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VALUATION AND ASSESSMENT OF PATENTS AND PATENT PORTFOLIOS THROUGH ANALYTICAL TECHNIQUES

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ABSTRACT

Patents today are essential assets for many companies, especially in high technology industries. Valuation of a patent is often essential in reaching an informed business decision on a matter involving technology. However, the inherent uniqueness of a patent typically makes value assessments complex, costly, and susceptible to inaccuracies. This article presents efficient and cost-effective analytical methods for valuing patents and patent portfolios.

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VALUATION AND ASSESSMENT OF PATENTS AND PATENT PORTFOLIOS THROUGH ANALYTICAL TECHNIQUES

MICHAEL S. KRAMER*

INTRODUCTION

Valuation of a patent is often essential in reaching an informed business decision on a matter involving technology, but the inherent uniqueness of a patent typically makes assessment susceptible to inaccuracies, potentially misdirecting decision makers. Economic risk can increase significantly where the scope of the patent in question encompasses multiple patents or business entities. Likewise, the complexity and, of course, the cost of performing a thorough assessment can increase rapidly with scope.[1] Assessment of patents pertaining to uncommercialized and under-commercialized technology is uniquely difficult and vulnerable to gross valuation errors that can yield negative economic consequences.[2] Nonetheless, it is possible to mitigate the risk and cost of patent and patent portfolio assessment by employing analytical methods to efficiently develop intelligence necessary to make informed business decisions.

An effective means for characterizing a patent landscape and valuing patents is a vital resource in a technology company's campaign to obtain maximum return from intangible assets and identify beneficial research and development ("R&D") opportunities. This article presents methodologies employing statistical analyses of patent characteristics and information about patents to quantitatively value patents and patent portfolios. It is proposed that essential patents of technical standards are more valuable, on average, than the general population of patents.[3] Measurable differences among the characteristics of essential patents and patents generally are

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[1] Edmund W. Kitch, *Elementary and Persistent Errors in the Economic Analysis of Intellectual Property*, 53 VAND. L. REV. 1727, 1740–41 (2000).

[2] *See* GORDON V. SMITH & RUSSELL L. PARR, INTELLECTUAL PROPERTY: VALUATION, EXPLOITATION, AND INFRINGEMENT DAMAGES 477–83 (2005).

[3] Essential patents of technical standards are patents that claim elements of a technical standard where it is impossible to meet the requirements of the standard without practicing one or more claims of the patent. A technical standard is a documented operational, functional, or performance requirement promulgated by a standards body, which must be met by products or services operating in the technology. Technical standards ensure interoperability among multiple technology providers and are prevalent among communications and electronics industries. *See infra* Section I.A for further discussion on essential patents of technical standards.

relied upon as the basis for establishing formulations employable to predict patent value. The formulations utilize accessible patent data to efficiently quantify value for a patent or portfolio of patents of interest.

The present knowledge economy has made the protection of an entity's innovative ideas nearly a prerequisite for success.[4] Patents are increasingly considered by corporate management and financiers as relevant elements of a business's core assets.[5] It is often essential to consider patents when evaluating the value of a business because patents and patent applications are commonly among the principal assets of technology companies today. For the startup or adolescent technology business, patent rights and prospective rights can facilitate acquisition of venture capital or other forms of financing. For the established technology company, patent royalties can account for an increasingly significant percentage of total revenue, and patent rights can even influence the share price of publicly traded corporations.[6] Further, nearly every business is routinely challenged with critical decisions of how to best allocate limited R&D resources, such as when to buy, license, or develop a technology, or how to avoid a competitor's existing patent rights when extending an existing product line or developing a new product. Further, publicly traded companies must assign a value to intangible assets such as patents to satisfy the disclosure requirements of Sarbanes-Oxley.[7]

The clearest application of patent and patent portfolio assessment is in the arena of patent licensing. Often, licensing transactions are straightforward, involving one or a limited number of patents that have clear commercial analogs, making accurate valuation tenable.[8] Accurate assessment can be cumbersome in more complex transactions, such as significant cross licensing negotiations. Such deals can involve multiple patents of various magnitudes, perhaps covering disparate technologies, and sometimes uncertain commercial applications. Likewise, patent rights are at the forefront in changes of business structure, such as mergers, acquisitions, and spinoffs.[9] Issues of infringement indemnification, license exclusivity, and royalty structure are among the critical elements to be resolved in

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[4] *See* Robert P. Merges, *The Law and Economics of Intellectual Property Rights: Intellectual Property Rights and the Institutional Economics*, 53. VAND. L. REV. 1857, 1862 (2000) (noting intellectual property rights play a role in the upward trend of production of research and development intensive input transactions); Russell Barron, Linda Hansen, Richard F. Bero, Patrick Thomas, Dr. Jan M. K. Jaferian, & Michelle Girts, *Intellectual Property Metrics Today: It Can be Done*, GLOBAL INTELL. PROP. ASSET MGMT. REPORT, June 2005, at 1.

[5] *See, e.g.*, *The Czars Are Coming*, IP LAW & BUS., Jan. 2007, at 16; Mark Voorhees, *Ethereal Asset*, IP LAW & BUS., May 2004, at 118. *See generally* Marc Lucier & Michael Milani, *The Emergence of IP Finance*, PATENT STRATEGY & MGMT., July 2005, at 1.

[6] *See, e.g.*, Tamara Loomis, *Express Route*, IP LAW & BUS., Aug. 2005, at 32; *see generally* Kenneth Klee, *Grand Opening*, IP LAW & BUS., Feb. 2005, at 38 (reporting on Procter & Gamble Company's innovative and profitable business method of licensing out patents and adding "in-licensing" to their business model).

[7] *See* 15 U.S.C. § 7241 (2006) (requiring executive corporate officers to certify that periodic reports fairly present in all material respects the financial condition and results of operations and to establish and maintain internal controls); Gary Bender, IP LAW & BUS., Jan. 2007, at 18.

[8] *See* Merges, *supra* note 4, at 1862 (stating that intellectual property rights are becoming more important in industries such as biotechnology and software because they are central to input transactions).

[9] *See* Erin-Michael Gill, *Technology Potency: Patent Citation Refinements for Merger and Acquisition or Joint Venture Analysis*, PATENT STRATEGY & MGMT., June 2005, at 3.

organizational changes of technology companies.[10] Further, relationships between growing technology developers and established technology integrators can be manipulated when patent rights are erroneously estimated.

A. Difficulties Arising in the Assessment of Patents and Patent Portfolios

The foremost barrier to effectively assessing the value of a patent is the inherent uniqueness of a patent. It is fundamental patent law that a patent may only be issued if the subject matter claimed in the patent is novel, that is, the invention is not in public use, published, or previously patented by another.[11] Further, the subject matter claimed by the patent must also be nonobvious to a person of ordinary skill in the art.[12] In light of the prerequisites to achieve patent protection, the value of a patent, by definition, must be unique.[13]

Before proceeding, it is necessary to articulate what is meant by patent value. Here, patent value is defined as the economic benefit that the patent can bestow upon its owner. Value is derived from the property right delineated by the subject matter claimed by the patent.[14] Value is highly dependent upon the subject matter of the invention. Thus, a patent claiming the active ingredient of a groundbreaking pharmaceutical is substantially more valuable than a patent claiming a method having trivial significance.[15]

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[10] *See* SMITH & PARR, *supra* note 2, at 564–69.

[11] 35 U.S.C. § 102 (2006).

> A person shall be entitled to a patent unless (a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof . . . or (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of the application for patent in the United States . . . .

Id.

[12] 35 U.S.C. § 103 (2006).

> Conditions for patentability; non-obvious subject matter (a) A patent may not be obtained . . . if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Id. See also Graham v. John Deere Co., 383 U.S. 1, 14 (1966) ("Patentability is to depend . . . upon the 'non-obvious' nature of the 'subject matter sought to be patented' to a person having ordinary skill in the pertinent art.").

[13] Furthermore, the subject matter must be patentable and useful. 35 U.S.C. § 101 (2006). It must also meet the requirements set forth in 35 U.S.C. § 112 (2006). Section 112 states in relevant part, "the specification shall contain a written description of the invention, and of the manner and process of making and using it . . . and shall set forth the best mode contemplated by the inventor of carrying out his invention. The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention." *Id.* These are necessities for patentability, but do not present direct barriers to valuation.

[14] *See* SMITH & PARR, *supra* note 2, at 140 (stating that the value to the owner is an estimate of the consideration or benefit that the owner would expect to receive from a hypothetical transaction involving the patent).

