WITH INTRODUCTION, MARGINAL ANALYSIS, ESSAYS, NOTES AND INDICES (1885), Vol. 1 of 2 (translating ARISTOTLE (384 B.C.-322 B.C.), POLITICS, Book II, Chapter III, 1261b. ". . . that which is common to the greatest number has the least care bestowed upon it. Every one thinks chiefly of his own, hardly at all of the common interest; and only when he is himself concerned as an individual."

[14] Michael A. Heller, *The Tragedy of the Anticommons: Property in the Transition from Marx to Markets*, 111 HARV. L. REV. 621, 621-88 (1998) [hereinafter Heller (1998)].

[15] *See also* Michael A. Heller, *The Boundaries of Private Property*, 108 YALE L. J. 1163, 1172 (1999) (noting that laws forbidding consolidation of small parcels of land may have the same result).

the so-called tragedy of the anti-commons. Heller identified actual anti-commons, noting that retail rights in post-communist Eastern European buildings are divided between so many parties that the buildings remain vacant and merchants sell goods in kiosks outside.[16] The anti-commons concern for patents is that "rights are held by so many different patentees that the costs for anyone to accumulate all the required licenses to enable production [are] prohibitive."[17]

For patents, two dimensions or flavors of hypothetical anti-commons are commonly recognized. Patent gridlock might occur where underlying products are so large, complex, and advanced that they require licenses from many different patentees, some of who may be negotiation hold-outs or may demand unreasonable shares of the profits. The products are already ripe in patent gridlock. By contrast, innovation disincentive may occur where mere research and discovery requires licensing from many different patentees, or possibly from a small number of very dominant patentees. Thus, Heller and Eisenberg have argued that the competition between patent rights in biomedical research (among other important areas) could prevent useful and affordable products from reaching the marketplace.[18] Especially where research tools are patentable, innovation disincentive has been a concern in the literature. Whatever the extent of the phenomena, strictly speaking, patent anti-commons of any type are transient because the rights will expire at latest within 20 years. Of course, most inventors and entrepreneurs cannot afford to wait that long. Also, the innovation anti-commons is speculative because it concerns, in part, what might be discovered or invented, whereas the progress of R&D is famously unpredictable.

As it turns out, examples of innovation declines due to third party patents are few and isolated, even in fields for which the patenting of research tools is common. It appears that a combination of regulatory policy and private ordering has made innovation lock-outs more the exception than the rule. For instance, the director of the technology transfer office for the federal National Human Genome Research Institute (NHGRI) at the National Institutes of Health (NIH) has noted the following for technologies such as diagnostic methods to which patent licenses or sub-licenses are refused to third parties:

> In my 10 or 15 years of doing this, I hear the same five examples or six examples repeated over and over. We can all name them by heart: BRCA1 and 2, Myriad Genetics, hemochromatosis; Canavan's disease. It's the same ones. Are there any new ones? Is it just these few that are exceptional? . . . I really think there are only a few, and I think it's the same ones over and over again. . . . I haven't heard any new examples recently.[19]

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[16] Heller (1998), *supra* note 14, at 643-47.

[17] Maureen O'Rourke, *Toward a Doctrine of Fair Use in Patent Law*, 100 COLUM. L. REV. 1177, 1179 (2000), available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1005650#PaperDownload.

[18] Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCIENCE 698, 698-701 (1998).

[19] Claire Driscoll, *Federal Sector Role*, National Institutes of Health (NIH) Secretary's Advisory Committee on Genetics, Health, and Society (SACGHS) Meeting Transcript (March 26-27, 2007), available at http://oba.od.nih.gov/oba/SACGHS/meetings/Mar2007/transcripts/fullday3-27.pdf (last visited April 23, 2009) [hereinafter Driscoll].

That director, Claire Driscoll, also explains that even the recognized lock-ups have occurred mostly only because universities in particular tend to grant exclusive patent licenses, thus while doing little innovation itself Athena Diagnostics amassed a monopoly on certain breakthroughs in neurological diagnostic tests, and refused to sublicense the rights to others.[20] Charges for the proprietary testing were considered exorbitant when that business model emerged.[21] By contrast, Driscoll's agency seldom grants exclusive licenses except under a Cooperative Research and Development Agreement (CRADA), and even then the license is limited to no more than the party needs to commercialize. Moreover, she notes that several major universities have signed on to a policy recommended in a white paper by the Association of University Technology Managers (AUTM) that she says is nearly identical to the NIH policy document (for favoring non-exclusivity).[22]

In fact, Driscoll's perceptions seem to have been correct. Economic studies have turned up little empirical evidence that the rise in biotechnology patenting had adversely affected innovation,[23] possibly because patent ownership was diffuse,[24] though diffuseness may (or may not) validate the concerns about whether there are too many competing patent rights. Some very extensive studies found that scientific researchers themselves have also reported few or no negative effects from the proliferation of patents.[25] S.A. Rose's observations of effects from judicial trends are consistent with

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[20] Driscoll, *supra* note 19, at 28 (characterizing Myriad Genetics and Athena as "the most hated" diagnostics companies, and stating that for neurological diagnostic tests, "out of those dozens and dozens of patents end licensed by Athena, only three did they develop in-house. The rest they end-licensed. They have mostly exclusive licenses. Nobody else can do these genetic tests except Athena, and they have a policy just like Myriad Genetics of not sub-licensing. So if you want that test done, you have to go to Athena. It's probably not a great public health situation.").

[21] *See, e.g.*, Bill Malone, *Proprietary Lab-Developed Tests: Responding to Innovation or Skirting Regulation?* CLINICAL LABORATORY NEWS, Dec. 2008, at 6, available at http://www.aacc.org/publications/cln/2008/december/Pages/CovStory2Dec08.aspx (last visited April 22, 2009) ("[C]ompanies like Myriad Genetics with its BRCA test for inherited breast cancer risk and Athena Diagnostics with its ApoE test for risk of Alzheimer's disease were making a name for themselves with novel tests that looked for links between genes and disease risk. These and a handful of other companies became the predecessors of the current boom in the proprietary test service market. . . . At first, the high cost of these early test services raised eyebrows. Take Myriad Genetics for example. When the company first began marketing its BRCA test for hereditary breast cancer, they charged more than $3,000. 'That was unheard of then . . . . It seemed like a fortune. Now people don't even blink. The insurers don't even blink.'" (quoting Shara Rosen and referring to Shara Rosen, DIAGNOSTIC TEST SERVICE COMMERCIALIZATION: A ROADMAP TO DIAGNOSTICS IN THE 21ST CENTURY (Kalorama Information 2008))).

[22] Driscoll, *supra* note 19, at 27-28.

[23] David E. Adelman & Kathryn L. DeAngelis, *Patent Metrics: The Mismeasure of Innovation in the Biotech Patent Debate*, 85 TEX. L. REV. 1677, 1709-29 (June 2007), *available at* http://www.utexas.edu/law/conferences/ip/AdelmanPaper.pdf (last visited July 8, 2008) [hereinafter Adelman & DeAngelis]; *see also* John P. Walsh *et al.*, *Effects of Research Tool Patents and Licensing on Biomedical Innovation*, in PATENTS IN THE KNOWLEDGE-BASED ECONOMY 28, 331-36 (Wesley M. Cohen & Stephen A. Merrell eds., 2003) [hereinafter Walsh, *Effects of Research Tool Patents*]; John P. Walsh *et al.*, *View From the Bench: Patents and Material Transfers*, 309 SCIENCE 2002, 2002 (2005).

[24] Adelman & DeAngelis, *supra* note 23, at 1698-1706.

[25] *See* Ronald Bailey, *The Tragedy of the Anticommons: Do Patents Actually Impede Innovation?* REASON MAGAZINE, Oct. 2, 2007, *available at* http://www.reason.com/news/show/122785.html (summarizing research findings from the National Academy of Sciences (2003 and 2006), NATURE

these results: the number of patent applications increased significantly during 1892-1930 and after 1983, when courts looked favorably upon patents.[26] That is, the appearance of patents did not act to down-regulate innovation or later patents, as might be indicative of anti-commons. Of course, alternative explanations exist for that observation.

It is possible that some fields of art are more susceptible to innovation suppression than others, and it has been argued that software is a special case.[27] Thus, Bessen and Hunt have published economic evidence from which they deduce that software patents act as substitutes for R&D at the firm level and are associated with lower R&D intensity (primarily by manufacturing firms) in industries known for strategic patenting.[28] Theirs is a controversial position, especially because other economic studies of strategic patenting and software R&D investment report that though Bessen and Hunt's data trends can be validated, their conclusions cannot.[29,30] If patenting truly represents innovation, then the innovation-suppression argument is self-limiting, because if suppression actually occurs then rates of patenting should stall. However, proponents instead cite increasing rates as evidence of anti-commons, which would be the case only if innovation and patenting have rates relatively independent of each other.[31]

Yet evidence for patent gridlock seems to be as limited as the evidence for suppression of innovation. New computer chips still enter the market. New behemoth software products are still launched. New biotech products continue to appear. Those are the three fields most commonly discussed in the patent anti-commons literature, yet their

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BIOTECHNOLOGY (2006) and the American Association for the Advancement of Science (2007)). There was little evidence of anti-commons, and third party patents were said to be rarely responsible for project delays and never for cancellations; in fact, the same experience seems to be global based on thousands of surveys from the United States, Germany, United Kingdom and Japan.

[26] Simone A. Rose, *Patent "Monopolyphobia": A Means of Extinguishing the Fountainhead?,* 49 CASE W. RES. L. REV. 509 (Spring 1999) (noting business boom and bust cycles might explain the economic result).

[27] Bessen & Meurer, *supra* note 3, at 201-14.

[28] James Bessen & Robert M. Hunt, *An Empirical Look at Software Patents*, (Federal Reserve Bank of Philadelphia Working Paper No. 03-17/R, 2004), *available at* http://www.researchoninnovation.org/swpat.pdf (last visited July 8, 2008).

[29] Michael Noel & Mark Schankerman, *Strategic Patenting and Software Innovation*, (London School of Economics, Center for Economic Performance, Discussion Paper No. 740, 2006), *available at* http://cep.lse.ac.uk/pubs/download/dp0740.pdf (last visited July 8, 2008) ("This finding suggests that the expansion of patentability over software during the 1980s and early 1990s was not associated with any major changes in R&D investment by these software firms as of the end of our sample period. Whether the expansion of software patentability will eventually intensify innovation incentives remains an important, but open, question. Nonetheless, we emphasise that our findings contradict the controversial claim by Bessen and Hunt (2003).").

[30] *See also* Robert Hahn & Scott Wallsten, *A Review of Bessen and Hunt's Analysis of Software Patents* (Nov. 2003), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=467484, and the response by James Bessen & Robert M. Hunt, *A Reply to Hahn and Wallsten* Federal Reserve Bank of Philadelphia (March 10, 2004), *available at* http://209.85.165.104/search?q=cache:uNuq-2HJ3wcJ:www.researchoninnovation.org/hahn.pdf+patent,+bessen,+Hahn+and+Wallsten+(2003).&hl=en&ct=clnk&cd=1&gl=us.

[31] *See* John H. Barton, *Reforming the Patent System*, 287 SCIENCE 1933 (2000) (arguing that the growth in patenting rates was more strongly correlated with growth in the number of intellectual property lawyers than with the amount of research).

commercial innovation continues despite the myriad of third-party patents that may need to be licensed. One explanation for this robustness is that most firms simply ignore the universe of patents.[32] Observations consistent with that view suggest that most infringement is inadvertent.[33]

However, a number of other observations suggest that free markets also find more deliberate ways to limit gridlock efficiently. For example, some firms practice "patent flooding" when patent applications for broad, basic inventions are published.[34] After applications in Japan were "laid open" 18 months after filing, competitors would smother valuable inventions with dozens or hundreds of follow-on applications on every conceivable improvement,[35,36] to create leverage for (cross-)licensing the basic invention on favorable terms.[37] It also appears that hold-outs are not especially common in thickly patented industries and that at least large players in a mature industry cross-license their portfolios even to competitors.[38] In another practice, competitors design around patents. Design-arounds, together with the illusory quality of density in patent thickets, are likely responsible for the fact that only a small percent of patents are ever useful in licensing or

[32] Lemley, Mark A., *Ignoring Patents* (July 2007) (Stan. Pub. L. Working Paper No. 999961), Mich. St. L. Rev., Vol. 2008 (2008), *available at* http://ssrn.com/abstract=999961 (arguing that innovation has not been crushed only because researchers and companies in affected industries virtually universally ignore third party patents at all stages of endeavor).

[33] Christopher A. Cotropia and Mark A. Lemley, *Copying in Patent Law*, (2009) (Stan. Pub. L. Working Paper No. 1270160), *available at* http://ssrn.com/abstract=1270160 (arguing that inadvertent infringement occurs in essentially every patent case outside the chemical and pharmaceutical industries).

[34] Frederick J. Telecky, Jr. (Senior Vice President and General Patent Counsel, Texas Instruments), Statement for the FTC/DOJ Hearings on "Competition and Intellectual Property Law and Policy in the Knowledge-Based Economy" (Submitted June 03, 2002), *available at* http://www.ftc.gov/opp/intellect/020228telecky.pdf (last visited July 8, 2008) [hereinafter Telecky]. Note the term "patent flooding" here is not entirely coextensive with the term "patent flood" as used by Bessen & Meurer, *supra* note 3, at pp. 68-71 to describe the rise in U.S. patent rates.

[35] This should be kept in perspective. Formerly, Japanese patents were limited to a much narrower claim scope than U.S. patents. *See, e.g.*, Hatsushi Shimizu & Stephen B. Maebius, *Maximizing the Value of Biotechnology Patents in Japan*, 19 BIOTECH. L. REPORT 1, 1-6 (Feb. 2000), *available at* http://www.liebertonline.com/doi/abs/10.1089/073003100320948?cookieSet=1&journal Code=blr (last visited July 11, 2008). To preempt improvements requires more of the narrow patents. Note that flooding is not foolproof because the claims are often prophetic and implausible for at least some variations they include. When the author searched literature on electrically conducting polymers for his Ph.D. dissertation, in a striking number of Japanese patent abstracts for apparently follow-on flooding, he noted highly improbable methods and materials among listed variants.

[36] The apparent thinking in the described practice is that the original applicants would want to adopt some of the inventions covered by the improvement patents or might cross-license just to avoid infringement themselves.

[37] Yet patent flooding can be foiled. During the author's years in Motorola's Energy Products Division in the 1990's, the company faced aggressive competition from mostly Japanese firms for battery products. The company's standard practice for a valuable, proprietary, battery-related new invention was to file for both a basic patent and several improvement patents, thus creating a "picket fence" (the company's term) to preempt competitive filings.

[38] *See* Telecky, *supra* note 34 (discussing patent cross-licensing); *see also* Texas Instruments, Inc. v. Hyundai Elecs. Indus., Co. Ltd., 49 F. Supp. 2d 893. Indeed, the possibility of mutual infringement seems to drive both patenting and licensing, thus scholars should view patents more seriously as not just offensive but also defensive weapons.

litigation.[39] Network effects and non-rival qualities may also drive licensing, as in C.M. Rose's "Comedy of the Commons" whereby a resource becomes more valuable when many individuals use it (i.e. a patentee has more to gain by growing markets through a license than by exclusivity).[40]

Other factors that rationalize the absence or dispersion of gridlock are the well-known phases of industry cycles.[41] An industry in its introductory and growth stages often has many players, competing choices, and diverse and abundant low-hanging fruit because no participant is big enough to capture all the easy opportunities. There, few players find themselves completely locked out of chosen markets by patents. The proliferation of computer manufacturers in the 1980s, dot-com firms in the 1990s and bioscience ventures today illustrates this pattern. After an industry reaches maturity, i.e., expands to the full extent of available perceived opportunity, the competition becomes fierce, and the industry consolidates as less efficient players are acquired or shuttered when prices fall. But typically at that point key product features have already been standardized and inventions are more incremental. Otherwise, inventions at this stage would create unprecedented market opportunity. Also, in the maturity and decline of an industry each surviving player already has a core technology and sustainable market strategy. So anti-commons may be moot or avoided in both young industries (because they offer many growth alternatives) and mature industries (because firms are established and have leverage to build or cross-license).

In addition, and possibly counter-intuitively, in highly competitive markets the window of opportunity tends to be defined by how quickly the first entrants can ascend the learning curve to scale up production and marketing. Late-comers are often locked out not by the lack of access to patent rights but because they cannot compete economically with the established parties.[42,43] Thus, this factor likewise suggests that the

[39] *See* Telecky, *supra* note 34 (discussing design-arounds and his rule of thumb that few patents are useful for licensing or litgation).

[40] Carol M. Rose, *The Comedy of the Commons: Commerce, Custom and Inherently Public Property*, 53 UNIV. CHI. L. REV. 711 (1986), *reprinted in* CAROL M. ROSE, PROPERTY AND PERSUASION: ESSAYS ON THE HISTORY, THEORY AND RHETORIC OF OWNERSHIP (1994).