[15] *Compare, e.g.*, U.S. Patent. No. 5,443,036 (filed Nov. 2, 1993) (method of exercising a cat)

The value of the property right is further defined in two important ways. First, the scope of the property right is established by the claims of the patent.[16] The claim language signifies the potential vastness of the patent property right. Generalizing, a patent employing broad claim language is typically more valuable than a patent of narrowly written claims in the same technology arena.[17] Second, a patent merely provides its owner with the right to exclude others from making, using, selling, or importing the invention.[18] Thus, the potential value of a patent must obviously vary with the market demand for the patented innovation and the availability of substitutionary technology.[19]

The value of a patent is derived from an ability to preclude others from practicing the unique innovation described by the words of the patent's claims. Ascertaining value from assessing those words, however, requires substantial technical knowledge and legal expertise. Endeavoring to evaluate dozens or potentially hundreds of patents that might be relevant in a significant business decision is impractical and generally fails to consider the context and interactions of the market.[20] Thus, an efficient yet accurate means of patent valuation is needed to facilitate the inquiry.

B. The Analytical Method of Patent Valuation

Scholars, primarily in the field of economic research, and more recently those in the legal community, have proposed methods of patent valuation founded on the

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with U.S. Patent. No. 4,659,716 (filed Mar. 12, 1986) (one of the patents claiming the active ingredient of Claritin ®). "Claritin was making about $3 billion in sales when it lost patent exclusivity . . . ." Aaron Smith, *New Profit Twist for Drugmakers*, CNN, May 11, 2005, http://money.cnn.com/2005/05/11/news/fortune500/generic/.

[16] *See* Phillips v. AWH Corp., 414 F.3d 1303, 1312 (Fed. Cir. 2005) (en banc) ("It is a 'bedrock principle' of patent law that 'the claims of a patent define the invention to which the patentee is entitled the right to exclude.'") (quoting Innova/Pure Water, Inc. v. Safari Water Filtration Sys., Inc., 381 F.3d 1111 (Fed. Cir. 2004)). Further, patent claims are read in light of the claim language, the specification and the prosecution history of the patent. *See id.* at 1314 (stating the appropriate sources for claim construction "include 'the words of the claims themselves, the remainder of the specification, the prosecution history, and extrinsic evidence concerning relevant scientific principles, the meaning of technical terms, and the state of the art'") (quoting *Innova*, 381 F.3d at 1116).

[17] *See* Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 COLUM. L. REV. 839, 839 (1990) ("The economic significance of a patent depends on its scope: the broader the scope, the larger the number of competing products and processes that will infringe the patent.").

[18] *See* 35 U.S.C. § 271(a) (2006) ("[W]hoever without authority makes, uses, offers to sell, or sells any patented invention, within the United States, or imports into the United States any patented invention during the term of the patent therefor, infringes the patent").

[19] *See generally* Vincent E. O'Brien, *Economics and Key Patent Damage Cases*, 9 U. BALT. INTELL. PROP. L.J. 1, 6 (2000) ("Substitutes are important in determining the damages caused by an infringement, because they determine the amount of lost sales caused by an infringement or the value of being able to exclude others from using the patented technology.").

[20] *See* SMITH & PARR, *supra* note 2, at 140. The market context and interactions include consideration of the conditions of exchange such as position of the parties to the exchange and third parties. *Id.*

statistical analysis of patents.[21] The analytical approach to valuation utilizes readily available information about patents as inputs to mathematically model patent value and ultimately predict value. Specifically, the analytical approach employs characteristic information collected on a significant sample of patents, such as the number of prior art references that a patent cites, the number of times the patent is cited by subsequent patents, the number of claims, the length of claims, and similar measures. The collected characteristics are input into a mathematical model and model inputs are regressed against a dependent output variable that represents the value of the patents.[22] A mathematical formulation results from equating the input information to the variable representing value.

A hurdle in practicing the analytical methodology is the difficulty of acquiring the dependent variable value data, ostensibly leaving the practitioner without the information necessary to perform the analysis. Employing the formulations discussed herein, the need for the data is alleviated. A second limitation of the analytical method is that absolute monetary valuation is generally not achievable today without a basis of fiscal correlation.[23] Nonetheless, the methodology provides a highly efficient means of comparative quantification and ranking applicable to patent transactions, R&D strategy, and business transactions. The efficiency of the analytical methodology makes it particularly well suited to the management of patent portfolios.

This article presents methods for successfully employing analytical methods of

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[21] *See generally* John R. Allison, Mark A. Lemley, Kimberly A. Moore & Derek R. Trunkey, *Valuable Patents*, 92 GEO. L.J. 435, 436–38 (2004) (discussing the high correlation between valuable patents and litigation); Jonathon A. Barney, *A Study of Patent Mortality Rates: Using Statistical Survival Analysis to Rate and Value Patent Assets*, 30 AIPLA Q.J. 317, 320 (2002) (describing an objective method of rating and valuing patents based on abandonment rates of patent with similar characteristics); Bronwyn H. Hall, Adam B. Jaffe & Manuel Trajtenberg, *The NBER Patent Citations Date File: Lessons, Insights, and Methodological Tools*, PATENTS, CITATIONS & INNOVATIONS, 403 (2002) [hereinafter *The NBER Patent Citations Data File*]; Dietmer Harhoff, Francis Narin, F.M. Scherer & Katrin Vopel, *Citation Frequency and the Value of Patented* Inventions, 81 REV. ECON. STATISTICS 511, 511 (1999) (summarizing research based on the theory that the more valuable patents are those that are cited more frequently); Jean O. Lanjouw, Ariel Parkes & Jonathan Putnam, *How to Count Patents and Value Intellectual Property: Uses of Patent Renewal and Application Data*, 46 J. INDUS. ECON. 405 (1998) (arguing that patent counts are an imperfect measure of innovative output and advocates the use of multiple pieces of information); Manuel Trajtenberg, *A Penny for Your Quotes: Patent Citation and the Value of Innovations*, 21 RAND J. ECON. 172, 178–84 (1990) [hereinafter *A Penny for Your Quotes*] (discussing two hypotheses related to patent counts and innovation values); Manuel Trajtenberg, Rebecca Henderson & Adam Jaffe, *University versus Corporate Patents: A Window on the Basicness of Invention*, PATENT, CITATIONS & INNOVATIONS, 51 (2002) [hereinafter *University versus Corporate Patents*].

[22] Prior research has successfully engaged several measures as dependent variables including the payment of periodic patent maintenance fees, commencement of patent infringement litigation, inventor surveys of value, and measures of innovation. *See, e.g.*, Lanjouw et al., *supra* note 21, at 405 (using payment of patent maintenance fees); Barney, *supra* note 21, at 324 (using payment of patent maintenance fees); Allison et al., *supra* note 21, at 439 (using patent litigation); Harhoff et al., *supra* note 21, at 511–15 (using inventor surveys of value); *A Penny for Your Quotes*, *supra* note 21, at 173–75 (using measures of innovation).

[23] Assigning an absolute value in dollars to a patent requires response transaction data in dollars. Estimates of absolute economic worth are obtainable by fitting the valuation response of an analytical model to a sample of transaction data. A business may achieve absolute valuation of a patent as a history of transactions is monitored.

patent analysis and valuation. The methods are applicable to both strategic and tactical scenarios involving technology decisions concerning patents. In Part I, an analytical approach to patent valuation that employs the differences among patent characteristics observed in essential patents of technical standards relative to the general population of patents is proposed. The characteristic differences are exploited to construct universal and technology specific models to quantitatively value patents and patent portfolios in Part II. The valuation models are further applied to datasets to assess model performance and suitability to addressing practical patent valuation problems.

I. AN ANALYTICAL APPROACH TO PATENT VALUATION

Analytical patent analysis is attractive in part because of the overwhelming wealth of patent data in existence and the availability of the data. An array of mathematical models employing patent data to predict a variety of responses can be envisioned, but in practice, creating and assessing the validity of such models is less straightforward than their conception.[24] Although patent data are rich and accessible, the response or responses to be predicted by a model seldom, if ever, approach the depth and availability of the patent data.[25]

Without response data, there are no means of ascertaining model validity, whether the model is a suitable predictor of a response, and whether the model is of any utility.[26] The supreme challenge in modeling patent value thus becomes one of appropriately selecting a response that is representative of patent value. Furthermore, the response data must be in sufficient supply and possess sufficient breadth.[27] Only with an adequate quantity of response data can statistically

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[24] *See, e.g.*, Ricardo J. Caballero & Adam B. Jaffe, *How High Are the Giants' Shoulders: An Empirical Assessment of Knowledge Spillovers and Creative Destruction in a Model of Economic Growth*, *in* PATENTS, CITATIONS, & INNOVATIONS 89 (The MIT Press 2002) (analyzing economic growth via patent data); *A Penny for Your Quotes*, *supra* note 21, at 184–85 (characterizing R&D outlays through patent data); Adam B. Jaffe, Michael S. Fogarty & Bruce A. Banks, *Evidence from Patents and Patent Citations on the Impact of NASA and Other Federal Labs on Commercial Innovation*, *in* PATENTS, CITATIONS, & INNOVATIONS, 261 (The MIT Press 2002) (analyzing the knowledge transfer of government R&D via patents); Allison et al., *supra* note 21, at 441 (highlighting the relationship between litigation of a patent and the high value of that patent); Barney, *supra* note 21, at 320–34 (using patent data to analyze patent value and patent policy).

[25] In a study using litigation as the response, all U.S. patents issued from 1963 through 1999 (2,925,537 patents) were compared with all patents for which a lawsuit was filed in federal court and terminated during 1999–2000 (6,861 patents). Allison et al., *supra* note 21, at 445. In a study relying on maintenance fees and inventor surveys a sample of 964 patents were analyzed. Harhoff et al., *supra* note 21, at 511. In another study using maintenance fees, a sample of 70,000 patents issued in 1986 were considered. Barney, *supra* note 21, at 327.

[26] *See generally* C.M. CREVELING ET AL., DESIGN FOR SIX SIGMA IN TECHNOLOGY AND PRODUCT DEVELOPMENT 520–27 (Bernard Goodwin ed., Pearson Education, Inc. 2003) (discussing multi-variable studies conducted to identify critical and noncritical factors and response of the product).

[27] The breadth of response data needed depends on the anticipated breadth of model application. A model constructed to value patents within only a single defined technology area can rely, and preferably should only rely, on patents within the scope of that technology space. A broadly applicable model should rely on a spectrum of response data. However, a broad model can seldom achieve the accuracy that a focused model can provide within the realm of that model. Thus, model scope should be a consideration during the model development phase and should be balanced

significant conclusions as to model suitability and output be drawn.[28]

Patent transactions, such as licenses or assignment of ownership, provide a direct measure of patent value. Furthermore, transactions are ostensibly objective measures of patent value as a result of arm's-length negotiation.[29] Unfortunately, there is little transaction data available to the public.[30] The financial terms of most patent transactions are kept in confidence by the transacting parties.[31] In the absence of direct transactional data, a suitable proxy for patent value is required to develop a verifiable patent valuation model.[32] The value proxy should have a close nexus to an economic reward or cost associated with ownership of the patent.

A. Essential Patents of Technical Standards as Indicators of Patent Value

It is presently suggested that the recognition of a patent as being essential to a technical standard is a proxy for patent value. It is helpful to present some background on technical standards to support this proposition. A technical standard is a group of documented operational, functional, or performance requirements promulgated by a standards body, which must be met by products operating in the technology.[33] Standards bodies are typically independent organizations consisting of representatives from entities with a significant interest in the technology.[34]

Technical standards are typically created where the public can significantly benefit from the developers of technology following a set of common rules defining the foundational elements of that technology.[35] A common technical foundation offers

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against anticipated analysis objectives.

[28] *See generally* C.M. Creveling et al., *supra* note 26, at 540–42 (using regression analysis to relate many predictors to one response).

[29] *See generally* Panduit Corp. v. Stahlin Bros. Fibre Works, Inc., 575 F.2d 1152, 1164 n.11 (6th Cir. 1978) (discussing factors for deriving a reasonable royalty). Licenses taken in the face of litigation represent one licensing scenario that is arguably not an objective measure of patent value. *Id.*

[30] *See* Richard A. Neifeld, *A Macro-Economic Model Providing Patent Valuation and Patent Based Company Financial Indicators*, 83 J. PAT. & TRADEMARK OFF. SOC'Y, 211, 216 (2001).

[31] Often licenses are granted on the premise that royalties are due on a condition subsequent, such as eventual commercial implementation or the future revenue stream of an associated product. These are conditions that further mitigate the usefulness of employing licensing transactions as a response variable. However, an owner of a large patent portfolio that has undertaken significant transactions might successfully employ its own historical transaction data as a response. An entity that takes licenses could also be in a position to follow such a methodology.

[32] *See, e.g.*, Harhoff et al., *supra* note 21. Several metrics have been suggested as proxies for patent value. *Id.*; Barney, *supra* note 21 (using the payment of statutory periodic maintenance fees which preserve patent enforceability); Lanjouw et al., *supra* note 21 (using patent family data, that is the number of countries in which an invention has been patented); Allison et al., *supra* note 21, at 441 (considering litigation over a patent as an indicator of value).

[33] *See* Mark A. Lemley, *Intellectual Property Rights and Standard-Setting Organizations*, 90 CAL. L. REV. 1889, 1896 (2002) (presenting a thorough analysis of the issue of patents and standard settings organizations).

[34] For example, the European Telecommunications Institute includes among its members: Alcatel, Ericsson, Lucent, Motorola, Nokia, Phillips, Siemens, T-Mobile and hundreds of others. *See* ETSI Membership Information, http://portal.etsi.org/Portal_IntegrateAppli/QueryForm.asp?Param (last visited April 10, 2007).

[35] Organizations supporting the development of technical standards include: the American

consumers the benefits of product interoperability and purchase stability.[36] Likewise, technology developers rely on a standard to sustain a predictable market for their products.[37] For instance, timely promulgation of a technical standard can alleviate the costly duplicative development and subsequent purchase by unsuspecting consumers of incompatible products. A technical standard permits consumers to purchase a wireless computer network card from a manufacturer of choice without concern whether the card will be compatible with their computer or whether their card will function at home and at the local coffee shop.

Successful technical standards require cooperation by the developers of technology. Thus, standards are most commonly encountered among evolving technologies amenable to technical definition.[38] It is typical for technology developers to sit on the standards body, propose standards, and adopt the technical requirements.[39] The standards development process typically consists of a member of the standards body defining a technical means or method for achieving a particular result pertaining to a new element of the technology useful to the body as a whole.[40] The proposal is presented to other members of the body, typically competitors and providers of the technology, for consideration and a decision is made as to the merit of the proposal and whether the proposal should be adopted as a standard for all developers to henceforth comply.[41]

Where there is a new and useful technical innovation under development, the prospect of patents lurks nearby, and the standards development process is not immune. Indeed, those that propose standards are highly motivated to seek patent protection of their proposals because the owner of a patent that addresses all or a portion of a technical standard can assert its patent rights against competitors. Patents covering a required element of a standard are generally considered essential.[42] It is technologically infeasible to meet the requirements of a standard

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National Standards Institute ("ANSI") http://www.ansi.org/standards_activities/overview/overview.aspx?menuid=3; International Electrical and Electronics Engineers ("IEEE") http://standards.ieee.org/; International Standards Organization ("ISO") http://www.iso.org/iso/en/ISOOnline.frontpage; European Telecommunications Standards Institute ("ETSI"). http://www.etsi.org/services_products/freestandard/home.htm; The 3rd Generation Partnership Project ("3GPP"), http://www.3gpp.org/specs/specs.htm; World Wide Web Consortium ("W3C"), Telecommunications Industry Association ("TIA") http://www.tiaonline.org/standards/.

[36] STANDARDS DEVELOPMENT AT THE IEEE STANDARDS ASSOCIATION, "BACKGROUNDER," http://standards.ieee.org/announcements/bkgnd_stdsprocess.html (last visited April 10, 2007).

[37] *Id.*

[38] Technical standardization within an established industry might require one or more well established manufacturers in the industry to significantly redesign their processes and products, a costly proposition with little prospective benefit for those manufacturers.

[39] James C. De Vellis, *Patenting Industry Standards: Balancing the Rights of Patent Holders with the Need for Industry Wide Standards*, 31 AIPLA Q.J. 301, 316 (2003).

[40] *Id.*

[41] *Id.*

[42] The European Telecommunications Standards Institute, which promulgates standards for cellular and other communication systems, defines "essential patents" as: "'Essential' as applied to IPR means that it is not possible on technical (but not commercial) grounds, taking into account normal technical practice and the state of the art generally available at the time of standardization, to make, sell, lease, otherwise dispose of, repair, use or operate EQUIPMENT or METHODS which comply with a STANDARD without infringing that IPR. For the avoidance of doubt in exceptional cases where a STANDARD can only be implemented by technical solutions, all of which are infringements of IPRs, all such IPRs shall be considered ESSENTIAL." IPR in ETSI Deliverables,

and to offer a product that includes the technology addressed by the standard without infringement of an essential patent.

Ownership of an essential patent of a technical standard bestows upon the patent owner a true limited monopoly in the covered elements of the standard. Moreover, in light of the adoption of the standard by competitors and providers of the technology, the monopoly is objectively valuable. To prevent misappropriation of the power created by ownership of essential patents, standards bodies typically establish rules requiring the prompt disclosure of potential intellectual property rights for standards that are under consideration,[43] as well as a promise by the essential patent holder to offer licenses on fair, reasonable, and non-discriminatory terms.[44]

In view of the foregoing features of technical standards, there is a clear and significant beneficial economic nexus in a patent obtaining essential status. The owner of the essential patent is practically guaranteed a broad opportunity to license or cross license the patent to all competitors or users of its innovation on its own terms. The standards process also enhances the economics of the licensing opportunity through the addition of structure and predictability because licensees, licensors, and technology are brought together for efficient transactions.[45] Thus, there is significant incentive for technology developers to expend R&D effort developing technology applicable for insertion into technical standards, to prioritize patent development efforts on promising technologies, and to advocate adoption into a standard. Moreover, adoption by a standards body is an inherently objective measure of the value of the patent covering the technical solution of the standard.[46]

Essential patents of a technical standard are valuable and the technology developers operating in technologies subject to technical standards place significant importance on such patents. Further, royalty costs can make it prohibitively costly

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Legal Frequently Asked Questions, http://www.etsi.org/legal/IPR_database/FAQ_IPR-Policy.htm (last visited April 10, 2007) (emphasis in original). The Institute of Electrical and Electronic Engineers ("IEEE"), which promulgates various standards including the Wi-Fi 802.xx standards, employs a similar definition for "essential patents" and asserts essential patents apply to mandatory and *optional* elements of the standards. IEEE-SA Standards Board Bylaws, 6. Patents (2007), http://standards.ieee.org/guides/bylaws/.