[41] For general discussion of life cycles for products and industries, see EVERETT M. ROGERS, THE DIFFUSION OF INNOVATIONS (1962); Theodore Levitt, *Exploit the Product Life Cycle*, HARV. BUS. REV. 81-94 (November-December 1965); PHILIP KOTLER, MARKETING MANAGEMENT: ANALYSIS, PLANNING, AND CONTROL, 6th ed., ch. 11 (1984); and ROBERT M. GRANT, CONTEMPORARY STRATEGY ANALYSIS, 3rd ed., 242-52 (1998).

[42] *See* GRANT, *supra* note 41, at 251 ("Once the **growth stage** is reached, the key challenge is scaling up. As the market expands, the firm needs to adapt its product design and its manufacturing capability to large-scale production. ... [I]nvestment in R&D, plant and equipment, and sales tends to be high during the growth phase. To utilize increased manufacturing capability, access to distribution becomes critical. At the same time, the tensions that organizational growth imposes create the need for internal administrative and strategic skills."); s*ee also id.* at 272 ("The essence of [the competitive advantage that innovation confers] is **lead time**: the innovator has the opportunities to invest in further technical development, production facilities, and market position that will be available to rivals only in the future. The critical issue is to exploit it effectively and not allow the opportunity to pass.").

[43] Another distinction is the difference between sequential advances (essentially improvement patents based directly on a prior invention), and complementary advances (essentially parallel but non-identical kindred pathways) for semiconductor and software R&D. *See* James Bessen & Eric Maskin, *Sequential Innovation, Patents, and Imitation* (Dept. of Econ., Mass. Inst. of Tech.,Working Paper No. 00-01, Jan.

industrial context may be much more important than the distribution of patent ownership when discussing whether an anti-commons exists.

C. The Pricing Bottlenecks as Pseudo-Anti-Commons

If there is not in fact a prolific demonstrable incidence of patent anti-commons, then why does a debate about it continue to rage in the scholarly literature and popular press? I would argue that they suffer from an erroneous but unexamined assumption that widespread inefficiency in the transfer of patent rights can be caused only by a poor design of those rights. Recall that our recent national dialogue on the subject has focused almost exclusively on the relative merits of proposals to trim patent rights, such as by curtailing their interpretation, scope, subject matter, etc. Certainly U.S. patent policy might benefit from some of these changes, but the discussion of rights has overlooked the consequences of pricing (and thus licensing) difficulties, which cannot be rectified by modifying rights apart from eliminating patents altogether.

Consider a case in which each party genuinely wants to do a licensing deal and would readily accept an offer at demonstrable fair market value, but neither one can identify a rational, neutral way to price the deal. Eventually, the deal will likely get done, but it may not happen until after protracted negotiations, each side trying to convince the other to adopt its own best guess on price. Particularly, because licensors often have unrealistic opinions of the importance of their patents whereas licensees know all too well the limits on profit potential, there may be good-faith frustration on both sides. Further, suppose that the developer of a behemoth product must successfully negotiate and close hundreds or thousands of such deals with third parties. A presumed remedy such as compulsory licensing would only feed the pricing bottleneck.[44] The pricing headaches of split royalties would also survive the other legal reforms proposed to date (such as limiting claim scope), with the exception of patent abolition. Each patent is unique, after all, and few have trading histories or useful comparable sales data from which to calculate a value. I will also show below that the available financial science for patents has been weak historically.

In fact, market hang-ups over patent pricing are much more common than are those due to hold-outs or anti-commons. An intensive search by Microsoft failed to find even one published method for partitioning value and corresponding royalties rationally

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2000) *available at* http://www.researchoninnovation.org/patent.pdf (last visited July 8, 2008). The potential effect of these distinctions on ripeness for an anti-commons is not clear, nor is its possible relation to phases of the industry cycle. But hypothetically, as a field becomes more crowded the average number of patentably distinct parallel paths to any new invention could begin to dwindle.

[44] But note that the United States has long abhorred compulsory patent licenses. "[The patentee's] title is exclusive, and so clearly within the constitutional provisions in respect of private property that he is neither bound to use his discovery himself nor permit others to use it." Bement v. National Harrow Co., 186 U.S. 70, 90 (1902). The policy does protect patentees, since it prevents parties from developing a patent's own workaround with the aid of a compulsory license. But patent rights are essentially commercial, and thus, even they tend to be for sale voluntarily at the right price. The question then is *how can parties recognize the right price?*

when many patents must be licensed for a single product.[45] The company licenses thousands of third-party patents, and reports that many licensors believe their respective inventions are more valuable than all others—to the extent that if all preliminary demands were satisfied the aggregate cost of royalties would substantially exceed the total amount of revenues from the products.[46] In theory, a licensee could just explain its commercial realities to each licensor, but on what basis will the prospective licensee explain why a patent on the table is not superior (and thus worth a higher respective royalty) to hundreds of others supporting the same product? And what licensee has the time or even sufficient wisdom for effective claim-by-claim value comparisons of that many patents anyway?

Generally, willing parties find a way to muddle through a deal, but the process inefficiency represents a social cost. That cost increases when inadvertent infringement is discovered or when a third party litigates its patent. There the licensee has less leverage with which to negotiate a commercially rational rate, and still lacks a compelling benchmark for pricing. The courts are in no better position to find the solution, given that they rely upon industry experts for their information, so their damage assessments will necessarily be arbitrary and unpredictable. Thus, we have not so much an anti-commons as a pseudo-anti-commons, where complex products begin to sink slowly but perceptibly into a bog of unavoidable inefficiency under the weight of their own licensing requirements and intrinsic limits on rationality.

How much difference would it make to have effective pricing mechanisms in the absence of other patent reforms? History suggests the effect might be huge, as illustrated by pricing inefficiencies that existed for options on stocks and commodities before the mid-1970s.[47] Traditionally, the options market had been morbid because pricing calculations were so tedious that most parties and brokers did not bother. The pioneering Chicago Board Options Exchange (CBOE) was launched in 1973 to try to create a market in these instruments. The user-friendly Black-Scholes option pricing model appeared the same year, was adopted by the CBOE two years later, and option sales skyrocketed. Twenty-five years after the CBOE's launch it was handling thirty-two million trades in a quarter, and three other options exchanges had also sprung up. Options finance was further validated by the 1997 Nobel Prize in economics to Robert Merton and Myron Scholes, for their work dealing with the equation. Thus, improving the mechanics of

[45] Communications to the author during a non-confidential telephone conference with senior Microsoft financial and technical personnel, Matt Gordon, Director of IP Acquisitions, Microsoft Corp.; Yongbai Choi, IP Acquisitions & Investments Manager, Microsoft Corp.; and Dr. Allen Brown, Jr., Software Architect/Senior Program Manager, Web Data Access Group, Microsoft Corp., in Redmond, Wash. (Dec. 8, 2006) [hereinafter Microsoft Conference Call].

[46] *Id.*

[47] For an example of a seminal option pricing publication, see Fischer Black & Myron Scholes, *The Pricing of Options and Corporate Liabilities*, 81 J. POL. ECON. 637 (1973) (introducing a statistical equation for rapid options pricing); Robert C. Merton, *Theory of Rational Option Pricing*, 4 BELL J. ECON. & MGMT. SCI. 141 (1973) (showing how to factor out dividend effects on option value). *See also* Carol Bere, *Exchange-traded equity options come of age*, GLOBAL FINANCE (June 1998) *available at* http://findarticles.com/p/articles/mi_qa3715/is_199806/ai_n8793098 (last visited July 12, 2008). Bere offers a 25th anniversary retrospective on CBOE, which was launched April 26, 1973 by Robert Rubin (later Pres. Clinton's second Treasury Secretary) and recorded 911 transactions the first day.

pricing had a huge impact on satisfying the pent-up pressure from both supply and demand for futures that remain among the most popular financial instruments today. Therefore, if we find that markets for patents are sluggish in the face of buyer need, we should not necessarily conclude that the inefficiency is simply due to presumed greed or recalcitrance among prospective sellers, or that the market has choked on an excess of patents. The mechanics of pricing may be the issue.

D. Scenery Changes in the Commons and Anti-Commons

Having identified pricing as the true bottleneck in transferring patent rights to their most efficient users, the next step is to identify a solution. Here, we might also use real options pricing as a guidepost. Most patent valuation has focused on particularized analysis of facts in an economic snapshot. By contrast, real options pricing quantifies the risk-reward ratio for a dynamic pricing history: that analytical context is more of a motion picture than a snapshot. And in fact, patent value is itself dynamic. We have already noted that any anti-commons in innovation necessarily dissolves when the underlying exclusivity rights expire. Thereafter, the innovation is in the public domain. By contrast, bottlenecks based on pricing are carried over to every generation of new patents. That insight alone is not enough, because as was also noted entrepreneurs can seldom afford to wait for third party patents to expire. Though patent value is dynamic, it is not riotously so. But recognizing that anti-commons are transient leads to a paradigm in which patent value can be characterized quantitatively by its place within a rolling equilibrium of value. The following account of the logic is necessarily didactic but is kept brief.

Unlike most tangible commons, the intangible commons is constantly expanding. Some of this growth never proceeds through private ownership: examples would be open-source software development and published, unpatented university inventions. By contrast, patents represent a receding ripple or fringe of private ownership at the frontier between the expanding commons and the wilderness of the unknown. The near edge of that ripple ever recedes to leave new material in the public domain, and the far edge flows inexorably into the latest-charted territory. This ring of proprietary ownership around the commons is seldom completely blanketed with claim stakes anywhere in the perimeter, hence unclaimed discovered territory becomes public immediately. But blanket-like coverage does happen when certain discovered terrain features have high apparent value. Then a land rush ensues, including claims to successively distant parcels for which access is difficult without obtaining a right-of-way through the nearer parcels.[48]

As the outer edge surges to new horizons of terrain, a vista unfolds that sheds new light on the value features of the parcels that were acquired earlier. In some cases, the parties realize that certain earlier-claimed lots occupy the only convenient corridor to reach the more distant parcels that have the most value. But in other cases, it becomes apparent that a desirable distant lot can be reached by an alternate route, just as a vein of

[48] *See, e.g.*, Bessen & Meurer, *supra* note 3, at 68-71 (particularly for semiconductors). Assumptions about anti-commons development may be debatable, but let us momentarily assume *arguendo* they are correct.

gold or an oil reserve can be accessed from more than one claim stake. Alternatives reduce the value of earlier-discovered claim stakes, and occasionally it is noticed after the fact that a heavily trafficked corridor to distant properties runs through proprietary turf that was assumed in error to be in the public domain. So movement of the anti-commons creates new uncertainties for pre-existing properties.

In turn, the uncertainty about alternatives, inadvertent trespass, and the value of the nearest uncharted territory hinders valuation of such virtual rights-of-way. This would not be true if the margin of private ownership were static in time (i.e., technology neither advanced nor regressed, and patents never expired nor were new patents granted). In a truly static situation, all of the rights and their relative uses, values and overlaps would be sorted out and the market would approach steady-state equilibrium within a few years despite any initial confusion. At the steady state, the market could designate consensus license fees for properties, just as for real estate. Moreover, the technical field's development history or future trends would be irrelevant because the situation would be frozen in time. However by the time a fair market value in a hypothetical static patent situation could be determined and the anti-commons eliminated, in the real world new progress in the field might make the initial invention obsolete. And because valuation depends on expectations and future probabilities, the valuations determined accurately for the static model would be incorrect for a real-world system anyway. Thus, examining a patent situation as the equilibrium at a frozen moment in time omits some of the most essential data for valuation.

But that is not to say that a changing system has nothing like an equilibrium condition by which we can set pricing. Instead we can describe the equilibrium-like qualities of a changing situation by means of a dynamic attribute such as momentum, diffusion rate or relativistic context. This is comparable to the adaptation of static models of physics and engineering to characterize steady-state conditions of particles in motion. It is like the difference between modeling standing water and modeling fluid running through a pipe, or like the gravity effect differences between Newton's apple and Kepler's planetary motion. In other words, we can tease out characteristics of a "rolling" equilibrium that migrates with the market, after which we will be able to assign values. Thus, I argue that the key to preventing and dispersing (pseudo) anti-commons at least for innovation is to analyze them as the dynamic "pre-commons" they are.

E. Rewriting the Script for the Pre-Commons

Finding an analytical framework for a mathematical model is only half the answer; the design of the solution must also address felt needs of the parties.[49] The tragedy of the anti-commons (or pseudo-anti-commons) begins with an anxious patentee who yearns to receive fame and fortune from a licensee, and ends with a negotiation

[49] *See* F. Russell Denton & Paul J. Heald, *Random Walks, Non-Cooperative Games, and the Complex Mathematics of Patent Pricing*, 55 RUTGERS L. REV. 1175, 1219-24 (2003) [hereinafter Denton & Heald] (introducing a patent valuation model based on a real options algorithm, and explaining how its features accommodate parties' concerns over proprietary efficiencies, information asymmetries, impact of license costs on profitability, and respective post-licensing efforts in commercialization and invention).

stand-off or significant delay in which nobody benefits because the offered patent rights were over-priced but neither side can prove the other wrong. If we are to turn that paradigm on its ear, i.e., create a comedy of the pre-commons, then we must not only invert the mood of the scenes but also reverse their order. Thus, the comedy must begin with standards for pricing that both parties can recognize as reasonable, so that it can end with a successful deal and revenue sharing (fame is optional). Moreover, to be efficient the model must also be straightforward and readily balanced, as opposed to a laundry list of check-off items that are not differentiated in their relative importance.[50]

In particular, the pricing standard must address the parties' felt needs regarding the uncertainty of alternatives, inadvertent trespass and the value of the nearest uncharted territory already discussed. Prospective patent licensees commonly articulate these concerns as follows.[51]

- How easily would this patent be worked around?

- How much will we have to pay in license fees to parties whose relevant patents have not yet come to our attention despite a diligent patent clearance search?

- How important is this patent as an enabling technology relative to the others that we are licensing or have patented ourselves?

The first question can be answered confidently by technical experts, though later discovery might provide an unprecedented workaround. The second question can be addressed by industry statistics on deals and litigation as a guideline, but has more uncertainty and so implies more risk. The third question presumably can have objective answers yet to date has eluded development of successful bright line criteria, so this is the point at which any effective solution probably must begin. Especially for splintered licensing situations the valuation model must incorporate a credible objective proxy for the importance of any given patent relative to others.

A valuation model must also be easy to use. When licensing thousands of patents for a complex product it is not feasible to conduct a close inspection of every word in every patent to compare and contrast functionality, patent strength, claim scope, creativity, or relative role in the product.[52] Thus, a valuation model for complex situations must be easily and quickly computed, using only readily available public data, with no bias that favors a party or class of parties or any art. Additionally, it must require only straightforward analyses and minimize arbitrary discretion. Conveniently, these requirements are consistent with judicial preferences for damages, in order to move cases

[50] *See infra* Part IV (discussing the prevailing *Georgia-Pacific* test on patent damages requiring assessment of fifteen different factors, most of which are not differentiated in their relative importance.

[51] Microsoft Conference Call, *supra* note 45.

[52] *See, e.g.*, Microsoft Conference Call, *supra* note 45; Bessen & Meurer, *supra* note 3, at 54-55, 200, and 237-39 (complaining of the difficulty of searching patent scope due to terms that are general or that are chosen at the patent applicant's discretion). Note that currently most electronic searches of patent content are guided by keywords, thus they can overlook relevant material and only personal review can be comprehensive. In the author's patent prosecution experience, even U.S. patent examiners do not read every word of the applications.

along efficiently. Of course occasionally a prolific licensee may still need a small army of professionals to review its huge inventory of patents and in-licensed rights.

III. PATENT LICENSE PRICING & DAMAGES

A. Background, and the Road to Pricing as Real Options

The historic patent valuation models have been described disdainfully in terms ranging from "crude"[53] to "inappropriate"[54] to "inherently unreliable"[55]. These methods have been reviewed with commentary elsewhere,[56] but are briefly described here.[57]

The COST method[58] assigns a patent's present value as an arbitrary percentage above the total cost to invent and patent. Such costs can be easy to determine. The problem of course is that a cheaply developed invention such as a hula hoop may be hugely profitable while a hugely expensive nuclear reactor may never earn a cent due to design flaws or regulatory politics. Even the choice of mark-up percentage can be problematic: commodity retail mark-ups are low, drug mark-ups can be very high, and there is no standard selection rule for percentages. The cost method also does not show how to split costs between two parties in a bargain for rights.

The MARKET method[59] treats a patent's value as the market value of all outstanding stock in a public company that owns the patent, less the value of all tangible assets and non-patent intangibles. This method leverages the value of assessments in arm's length transactions and lends itself to non-discretionary calculations. However, stock market volatility would suggest that patents regularly oscillate in value randomly, which is unlikely, and in any case the method provides no rule for differentiating worth between intangible assets. The market method also does not show how to split the costs in a deal for rights.