[43] *See* EUR. TELECOMM. STANDARDS INST., RULES OF PROCEDURE, ANNEX 6: ETSI INTELLECTUAL PROPERTY RIGHTS POLICY 4.1 (2006), http://www.etsi.org/legal/documents/ETSI_ IPRPolicy.pdf (stating that ETSI members are bound to disclose any Intellectual Property Rights that they consider essential for the implementation of an ETSI STANDARD); *see also* AM. NAT'L STANDARDS INST., GUIDELINES FOR IMPLEMENTATION OF THE ANSI PATENT POLICY: AN AID TO MORE EFFICIENT AND EFFECTIVE STANDARDS DEVELOPMENT IN FIELDS THAT MAY INVOLVE PATENTED TECHNOLOGY IIIA (2003), http://www.niso.org/committees/OpenURL/PATPOL.pdf (commenting that early disclosure enhances efficiency of the process).

[44] *See* IEEE STANDARDS ASS'N, IEEE-SA STANDARDS BOARD BYLAWS, *supra* note 42, at 6. Patents (stating that ETSI members are bound to grant licenses with regard to IPRs on fair, reasonable, and non discriminatory terms).

[45] *See* Lemley, *supra* note 33, at 1897.

[46] Commentators have questioned the "essentialness" of patents deemed essential by standards bodies. *See generally* David Goodman & Robert A. Myers, *3G Cellular Standards and Patents*, http://www.nokia.com/NOKIA_COM_1/Press/sidebars_new_concept/Other_materials/wirelesscom2005.pdf (last visited Mar. 24, 2007) (discussing distributions of patents declared essential and patents judged essential of 7,796 patents and patent applications). One study has suggested that a low percentage of patents that have been deemed essential for the third generation cellular communications technology standard are actually essential. *See id.* at 5.

to compete in the field when one does not have ownership of an essential patent.[47] The important question here is whether essential patents are valuable chiefly because of their status as essential, or these patents have independent value because of characteristics they share with valuable patents generally. Veracity of the latter proposition justifies using essential patents as a proxy for value, and thus suitable for use in constructing a generally applicable patent valuation model.

The fundamental purposes in implementing technical standards suggest that their essential patents have independent value. Standards are introduced to support impending mass market demand for a significant technical innovation; thus, the patents enjoy a technologically significant and sound economic market basis.[48] Most standards are adopted on an open, collaborative, and objective basis and typically with international or regional enforcement, thereby creating a significant market for the innovation.[49] By definition, essential patents eliminate all options for pursuing substitutionary technology to bypass the patent rights, making acquiescence unavoidable.[50] Therefore, there is qualitative evidence to support the argument that essential patents possess characteristics typically found among the general population of valuable patents.

Nonetheless, some attributes common among technical standards suggest that essential patents may not provide a representative proxy for patent value in general. First, technical standards are not present across all industries, but have primarily been established among a limited set of technology areas. Standards are most prevalent in the electronics and communications industries.[51] Nevertheless, the absence of standards in other industries is a concern only if the patent characteristics in the valuation model that identify value vary significantly from the characteristics that identify value among patents in other industries.[52]

Second, patent ownership within technical standards is dominated by large corporate entities.[53] These firms typically have significant research programs and

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[47] *See* Tamara Loomis, *Cell Break*, IP L. & BUS., July 2, 2005, at 32 [hereinafter *Cell Break*] (stating that it is alleged that a manufacturer must pay over eighteen dollars in royalties per mobile phone to the companies owning patents incorporated in the ETSI GSM standard). Furthermore, over the next twelve years the highly standardized cellular phone industry is expected to take in \$80–\$100 billion in licensing royalty revenue. *Id.* *See also* Goodman et. al. *supra* note 46 (stating that in 2004 there were 1.52 billion people using GSM cellular phones complying with the ETSI standard).

[48] *See, e.g.*, EUR. TELECOMM. STANDARDS INST., *Who is ETSI?*, http://www.etsi.org/about_etsi/5_minutes/5min_a.htm (last visited Mar. 24, 2007) (articulating the benefits of standardization).

[49] *Id.* *See also* Goodman & Myers, *supra* note 46, at 2 (stating 1.52 billion people used GSM cellular phones in compliance with the ETSI standard in 2004).

[50] Standards bodies generally define essential patents as those that make compliance with the standard impossible on a technical basis without adopting the patented method or infringing. *See, e.g.*, "IEEE" *supra* note 36.

[51] *See* Lemley, *supra* note 33, at 1903.

[52] Ted J. Ebersole, Marvin C. Guthrie, & Jorge A. Goldstein, *Patent Pools as a Solution to the Licensing Problems of Diagnostic Genetics*, NATURE BIOTECHNOLOGY, Aug. 2005, at 937. If significant differences are present, the patents within recognized patent pools existing in other technology sectors might be considered as a substitute for the patents of technical standards. The definition of a patent pool is "an arrangement in which 'two or more owners agree to license certain of their patents to one another and/or third parties.'" *Id.*

[53] *See* Goodman & Myers, *supra* note 46, at 4. Four companies own seventy-five percent of the patents and twelve companies own ninety percent of the essential patents of the WCDMA and

budgets and can choose to emphasize research programs directed at the standards. As a result, ownership of patents, and ownership of valuable patents in general, is skewed toward large corporations.[54] Nonetheless, insertion of patents into standards is generally an open process and emerging companies are invited to insert intellectual property into standards and participate in the standards-making process through membership.

Finally, the standards development process typically addresses relevant technical advances in evolving but commercially established technologies. The initial groundbreaking development within a field typically occurs among the pioneers of the industry, then additional technology developers begin producing in the field, and a vision of market necessity emerges. The very purpose of standards bodies is to bring technological consensus among industry competitors and partners.[55] However, technology developers insert their early foundational patents, developed prior to the formation of a standard, or even the standards body, where there is applicability to the new standard.[56]

Thus, essential patents of technical standards qualitatively present a suitable basis for use as a proxy for patent value. There is a clear nexus between the insertion of patents into technical standards and the economic success of patent owners and others competing within the field. The following sections quantitatively address the characteristics of essential patents and demonstrate that essential patents are a suitable value proxy for a patent valuation model.

B. An Analytical Analysis of the Characteristics of Essential Patents

A body of literature has developed among economic scholars, and to a lesser degree within the legal community, on quantifying the value of patents.[57] Initial

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CDMA2000 standards, the third generation cellular standards that will come to replace GSM in the marketplace. *Id.* *See also Cell Break*, *supra* note 47, at 32 (stating that fifteen companies control the essential patents of the GSM standards including Alcatel, Ericsson, Lucent, Motorola, Nokia, and Siemens).

[54] *See Annual Corporate Patent Scored*, INTELL. PROP. TODAY, July 2005, *available at* http://www.iptoday.com/pdf/2005/7/From%20the%20Editor_Proof%201.pdf (reporting IBM, Matsushita, Canon, HP, Micron, Samsung, Intel, Hitachi, Sony, and Toshiba were the top ten recipients of United States patents issued in 2004); *see also Fortune Global 500 Index*, FORTUNE, July 25, 2005, at 142 (listing worldwide corporate revenue rank in 2005 against the top ten in patent ownership: IBM - 20, Matsushita - 25, Canon - 154, HP - 28, Micron - N/A, Samsung - 39, Intel -141, Hitachi - 23, Sony - 47, and Toshiba - 72).

[55] *See* Lemley, *supra* note 33, at 1897.

[56] *See* IPR in ETSI Deliverables, http://webapp.etsi.org/ipr/Menu1.asp (last visited Mar. 31, 2007) (providing a searchable database of the essential patents for the GSM cellular telecommunications standard from ETSI and revealing that fifty-five percent of the GSM patents issued through 2001 were issued prior to the rollout of the initial standard).

[57] *See generally* Allison et al., *supra* note 21, at 438 (stating that valuable patents are targets of a more intensive prosecution process); Lanjouw et al., *supra* note 21 (arguing that information on patent application data and renewal is a more accurate gauge of a patent's value compared to simple patent counts); Harhoff, *supra* note 21, at 511; *A Penny for Your Quotes*, *supra* note 21, 178–84; *The NBER Patent Citations Data File*, *supra* note 21, at 403; Barney, *supra* note 21, at 320 (describing an objective manner to compare patent values based on reported abandonment rates that share statistically similar characteristics); *University versus Corporate Patents*, *supra* note 21, at 51.

forays proposed counting patents and applying the counts to predict various external effects.[58] These studies appropriately recognized that there is considerable variance in value from patent to patent that cannot be captured by merely counting patents issued in a given time period, technology, or other categorization.[59] However, more informative patent characteristics offer a rich data resource that may be employed to predict patent value and other phenomena.[60] There are a number of relevant characteristics, and two of the most significant are the number of citations received by a patent and the number of prior art references made by a patent. The number of citations is the count of subsequent patents that reference the patent, which alone has been shown to be a predictor of patent value.[61] Likewise, the number of references, the number of earlier patents and the other forms of prior art that the patent itself cites, have been shown to correlate to patent value.[62] These metrics and others are employed herein to determine if there are significant differences between essential patents of technical standards and patents among the general population of patents. In particular, citations, references, citation age, reference age, backward technology adoption, and forward technology spread are addressed.

For each metric, the mean response of the metric is calculated and a statistical test is conducted to determine if the observed difference in the means of essential patents and non-essential patents is statistically significant.[63] The tests are performed to compare populations of essential patents to a sample of the general patent population and to a sample of patents that reside within the same fields of technology as the essential patents, the technology subpopulation.[64] Descriptive statistics are also computed for each of the populations.[65] The relevant means and

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[58] *See* JACOB SCHMOOKLER, INVENTION AND ECONOMIC GROWTH 196–215 (Harvard University Press 1966).

[59] *See* Zvi Griliches, Bronwyn H. Hall, & Ariel Pakes, *R&D, Patents, and Market Value Revisited: Is There A Second (Technological Opportunity) Factor?*, NAT'L BUREAU OF ECON. RESEARCH, 1988, at 26–28, *available at* http://elsa.berkeley.edu/~bhhall/papers/GrilichesHallPakes88%20NBER%20WP2624.pdf.

[60] *Id.*

[61] *Id.*

[62] *See* Allison et al., *supra* note 21, at 451–56.

[63] GEORGE E.P. BOX, ET AL., STATISTICS FOR EXPERIMENTERS 21–145 (John Wiley & Sons 1978). In making a comparison of two populations it is necessary to perform a statistical test to determine if the difference observed between the means, or other metric, of two of sample populations is significant or if the difference is merely an artifact of the data selection, experimental process, or other ambient noise. *Id.* at 34–55, 57–60, 95–97. The outcome of the statistical test indicates whether the observed difference occurred merely by chance variation or if there is a genuine, statistically significant difference between the two populations. *Id.* The "t-test" is commonly employed to compare the means of two sample populations. *Id.* at 38–55. The outcome of the test is a function of the number of samples included in each population, the standard deviation or "spread" of the data in the population, and the distance between the means of each population. *Id.* For example, where there is a small difference between the means of two populations, more samples within each population are necessary to ensure that the populations are truly different and the observed difference did not occur by mere chance, assuming statistically equal variance between the populations. *Id.* at 57.

[64] Here, the primary United States Patent and Trademark Office class number of the essential patents was employed to develop the technology subpopulation of patents. Patents were drawn from the general population of patents from the classes that composed over ninety-three percent of the essential patents, class: 348, 370, 375, 455, 235, 382, 704, 714, 386, 341, and 710.

[65] Descriptive statistics refer to the distribution, mean, and variation of a sample of data. *See*

descriptive statistics are reported for each metric.[66]

The comparisons are conducted using essential U.S. patents from standards in three technology areas promulgated by three standards bodies: the Global System for Mobile Communications ("GSM") standard promulgated by the European Telecommunications Standards Institute ("ETSI") for cellular phone communication;[67] the Wi-Fi 802.11 standard for computer wireless networks promulgated by the International Electrical and Electronics Engineers ("IEEE");[68] and the Moving Picture Experts Group ("MPEG") standards for digital video and audio.[69] The three standards impact consumer technology that is pervasive throughout the developed world. Moreover, each standard incorporates a substantial number of patents issued during the 1980s and 1990s. The results of the analyses indicate that the characteristic metrics of patents identified as essential by the standards bodies differ significantly from both the general population of patents and patents within the fields of technology covered by the standards.[70]

1. *Citations and References*

Essential patents receive significantly more citations compared to patents of the general population. A patent receives a citation when a subsequently granted patent cites the earlier patent among its references. Considering citations of the standards independently, the 101 GSM essential patents granted between the years 1983 and 1998 received a mean of 9.52 citations each. The thirty-five essential patents of the

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CREVELING, ET AL., *supra* note 26, at 472–78.

[66] *The NBER Patent Citations Data File*, *supra* note 21. Many of the metrics considered are not normally distributed. In such cases, the reported results have undergone lognormal transformation to achieve normality, analyzed, and then untransformed for reporting. It is well known that patent metrics, such as the number of claims, references, and citations, are log-normally distributed. *Id.*

[67] *See* IPR in ETSI Deliverables, *supra* note 56 (providing a searchable database of the essential patents for the GSM cellular telecommunications standard from ETSI). The GSM standard was the exclusive second-generation cellular communication standard of Europe. The GSM standard is also in wide use in North and South America, and Asia. *Id.*

[68] *See* IEEE Standards Association - 802.11 Patent Letters of Assurance, http://standards.ieee.org/db/patents/pat802_11.html (last visited Mar. 31, 2007) (providing the essential patents for the 802.11 wireless networking standard from IEEE). The 802.11 standard is employed worldwide in homes, businesses, and offices to allow computers and computer peripherals to communicate over a wireless data network.

[69] *See* MPEG LA, http://www.mpegla.com/index1.cfm (last visited Mar. 31, 2007) (listing the essential patents of the MPEG-2 and MPEG-4 standard from MPEG LA, a body that provides licenses to the essential patents and other standards adopted by MPEG under the auspice of the International Standards Organization ("ISO")). The MPEG-2 standard covers digital television and DVD and the MPEG-4 standard covers multimedia on the Internet. *Id.*

[70] Patent data for the analyses were obtained from the NBER and Updated NBER patent databases covering United States patents issued between 1963 and 2002. Bronwyn H. Hall, Bronwyn Hall Papers, http://emlab.berkeley.edu/users/bhhall/bhdata.html (last visited Mar. 24, 2007) [hereinafter Hall Papers] (listing the updated NBER patent database). The NBER patent database is found at the National Bureau of Economic Research's website. *See* BRONWYN H. HALL ET AL., NAT'L. BUREAU OF ECON. RESEARCH, THE NBER PATENT CITATIONS DATA FILE: LESSONS, INSIGHTS AND METHODOLOGICAL TOOLS, http://www.nber.org/patents (last visited Mar. 24, 2007) [hereinafter NBER Data].

802.11 standard granted between 1980 and 1998 received a similar number of citations, a mean of 10.2 citations. The eighty-seven patents granted between 1983 and 1998 essential to the MPEG-2 and MPEG-4 standards received a mean of 8.2 citations. Overall, the 223 essential patents considered received a mean of 8.77 citations.

The mean number of citations received by essential patents is compared to a mean of 2.3 citations received by the general population of more than 1.28 million patents granted between 1986 and 1998.[71] On average, the essential patents received more than three times the citations than did the general population of patents.[72] Performance of the statistical means comparison test confirms that essential patents receive significantly more citations, P value < 0.0001, than the general patent population.[73]

The mean number of citations received was also calculated for a subset of nearly 53,000 patents from the general patent population that were from the technology classes represented by the essential patents and of the same time period.[74] The mean number of citations received was calculated for each of the technology classes and weighted according to the distribution of technology classes among the essential patents. This technologically similar group of patents received a mean of 3.8 citations. Although the technology classification influences the mean number of citations received, this effect does not account for the substantial difference in the mean number of citations the essential patents received. Again, the difference in the number of citations between essential patents and patents from the general population of the same technology class is highly statistically significant, P value <0.0001. Therefore, over a comparable time period, essential patents received a significantly greater number of citations on average than both the general population

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[71] Issues of citation truncation were avoided by comparing essential patents and all patents from the span of time. The general population was taken beginning in 1986 because the vast majority (97.3%) of the essential patents considered were granted in 1986 or later.

[72] *See* Allison et al., *supra* note 21, at 455. The study considered all patents granted between 1963 and 1999 and found the general population received a mean of 4.1 citations per patent and litigated patents received an average of 12.2 citations. *Id.* This result corresponds favorably to using litigation as a proxy for patent value.