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[53] Russell Parr, *Singapore-WIPO Joint Training Course for Asia and the Pacific Region on Intellectual Property and Technopreneurship Development* WIPO/IP/SIN/99/13 25 (October 1999), *available at* http://www.wipo.int/mdocsarchives/WIPO_IP_SIN_99_E/WIPO_IP_SIN_99_13.pdf.

[54] Paul E. Schaafsma, *An Economic Overview of Patents*, 79 J. PAT. & TRADEMARK OFF. SOC'Y 241, 252 (1997).

[55] Brunswick Corp. v. United States, 36 Fed. Cl. 204, 209 (1996).

[56] Denton & Heald, *supra* note 49, at 1181-93.

[57] These commercial valuation methods are not to be confused with macroeconomic analytical ratios, such as those that compare the gross domestic product to the number of unexpired patents. *See e.g.*, John M. Golden, *"Patent Trolls" and Patent Remedies*, 85 TEXAS L. REV. 2111, 2111 n.3 (2007). Note that measuring GDP alone would ignore unpatented production know-how in any case. Commercial valuations in the present paper are also not to be confused with calculations based on litigation probabilities or policy-based pricing that deviates from market valuation. For an intriguing discussion of these other areas, see *id.* at 2111-61; *see also* Mark A. Lemley & Carl Shapiro, *Patent Holdup and Royalty Stacking*, 85 TEXAS L. REV. 1991 (2007).

[58] *See* Denton & Heald, *supra* note 49, at 1183-84 (comparing a damages award under the cost method to the price of a lottery ticket instead of its winnings, and reporting scornful descriptions of the cost method by valuation professionals and scholarly reviewers).

[59] *Id.* at 1184-87.

The INCOME method[60] computes the net present value of all net cash flow from the patented product or service, with a risk-reflecting discount rate. This is one of the better methods because it is based on the actual source of value—public demand translated into product revenues. Moreover, it accounts for the time value of money. The shortcomings are serious but less obvious. For instance, not all of a product's value comes from the patent, particularly if only a minor feature is patented. Moreover, the rules on selecting discount rates are hardly scientific, though some are better than others.[61] And even more problematic in terms of licensing, this method values the patent for only one party: it does not show how to split profits with a licensee.

The RULES OF THUMB methods[62] use a standard percentage of revenues such as 0.5%, 8%, 25% or another percentage as the patent license royalty rate. These are easily calculated, and unlike the valuation methods *supra*, rules of thumb provide explicit rules for splitting profits between parties and enable rapid value calculations. These rules have sometimes been characterized as nonsensical or arbitrary; however, in many industries these rates represent a ratio between 45:55 and 55:45 of debt-free net income for splitting the profits between parties.[63] But it is not a perfect approach: the split assumes a patent contributes about half the value of the product or service, whereas actual fractions of value added vary widely depending on the nature of the invention, type of benefit it provides, and commercialization requirements. Unfortunately, because parties and courts generally have several rules of thumb at their disposal and do not know their origins, they typically do not know which rate is most apt for a transaction at issue or how the rate should be adjusted for common conditions.

In addition to the mainstream methods a few alternatives exist;[64] they tend to be special cases of prior methods, e.g., industry standards are really rules of thumb. Likewise, patent rankings and the auction method (pricing through party bids) both require an independent valuation basis in one of the methods discussed above. Monte Carlo methods are probabilistic simulations, and are essentially substitutes for Black-Scholes below. Attempts to assess the effect of future litigation prospects on negotiation have become fairly sophisticated,[65] but damages are also awarded as a function of industry pricing habits. As a result, if prospective punitive damages are factored into bargaining power analysis, then over time this will produce an inflationary spiral for license pricing because parties and the courts are reasoning in a closed loop. Thus, the specialty methods do not offer much that is fundamentally better than other methods.

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[60] *Id.* at 1188-90.

[61] An intriguing variation is William Choi & Roy Weinstein, *An Analytic Solution to Reasonable Royalty Rate Calculations*, 41 IDEA 49, 49-63 (2001). The authors applied discounts based on the weighted average of the cost of capital (WACC), and adjusted the profit split based on the value of each party's best alternative to a negotiated agreement in a Nash equilibrium. For a critique of the method, see Denton & Heald, *supra* note 49, at 1238-40.

[62] Denton & Heald, *supra* note 49, at 1190-92.

[63] *Id*. at 1191-1192, Table 1 at n.54.

[64] *See* RICHARD RAZGAITIS, VALUATION AND PRICING OF TECHNOLOGY BASED INTELLECTUAL PROPERTY (John Wiley & Sons 2003).

[65] *See* Golden, *supra* note 57, at 2111; Lemley & Shapiro, *supra* note 57, at 1991 (explaining and critiquing calculations based on litigation probabilities or policy-based pricing that deviates from market valuation between a willing licensor and licensee).

The REAL OPTIONS methods have been more promising. An early Black-Scholes approach for patents calculated the value of a patent as the price of a real option.[66] Thus, Merck treated sunk costs of research as the current asset price (though the invention was inchoate), and contemplated future research costs as the option's exercise price, using Monte Carlo simulations to derive a price.[67] This model's strengths are that it relies on known data, quantifies effects of uncertainty, and prices as a rational function of risk using widely accepted financial equations. Unfortunately, it is a variant on the cost method: its costs are poor proxies for income. So at best, this protocol is an internal decision tool.

Others have also claimed to adapt Black-Scholes for patent valuation, but based on markets or comparable markets for corporate stock instead of costs.[68] This has the same problems as the market method. Nevertheless, valuation professionals and scholars have recognized that real options offer a valid basis for valuation.[69] Unfortunately, the field made little progress after its initial recognition that patents might be suitable candidates for valuation as real options. In part, this may be due to the fact that theorists in math or economics have had little experience with the variety of gritty realities encountered in mundane technology transfer and commercialization.

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[66] A "financial option" is a right to buy a financial asset such as a commodity or publicly traded corporate stock at a certain price within a certain time period; the option price is usually a small fraction of the asset price. For assets in a frequently traded category (e.g., for a call option), the buyer hopes the market price will rise to exceed the contractual exercise price, allowing quick re-sale at a profit. The option price under Black-Scholes neutrally and efficiently allocates risk and reward between buyer and seller based on the trading history of the asset, though the two parties in essence bet against each other. A "real option" uses the same pricing math, but instead of stock or commodity re-sales concerns the value of exploiting a certain future opportunity. In either case, the option buyer is under no obligation to exercise it. Call options are popular in markets where the underlying asset price may fall substantially: the rational call option buyer can walk away from the deal and lose nothing more than the option price. Sellers of call options like them because revenue from selling the option reduces their potential losses in the event of falling prices, and still offer a modest profit if market prices rise. Other option types also exist.

[67] For a fuller description, see Gary L. Sender, *Options Analysis at Merck*, 72 HARV. BUS. REV. 92 (Jan./Feb. 1994).

[68] Alexander K. Arrow, *Managing IP Financial Assets: Principles from Securities Markets*, *in* FROM IDEAS TO ASSETS: INVESTING WISELY IN INTELLECTUAL PROPERTY 111, 111-37, 123 (Bruce Berman ed., 2002). Arrow was Chief Financial Officer for the Patent and Licensing Exchange (PL-X), which used his Technology Risk/Rewards Unit (TRRU) method but no longer maintains an Internet presence. Details of its [former] use are described in Anonymous, *The Patent & License Exchange Launches the TRRU Metrics System for Valuing and Pricing Intangible Assets*, BNET BUSINESS NETWORK, *available at* http://findarticles.com/p/articles/mi_m0EIN/is_2000_August_29/ai_64991518 (last visited July 10, 2008). There the TRRU metric was based on Black-Scholes analysis of financial information (i.e., stock prices) from 1,100 publicly traded "pure play" micro-cap companies as proxies for the respective value of each of new technologies. Each of these companies drew most of their value from a single technology. The firms were divided by technology categories so as to assess reasonable value between like inventions. Note that as described, this method also has the same pros and cons as the market method.

[69] Lauren Johnston Stiroh & Richard T. Rapp, *Modern Methods for the Valuation of Intellectual Property*, 532 PLI/PAT 817, 827-42 (1998) (applying Black-Scholes equation to calculate value of hypothetical patent); s*ee also* Microsoft Excel spreadsheet for patent valuation by Prof. Aswath Damodaran at New York University's School of Business *available at* http://pages.stern.nyu.edu/~adamodar/pc/project.xls (also linked at *product.xls: Estimate the value of a patent, available at* http://pages.stern.nyu.edu/~adamodar/New_Home_Page/valuation/val.htm) (last visited July 10, 2008).

Because of the valuation drawbacks described above, and the historical scope and importance of the problem, this author developed and co-published a BLACK-SCHOLES VARIANT.[70] That pricing solution attracted attention from one of the largest U.S. banking firms, Wachovia (for pricing bonds based on diverse baskets of patents);[71] the largest U.S. patent auction house, Ocean Tomo (for patent pricing),[72] and Microsoft (concerning splintered licensing);[73] among others. The method has also been adopted by economists who specialize in pricing intellectual assets.[74] The algorithm is summarized below; the original paper discusses details of the rationale, applicability, data sources and mathematical basis.

Briefly, the model exploits the many similarities between patent rights and stock options.[75] First, both represent a future right to exploit an asset, and both exclude others during the instrument's lifetime. The patent's exclusivity is like a market placeholder, just as the seller of a stock option must provide the stock at the agreed exercise price when the option buyer exercises the right to buy. Both the stock option and the patent require further investment to capitalize on the opportunity. Both have expiration dates. Both are priced based on an opportunity's risk-reward ratio. Both can be used to speculate on or hedge against price variance or inherent risk in that or another asset. The value of both is affected by third-party market activity.

Important differences exist between patents and stock options. In particular, a stock option buyer and seller bet in opposite directions (one that the price will rise, the other that the price will fall or remain unchanged). By contrast the patent licensor and licensee bet in the same direction—that the product will make money. Thus the current value (S_o) of patent opportunities should generally also be the option exercise value (E) for licensing.[76] For that reason and several others patents deserve their own real options algorithm.

My method[77] begins by approximating a bell curve for each of the market size ($), market share (%), and profitability (%) in the expected market, based on how ventures of similar size and resource levels have performed in closely comparable markets. A bell curve can be fully described by just its average (mean) and standard deviation. These

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[70] Denton & Heald, *supra* note 49, at 1193-1240 (explaining the development, use, and justification of patent valuation by the Denton variant of the Black-Scholes method).

[71] Personal meetings with Thomas Viera, who was a divisional chief financial officer for $13 billion in assets at Wachovia (Summer 2004). Wachovia is a leading national bank.

[72] Series of telephone calls with Douglas R. Elliott, who was a director of Ocean Tomo at the time (Summer 2004).

[73] Microsoft Conference Call, *supra* note 45.

[74] *See, e.g.*, *Intellectual Asset Economics: Articles and Analysis on Intellectual Property and Economics*, *available at* http://formulatorres.blogspot.com/2006_05_01_archive.html (last visited July 5, 2008); Fernando Torres (Consor Intellectual Asset Management), *Establishing Licensing Rates Through Options* (Sept. 11, 2006), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1014743#PaperDownload [hereinafter Torres, *Rates Through Options*].

[75] Denton & Heald, *supra* note 49, at 1194-95; Arrow, *supra* note 68, at 111-37, 123; RAZGAITIS, *supra* note 64, at 244-50.

[76] Exceptions exist, such as when the licensee is waiting for more favorable operating conditions or consumer demand before entering the market.

[77] Denton & Heald, *supra* note 49, at 1204-07.

three bell curves are then consolidated faithfully into one bell curve of profit probabilities by multiplying the means together to derive a master mean ($), and taking the square root of the sum of the squares of the standard deviations to derive a master standard deviation ($). Because commercial products often have predictable life cycles, the calculation is performed independently for each year of expected sales; the annual values are each discounted to net present value and summed to obtain a profile of the total contemplated value. Master curves serve as a substitute for the trading history that is the basis for pricing real options in stock markets.

In determining how to split profits between parties in a licensing deal, my method partitions value contributions into two components: commercialization value, and intellectual property value. One or both parties may contribute to either component, and each rational party wants to be compensated in proportion to the value it adds to each component. These factors are inherently present in party negotiations but had not been recognized in the valuation literature.

The commercialization component concerns non-invention value that each party contributes to bring the invention to market (optimization, manufacturing, process development, marketing, etc.). This component addresses the sharing of profit levels that could be achieved in the absence of a patent, e.g., commodity profit levels. These profits are prorated based on the proportion of each party's contribution to the whole of the commercialization effort.

The intellectual property component concerns the extent to which each party invents product features, manufacturing processes or other innovations necessary to bring a product to market. This component concerns only the proportion of profits above the commodity level, i.e., those that reflect a patent premium. The master bell curve provides the data on risk and reward (essentially a borrowed pricing history) needed to compute the price of the innovation as an option. In raw form the option price is the percentage of profits a licensee would pay to license a patent for which no further innovation was needed. My Black-Scholes variant reflects the fact that the licensee and licensor bet in the same direction; my model also factors out the license cost from contemplated profits, which the original equation failed to do but rational parties would agree to. If the licensee must innovate (e.g., to perfect manufacturing processes), royalties are prorated downward. The percentage of licensee invention necessity can be benchmarked against industry abandonment rates for products after commercialization has started. My model also adjusts the discount rate to recognize that in the year uniform continuous revenue is received, risk-free interest upon it is only half that of a later year (revenues near the end of a current year have no interest). The model also discounts royalties as a function of up-front payments for a license. The model also accommodates value leakages and special cases when E and S_o are not identical.

The equations are as follows. The terms μ and σ below have their usual respective meanings of a mean and a standard deviation in statistics; the term ROI has its usual accounting meaning of return on investment. The other terms have the meanings shown below.

DENTON VARIATION OF BLACK-SCHOLES FOR PATENTS [78]

Master Equation: $C = License\ Price = Commercial\ Fee + Intellectual\ Property\ Fee$

Calculated per phase (i.e., in annual forward-looking increments), discounted to Present Value, & summed:

$$C = \sum_{i=1}^{i=n} C_i \cdot e^{-rt_i}$$

COMMERCIAL FEE (FEE FOR LICENSOR COMMERCIALIZATION EFFORT)

Mean Pre-Dilution Value (S_o) of Patent X: $\left[\mu_{Market\ Size} \cdot \mu_{Market\ Share} \cdot \mu_{Profitability}\right]$

× **%Commercialization Component (IC)** $\left(\frac{\%ROI_{No\ Patent}}{\%ROI_{Projected}}\right)$

× **Licensor Commerc. Component Profit Sharing (CCPS) %** $\frac{Licensor\ \ Comm'n\ Contribution\ \%}{Total\ \ Comm'n\ Contribution\ \ (=100\%)}$

\+ **INTELLECTUAL PROPERTY FEE** (FEE FOR LICENSOR INVENTIVE VALUE)

Mean Pre-Dilution Value (S_o) of Patent X: $\left[\mu_{Market\ Size} \cdot \mu_{Market\ Share} \cdot \mu_{Profitability}\right]$

× **% Inventive Component (IC) based on industry averages** $\frac{\%ROI_{Projected} - \%ROI_{No\ Patent}}{\%ROI_{Projected}}$

× **% Black-Scholes Factor with license price-vs-profit adjustment** $\frac{\{[e^{-qt} \cdot N(d_1)] - [(1+b) \cdot N(d_2)]\}}{e^{rt} + \{[e^{-qt} \cdot N(d_1)] - N(d_2)\}}$

q represents payouts or leakage of value (usually $q = 0$); b = $\frac{E}{S_o} - 1$

usually $e^{-qt} = 1$ and b = 0, so this is: $\frac{N(d_1) - N(d_2)}{e^{rt} + [N(d_1) - N(d_2)]}$

Standard Deviation needed to compute $N(d_{1\ or\ 2})$ =

$$\left[(\sigma_{MarketSize})^2 + (\sigma_{MarketShare})^2 + (\sigma_{Profitablity})^2\right]^{1/2}$$

r needed to compute $N(d_{1\ or\ 2})$ = $\frac{risk\text{-}free\ rate}{2}$ due to continuous revenues approximation

Royalty Rate Before Dilution (usually $S_0 = E$) $\frac{C \cdot (upfront\ \ payment\ )}{1/2 \cdot (E + S_o)}$

× **License Price Dilution** $\frac{Total\ \ Inventive\ \ Value\ - Licensee\text{-}Added\ \ Inventive\ \ Value}{Total\ \ Inventive\ \ Value}$

Alternatively: (100% - Industry Mean Abandonment%)

This variant on Black-Scholes has several benefits. It relies only on publicly available data, demystifying negotiation and adjudication. It relies on industry averages, so the effect of relative (in)efficiency is not transferred between parties. It differentiates between total revenues and royalty payouts, unlike most prior valuation methods. It splits profits as a rational licensor and licensee would when both bet in the same direction. It deducts an option's price from the option buyer's profit expectations. It recognizes that licensed patents often require supplemental invention in order to satisfy operational requirements. It adjusts the royalty rate to reflect the source and value of

[78] *Id.* at 1225-26.

commercialization efforts between parties. Importantly, it substitutes statistical profiles from relevant markets for statistical characteristics of the (non-existent) patent trading history that are needed for pricing real options. And Black-Scholes math is common in statistical finance: economists, accountants, financial professionals, and many investors know how to use the equation and would recognize how to compute with my variant. The original publication has complete details on the method's use and justification.