[73] The statistical means comparison test returns a P Value, or a probability, that the difference observed in the means between the groups of patents is by chance alone. The P Value is obtained at a desired confidence level. A confidence level of ninety-five percent or ninety-nine percent (alpha = 0.05 or 0.01, respectively) is frequently used as the analysis confidence interval. Unless noted otherwise, a ninety-five percent confidence interval is used throughout the paper. Therefore, a P value less than 0.05 signifies that with ninety-five percent confidence the means of the two groups under consideration are different. Equivalent variance between the groups is an additional requirement for application of the means comparison t-test. Here, wherever the variance between the groups was found to be unequal the P Value reported is computed using the Welch-ANOVA test. The Welch-ANOVA test corrects for unequal variances between the groups. *See* Do two processes have the same mean?, http://www.itl.nist.gov/div898/handbook/prc/section3/prc31.htm (last visited Mar. 23, 2007) (discussing tests of data with unequal variances). Finally, for metrics where lognormal transformation failed to achieve distribution normality, the Wilcoxon Signed Rank nonparametric test is calculated in addition to the parametric value. BOX ET AL., *supra* note 63, at 79–80.

[74] The technology distribution was determined using the international patent classification system. Classification was based on the four characters of the class code or the third level of classification. For example the class code G06F represents: G, Physics; 06, Computing, calculating, and counting; and F, Electrical digital data processing.

of patents and patents within the same technology groups. Table 1 summarizes the mean citations and means comparison tests presented above.

		Citations	References	Citation Age	Citation Age of Patents with Citations	Reference Age	Originality	Generality
General Population	mean	2.32	6.32	2.13	3.22	10.28	0.357	0.224
	t-test	<0.0001	N/A	<.0001	0.158	<.0001	N/A	<.0001
	Wilcoxon	N/A	0.4	N/A	N/A	N/A	<.0001	N/A
Technology Subpopulation	mean	3.82	5.9	2.28	3.16	5.72	0.375	0.311
	t-test	<.0001	N/A	0.007	0.065	0.043	N/A	<.0001
	Wilcoxon	N/A	0.077	N/A	N/A	N/A	<.001	N/A
Combined Essential	mean	8.77	6.42	3.02	3.39	5.24	0.441	0.361
MPEG	mean	8.2	6.11	2.24	2.71	4.55	0.412	0.293
Wi-Fi 802.xx	mean	10.17	5.44	2.88	2.88	4.81	0.441	0.396
GSM	mean	9.52	7.10	3.84	4.19	6.09	0.460	0.409

Table 1: Summary Statistics of Essential Patent Characteristics

Essential patents reference, on average, a slightly higher number of U.S. patents than the average number referenced by the general population of patents.[75] The trend holds when comparing essential patents to the technology subpopulation. In general, references are the number of patents, domestic and foreign, as well as other publications, cited as prior art to the patent. Here, the number of references has been restricted to U.S. patents.

Essential patents of the GSM standard granted through 1999 reference a mean of 7.1 patents.[76] Essential patents of the 802.11 standard reference a mean of 5.4 patents. Similarly, the MPEG essential patents reference a mean of 6.1 patents. Considering essential patents together, the group references a mean of 6.4 patents.[77]

The general population of patents references a mean of 6.3 patents. The technology subpopulation of patents references a mean of 5.9 patents.

In aggregate, the number of references made by essential patents is somewhat greater than the general and technology subset patent populations. Interestingly, the difference is not statistically significant, yielding a P value of 0.391 for the general population and a marginally insignificant P value of 0.089 for the technology subset population.[78] Table 1 summarizes the mean reference data and the means comparison tests presented above. The number of references made by essential patents does not differ significantly from the number of references made by patents of the general population or the technology subpopulation of patents.[79] Under the

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[75] On average, essential patents reference 6.42 patents, whereas the general population of patents reference 6.32 patents.

[76] Because references are strictly backward looking, there is no issue of truncation and the full dataset through 1999 could be used in calculating the mean number of references.

[77] It should be observed that the aggregate mean is substantially influenced by the number of references made by the GSM patents.

[78] Normality was not achieved via lognormal transformation for patent references. The nonparametric P value was computed to be 0.400 and 0.077 for the general population and technology subset population, respectively.

[79] Other studies have found significant differences in the average number of references made by a selected sample of patents and the average number of references made by patents of the general population, but the studies have differed as to whether references correlate positively or

present analysis, the number of references made to U.S. patents is not a significant indicator of patent value.

2. *Citation Age and Reference Age*

Subsequent patents tend to cite essential patents for a slightly longer period compared to the period that the general population of patents is cited. Furthermore, essential patents reference more recent patents compared to the references made by the general population of patents. The average citation age of a patent is calculated by taking the difference of the application year of a citing patent and the application year of the patent being cited for all patents citing the patent.[80] An older average citation age can be indicative of either a patent that retains technical relevance or a patent that represents a more basic and discontinuous innovation.[81] Under the former assumption, the patent continues to receive citations over a longer period relative to a patent with a younger average citation age. Under the latter assumption, the incubation period necessary for follow-up innovation and citation takes longer to achieve than a patent with a younger average citation age. The average patent reference age of a patent is calculated similarly to the average patent citation age, but the patent grant year is used in place of the application year.[82] A younger average reference age means that the patent is citing more recent patents and suggests that the patent is at the technological forefront relative to a patent with an older average reference age.[83]

Mean citation age is reported as a lognormally transformed mean and a lognormally transformed independent mean.[84] In calculating the last mean, only patents that have received citations are considered. By selecting only patents that have received at least one citation, mean citation age becomes an independent metric that is decoupled from the number of citations metric discussed above. Mean citation age for patents of the general population and the standards technology subpopulation are weighted by the distribution of grant year for the essential patents to eliminate discrepancies resulting from citation truncation.

Substantial variation in mean citation age among the three standards exists. Essential GSM patents have the oldest mean citation age of 3.8 years and the oldest independent age of 4.1 years.[85] The eighty-one MPEG essential patents have a mean citation age of 2.9 years and independent age of 2.9 years. Finally, the 802.11

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negatively with value. *See, e.g.*, Allison et al., *supra* note 21, at 449 (comparing litigated and non-litigated patents and suggesting that higher than average references is indicative of patent value); *University versus Corporate Patents*, *supra* note 21, at 51 (comparing patents assigned to universities to patents assigned to corporations and stating that numerous references is suggestive of a patent building upon significant prior art); Jean O. Lanjouw & Mark Schankerman, *Patent Quality and Research Productivity: Measuring Innovation with Multiple Indicators*, 114 ECON. J. 441, 441–45 (2004) (using a measure of patent families a comparative index and stating that a high number of references intimates an incremental invention).

[80] *The NBER Patent Citations Data File*, *supra* note 21, at 421.

[81] *University versus Corporate Patents*, *supra* note 21, at 61.

[82] *The NBER Patent Citations Data File*, *supra* note 21, at 421.

[83] *University versus Corporate Patents*, *supra* note 21, at 61–62.

[84] *The NBER Patent Citations Date File*, *supra* note 21, at 421.

[85] The mean citation age is reported in the order of transformed and independent hereinafter.

patents have a mean citation age of 2.2 years and independent age of 2.7 years. In aggregate, essential patents have a mean citation age of 3.0 years and independent age of 3.4 years. The general population of patents has a mean citation age of 2.1 years and independent age of and 3.2 years, while the technology subpopulation of patents has a mean citation age of 2.6 years and independent age of 3.2 years.

Comparison of the mean citation age shows that essential patents have a statistically significant older mean citation age than the general population of patents and the technology subpopulation of patents for the transformed age. The difference in citation age is not significant when only patents having received at least one citation are considered, P value of 0.158 for the general population and 0.065 for the standards technology subpopulation. This indicates that when citation age is independent of the number of citations received, there is little difference in mean citation age between essential patents and the general population of patents or the technology subpopulation of patents. Table 1 summarizes mean citation age findings.

Essential patents reference patents, which are significantly younger relative to their counterparts in the general population of patents. Among the standards, GSM essential patents have the oldest mean patent reference age, a mean age of 6.1 years. The mean reference age of the MPEG patents is 4.6 years while the 802.11 patents average 4.8 years. Aggregated, the essential patents have a mean reference age of 5.2 years.

The general population of patents, with a mean reference age of 10.3 years, is substantially older than the average reference age of the standards patents. Technology class is a significant driver of the mean reference age. The mean reference age of 5.7 years for patents in the technology subpopulation is nearly half that of the general population. Nonetheless, the results of the means comparison tests indicate that there is a statistically significant difference in the mean reference age of essential patents compared to the general population, as well as the technology subpopulation of patents. Thus, essential patents, even when compared to patents within the same fields of technology, are timelier than those of the general population. Table 1 summarizes the results of the mean reference age.

3. Forward and Backward Diversity of Technology

The relative breadth of the technology that the patent drew upon and an analogous measure of the subsequent breadth of technologies impacted by the patent are useful for assessing the technological spread of patents.[86] The first measure is backward looking and has been coined *originality*.[87] Patent originality looks to a patent's references and the distribution or the spread of the references among technological classifications.[88] The originality metric ranges from zero to one, where

[86] *University versus Corporate Patents*, *supra* note 21, at 60–63. However, one study has argued that the measures are flawed because they rely on the classification system in use by the United States Patent and Trademark Office. *See* Allison et al., *supra* note 21, at 455–56.