B. Special Situations: Royalty Splits

The patent royalty model just shown determines royalties on a market-by-market basis, but was not adapted to address splintered licensing for a portfolio of rights. That is, it does not show how to prorate value rationally when many patents with overlapping utility must be licensed in for the same behemoth product. In some cases an analysis might value individual respective contributions of a few dozen licensed patents using some modest adaptation of my real options method as originally provided. However, to conduct parallel analysis at that level of detail for thousands of patents, when they all pertain to the same product or small group of products, would require a huge and misplaced effort. This is the valuation problem of the (pseudo-) anti-commons: multiple patents share the same end market and or use.

To date no published method seems to describe how to parse splintered contributions with proportional precision or rationality. Yet without a universal tool for this purpose, value perceptions will continue to differ widely, expectations will be in conflict, and adjudication will remain crude. Thus we now consider the nuts and bolts of extending my earlier model.

C. Metrics – Descriptive vs. Deductive

In order to discriminate quickly between portfolio patent values, representative metrics are needed and their relative merits must be understood. The difference between deductive and descriptive metrics is critical. Most patent metrics to date have been *deductive*, attempting to derive insights about the presumed value, social cost, or, e.g., litigation effect of a patent based solely on characteristics that are in view during prosecution at the patent office,[79] or based on a macroeconomic criterion.[80] Deductive analyses are—abstract, distant, and often esoteric—of little use to industry. By contrast, *descriptive* patent metrics as I define them quantify the relative benefit of a patent for a specific party and use in commerce. I employ parameters similar to those of deductive metrics, but modify them to create descriptive metrics.

To date, deductive metrics have often been invalid. Adelman and DeAngelis's review of biotech patent value literature found disappointing statistical correlations for

[79] *See, e.g.*, Adelman & DeAngelis, *supra* note 23, at 1707-29 (reviewing various patent metrics and the weakness of their correlation with patent value).

[80] *See, e.g.*, Golden, *supra* note 57, at 2111 n.3 (discussing the ratio of average number of issued patents per billion dollars of real gross domestic product in "chained 2000 dollars" as a possible benchmark for assessing whether patents had become a tax on modern economic activity).

investigated metrics including the amount of art in a technology subclass, prosecution times, number of claims, citation counts, patent counts, citations made and received, and so forth.[81] Statistical analysis of patent economic characteristics has also been frustrated by their distribution's lack of a bell shape.[82] However, a patent's citation number is significantly correlated with its value.[83] Backward citations to patent literature limit the scope of novelty[84] but are correlated with non-technical economic benefit,[85] and correlate inversely with litigation probability.[86] Citation counts in combination with network theory may be even more predictive.[87] So deductive metrics are not entirely useless.

While no study has shown definitively why deductive metrics are poor predictors, some reasons suggest themselves. F.M. Scherer provided early evidence that innovative success is chaotic and also that its distribution cannot be assessed by standard statistical methods,[88] so these inventions are difficult to categorize until after commercialization. Those observations are consistent with Schumpeter's speculation that a small number of inventions account for a disproportionate share of total profits from inventive activities.[89] Rare and uneven distribution of innovative success is also rationalized by business philosopher Peter Drucker's observation that great inventions tend to be either the result of a series of incremental steps (for which end point timing is seldom known far in advance) or serendipitous discovery, whereas successful inventions due solely to sudden brilliant ideas are a myth.[90] That is consistent with my own observations in research.[91]

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[81] *See* Adelman & DeAngelis, *supra* note 23, at 1707-29 (reviewing the use of predictive metrics and the weakness of their correlation with patent value).

[82] *Id.* at 1707-08.

[83] John R. Allison et al., *Valuable Patents*, 92 GEO. L.J. 435, 438, 451, 462 (2004).

[84] Paola Criscuolo, *Reverse Technology Transfer: A Patent Citation Analysis of the European Chemical and Pharmaceutical Sectors*, Maastricht Economic Research Institute on Innovation and Technology (MERIT) and Scient and Technology Policy Research (SPRU) (2003).

[85] Markus Reitzig, *What Do Patent Indicators Really Measure? Testing Current Theory on Value Drivers of Innovations Within a Structural Two-Stage Discrete Choice Simultaneous Equation Model*, (Center for Law, Econ. And Financial Institutions at Copenhagen Business School, Working Paper 2003-1); Markus Reitzig, *What Do Patent Indicators Really Measure? -- A Structural Test of 'Novelty' and 'Inventive Step' as Determinants of Patent Profitability*, (Feb. 24, 2004), *available at* http://www.druid.dk/uploads/tx_picturedb/ds2004-1283.pdf.

[86] Jean O. Lanjuow & Mark Schankerman, *Stylized Facts of Patent Litigation: Value, Scope and Ownership*, (Nat'l Bureau of Econ. Research, Working Paper No. 6297, 1997), *available at* http://www.nber.org/papers/w6297; Jean O. Lanjuow and Mark Schankerman, *Characteristics of Patent Litigation: A Window on Competition*, 32 RAND J. of Econ. 129, 129-51 (2001).

[87] *See* Gábor Csárdi et al., *Modeling Innovation by A Kinetic Description of the Patent Citation System*, 374 PHYSICA A: STATISTICAL MECHANICS AND ITS APPLICATIONS 783 (2007) (noting that their results are consistent with a patent thicket in which more and more patents are issued on minor technical advances).

[88] Fredrick M. Scherer, *Firm Size, Market Structure, Opportunity, and the Output of Patented Inventions*, 55 AM. ECON. REV. 1098, 1098 (1965); Fredrick M. Scherer & Dietmar Harhoff, *Technology Policy for a World of Skew-Distribution Outcomes*, 29 RES. POL'Y 559, 563 (2000).

[89] JOSEPH A. SCHUMPETER, CAPITALISM, SOCIALISM, AND DEMOCRACY 73-74 (6th Uwin Paperbacks 1987) (1942).

[90] PETER F. DRUCKER, INNOVATION AND ENTREPRENEURSHIP: PRACTICES AND PRINCIPLES 130 (HarperCollins 1985).

[91] I first read Drucker's book as a Motorola manager, and found this thesis distasteful. Yet upon mentally reviewing the accomplishments of all inventors in our organization, including some extremely bright people, I had to conclude that our most successful inventor by far was a remarkably dogged individual who tirelessly performed an endless series of incremental experiments. In scientific circles today

It is not just invention anomaly that hinders prediction: commercialization is less unified or predictable than many studies implicitly assume. The chain of value realization has many links: a patent is just one, and other links often break. Success rides on serendipitous fortune, sufficiency of managerial know-how, availability of necessary resources, and the self-discipline and force of personality to make things happen.[92] An example is process "ownership." Many inventors decline to get involved in business development for their widgets—they would rather invent—and even in big companies nobody else has the requisite passion or spare time to take the invention forward. In corporate argot, the project needs a "champion."[93] And managerial know-how is often not in abundance, especially in new ventures.[94] Even in world-class firms everyone with much tenure has first-hand knowledge of mismanaged projects.[95] The list of non-patent reasons for failure goes on,[96] though certainly many patented inventions are duds. [97]

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such incrementalism is sometimes disdained as "Edisonian" and primitive. In light of Edison's many successes that disdain seems misplaced, yet it survives. For non-fiction accounts that portray invention and product development in a way that captures the industry environments well, see MATTHEW JOSEPHSON, EDISON (McGraw-Hill 1959) (the definitive biography of the man and his inventions); TRACY KIDDER, THE SOUL OF A NEW MACHINE (Little, Brown 1981) (the Pulitzer prize-winning story of Data General Corporations's development of the first 32-bit minicomputer in a race with Digital Equipment Corporation); BARRY WERTH, THE BILLION DOLLAR MOLECULE: ONE COMPANY'S QUEST FOR THE PERFECT DRUG (Simon & Schuster 1995) (the story of Vertex Pharmaceutical as a start-up company, and development of its first new drug).

[92] One implication is that economic analysis of the role and value of patents in commercialization will never be adequate in the absence of a systems analysis approach that extends outside of the patent office. Systems analysis has in fact revolutionized a variety of fields in recent decades. For instance, the advent of genomic, proteomic, and now glycomic analysis has resulted in regular reports of previously unsuspected interactions in human physiology.

[93] *See, e.g.*, THOMAS J. PETERS & ROBERT H. WATERMAN, JR., IN SEARCH OF EXCELLENCE: LESSONS FROM AMERICA'S BEST RUN COMPANIES 207-09 (HARPER & ROW) (1982) (discussing "champions").

[94] Failure rates for new ventures are significant, though undocumented drastic claims in wide circulation are far worse than reality. For an influential recent report, see Brian Headd, *Redefining Business Success: Distinguishing Between Closure and Failure*, 21 SMALL BUS. ECON. at 51 (2003) *available at* http://www.sba.gov/advo/stats/bh_sbe03.pdf) (finding that just over half of new businesses have closed by their fourth anniversary, but about a third of those closures are based on success such as sale of the company). *See, e.g.*, *id.* at 59; *see also* Amy E. Knaup, *Survival and Longevity in the Business Employment Dynamics Data*, MONTHLY LAB. REV. 50, 52-53 (May 2005) *available at* http://www.bls.gov/opub/mlr/2005/05/ressum.pdf, (reporting figures similar to Headd's).

[95] Scott Adams' "Dilbert" cartoons have been popular wall art in workplaces for decades because they caricature mismanagement so credibly and skewer it so pithily. Persons who have not worked in corporations have been heard to say that the Dilbert series is over the top; the rest of us know better. Mismanagement is more the rule than the exception in many offices, and this author confesses to having made a variety of missteps himself as a manager.

[96] Instructive lists abound in the area of common mistakes in entrepreneurship and commercialization. For one of the better lists see Frederick J. Beste, *25 Entrepreneurial Death Traps: How to Avoid the Classic Entrepreneurial Mistakes* (1996) *available at* http://www.yesatyale.org/files/lecture_06.pdf; *see also* WILLIAM J. STOLZE, START UP: AN ENTREPRENEUR'S GUIDE TO LAUNCHING AND MANAGING A NEW BUSINESS 88-95 (Career Press 5th ed.) (1999). Beste was CEO of the General Partners of the Midatlantic Venture Fund, Bethlehem, PA and had long worked with new ventures. His headings include: 1. Overreliance on one or two customers, 2. [Not picking a leader from the start as opposed to being equal in authority], 3. 50:50 Partnerships [in ownership of the firm], 4. [Expertise in inventing but not in commercialization], 5. Underpricing, 6. Insufficient start-up capital, 7. Failure to consider the downside, 8. Failure to look at industry norms, 9. Lack of focus, 10. Bringing on the vulture [capitalist], 11. [Spending

By contrast, value analysis for royalties is less vulnerable to operational factors (though not immune to them) because most or all requirements for successful commercialization have already been met by the time of negotiation or litigation. The question then is no longer whether a patent has value, but rather how to price it. That changes the analysis and objectives. The parties now ask how broad and credible the claims of interest are, how easy the workarounds are (they drive the price down), how much benefit the patent's use offers, etc. The relevant descriptive metrics can be much more useful than the deductive type.

Caution is still needed to ensure the descriptive metrics chosen are credible; otherwise they will be unacceptable to one or both parties. This requires identifying the most pragmatically rational and easily used metrics and ensuring calculation reproducibility by means of uniform analytical protocols. Of course, any choice we make could be improved upon by better knowledge. But pragmatism, rationality, efficiency, and uniformity are reasonable guidelines.

D. Designing Metrics Based on Physical Analogies

Physical analogies can tease out useful metrics for patent value. Professional scientific literature features sober publications modeling patents as if they were molecules.[98] In fact an analogy from quantum physics helped guide the design and justification of my earlier-published patent valuation model.[99] The current extension of my model again uses physical analogies. The following explanation illustrates my priorities and rationales.

At the outset, we begin with the intuition that each patent has its own degree of heft, which we can alternatively call weightiness. Familiar tests in patent law address the necessary threshold level for heft, e.g., in terms of enablement, scope of claims, advancement in the state of the art, and non-obviousness of logic behind the invention.

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on luxuries] from the start, 12. Diversification into the unknown, 13. Emotional litigation, 14. Product never ready for market, 15. Low barrier to entry growth industry, 16. Inadequate market research, 17. Failure to segment the market, 18. [Providing] [n]o reason for the customer to change, 19. Payback can't be calculated, 20. Failure to admit a mistake, 21. Step function growth, 22. Betting the ranch, 23. Ignoring the handwriting on the wall, 24. Spiraling costs, and 25. Silliness phase [overspending on perks].

[97] Perhaps counterintuitively, venture capitalists and lenders prefer to work with entrepreneurs who have been involved with new ventures before, even if those businesses had failed (most new ventures do within a few years). This is because such managers have already learned from the school of hard knocks many of the business pitfalls they must avoid. *See* Ronald K. Mitchell et al., *Failing to Succeed: New Venture Failure as a Moderator of Startup Experience and Startup Expertise*, FRONTIERS OF ENTREPRENEURSHIP RES. (2004), *available at* http://www.ronaldmitchell.org/publications/failing%20to%20succeed.pdf.

[98] *See, e.g.*, Csárdia et al., *supra* note 87, at 783-93; EMANUEL DERMAN, MY LIFE AS A QUANT: REFLECTIONS ON PHYSICS AND FINANCE (2004). Derman earned a Ph.D. degree in theoretical physics from Columbia University (NY), after which he spent many years at Goldman Sachs, and then returned to Columbia to lead its program in financial engineering. Note that physicists have made many contributions to modeling in other fields.

[99] Denton & Heald, *supra* note 49, at 1281-86.

All these attributes are merely different faces of the same die.[100] Of course those judicial and statutory tests merely verify validity, the lowest acceptable standard for heft, whereas valuation considers just how far beyond the minimum a patent extends in a commercially useful way. The physical analogy to heft is mass, which can be described quantitatively in a straightforward way.[101]

Weightiness alone is not enough. A patent that is weighty by comparison to nearest prior art may still be worth little if the respective art is relatively unimportant. Importance can be measured by the market's interest in a field of art, which is attested by growth in the number of patents issued in that field. This confirms that the weightiness should not be evaluated in terms of a frozen moment in time but rather in terms of how the field has changed over time. As such, physical parameters relating mass (i.e., weightiness) to motion would be an appropriate basis for amplifying or reducing the weightiness to estimate its ultimate impact. That brings us tentatively to three physical analogies relating mass to motion, distributed along a continuum of time-dependence:

> WORK (mass x distance moved). This analogy can be eliminated because it is independent of time, whereas a growth rate is time-based and is more informative than the absolute amount (distance moved) of activity in a field; e.g., doubling a technical art's activity level in one year is more impressive than taking a century to do it.
>
> MOMENTUM (mass x velocity, the same as mass x distance divided by time). This analogy appears to be the most useful, and relies on the growth rate as desired, however this analogy should not be carried too far. The patent itself does not move, nor do its claims expand to capture new scope later in time. Rather, an art category's growth rate indicates the field's importance and extent of use in the market, thus the relative importance of patents in that field is scaled up accordingly. It is also more likely in a rapidly growing field than in a slowly growing field that an earlier-filed patent being licensed was pioneering, and thus of special value, as well as catalytic for future innovation.
>
> FORCE (mass x acceleration, the same as mass x change in velocity over time). The force analogy is appealing because acceleration in the art could indicate that relevant market interest is almost viral in its growth rate. But a force analogy could also lead to absurd results. No matter how fast a field grows, if the growth rate is steady then both acceleration and the force are zero. We therefore eliminate this analogy.

[100] Regarding shades of contribution, see, for example, Atlantic Works v. Brady, 107 U.S. 192, 200 (1883) ("The design of the patent laws is to reward those who make some substantial discovery or invention which adds to our knowledge and makes a step in advance in the useful arts. Such inventors are worthy of all favor. It was never the object of those laws to grant a monopoly for every trifling device, every shadow of a shade of an idea, which would naturally and spontaneously occur to any skilled mechanic or operator in the ordinary progress of manufactures.").

[101] Extending the analogy, we might describe the patent's scope as its volume and the inventive extent as its density.

Thus we now have two complementary properties (weightiness and velocity) whose product is a comparative figure of merit (momentum) by which to discriminate between value levels. The task then is to assign metrics by which each of the two properties may be defensibly quantified. In order to address these choices systematically, I show below a full suite of equations for the valuation paradigm, followed by a detailed explanation of each term. These equations will not please everyone. Perfectionists will rightly note that neither patents nor patent systems exhibit ideal behavior, and that there are reasonable, alternative ways to assign weightiness or velocity. Because of this, undoubtedly some users will modify this paper's model. That alone, however, is not a fatal flaw because in science, as in law, for complex phenomena the question is not whether the calculation is perfect but whether the method is plausible and "close enough" to the needed level of accuracy. Particularly since patent valuation has suffered from inadequate pricing mechanisms and had few major advances, we should focus on practical utility instead of imaginary theoretical ideals.

W ("Weightiness") = Proxy for Patent Breadth =

$$\frac{No.\ of\ applicable\ independent\ claims}{Average\ No.\ of\ limitations\ per\ applicable\ independent\ claim}$$

V ("Velocity") = Proxy for Importance =

$$\frac{total\ no.\ patents\ in\ closest\ PTO\ tech\ subclass\ on\ (projected)\ product\ launch\ date}{[total\ no.\ patents\ in\ closest\ PTO\ tech\ subclass\ at\ priority\ filing] \times [difference\ in\ years]}$$

M ("Momentum") = Individual Patent Metrics =

$$W \times V$$

Master Royalty Rate =

Aggregate determined by calculating rate as if for a single composite patent.

Increase for Set-Aside for Unknown Patents =

Based on industry statistics for patent surprises – OR –

$$= 100\% \times \left[1 + \frac{avg.no.of\ tech\ subclasses\ searched\ per\ patent}{100}\right]$$

Individual Royalty Rate =

$$Master\ Royalty\ Rate\ \times \frac{M_i}{\left[\left(\sum_{i=1}^{i=n} M_i\right) \times (100\% + \ Increase\%\ for\ Set\text{-}Aside)\right]}$$

The number of applicable independent claims is used as a proxy in fraction W (weightiness) for the breadth of utility acquired. Other patent claims cover no more scope than the independent claims, so proliferation of dependent claims is irrelevant. Sometimes, but not always, multiple independent claims within the same patent are overlapping in scope. For instance, a composition might have a key limitation of being acidic, but a narrower independent claim uses the limitation of a pH less than four. Ideally the licensor will discount the independent claims whose applicability for the end-user is subsumed within a broader independent claim in the same patent as superfluous for royalty calculations. This is because the one with lesser scope provides no additional utility to the end-user. The same might also be true of two licensed patents in which one has a terminal disclaimer over the other because of overlapping subject matter. Alternatively, this might be true of a continuation or divisional patent that claims some narrower subset of a broader earlier patent. This is a rule of reason, partly in fairness so that the split share for other licensees is not diluted frivolously. But also, if licensees do *not* discount superfluous independent claims and this becomes widely known, future licensors will attempt to game the standard by unnecessarily inflating the number of independent claims during patent prosecution in order to pad their expected royalty receipts. However, where circumstances require rapid computation and a minimum amount of discretion, all the applicable independent claims might be simply included in the count.

An example where independent claims in the same application do not have complete overlap of scope even though they pertain to the same invention would be claims in the same patent to: (a) a new class of drug compounds; (b) particularly useful polymorphs (crystalline forms) for the compounds; and (c) methods of synthesis including crystallization. For a licensee who uses all three, each has distinct value. For a licensee with its own proprietary polymorph and alternative synthetic route, on the other hand, the only value from a license might be for the compound itself.

An alternative to this approach is to count just the patents themselves or their number of pages. In the 1990's, anecdotes circulated in the industrial community about the negotiation style of Japanese firms,[102] which alleged the practice was for each party to bring a stack of all their applicable patents to the table. The party with the higher stack won and the other would pay fees for a cross-license. That model, however, may not be refined enough in today's business environment.

Another alternative to define weightiness or breadth would be in terms of avoided cost; i.e., how easy is it for the licensee or defendant to substitute a non-infringing

[102] Denton, *supra* note 1.

technology, and how much would it cost?[103] Certainly this approach is possible, but particularly for behemoth products the analysis might be cumbersome and unreliable. For each of thousands of licensed technologies we would need to identify, *inter alia*, the following: the next-best available technology; exact costs including R&D and operations for it; revenues and license rates for it in the exact contemplated market.[104] The answers may be quite arbitrary and much of the information needed to assess this would not be public. In some arts the answer or cost may not even be very predictable. Thus weighting based on claim counts would be much faster and not necessarily less accurate.

The validity of using claim counts deserves a further word. Of all the conceivable predictive metrics, only claims are licensed because they alone are enforced. By contrast, not even citation counts are licensed. Yet, although the number of claims has been a popular basis for predictive metrics, their prior statistical correlations with value within that area are weak.[105] The present approach is different. First, the claims valued here have already been identified as needing to be licensed. Also, we have imposed the qualifications above concerning claim independence, overlap and applicability to ensure that only material differences are counted, thus relative multiplicity is significant. Hence the claim count here is validated by the licensee's own implicit admission of value.

There are many ways in which someone could tweak this valuation framework. For instance, the weightiness fraction could be adjusted for legal factors by multiplying the number of back citations the patent applicant made since this corresponds statistically to the litigation strength of claims as mentioned *supra*. This is susceptible to applicant gamesmanship and uniformity would require performing the same step for every patent licensed. But the equation shown here of counting and weighting claims seems adequate without back citations.

The average number of limitations in the counted independent claims is a proxy that facilitates discounting in fraction W based on the narrowness of the patent scope and/or the incremental character of the patent. Counting claim elements or limitations recognizes that pioneering patents[106] tend to have fewer of them—thus are more valuable because there is less prior art to limit them—and that claim scope exists on a continuum.[107] The number of limitations is only occasionally a matter of interpretation,

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[103] Comments by Mark Lemley in private communication (September 22, 2008) (on file with the author).

[104] *See* Denton & Heald, *supra* note 49, at 1184, 1208.

[105] *See* Adelman & DeAngelis, *supra* note 23, at 1707-29 (reviewing the use of predictive metrics and the weakness of their correlation with patent value).

[106] *See* Westinghouse v. Boyden Power Brake Co., 170 U.S. 537, 562 (1898) (explaining that a pioneering invention is "a distinct step in the progress of the art, distinguished from a mere improvement or perfection of what had gone before.").

[107] *See* Texas Instruments, Inc. v. United States Int'l Trade Comm'n, 846 F.2d 1369, 1370 (Fed. Cir. 1988) (citation omitted) ("Courts early recognized that patented inventions vary in their technological or industrial significance. Indeed, inventions vary as greatly as human imagination permits . . . There is not a discontinuous transition from 'mere improvement' to 'pioneer' . . . The judicially 'liberal' view of both claim interpretation and equivalency accorded a 'pioneer' invention is not a manifestation of a different legal standard based on an abstract legal concept denominated 'pioneer'. Rather, the 'liberal' view flows directly from the relative sparseness of prior art in nascent fields of technology.").

and even then interpretation has only a small effect on the overall count.[108] Also, every first-year associate in a patent practice is firmly instructed to omit all but absolutely necessary limitations from independent claims,[109] and thus counting limitations will leave patent holders at no disadvantage regarding advance notice of licensee priorities.

One point where discretion may still be needed is when the claim limitation itself is worded broadly—e.g., "a widget processing unit"—yet its definition or description in the specification contains several internal limitations. For example, the widget processing unit might be defined as ceramic, comprising certain components, and operating within a certain range of current or revolutions per minute. A rule of reason would suggest counting those internal limitations. Of course licensees need analytical flexibility depending on the circumstances, but they should aspire to uniformity for the sake of efficiency as well as to show objectivity in royalty splits.

The velocity (V) was explained briefly above, but its validation merits fuller discussion. Velocity is a metric for the diffusion of innovations through society. Diffusion begins slowly, accelerates, and then plateaus. The diffusion typically has an S-curve over time for the overall number of adopters,[110] corresponding to a market-segmentable bell curve of buyer adoption rates over time.[111] Statistically, patents filed at

[108] In theory every single word in a claim could be a limitation, but in practice they are not so finely divided. Picking a patent at random illustrates this, as seen with claim 1 of U.S. Patent No. 7,000,000 (applied for January 19, 2000), where the terms underscored here each represent a limitation. "A polysaccharide fiber, comprising: a polymer comprising hexose units wherein at least 50% of the hexose units are linked via an α (1→3) glycoside linkage, said polymer having a number average degree of polymerization of at least 100, and wherein said fiber has a tensile strength of at least 1 gram per denier." [emphasis added]. There are eight real limitations here. The term "A" is not limiting: more than one fiber would still include one fiber. "Polysaccharide" and "fiber" have distinct and independent meanings, and thus each is a limitation. A polysaccharide is by definition a polymer, and no other polymer types are taught in the application, so "a polymer" is not an additional limitation. "[C]omprising hexose units" is a limitation because polysaccharides are not by scientific definition so limited though most natural polysaccharides comprise hexose units. The term "glycoside linkage" is not limiting because by definition in a polysaccharide any comprised hexoses have glycoside linkages, and also glycoside is implicit in the (1→3) term. The term "at least 50% ... α(1→3) glycoside linkage" is limiting, because hexose units are not necessarily linked that way or to that degree; it represents three limitations because frequency (≥ 50%), location (1→3) and orientation (α) are independent aspects of linkage. The degree of polymerization clause is either meaningless or indefinite except as a whole, so it is a single limitation. Likewise, the tensile strength clause must be read as a whole and is a limitation. Thus there are 8 limitations. Their relationships might be mapped if desired, for example as < fiber [polysaccharide (hexose {(≥ 50%), (α), (1→3)})], [n.a.d.p.≥100], [tensile strength] >, where the nested brackets designate subordinate relationships among limitations. Yet circumventing even one limitation makes a competitor's manufacture non-infringing, so all limitations have the same value for counting purposes here regardless of subordinate status or scope. Every claim limitation provides another opportunity for a workaround and makes the patent less valuable. This type of analysis is obviously easiest for someone who has relevant technical expertise, but in licensing and litigation typically both parties are well informed about the subject matter, otherwise they would not be there.

[109] *See generally* RONALD D. SLUSKY, INVENTION ANALYSIS AND CLAIMING: A PATENT LAWYER'S GUIDE 12 (ABA, 2008) (discussing the broadening of claims and eliminating limitations).

[110] *See* B. Ryan & N.C. Gross, *The Diffusion of Hybrid Seed Corn in Two Iowa Communities*, 8 RURAL SOCIOLOGY 15-24 (1943).

[111] *See generally* ROGERS, *supra* note 41.

the beginning of a relevant S-curve tend to be the most valuable, thus close-technology classifications and their positions on the S-curve are charted for comparisons in some of the leading patent analysis software.[112] Technologies experience multiple generations of S-curves and patent grouping is significant, thus that software employs a neural network analysis to identify the most closely related 100 patents based on semantic probabilities including similar patents that use alternative terms.[113] The same software identifies their location on the respective S-curve as well as the invention diffusion rates (e.g., measured by citation counts across an enormous patent database). This is a useful approach but it does not price the length or intensity of a curve and it requires a large investment of resources to make comparisons.

When those types of analytical tools are available, their output can be adapted to assign a velocity for each of many patents to value by my method. In the absence of such tools, however, we need a simple approach that can approximate the same result in a non-arbitrary way. Beginning with a patent's priority filing date, my solution is to quantify the rate of growth for patent application filings in the closest relevant art category as defined by the U.S. Patent and Trademark Office. While this may be somewhat less accurate than semantic neural networks for identifying closest related inventions, and it does not measure diffusion *per se*, the category growth (V) will nevertheless tend to reflect a patent's place on the relevant S-curve(s). Inherently, the length and intensity of subsequent growth will be most marked for patents filed at the beginning of a curve, allowing us to circumvent resource-intensive curve analysis. Purists might refine this by a total growth multiple, or by growth only in the five years after filing, so as to reduce artifacts from later-emerging or unrelated S-curves in the same art class. Nevertheless, there are probably important reasons for the staying power of a venerable but unexpired patent that is being licensed. Therefore my approach calculates growth over the entire period, starting with the priority filing. Note that even though some firms delay or avoid research in sub-classes where there are significant patent positions and litigation costs,[114] category growth and serial S-curves still propagate.

The total number of patents in the closest USPTO technology subclass on the priority filing date is a proxy for the size of the field when the patent application was filed. The patent examiner searches coded classes and subclasses for potentially relevant art;[115] identifying the most relevant subclass, but typically also searching several others.

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[112] *See* Andy Gibbs, *Application of Multiple Known Determinants to Evaluate Legal, Commercial and Technical Value of a Patent*, Working Paper 400 1, 9-10 (Charts D, E) (2005), *available at* http://www.patentcafe.com/library/whitepapers/patent_factor_whitepaper.pdf [hereinafter Gibbs].

[113] *See id.* at 4, 5 (discussing latent semantic analysis and noting that software relies on context for comparisons and does not attempt valuation: ". . . only an uneducated mind would expect a patent analysis report to return the precision of a defined economic value (dollar amount) or a singular rating that disregards the complexity and dynamic nature of patent valuation"). Licensing parties, however, cannot leave value undefined.

[114] *See generally* Walsh, *Effects of Research Tool Patents*, *supra* note 23, at 285-352; Josh Lerner, *Patenting in the Shadow of Competitors*, 38 J. L. & Econ., 463-95 (1995).

[115] *See* USPTO Patent Full-Text and Image Database, http://patft.uspto.gov/web/offices/opc/ (last visited Dec. 1, 2008); USPTO Patent Full-Text and Image Database, http://patft.uspto.gov/netahtml/PTO/search-adv.htm (last visited Dec. 1, 2008); *see also* USPTO Patent Full-Text and Image Database, http://patft.uspto.gov/netahtml/PTO/srchnum.htm (last visited Dec. 1, 2008)

The most relevant subclasses for every issued claim are identified on the face of the patent.[116] Subclasses are sometimes telescopically nested, and are updated from time to time.[117] A patent's primary subclass is not necessarily the one a licensee uses; the licensee's use trumps—but in any negotiation this should create a burden of proof on the licensee to defend the applicability of the selection since this choice will only be asserted by a rational licensee if it results in a lower payment to the licensor. Also, the priority filing date is the logical starting point as it is the earliest indisputable time at which the invention was officially disclosed.

The subclasses themselves are each an arbitrary size, being defined by merely administrative boundaries. However, as long as membership of patents within a subclass is administered consistently by the USPTO once the category is defined, then the arbitrariness of the initial size is not problematic because the (percent) growth rate of the subclass will be representative of activity in the field and the initial and ending sizes are factored out. Moreover subclass histories (e.g., their further division) can be tracked where necessary when measuring category growth.

The total number of patents in the closest USPTO technology subclass on the (projected) launch date represents the degree of growth (and increased crowding) in the field by that date. When it is combined in a time-dependent fraction with the same information for the patent priority date, the fraction is a proxy for the field's growth rate ("velocity") (i.e., the field's market importance). When an older patent in a burgeoning field is still being licensed, it suggests there are no better workarounds, that this was a particularly enabling patent, and that the field itself is recognized as important. The fraction (V) will never be less than 1, and may be much greater, as it amplifies the royalty share for the individual patent.[118] The same known or projected launch date is used for all patents that are licensed in for the corresponding behemoth product, because that date represents a cut-off after which no emerging technology can act as prior art for infringement or patent clearance purposes. If the launch date is projected (i.e., not yet realized), then growth must be extrapolated to that date. The fraction V measures the inertial movement or diffusion of the direction and priorities of technology in the pre-

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(some older classification codes have been reclassified, so updated codes should be used as listed for respective patents on the electronic USPTO patent database); Bronwyn H. Hall et al., *The NBER Patent Citations DATA File: Lessons, Insights and Methodological Tools*, Working Paper 8498, 12-13 (2001), available at http://www.nber.org/papers/w8498, accessed July 12, 2008. The interested reader may find and examine the respective USPTO raw search results at the publicly available PAIR database files for each case. These can be accessed at http://portal.uspto.gov/external/portal/pair. The PTO has categorized patents into over 400 main (3-digit) classes and over 120,000 subclasses, which evolve and develop over time with technological advances.

[116] *See* MPEP, *supra* note 10, § 903.07 ("Classifying and Cross-Referencing at Allowance").

[117] *See generally* Classification Definitions: Class 705, Data Processing: Financial, Business Practice, Management, or Cost/Price Determination (July 2006) *available at* http://www.uspto.gov/web/patents/classification/uspc705/defs705.pdf (offering an exemplary series of classification codes and their descriptions).