[87] *University versus Corporate Patents*, *supra* note 21, at 63.

[88] *Id.* Originality of a patent is determined from the following equation:

a larger originality score indicates that the patent has drawn upon patents from more numerous technological classifications and is indicative of an original innovation.[89] A lower originality score suggests that the patent is focused upon a narrow field, does not integrate multiple technical concepts, and is likely more incremental. The second metric, *generality*, addresses the same concept of technology breadth, but considers the downstream technology impact of the patent by substituting citations for references in the calculation.[90] A higher score indicates that the patent has been cited by subsequent patents in a broader range of technological classifications, suggesting high social return.[91] On the other hand, a lower originality score is indicative of a technologically narrow patent.

Essential patents are both significantly more original and more general than the overall population and the technology subpopulation of patents. Essential patents of each of the three standards have similar mean scores for the backward looking originality metric: 0.41 for MPEG, 0.44 for 802.11, and 0.46 for GSM. In aggregate, essential patents have an originality score of 0.44. Patents of the general population have a mean originality score of 0.36 while patents of the technology subpopulation have an originality score of 0.38. Differences in the originality scores of the essential patents and the general populations were found to be statistically significant in both instances. Therefore, essential patents of technical standards integrate a broader range of technological innovation than do patents of the general population.

Greater variance is observed among the mean generality scores, the forward looking metric, of the essential patents. The 802.11 generality score of 0.40 and the GSM score 0.41 are similar, but the MPEG score is substantially lower at 0.29. In aggregate, essential patents have a mean generality of 0.36. Patents of the general population have a mean generality score of 0.22, while patents of the technology subpopulation have a mean score of 0.31. Again, the differences in the mean scores are statistically significant for the general population and the technology subpopulation. Therefore, essential patents of technical standards have broader downstream application than the patents of the general population. The result is somewhat surprising because one might believe that patents within a standard would have limited applicability to technologies outside of the standard. Table 1 summarizes patent originality and generality.

In sum, several characteristics are significantly different for essential patents of

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$Originality = 1 - \sum_{k=1}^{Ni} \left[\frac{references_{ik}}{references_i} \right]^2$ where the numerator within the summation is the number of references made by the patent that are within a given technology class and the denominator is the total number of references made by the patent. *Id.* By way of example, if a patent had made reference to ten prior patents and those ten patents fell within four different technology classes as follows: one references in class A, two references in class B, three references in class C, and 4 references in class D, the calculation would be as follows: $1-[(1/10)^2 + (2/10)^2 + (3/10)^2 + (4/10)^2] = 0.70$. *Id.*

[89] *Id.* The NBER patent dataset includes a measure of originality based upon the three digit classification of the United States Patent and Trademark Office. *Id.*

[90] *Id.* Generality of a patent is determined by the following equation: $Generality = 1 - \sum_{k=1}^{Ni} \left[\frac{citations_{ik}}{citations_i} \right]^2$ *Id.*

[91] *Id.*

technical standards relative to the general population of patents. The differences are somewhat mitigated when comparing essential patents to the population of patents of like technology, but they remain statistically significant. Thus, the hypothesis that essential patents are valuable is supported.

II. A VALUATION MODEL DERIVED FROM ESSENTIAL PATENTS OF TECHNICAL STANDARDS

Analytical methods of patent valuation provide an efficient means of quantifying the relative value of a patent. Efficiency of the analytical method makes the technique especially well suited for scenarios involving multiple patents, patent portfolios, or R&D decisions that can be influenced by patents. Further, the general accessibility of the characteristic patent data makes the analytical approach particularly appealing.

Herein, an analytical patent valuation model based on patent characteristics is introduced. The model relies on the hypothesis that patents deemed essential by technical standards bodies are more valuable on average than the general population of patents, as presented in Part I of this article.[92] Statistical analyses of patent characteristics confirm that essential patents differ significantly from patents of the general population.[93] Consequently, it is hypothesized that a model employing these characteristics can be created to provide quantitative valuation information and rank the value of any patent. Following a discussion of model creation, valuations for various patent samples and the general population are presented.

A. Creation of the Analytical Patent Valuation Model

An analytical patent valuation model is generated through statistical analysis of characteristic patent data. Model inputs consist of the characteristic patent data such as the number of references, citations, claims, citation age, reference age, and upstream and downstream technology breadth. The model is a mathematical function that equates the model response, which is patent value, to the model inputs. Through the analysis, statistically significant and insignificant input variables are identified. Most importantly, the analysis determines the appropriate coefficient, or weight, for each of the model inputs. For example, the model for patent value could be described as the function of (A) citations + (B) references + (C) claims, and so forth.[94] Statistical principles mathematically generate the model weights A, B, C, . . . *n* and ascertain which, if any weights, are so small as to be statistically insignificant.

Because of the inherent difficulty of acquiring actual monetized patent value data, a proxy for patent value is necessary to complete the model. It has been demonstrated that essential patents of technical standards are characteristically

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[92] *See supra* Part II.A.

[93] *See supra* Part II.B.

[94] *See generally* Kimberly A. Moore, *Worthless Patents*, 20 BERKELEY TECH. L.J. 1521, 1545–47 (2005). An intercept value also is generally present making the expression: value = I + (A) · citations + (B) · references + (C) · references. . . ., where I is the model intercept. *Id.*

different from the general population of patents and this difference is proposed as the value proxy of the model response. Thus, the model response is a nominal binary condition: a patent is defined as either an essential technical standard patent or a patent among the general population of patents.[95]

A nominal logistic analysis is employed to determine factor significance and obtain the weighting coefficients for the multifactor model.[96] A probability function is generated that expresses the likelihood that a patent is valuable given its characteristics and thereby yields the model weights necessary to construct the continuous valuation model. Quantitative ranking and comparison of a patent can occur by applying the function to any patent where the basic patent characteristics are known.

A series of seven models were constructed both isolating and aggregating patents of the technical standards and using a sample of the general population of patents as well as the technology subpopulation to ascertain factor sensitivity, model stability, and uncover potential inconsistencies.[97] Each model constructed was found to be highly statistically significant with a P value less than 0.0001.[98] Significance of the individual factors generally matched the results obtained when the factors were assessed individually.[99]

Specifically, the number of citations received by a patent is significant for all models and highly significant whenever essential patents are considered in aggregate.[100] Patent generality is also statistically significant in all cases and highly significant in the aggregate models.[101] Interestingly, the number of references is

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[95] NBER Data, *supra* note 70. Only a sample of all essential standards patents were used for the analysis. Essential patents were cultivated from the three technical standards described in Part II: the GSM, MPEG, and 802.11 standards. *See supra* Part II.B. There are many more technical standards beyond these with essential patents and thus there may be a small number of essential patents not described as essential among the sample of the general population of patents used in the analysis. *Id.*

[96] *See* SAS INSTITUTE INC., JMP STATISTICS AND GRAPHICS GUIDE 352 (2005). A linear model is fit using a multilevel logistic response function and the maximum likelihood is obtained with a modified Newton-Raphson iteration. *Id.*

[97] *See supra* Part I. Factor significance should generally match the results obtained. *Id.* However, variation in parameter significance can occur when integrating multiple factors of various single factor analyses. *Id.* The technology subpopulation of patents was used with models using patents from a single standard. *Id.*

[98] *See* BOX, ET AL., *supra* note 63. Here, the P value is the Wald test chi squared probability that the parameter value has a value of zero. Likewise, the models passed a "lack of fit test." The lack of fit test determines if the model factors provide sufficient information or if more complex terms need to be added. The Lack of Fit test calculates a pure-error negative log-likelihood and tests whether this log-likelihood is significantly better than the model. *Id.*

[99] *See supra* Part I.B.1.

[100] *See generally supra* Part I. The number of citations that a patent has received is a significant factor but must be corrected for the truncation effect. The number of citations received by a patent is normalized to a common duration. A Weibull distribution is fit to the citation rate data and the cumulative density function of the distribution is determined. The Weibull distribution is a flexible distribution that can fit non-normal data and includes a scale and shape parameter and may include a threshold parameter. *Id.* The Weibull cumulative distribution function is defined by: $F(t) = 1 - e^{-\left(t/\alpha\right)^{\gamma}}$ where α is the scale parameter and γ is the shape parameter. *Id.*

[101] *See* discussion *supra* Part I.B.3. (describing the generality metric).

statistically significant and highly significant for the general population models, but patent reference age is statistically significant only for the general population models, contra to results obtained when analyzing the factors in isolation.[102] Table 2 summarizes the factor significance results for the seven models.