[118] V is the number of patents in a class at a later time divided by the number from an earlier time. The number of patents listed in a class does not shrink, so V is never <1. V does not attempt the herculean task of assessing the status of all earlier and later patents as to expiration, validity, enforceability, and withdrawal. V simply measures the relative growth in the number of times players deemed it worth the cost to pursue a patent to issuance.

commons, so it represents the rolling equilibrium that was referenced above. Optionally, the individual contribution of an early patent in a growing field might be deemed to rise over several years as it continues to be licensed if field growth would drive the fraction higher. That would not be the best approach, even apart from the inconvenience of requiring annual recalculation of royalty splits across the board. The product for which a patent was licensed usually does not change enormously after its launch date, and moreover the role of a licensed invention in the commercial product does not change. If shares of the split were allowed to be re-prorated and downgraded unilaterally by the licensee, licensors on the losing end would likely perceive the unpredictability of the result as capricious or even cheating.

In most cases, V might be chosen based on the primary field of art that was searched by the examiner, however one aspect of V is that it leaves flexibility for a licensor and licensee to discuss whether another art class is actually more relevant. Thus a motivated licensor, after understanding the licensee's particular use of the invention, might timely show before the close of negotiations that another, faster-growing subclass is more relevant to the particular end use. The licensor is more likely to be satisfied by an opportunity to confirm the fit than by terms strictly dictated by a licensee. The same principle holds true for other variables. Although negotiation efficiency is a goal, human factors must also be considered. Thus one objective of the algorithm is to focus parties on neutral facts instead of opinions. The wise behemoth licensee might share its licensing algorithm so prospective licensors will raise their concerns efficiently.

The difference in years refers to the difference between the priority filing data and the (projected) product launch date.

The momentum (M),discussed above, warrants further comment. W and V are multiplied to derive M, a measure of a patent's practical impact. Since the validity of metrics for W and V were discussed *supra*, the remaining question is whether the mathematical operation for their combination is reasonable. There are of course many other operators: we could add, subtract, divide, use exponents or logarithms or matrix operations, and so forth. Patent scope and field importance are powerful in synergistic combination, not independently, which eliminates arithmetic operators. Moreover, W and V do not dilute each other, so we can eliminate division. Furthermore, although more sophisticated operations than multiplication exist, they are more complex and have no rational justification, so we can eliminate them using Occam's razor. Thus multiplication of W by V is the most appropriate way to embody the synergy of those two variables.

The master royalty rate is the royalty when all the licensed inventions are treated as just one composite patent from just one hypothetical licensor. Any valuation method may be used to determine this rate, but for the reasons stated above and elsewhere[119] the method based on my variation of the Black-Scholes equation is particularly rational, systematic, and industrially practical. For instance, the Black-Scholes variation discounts the rate to reflect the ordinary market value of unpatented contributions that the licensee

[119] *See* Denton & Heald, *supra* note 49, at 1193-1240.

or defendant made in developing and commercializing the product. In any case, the master royalty rate is ultimately subdivided between licensed patents. Where licensed patents will apply to more than one product, a master royalty rate should be determined for each product.

The increase for the set-aside for unknown patents discounts payouts for known patents to compensate for the possibility that obscure additional art will require royalties and or damages to be paid. The set-aside can be based on industry statistics for the incidence of such things, where the data is available. Where it is not available, the number of technology subclasses searched or assigned to a patent by examiners provides insight into the probability that there might be relevant art in an unsearched subclass: the more art that she feels applies, the more likely it is additional relevant art may be dispersed in other subclasses. For example, if the average number of classes searched or labeled on the patent face is eight, then eight percent might be a reasonable set-aside; if it is three, then three percent might be. This is a guesstimate; the correlation between code counts and missed art might be different from a one percent relationship per class, but in any case the method leverages examiner perceptions of the breadth of relevant prior art and the probability of finding more. Licenses might stipulate that after six year deadlines for filing for infringement damages,[120] the unused buffer from that period would be distributed *pro rata* between licensors to raise their rate and/or erase the slight discount in early years for uncertainty about unknown patents.

The individual royalty rate is calculated by first computing fractions V and M for each patent individually. Then the M value for the individual patent is divided by the sum of M values for all the patents and is further discounted by dividing out (100% plus) the percentage increase for the set-aside. The basis patents should include not only third-party patents but also the licensee's own patents to the extent they are relevant to the product. Trade secrets (whether proprietary or licensed in) that apply to the invention may also be mocked up (e.g., with a claim set and internal disclosure date) as if they were patents so as to include their contributions to value when using the model. Where licensed patents will apply to more than one product for which the patent is being licensed, the individual royalty rate should be determined for each product.

As an example of the methodology, consider a licensed patent "A" with three applicable, significantly non-redundant, independent claims, and an average of eight limitations per claim, yielding a preliminary fraction of three-eighths. If, when A was filed, a total of 100 issued patents were in the USPTO art category closest to the intended usage, and extrapolation from growth trends in the category is projected to be 300 issued patents on the projected product launch date with a 5-year difference in dates, then V = 300/(100 x 5) = 3/5, so M = (3/5)(3/8) = 9/40. If the sum total of all the M values in the applicable patent rights portfolio is 240, then the raw proportional split of the royalties for A is (9/40)/240 = 9/9600. If the average number of art categories searched over all licensed patents is five, then the increase for the set-aside is five percent, so A is

[120] *See* 35 U.S.C. § 286 (2000) ("Except as otherwise provided by law, no recovery shall be had for any infringement committed more than six years prior to the filing of the complaint or counterclaim for infringement in the action."). For more on recovery under this section, see generally LAWRENCE M. SUNG, PATENT INFRINGEMENT REMEDIES 138-41 (BNA Books 2004).

decreased by dividing out 105% or 1.05, i.e., A's share is 9/(1.05 x 9600) = 9/10,080 = 1/1120 of the master royalty. If the master royalty rate had been determined to be ten percent, then the individual royalty rate is (1/1120)(10%) = (1/112)% = 1/11,200, or slightly less than one percent of one percent. While that may not sound large, a product with $1.12 billion in annual revenues would yield $100,000 in annual royalties for that patent alone, which is clearly a non-trivial amount.[121]

Some patents may expire. When one does, the royalty rate for the other portfolio licenses remains unchanged because their role in the invention is unchanged (the licensee merely ceases to pay royalties for an invention now in the public domain). This is comparable to a company leasing one car from each of ten different owners. If under contract terms the tenth car is then paid off and owned free and clear by the company, the rational CEO does not start paying more per mile per car to lease the other nine, because no additional value is received. The company merely pockets the lease amount that no longer must be paid for the tenth, as contemplated by all parties at the signing of each lease. Similarly, bumping up royalties to remaining licensees when a patent expires would ultimately send windfall profits to the last patents to expire regardless of merit. However, although a behemoth licensee pockets the expired patent's royalty, it is not a windfall or free ride because the mega-product is becoming obsolete and so are many of the licensed inventions. Thus to survive, the company must reinvest by adding features or new products and hence probably must also pay new patent licensees. The equilibrium of value keeps rolling outward.

As for the beginning of royalty payments, they should date back to (or be paid retroactively as far back as) the date the particular invention began to be used in development by the licensee, since they would likely not qualify under the narrow exception that exists for experimental use.[122] In this case, the approximate total cost for licensing and other attributes will be known because behemoth patent products do not arise overnight. Thus the license price should be set conservatively based on product expectations, and readjusted when the exact parameters of the licensee's patent rights portfolio are more fully established.

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[121] It will be noted that the value of a patent worth "only" a few hundreds of thousands of dollars might be dwarfed by litigation costs for enforcement. On the flip side, a holder of a patent that is worth relatively little might still demand an exorbitant payoff, i.e., might stage a hold-up to obtain a disproportionate share of royalties from a licensee who has so much at stake that it is unwilling to sacrifice the larger program. *See* Lemley & Shapiro, *supra* note 57, at 1991. However these threat-based distortions can be ignored for a willing buyer and seller who seek merely a rational pricing scheme for invention rights, particularly as is common for assumptions in assessing actual damages and in royalty fees under foreign compulsory licensing.

[122] Justice Story's experimental use exception is narrow in Whittemore v. Cutter, 29 Fed. Cas. 1120, 1121 (C.C.D. Mass. 1813) ("[I]t could never have been the intention of the legislature to punish a man who constructed such a machine merely for philosophical experiments, or for the purpose of ascertaining the sufficiency of the machine to produce its described effects."). *See, e.g.,* Madey v. Duke University, 307 F.3d 1351, 1362. (Fed. Cir. 2002) ("[R]egardless of whether a particular institution or entity is engaged in an endeavor for commercial gain, so long as the act is in furtherance of the alleged infringer's legitimate business and is not solely for amusement, to satisfy idle curiosity, or for strictly philosophical inquiry, the act does not qualify for the very narrow and strictly limited experimental use defense. Moreover, the profit or non-profit status of the user is not determinative.").

IV. OVERCOMING THE UNPREDICTABILITY OF *GEORGIA-PACIFIC* PRICING ANALYSIS

A. The Background and Shortcomings of *Georgia-Pacific*

Under the patent statute a patent owner is entitled to "damages adequate to compensate for the infringement, but in no event less than a reasonable royalty for the use made of the invention by the infringer."[123] The relevant damages are well settled under case law. Lost profits are available where the patent owner proves by a preponderance of the evidence that it would have made more sales "but for" the use made by the infringer and provides adequate quantification of its loss.[124] That proof includes: "(1) demand for the patented product, (2) absence of acceptable non-infringing substitutes, (3) his manufacturing and marketing capability to exploit the demand, and (4) the amount of profit he would have made [but for the infringement]."[125]

To the extent that lost profits cannot be proven, a reasonable royalty is available. That amount is determined according to a flexible, fifteen-factor test that was first articulated in *Georgia-Pacific*[126] in the federal Southern District of New York. The Federal Circuit adopted the *Georgia-Pacific* test, which, when applied, requires courts to imagine a "hypothetical negotiation" between the parties just prior to the time the infringement began.[127] The *Georgia-Pacific* test has also been adopted in other circuits to adjudicate cases under private ordering (for industry standards) in which breaches of duty to license patents fairly were alleged.[128] The district court indicated, "there is no formula by which these factors can be rated precisely in order of their relative importance,"[129] thus the fifteen factors are not all equally important and all the factors are not required to be applied in every case.

The *Georgia-Pacific* test is controversial and has come under congressional fire because its results in the hands of courts are unpredictable,[130] but as of this writing, *Georgia-Pacific* is still good law. The myriad of possibilities for parties to manipulate an imagined hypothetical negotiation[131] and cherry-pick its constellation of fifteen separate

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[123] 35 U.S.C. § 284.

[124] *See, e.g.*, Panduit Corp. v. Stahlin Bros. Fibre Works, 575 F.2d 1152 (6th Cir. 1978).

[125] *Id.* at 1156.

[126] Georgia-Pacific Corp. v. United States Plywood Corp., 318 F. Supp. 1116, 1120 (S.D.N.Y. 1970), *modified* 446 F.2d 295 (2d Cir. 1970), *cert. denied*, 404 U.S. 870 (1971).

[127] Minco, Inc. v. Combustion Eng'g, Inc., 95 F.3d 1109, 1119-20 (Fed. Cir. 1996).

[128] *See* Broadcom Corp. v. Qualcomm Inc., 501 F.3d 297 (3rd Cir. 2007) (discussing the Universal Mobile Telecommunications System (UMTS) standard for Global Systems for Mobility (GSM) third generation (3G), for which the European Telecommunications Standards Institute (ETSI) and its counterparts elsewhere require a commitment from vendors whose technologies are included in standards to license their technologies on fair, reasonable, and non-discriminatory (FRAND) terms; neither the ETSI nor its counterparts elsewhere further define FRAND). The Third Circuit noted that earlier cases in other jurisdictions had already applied the Georgia-Pacific test successfully for cases concerning FRAND terms, and adopted it in this case. *Id.*

[129] *Georgia-Pacific*, 318 F. Supp. at 1120.

[130] *See, e.g.*, Marcia Coyle, *Patent Reform Finds Traction: Debate on Damages, Validity Vhallenges*, NAT'L L. J., (August 2, 2007), *available at* http://www.law.com/jsp/article.jsp?id=1186045598419.

[131] *Minco*, 95 F.3d at 1119-20.

factors[132] probably doomed the reproducibility of outcomes from the outset. A leading handbook on patent litigation provides over 300 pages of detail on how to trivialize financial standards from the adverse party's expert testimony as either grossly inadequate or grossly generous.[133] Not surprisingly the Federal Circuit characterized the reasonable royalty calculation as involving "the talents of a conjurer."[134] The *Georgia-Pacific* test is a rule of reason analysis, but is hardly improved over historic analyses that provoked Joseph Story's preference for injunctions to encourage settlement and avoid judicial calculation of infringement damages in patent and copyright cases.[135]

Georgia-Pacific has also been under scholarly attack. All of the *Georgia-Pacific* factors are problematic because their valuation effects and relative weights are unassigned, but special objections are raised to *Georgia-Pacific*'s search for evidence of a patentee's and industry's royalty practices, which, when present, tend to trump the other factors. Lemley and Shapiro are particularly critical of judicial deference to prior defective patent pricing.[136] Some policy arguments can be paraphrased as follows. When calculating their bargaining leverage some patentees estimate the reasonable royalty damages they could win in litigation if they refuse to deal, and the sky is the limit. But courts set no inherent ceiling on reasonable royalty damages, thus patentee bargaining expectations tend to become self-fulfilling, creating a platform for an escalating spiral of damages.[137] This empowers naive infringement plaintiffs to win outsized damages merely because they had demanded higher royalty rates than the rational market would bear, and equips crafty infringement plaintiffs to write their own tickets merely by creating a paper trail of outsized royalty demands in advance. Given that industries themselves have defective pricing methods (e.g., using rules of thumb without understanding either their origin or their fact-intensive adaptability), courts should defer to neither party practices nor industry practices when deciding reasonable royalties apart from a showing of market aptness. There are of course limits on inflationary trends: courts will not assess trillion dollar damages for infringing in a merely billion dollar annual market. But merely avoiding absurd extremes is hardly a strong case for the *Georgia-Pacific* test.

A related concern is the effect of injunction availability on royalty rates and money damages. Similar to what occurs with regards to royalty damages, using the threat

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[132] Choi & Weinstein, *supra* note 61, at 51 ("[L]icensing experts run down the list [of the fifteen factors] and identify some factors that support 'high' royalty rates, while others identify those factors that support 'low' royalty rates, whichever seems to benefit them most.").

[133] *See generally* RUSSELL L. PARR, INTELLECTUAL PROPERTY INFRINGEMENT DAMAGES: A LITIGATION SUPPORT HANDBOOK (1993).

[134] Trell v. Marlee Elecs. Corp., 912 F.2d 1443, 1447 (Fed. Cir. 1990).

[135] *See* 2 JOSEPH STORY, COMMENTARIES ON EQUITY JURISPRUDENCE AS ADMINISTERED IN ENGLAND AND AMERICA 236–37 §§ 930-932 (Melville M. Bigelow ed., 13th ed., 1988) (1886) (citations omitted).

[136] *See* Lemley & Shapiro, *supra* note 57, at 1991.

[137] Mark Schankerman and Suzanne Scotchmer, *Damages and Injunctions in Protecting Intellectual Property*, 32 RAND J. ECON. 199, 200 (No. 1, Spring 2001) *available at* http://socrates.berkeley.edu/~scotch/publications.htm [hereinafter Schankermann and Scotchmer] ("The lost-profit (lost-royalty) doctrine leads to the following circularity: On one hand, prospective damages determine the maximum license fee that a licensee would pay. On the other hand, the presumed license fee determines the damages.").

of injunction to enhance bargaining power during license negotiation will lead to circular reasoning and inflationary spirals for pricing and damages as well.[138] Moreover, as has been noted for antitrust remedies, which like patents concern market monopolies, another problem with injunctions is the transitory character of markets. By the time the lengthy litigation is done the problem will likely have changed, so that plaintiffs are often put in the position of trying to remedy a problem that once was real, but now has become moot and perhaps replaced by a new one.[139]

In fact, royalty damages would be calculated more reasonably by rigorously partitioning the royalty portion and the deterrent or punitive portion. The value associated with market infringement can be calculated objectively by ordinary financial math, whereas the value of deterrent or punitive provisions is subjective and its effectiveness depends on the infringer, so deterrence and punishment should be left to established principles of jurisprudence. Indeed, as discussed *infra*, reasonable royalty calculations under *Georgia-Pacific* are supposed to assume the buyer and seller are each willing, rational, bona fide actors to commercialize an invention. In commerce, such parties focus most of their energy on market value and technology transfer issues, not litigation value. By stripping litigation contemplations out of the hypothetical negotiation, the courts will remove the circularity from the logic and conveniently excise the worst complexity of the calculation. The methodology prescribed in this paper in fact focuses on the objective piece: the reasonable royalty. Whether and how much to amplify that amount to achieve deterrence or punishment, or whether to apply an injunction, is beyond the scope of this paper, yet is within the traditional role for which courts are generally recognized to be competent.

In light of these considerations it would be advisable to scrap or overhaul the *Georgia-Pacific* test in a new statute or appellate decision. Unfortunately a large number of patent cases will likely be settled or decided before that happens, and for those cases a more enlightened application of the *Georgia-Pacific* test is still needed. Moreover any new rule that does not address these issues in a logically systematic way is unlikely to be an improvement. Thus although the present paper does not endorse the *Georgia-Pacific* test, I will nevertheless demonstrate that the option pricing paradigm can inject rationality even within the historical constraints of *Georgia-Pacific*. Additionally in fact, animation of the rule by the new options paradigm should stop the vicious cycle of erroneous but self-fulfilling valuations, thus *Georgia-Pacific* itself has the potential to become a reasonable rule.

B. Facile Judicial Adoptability of the New Method

The only fix for *Georgia-Pacific*'s analytical protocol is to identify a single patent valuation method that can satisfy the spirit and the requirements of the rule in a neutral,

[138] *See id.* at 201. *But see id.* at 200 (arguing that a potential licensee's and potential infringer's threats *not* to develop the product could have leverage because the patentee would lose value in that scenario).

[139] Einer Elhauge, *Disgorgement as an Antitrust Remedy*, Harvard Center for Law, Economics and Business Discussion Paper No. 613, 1, 12 (July 28, 2008,) *available at* http://ssrn.com/abstract=1136945 (citing Microsoft Corp. v. United States, 253 F.3d 34, 48-49 (D.C. Cir. 2001) (en banc)).

objective, quantitative, systematic, and reasonably consistent way. This will require the balance of factors in commercial negotiations to be manifestly evident in the method. Of course the *Georgia-Pacific* court expressly stated that there was no formula by which to rate the factors by order of relative importance, yet a professional who has spent more time working with inventions, patents, and licenses might find a way to incorporate their respective case-sensitive contributions in financial calculations. Thus it would have been more accurate for the court to say that "no formula currently known to the court would suffice." I now discuss why my prior-published variation on the Black-Scholes equation for patent license pricing, in combination to the extent necessary with the algorithm introduced in this paper, is the only existing known methodology that can serve that purpose. The fifteen factors are listed *infra*[140] with preceding and accompanying text to explain the fit between the valuation model and the respective requirement.

In general the factors can be divided into three categories. Factors a, b and to some extent n below focus on the evidence that an established royalty rate already existed, which if found could determine the rate for damages. My model questions the validity of those numbers but does not upset that rule. Factors d and e below each in part focus on identifying punitive aspects—in other words, was there a reason damages should exceed the price of an ordinary voluntary transaction between willing parties? In that case the market-based royalty rate would be calculated and then multiplied by some punitive-like amount. My model can calculate the market rate and a court can then use its own reading of the facts to decide what the punitive multiple might have been.[141] The remaining eleven factors and the residuum of factors d, e and n simply aim to ascertain facts from which an industry average royalty rate might be calculated. My model supplies them.

This approach allows faithful consolidation of the full *Georgia-Pacific* analysis into just three steps. First: identify any evidence of established royalty practice by either party or the commercial environment to determine whether an *a priori* royalty rate must be used. Here I merely rephrase the original rule, and courts are skilled at the task. Second: if not trumped by *a priori* rates, determine market royalty rates by my method. Third: identify any evidence of situations that would call for punitive-like multiplication of the market rate. This also rephrases the original rule, and courts are competent in selecting multiples. This model balances all the *Georgia-Pacific* factors in a consistent, pragmatic, fact-sensitive, and economically rational way, thereby removing historic difficulties including cherry-picking by parties. The math can be performed by economists, accountants, or financial professionals, and is also suitable for investor use. Note that I do not blindly endorse *a priori* rates. Hopefully courts will recognize the limited credibility of such rates—this paper merely acknowledges the full range of

[140] Georgia-Pacific Corp. v. United States Plywood Corp., 318 F. Supp. 1116, 1120 (S.D.N.Y. 1970); *see also* Roy J. Epstein & Alan J. Marcus, *Economic Analysis of the Reasonable Royalty: Simplification and Extension of the Georgia-Pacific Factors*, 85 J. PAT. & TRADEMARK OFF. SOC'Y 555 (2003); Choi & Weinstein, *supra* note 61, at 49 n.1 (2001). For a hornbook discussion, see SUNG, *supra* note 120, at 273-343. For a licensing-related discussion, see GORDON V. SMITH & RUSSELL L. PARR, INTELLECTUAL PROPERTY: LICENSING AND JOINT VENTURE STRATEGIES 142-48 (3d ed. 2004).

[141] My understanding from anecdotal accounts in industry is that 2x to 4x is a typical market multiple in such cases.

statutory and judicial objectives embodied by the *Georgia-Pacific* requirements and shows how to achieve them rationally.

a. The royalties received by the patentee for the licensing of the patent in suit, proving or tending to prove an established royalty;

This factor examines evidence of an ongoing established rate practice by the *patentee*, in order to use that rate to set damages. As noted above, my model questions the validity of the prior rate but does not upset that rule and would not necessarily alter a rate determination made under that rule.

b. The rates paid by the licensee for the licensing of the patent in suit;

This factor examines evidence of an ongoing established rate practice by the *licensee* in order to use that rate to set damages. As noted above, my model questions the validity of the prior rate but does not upset that rule and would not necessarily alter a rate determination made under that rule.

c. The nature and scope of the license, as exclusive or non-exclusive; or as restricted or non-restricted in terms of territory or with respect to whom the manufactured product may be sold;

All of these factors relate to the size and characteristics of the market(s) into which the invention is sold. These are inherently incorporated by my model's assessment of market size, market share, and profitability in the respective market(s) to determine royalty rate.[142] Moreover because the license can be paid as a royalty percentage of revenues, the pay-outs scale with sales volume.

d. The licensor's established policy and marketing paradigm to maintain his patent monopoly by not licensing others to use the invention or by granting licenses under special conditions designed to preserve that monopoly;

This factor essentially screens for evidence of conditions that would justify punitive-like damages, where such conditions likely would have involved a rate amplification if the patent was licensed at all. If the court finds that the licensor had its own policy for amplifying the royalty rate in such cases, that rate may be used provided it is not far beyond what any reasonable licensee would have paid (e.g., 1,000x the going market royalty rate would generally be excessive).

In cases where the patent owner would not license the patent voluntarily or had policies beyond what a court could reasonably award, an alternative must be found. The court essentially must compute the market rate that would have been determined voluntarily and then apply a

[142] Denton & Heald, *supra* note 49, at 1208-14.

punitive multiple to simulate the rate a reasonable but reluctant licensor might have charged. My model provides a rational basis for assessing the market rate. The punitive-like multiple would be determined at a court's discretion, but this is not extraordinary for a court.

e. The commercial relationship between the licensor and licensee, such as whether they are competitors in the same territory in the same line of business, or whether they are inventor and promoter;

This is similar to factor d. Licensing to direct competitors for sale of the same invention limits the size of one's own market share and also improves their own competitive position in the market. It happens more commonly than might be expected, for instance where the patent owner does not have the capacity or resources to exploit the entire market opportunity, or needs a cross-license from the competitor, or is considering exiting that particular market. But for a high enough price, even deals in aggressive direct competition outside those conditions are sometimes done.[143] A punitive multiple approximates the range of multiples that would have to be offered to make a deal happen in the absence of an express internal incentive for the patent owner to do the deal. Either way, the market rate would be determined (as by my model), and then the court would apply a punitive multiple to it if such was deemed appropriate.

By contrast, in my experience and observations in industry, an inventor licensing to a promoter usually does so at the market rate. If the royalty rate is lower than the market share, the difference is often a result of having paid the inventor other consideration as well. Again, my model provides the necessary rational method for computing what the market royalty rate would be, and how to adjust when other consideration such as an "up-front fee" is paid.

f. The effect of selling the patented specialty in promoting sales of other products of the licensee; that existing value of the invention to the licensor as a generator of sales of his non-patented items; and the extent of such derivative or convoyed sales;

This factor is satisfied directly because the values of commercialization efforts of both parties are considered independently when determining the royalty rates, as discussed in my original paper.[144] In addition, derivative or convoyed sales are also reflected in the market size, market share, and profit premium attributable to the patent under my model when statistical ranges for those values for the derivative or convoyed sales can be reasonably anticipated in advance.[145] When ranges

[143] *See* Telecky, *supra* note 34 (discussing patent cross-licensing); *see also* Texas Instruments, Inc. v. Hyundai Elec. Indus, Co. Ltd., 49 F. Supp. 2d 893 (E.D. Tex. 1999) (discussing portfolio licensing).

[144] Denton & Heald, *supra* note 49, at 1219-22.

[145] *Id.* at 1208-13.

cannot be anticipated in advance, a royalty for derivative or convoyed sales can simply be applied as for the patented product to reflect their contribution.

g. The duration of the patent and the term of the license;

This factor is satisfied directly, as addressed *supra* concerning when royalty payments begin and end. It is also addressed because the master royalty rate for my options method is the aggregate net present value of yearly increments of the lifecycle of the product in light of the obsolescence trends in the market.[146]

h. The established profitability of the product made under the patent; its commercial success; and its current popularity;

Using a percentage of revenues to determine the royalty rate, as is done by my method, automatically pays the licensor in proportion to the success and popularity of the licensee's product.[147] Parenthetically, in light of the fact that this *Georgia-Pacific* criterion refers to a retroactive analysis, let it be noted that negotiations under the current model can be either contemporaneous or hypothetically prior in time, yet will use the same body of data. Retroactive analysis is particularly strong because more data is available for actual market volume and volatility.

Also, my royalty-setting method is based on the option value of statistical distributions of patent-based profit levels in given markets.[148] This efficiently factors in the balance of risk and reward between parties to arrive at a single number. Options are widely used in the financial community because of this property.[149]

i. The utility and advantages of the patent property over the old modes or devices, if any, that had been used for working out similar results;

This is addressed in two ways. My original paper described an operational business "value-chain" analytical framework by which the type of contribution from a patent could be assessed and valued.[150] My current paper provides *supra* a trio of metrics, W, V, and M, which between them embody the extent of the patent claims used, their relative breadth, the degree of advance, that patent's importance in its own field, and the degree of importance of that field itself.

Case-by-case analyses of relative advances over prior art will always be highly subjective and thus disputed, leaving courts to wonder

[146] *Id.* at 1214-16, 1230-34.
[147] *Id.* at 1208-16 (discussing percentages reflecting product popularity and success).
[148] *Id.* at 1211-13.
[149] *See, e.g.,* NEIL A. CHRISS, BLACK SCHOLES AND BEYOND: OPTION PRICING MODELS (1997); JOHN HULL, OPTIONS, FUTURES, AND OTHER DERIVATIVES (2006).
[150] Denton & Heald, *supra* note 49, at 1271-72, app. D.

which side's experts are right. I submit that mine is the better approach because it provides simple but powerful objective criteria that yield highly predictable results that enable comparisons. Furthermore, my approach is biased toward neither patentees nor licensees.

j. The nature of the patented invention; the character of the commercial embodiment of it as owned and produced by the licensor; and the benefits to those who use the invention;

For a relatively straightforward (i.e., non-splintered) scenario, this factor is addressed by incorporating the value chain analysis referenced for item (i) above. For a more complex (i.e., splintered) scenario, this factor is addressed by the metrics W, V, and M disclosed in the present paper because they embody among other things the scope of relative utility, breadth, and importance of the invention. In particular, with respect to benefits to those using the invention, it should be noted that the proliferation of patents in a particular field is a reliable yet extraordinarily easily ascertained measure of importance to the market, which is why my model uses it. In general, parties in a foreseeably small market do not file for thousands of new patents related to it.

k. The extent to which the infringer had made use of the invention; and any evidence probative of the value of that use;

The extent of an invention's use is accommodated because my model uses royalty percentages of revenues. Evidence probative of the value of use is incorporated in the value chain analysis as when the effects of a relatively small number of products are being evaluated for a particular patent. Other probative evidence is uncovered by the metrics W, V, and M that embody the breadth and importance of a patent as well as art from its field generally, as discussed for factor i *supra*.

l. The portion of the profit or of the selling price that may be customary in the particular business or in comparable businesses to allow for the use of the invention or analogous inventions;

As shown in my earlier paper and mentioned above, the large differences between industry rules of thumb for royalty percentages can be reconciled by restating in terms of splitting debt-free net income: they are approximately 50:50 splits.[151] Also, as discussed in that paper, my numbers tend to fall into the same ballpark as terms from existing practice, but with more precision and justifiable basis.[152]

It should be noted that in many cases a 50:50 split is not plausible, for instance where both parties invent but one does all the commercialization, or as in software where one party commercializes a

[151] *Id.* at 1191-92, tbl. 1 at n.54

[152] *See id.* at 1233-34 (comparing real option pricing result with a five percent rule of thumb).

behemoth product and licenses from many different patent owners. My model shows how to address this and thus has an advantage over rules of thumb, the original bases for which generally have been long forgotten by the industry under review.

m. The portion of the realizable profit that should be credited to the invention as distinguished from any patented elements, the manufacturing process, business risks, or significant features or improvements added by the infringer;

My options method for determining the master royalty rate factors out the value of commercialization contributions from the parties, which can be rewarded independently. Manufacturing issues are inherent in that analysis, but my model is more comprehensive and includes, for instance, marketing contributions and others based on a value chain analysis. The use of options math precisely adjusts the profit split based on business risks to each side. The method also recognizes the necessary supplemental inventive contributions of the licensee/infringer.

n. The opinion testimony of qualified experts;

Qualified expert opinion testimony will always have a place in trials, and my model does not disturb that practice. However, under a rule of reason a court should also accord special weight to valuation recommendations of a paper such as this one because of the evidentiary credibility concerns in patent valuation at present.

(1) Prior valuation methods have been largely discredited or exposed as grossly oversimplified. As discussed above it is well established that traditional patent valuation methods are inadequate, and that consequently courts and industry have been at a loss. Logically, then, any expert opinion that is based only upon traditional patent valuation methods offers at best a crude approximation of value and at worst a gross distortion of value, so any supplemental information that represents a *prima facie* material improvement should be considered in the interest of justice and judicial efficiency.

(2) I am in fact a qualified expert, if that criterion can be satisfied by substantial patent-related work since 1992 including in industry, and by developing the most advanced patent valuation model on record.

(3) Mine is a neutral and disinterested voice. Unlike damages experts at trial, at the time of this writing I represent no party or interest in damages litigation, and have no particular expectation of doing so. Nor have I received any type or consideration for the development of my patent valuation models, other than a university faculty salary on terms that do not restrict ordinary academic freedom of research and expression. The protocols of my model also address only requirements for objective,

efficient, and impartial analysis: my model favors neither plaintiffs nor defendants, and is indifferent to the field of art. Furthermore, I have left in the public domain all rights to use of these patent valuation algorithms.[153]

(4) If offered in court, the facts and positions represented here would colorably satisfy the Daubert criteria for admissibility of expert evidence.[154] With regards to the prong of relevancy, these two papers directly bear on the issue of fair amounts for damages. As to the prong of reliability, I have shown my conclusions were derived from the methods of the relevant field of science—financial science—and my methods, though new, fall within Daubert's general legitimacy observations.

> Empirical testing: My technique provides precise answers using specific data and a rational protocol, thus it is falsifiable, refutable, and testable.
>
> Subjected to peer review and publication: My methods are published in scholarly legal journals[155] and the initial paper was also posted on the Social Science Research Network web site[156] where it has been freely searchable by the public, including economic and financial professionals. This Article will also be posted there. With regards to the peer review requirement, unlike technical journals, most scholarly law journals do not use referees and none of the American law journals that do use them specialize

[153] I am the sole inventor of the options method and algorithms disclosed in this and the prior paper; I dedicate them to the public. I likewise grant to the public free and unrestricted use of the extent of copyright that is reserved to me from my prior publication on patent valuation as well as this one, requesting only that users attribute the source properly when reproducing or otherwise quoting from them.

[154] Daubert v. Merrell Dow Pharmaceuticals, 509 U.S. 579 (1993). The Court held that federal trial judges are the "gatekeepers" of scientific evidence, thus they must evaluate proffered expert witnesses to determine whether that expert testimony is both "relevant" and "reliable," a two-pronged test of admissibility. The first concerns whether the expert's evidence is relevant to the issue at hand in the trial. For the second prong, in order for expert testimony to be considered reliable the expert must have derived his or her conclusions from the scientific method. *Id.* at 589. The Court offered the following "general observations" of whether proffered evidence was based on the scientific method, though the list was not intended to be used as an exacting checklist, the theory or technique must:

(1) Be subject to empirical testing and must be falsifiable, refutable, and testable,

(2) Be subjected to peer review and publication,

(3) Utilize a known or potential error rate and the existence and maintenance of standards concerning its operation, and

(4) Be generally accepted by a relevant scientific community.

Id. at 593-94.

[155] *See, e.g.*, Second Annual Intellectual Property Scholars Conference, Benjamin N. Cardozo School of Law (Yeshiva University), August 8-9, 2002, Schedule, *available at* http://www.peteryu.com/ipsc02.htm (last visited July 10, 2008) (where my coauthor presented the initial paper for discussion before submission for publication). The list of professional reviewers before submission is on file with the authors.

[156] The abstract continues to be posted at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=385843 and a draft manuscript of the full paper can be freely downloaded in .pdf format from that website.

in intellectual property.[157] Instead, a legal paper's credibility is usually validated by the respectable ranking of the journal in which it appears and by the number of times it is cited or downloaded. My relevant papers are published by law reviews ranked in the top twenty-five percent,[158] and my first Article had an extraordinary number of third-party downloads.[159] Thus they are within the spirit of the Daubert elements.

Known or potential error rate; maintenance of standards: The error rate in my method is only the degree of experimental error in collecting financial and market data, which affects all other patent valuation methods to the same extent. As for standards, the level of description in my articles rivals or exceeds that of professional treatises on using other methods.[160]

General acceptance by a relevant scientific community: To my knowledge the initial publication has been cited[161] in law reviews and elsewhere, but not contradicted in any publication. Additionally, the method disclosed there has already begun to be endorsed by the professional valuation community.[162]

o. The amount that a licensor (such as the patentee) and a licensee (such as the infringer) would have agreed upon (at the time the infringement began) if both had been reasonably and voluntarily been trying to reach an agreement; that is, the amount which a prudent licensee—who desired, as a business proposition, to obtain a license to manufacture and sell a particular article embodying the patented invention—would have been willing to pay as a royalty and yet be able to make a profit and which amount would have been acceptable by a prudent patentee who was willing to grant a license.

My original paper discusses at length how my royalty model is adapted to simulate the negotiation conditions necessary to achieve a win-

[157] *See* http://lawlib.wlu.edu/LJ/index.aspx (last visited November 16, 2008) (listing refereed law journals).

[158] For searchable rankings, see http://lawlib.wlu.edu/LJ/index.aspx (last visited November 16, 2008).

[159] As of April 16, 2009, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=385843 had logged 795 downloads at the Social Science Research Network (SSRN) database; it ranked 4,994th in downloads, thus in the top three percent for the 187,335 full-text papers posted there. See statistics at http://papers.ssrn.com/sol3/DisplayAbstractSearch.cfm.

[160] *See generally* Gordon V. Smith & Russell L. Parr, VALUATION OF INTELLECTUAL PROPERTY AND INTANGIBLE ASSETS (John Wiley & Sons 1989); RAZGAITIS, *supra* note 64.

[161] *See, e.g.*, Mark A. Lemley & Carl Shapiro, *Probabilistic Patents*, 19 J. ECON. PERSPECTIVES (2)75, 81 (Spring 2005) *available* at http://faculty.haas.berkeley.edu/shapiro/patents.pdf (last visited July 11, 2008). The authors are affiliated with Stanford Law School and University of California at Berkeley's Haas School of Business, respectively.

[162] *See, e.g.*, Fernando Torres, Options and Royalty Rates: The Real Options Approach to Accurate Licensing Rates, *available at* http://formulatorres.blogspot.com/2006_05_01_archive.html (last visited July 5, 2008); Torres, *Rates Through Options*, *supra* note 74.

win negotiation between a patent owner and licensee. In particular, the model uses only publicly available data so as to preempt bluff, puffery, and deception. The royalty is also based on statistical characteristics of the specific market in view. The model uses industry average performance values to avoid disputes over reasonableness.

The model accommodates operational factors in an unprecedented way. It proportionally adjusts the profit split to recognize licensee supplemental invention and licensor commercialization efforts where they are present. It differentiates between patent value and commercialization skill when parsing profits, and uses the differential of profit levels for patent exclusivity and commodity products. The model also factors out the effect of a licensee's non-average cost of capital from the royalty so that a licensor is not penalized for licensee inefficiency and a super-efficient licensee keeps the rewards of efficiency.

C. Compatibility with Recent Federal Reform Efforts

Given the ongoing recent congressional interest in patent reform including the area of damages, it is possible the *Georgia-Pacific* test will be modified or replaced by another that continues to look at factors without a ranking or balancing algorithm. For purposes of illustration, this section explains how the model introduced in this paper could be used consistent with guidelines under legislative consideration, based on the reasonable royalty as determined under the amendment bill for 35 U.S.C. § 284(b) that was passed by the House of Representatives most recently.[163] For the sake of clarity a

[163] *See* H.R. 1908, 110th Cong. § 5, (Amending 35 U.S.C. § 284) (as passed by House, September 7, 2007)*available at* http://thomas.loc.gov/cgi-bin/bdquery/z?d110:H.R.1908. The following language was included in Section 284 as part of this amendment:

(b) Reasonable Royalty-

(1) IN GENERAL- An award pursuant to subsection (a) that is based upon a reasonable royalty shall be determined in accordance with this subsection. Based on the facts of the case, the court shall determine whether paragraph (2), (3), or (4) will be used by the court or the jury in calculating a reasonable royalty. The court shall identify the factors that are relevant to the determination of a reasonable royalty under the applicable paragraph, and the court or jury, as the case may be, shall consider only those factors in making the determination.

(2) RELATIONSHIP OF DAMAGES TO CONTRIBUTIONS OVER PRIOR ART- Upon a showing to the satisfaction of the court that a reasonable royalty should be based on a portion of the value of the infringing product or process, the court shall conduct an analysis to ensure that a reasonable royalty under subsection (a) is applied only to that economic value properly attributable to the patent's specific contribution over the prior art. The court shall exclude from the analysis the economic value properly attributable to the prior art, and other features or improvements, whether or not themselves patented, that contribute economic value to the infringing product or process.

(3) ENTIRE MARKET VALUE- Upon a showing to the satisfaction of the court that the patent's specific contribution over the prior art is the predominant basis for market demand for an infringing product or process, damages may be based upon the entire market value of the products or processes involved that satisfy that demand.

(4) OTHER FACTORS- If neither paragraph (2) or (3) is appropriate for determining a reasonable royalty, the court may consider, or direct the jury to consider, the terms of any

condensed, paraphrased version with added emphasis is used to compare elements here. It will be noted that this bill's protocol, though it operates more like a flow chart than the *Georgia-Pacific* factors do, still has a significant number of qualitative independent factors. The reform approach could be made more efficient by optional implementation with a good pricing model as I show here. But it would be less cumbersome to eliminate the bill's hodgepodge of *ad hoc* elements for special cases, instead embedding a rational general solution such as the one I introduce.

> **(1) Based on the facts of the case, determine whether paragraph (2), (3), or (4) [below] apply in calculating a reasonable royalty. Identify factors relevant under the applicable paragraph, and consider only those factors.**
>
> The valuation model would of course follow the rules under those paragraphs.
>
> **(2) Upon a satisfactory showing that a reasonable royalty should be based on a portion of the value of the infringing product or process, apply a reasonable royalty only to economic value properly attributable to the patent's specific contribution over prior art. Exclude all other sources of economic value for the infringing product or process.**
>
> This requires a stepwise fact-sensitive analysis. *First*, an overall royalty rate would be determined by my real options algorithm. The analysis would initially calculate a total royalty based on *all* contributing patented art including but not limited to the patented art in the controversy. Prior art in the public domain would not be included. (Value from unpatented art that adds economic value would be represented by the profit rate for unpatented commodities in the respective market, so it does not need to be isolated by the calculation.) The royalty split for patented art in controversy would thus be a fraction of the total royalty calculated.
>
> *Second*, where some or all applicable patents could be parsed individually to determine specific values (e.g., one affords operational savings, another is a feature with a specific market), those would be analyzed by my earlier publication's protocol (including value chain) to determine respective royalty shares.
>
> *Third*, the residuum of royalty would be split between patents for which individual values could not be differentiated by the methods of the first paper (as in a splintered situation); the methods of the present paper would determine apportionment within the splintered group.

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nonexclusive marketplace licensing of the invention, where appropriate, as well as any other relevant factors under applicable law.

(5) COMBINATION INVENTIONS- For purposes of paragraphs (2) and (3), in the case of a combination invention the elements of which are present individually in the prior art, the patentee may show that the contribution over the prior art may include the value of the additional function resulting from the combination, as well as the enhanced value, if any, of some or all of the prior art elements resulting from the combination.

Fourth, the royalty shares of all art *not* at issue in the controversy would be subtracted from the master royalty rate. The remainder of the royalty would be allocated to the infringed patent(s).

(3) Upon a satisfactory showing that the patent's specific contribution over the prior art is the predominant basis for market demand for an infringing product or process, damages may be based upon the entire market value of the products or processes involved that satisfy that demand.

This part is punitive in some respects,[164] and would override my model's constraints. The royalty would be calculated as if one patent was responsible for all of the market size, market share, profitability, and every part of the value chain (i.e., as if the infringer did nothing for inventiveness or commercialization).

(4) If neither (2) or (3) is appropriate, consider the terms of any nonexclusive marketplace licensing of the invention, where appropriate, as well as any other relevant factors under applicable law.

This essentially explicitly applies factor (a) as described above for the *Georgia-Pacific* rule, and implicitly applies the remainder of the *Georgia-Pacific* factors. Thus the analysis would proceed as described above for *Georgia-Pacific*.

(5) For paragraphs (2) and (3), for a combination invention the elements of which are present individually in the prior art, the patentee may show that the contribution over the prior art may include the value of the additional function resulting from the combination, as well as the enhanced value, if any, of some or all of the prior art elements resulting from the combination.

In the case of (2), under my methods the valuation is based on the market benefits, thus it needs to look only at market share, market size and profitability, not whether the invention is a combination or not. So the pricing analysis would be identical to that described for (2). The provision for value chain assessments automatically identifies benefits of combination to the extent they can be parsed individually; the other provisions assess the remaining value in the alternative.

In the case of (3), the use of the entire market value would govern, so the combination analysis would be identical to that described above for (3) anyway.

[164] *See, e.g.*, Brian J. Love, *Patentee Overcompensation and the Entire Market Value Rule*, 60 STAN. L. REV. 263 (2007) (discussing the judicial history of the rule and arguing that in many cases the rule creates an undeserved windfall by compensating patent holders even for innovation they did not create).

V. LOOKING FORWARD

The approach provided here offers a fast track to precision, fairness, and efficiency in damages and royalty determination, as well as for protocols and controversies involving fair licensing under industry standards.[165] For negotiations and litigation, it minimizes the "us-versus-them" environment and focuses on specific publicly available data. For scholars, it provides a basis for post-mortem assessments of the validity and effect of "reasonable royalty" levels set by U.S. courts in patent infringement cases in recent decades. It also enables similar studies of the effect and fairness of reasonable royalties under compulsory licensing in foreign states, where such licenses are widely authorized in law.[166] Just as the U.S. requirement for payment of reasonable royalties merely created a mandate that eluded precise satisfaction, the foreign requirements for adequate remuneration for compulsory licenses seem to have done the same, so the new valuation model may have utility under international law. Note that the algorithm itself is not magical, and that reasoned, justified variations of it may also be appropriate from time to time. For instance, where two parties already had a rule of thumb master royalty percentage but no mechanism for partitioning the royalties in a splintered situation, then it might be appropriate to extend the rule of thumb by hybridizing it with the momentum metric comparison.

Looking further out, the emergence of this patent valuation method will better inform the decisions of inventors, and may also raise the bar for diligence in pricing. Fiduciary duties to shareholders make this relevant to firms that acquire patent assets or

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[165] For a discussion of the duty to license on fair, reasonable, and non-discriminatory (FRAND) terms for technologies in an industrial standard, see Broadcom Corp. v. Qualcomm Inc., 501 F.3d 297 (3rd Cir. 2007).

[166] *See, e.g.*, Agreement on Trade-Related Aspects of Intellectual Property [TRIPS] § 5, Art. 31, *Other Use Without Authorization of the Right Holder*, Arp. 15, 1994; Marrakesh Agreement Establishing the World Trade Organization, Annex 1C, Legal Instruments—Results of the Uruguay Round, 33 I.L.M. 1197, 1210 (1994) (providing that where the law of a member country allows for it, the subject matter of a patent may be used by the government or a third party without authorization from the holder of the right). Under part (b) the conditions require that "prior to such use, the proposed user has made efforts to obtain authorization from the right holder on reasonable commercial terms and conditions and that such efforts have not been successful within a reasonable period of time. This requirement may be waived by a Member in the case of a national emergency or other circumstances of extreme urgency or in cases of public non-commercial use." Part (h) provides that "the right holder shall be paid adequate remuneration in the circumstances of each case, taking into account the economic value of the authorization." Other relevant provisions include under parts (d), (e) and (f) respectively, the authorization shall be non-exclusive, non-assignable, and predominantly for the domestic market, however under part (k) the licensing attempt and domestic market requirements may be waived where a use has been officially deemed anti-competitive, in which case the remuneration may be affected. Provision (l) makes additional accommodations related to blocking patents). For additional discussion of foreign compulsory licensing and compulsory working see, for example, D'AMATO & LONG, *supra* note 9.

Subsequently the Doha Declaration clarified that TRIPS was expansive enough to include compulsory licensing "to promote access to medicines for all." *See* World Trade Organization, Doha Ministerial 2001; Declaration on the *TRIPS* Agreement and Public Health ¶ 4, WT/MIN(01)/DEC/2, 41 I.L.M. 755. The Declaration acquired legal effect in Canada as of 2005 and in the European Union as of 2006. *See* Bill C-9, Statutes of Canada 2004, Chapter 23 (14th May 2004) (enacted), *available at* http://www.parl.gc.ca/37/3/parlbus/chambus/house/bills/government/C-9/C-9_4/C-9_cover-E.html%20and%20Council Regulation 816/2006, 2006 O.J. (L 157) 1.

corporate patentees, or which are in bankruptcy. It would also be relevant to a trustee for a deceased patentee's estate. A negotiated price that differs by a few percent from the value determined by my method would likely pass muster, but differences of several-fold should raise eyebrows. In many splintered situations, fiduciary benchmarks might not have been identifiable quantitatively before this algorithm appeared.

The nature of the pricing conundrum also has implications. Prior descriptions of patent anti-commons and calls for radical patent reform may have been premature or overstated. Federal trial courts across the United States recognize that patent pricing has resisted rationality. Furthermore, in splintered situations, this has almost certainly imposed social costs. Because that has been overlooked in anti-commons literature, prevailing assumptions about the origins of patent anti-commons need a thorough reexamination. The most compelling evidence for the role of pricing effects would be findings of efficient transfer in markets where rapid neutral pricing mechanisms are introduced.

The problem of accurately correlating cause with effect is indeed the reason this paper's discussion of law and economics borrows more from the analytical framework of technology than from the usual social science toolbox. The analysis here adapts an interdisciplinary paradigm that models an entire system or environment to test causal hypotheses and working solutions. That approach has long been used in engineering with admirable results for refining products, for instance it is embodied in the SPICE family of programs for troubleshooting field interference in circuits.[167] Physicists and engineers introduced the systems approach to stodgy manufacturing environments, creating a field known as operations research, and achieved astounding improvements in quality, throughput and efficiency of production.[168] In increasing measure the biosciences have also adapted systems paradigms, where they are called systems analysis or systems biology. That led to explosive progress in ecology and environmental science, and birthed entire new fields including genomics, proteomics and as of 2008, glycomics.[169]

The field of law and economics also appears ripe for a systems approach, or at least for a fuller use of it than exists here. Particularly pricing and damages for intangible assets are likely to benefit from a systems approach, because there the judiciary already has a felt need for new solutions, having acknowledged the futility of old ones. Trademark and copyright valuation are particularly appealing targets for the approach because of murkiness in their damages. Naturally no one can guarantee systems

[167] SPICE (Simulation Program with Integrated Circuit Emphasis) is a general purpose electronic circuit simulator, widely used by electrical engineers to confirm the integrity of circuit designs, for instance to avoid cross-talk. Many specialized variants of the program now exist, for both analog and digital performance. For a brief account of SPICE's revolutionary early development see Larry Nagel, The Life of Spice (September 30, 1996), *available at* http://www.designers-guide.org/Perspective/life-of-spice.pdf.

[168] The Theory of Constraints (TOC) was first articulated by Eliyahu Goldratt, a physicist. For an overview, see LISA J. SCHEINKOPF, THINKING FOR A CHANGE: PUTTING THE TOC THINKING PROCESSES TO USE, (St. Lucie Press, 1999). For a highly readable allegory introducing TOC to manufacturing environments, see ELIYAHU M. GOLDRATT & JEFF COX, THE GOAL: A PROCESS OF ONGOING IMPROVEMENT (2d ed. 1992).

[169] *See* S. Srivastava, *Move Over Proteomics, Here Comes Glycomics*, 7 J. PROTEOME RES. 1799 (2008).

paradigms will improve law, but the approach has as much promise as anything, not least because its results are as relevant to private ordering as to adjudication.