Description / Model Factor	Model A	Model B	Model C	Model D	Model E	Model F	Model G
	All essential & technology subpopulation	*Mode A with citation normalization applied*	*All essential & general population sample*	*Model C with citation normalization applied*	*802.11 essential only & technology subpopulation*	*MPEG essential only & technology subpopulation*	*GSM essential only & technology subpopulation*
Intercept	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
claims	N/S	N/S	N/S	N/S	0.021	N/S	N/S
references	0.0011	0.0156	<.0001	<.0001	N/S	N/S	<.0001
citations	<.0001	<.0001	<.0001	<.0001	0.0126	0.0372	<.0001
generality	<.0001	<.0001	<.0001	<.0001	0.0185	0.0002	0.0193
originality	0.0031	0.0037	N/S	N/S	N/S	0.0089	N/S
citation age	N/S	0.0432	0.0183	0.0383	N/S	0.0195	<.0001
reference age	N/S	N/S	<.0001	<.0001	N/S	0.0087	N/S

Table 2: Summary of Factor Significance for Valuation Models

The four models employing the aggregated essential patents data were refined in light of the outcome of the factor significance tests. It was decided to include only factors that were found to be highly statistically significant with a P value less than 0.0001. The refined technology subpopulation models consist of two forward looking factors, *citations* and *generality*, while the general population models consist of four factors, two forward and two backward looking factors, *citations*, *generality*, *references*, and *reference age*. The factor weights for the refined models are provided in Table 3.[103]

Description / Model Factor	Model AA	Model BB	Model CC	Model DD	Model DDD
	All essential & technology subpopulation	*Mode AA with citation correction applied*	*All essential & general population sample*	*Model CC with Citation Correction Applied*	*Model DD full factor correction*
Intercept	6.0251	6.0784	6.2205	6.2451	6.055
references			-0.0166	-0.0148	-0.0211
citations	-0.0180	-0.0121	-0.0335	-1.9707	-0.0183
generality	-1.1727	-1.2426	-1.7664	-0.0184	-1.6777
reference age			0.1406	0.1375	0.1407

Table 3: Summary of Factor Weights for Valuation Models

Characteristic data for a patent or group of patents of interest are simply supplied and weighted per the factor coefficients to generate the model response. The patent valuation response is then obtained via a probability transformation of the model response.[104] Given the selection of significant model factors and the

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[102] *See* discussion *supra* Part I.B.2. (discussing reference age).

[103] The factor weights provided in the table are the raw factor weights used in the valuation model and they have not been scaled to reflect the magnitude of their associated factors. Although the weight of generality is much larger, 1.17 in Model AA, than the weight for citations, 0.018 in Model AA, generality is measured on a scale of 0.0 to 1.0 while the average the number of citations may be one or more orders of magnitude greater.

[104] The valuation response is calculated $1 / (1 + e^{z})$ where z is the preliminary model response. The valuation z response may be multiplied by a scalar to enhance readability. Thus, valuation under Model AA for a patent with fifteen citations and a generality index of 0.60 is: 6.0251 + (-.0180)

determination of the weighting coefficients presented herein, analytical patent valuation of any number of patents can be accomplished highly efficiently. The method provides a valuation response that is a continuous quantitative ranking but not of an absolute monetary value. Nonetheless, the valuation response can be equated to currency as economic data of patent transactions become available to the analyst employing the methods described.

B. Results Obtained Using the Analytical Valuation Models

Patent values were calculated using the described analytical models for a random sample of the general population of patents and the technology subpopulation of patents.[105] As anticipated, the distribution of patent value was highly skewed toward the low end of the value continuum. A substantial percentage of patents have nominal value, an ever decreasing number of patents have greater value, and a small percentage of patents, less than 2.5 percent, have substantial value. The average value of essential standards patents was found to be greater than the average value of both the general population sample and the technology subpopulation, but, as expected, the most valuable patents were not among the limited group of essential patents.

1. Results of the Technology Subpopulation Models

Valuations were obtained for the patents of the technology subpopulation using the two factor models for the raw number of citations and the normalized number of citations. There is little difference in the aggregate valuations under the two models. Both models calculated the mean value for the technology subpopulation of patents to be 4.52. Essential patents were found to have a mean value 6.46 using the raw number of citations and 6.18 using normalized citations. None of the standards considered alone deviated significantly from the average value. Table 4 summarizes these results.

		Mean Value	Mean Value Citations normalized	Max value	Max Value Citations normalized
Technology Subpopulation Model	Technology Subpopulation	4.523	4.524	584.61	427.22
	All Essential Patents	6.46	6.18	45.44	29.43
	802.11 Patents	6.34	6.23	17.89	13.67
	GSM Patents	6.58	6.01	45.44	23.46
	MPEG Patents	6.35	6.36	42.37	29.43
General Model	Sample of Full Population	1.580	1.583	810.64	999.80
	All Essential Patents	7.91	6.01	253.20	64.14
	802.11 Patents	5.99	5.58	33.16	16.67
	GSM Patents	8.03	5.37	253.17	61.36
	MPEG Patents	8.52	6.97	143.36	64.14

Table 4: Summary Statistics of Patent Value for Valuation Models

(10) + (-1.1727) (0.60) yielding a preliminary response of 5.1417. Then valuation becomes 1 / $(1+e^{5.1417})$ = 0.00581 which can be scaled by 1000 to be conveniently stated as a value of 5.81.

Nevertheless, differences in valuation generated by each model arise when patents are considered individually or when patent portfolios are compared, as a result of the relative age of individual patents. Citation normalization allows younger patents to be compared on a level playing field with older patents that have a longer opportunity to receive citations. When the top one percent of patents among 45,000 patents of the technology subpopulation were ranked by value using each model, the two rankings differed by an average of 169 positions.[106] Thus, citation normalization is critical to achieving competent analytical valuation.

Patent portfolio valuation calculated from individual patent values generated by the normalized citation model matched expectations. The top patent portfolios in the technology subpopulation, ranked by average patent value, were found to be held by large corporations with substantial operations in the industries corresponding to the technology subpopulation, electronics, and communications. Not surprisingly, the portfolios of these assignees also possess significant total value as a result of the number of patents held in the technology space. Nonetheless, the results illustrate that portfolio size does not necessarily equal portfolio quality.[107] Qualcomm was found to possess the highest average patent value, but the second lowest total value out of the top fifteen assignees in this technology space.[108] Qualcomm's high average value is explained by its significant technological presence in the cellular standard that is the principal alternative to the GSM standard and its key position in the next generation of cellular standards. Qualcomm is well known for its strategy of pursuing intellectual property rights and licensing, but its focus on multiple technology sectors by other top assignees substantially elevates its total portfolio value.[109] It was not expected that unassigned patents would have the fourth

Assignee	Total Value	Average patent value
Qualcomm	2190	14.04
AT&T Bell Labs	6136	5.82
IBM	5599	5.12
Unassigned	12463	4.93
Hitachi	4152	4.52
Motorola	9594	4.46
Toshiba	4853	4.40
Fujistu	4136	4.37
Mitsibushi	2531	4.04
NEC	7066	3.99
Sony	5676	3.97
Phillips	4424	3.86
Canon	4726	3.82
Matsushita	3828	3.78
Samsung	2054	3.38

Table 5: Top Fifteen Assignees by Average Patent Value in the Technology Subpopulation

[105] The random sample of the general population consisted of 120,000 patents granted between 1986 and 1999.

[106] The rank difference of 169 positions is the absolute value. Thus, if the calculated value of a patent using the raw number of citations resulted in a 200th ranking, on average, the normalized citation rank could be 169 positions away from the 200th position, *i.e.*, a rank of 31 or 369.

[107] A linear regression of total value and average value shows no correlation between the factors with an R value of 2 0.04. The R value is a measure regression fit ranging between zero, no correlation, and 1.0, perfect correlation.

[108] Removing Qualcomm as an outlier and repeating the linear regression for total value and average value still shows a lack of correlation between the responses, yielding an R value of 0.22.

[109] *See generally* David Whelan, *Cellular Scion*, FORBES, Nov. 28, 2005, at 130 (detailing the career and future plans of Qualcomm's new executive, Paul Jacob, at his new job). Qualcomm brought a patent infringement suit against Nokia for violation of GSM patents held by Qualcomm. Dan Bilefsky, *Qualcomm Sues Nokia Over Patents*, N.Y. TIMES, Nov. 8, 2005, at 4.

highest average value, particularly in the electronics industry where establishing significant research and development capabilities can be prohibitively expensive. Table 5 summarizes these findings.

2. Results of the General Population Sample

Valuations were obtained for a random sample of patents from the general population of patents using the four-factor models for the raw number of citations and the normalized number of citations. Like the outcome for the technology subpopulation models, there is little difference in the overall valuation properties produced by the models. Both models calculated the mean value for the sample of patents to be 1.58. A more substantial difference was observed among the essential patents, where a mean value of 7.91 was reported using the raw number of citations and 6.01 using normalized citations. Greater variation in mean value was observed among the individual standards relative to the variation of the technology subpopulation. The increased variation observed among the standards highlights the tradeoff between broad model applicability and model accuracy. Table 4 above summarizes the results.

Patent generality exhibits a downward trend over time for the general population, just as it did among the technology subpopulation. The mean reference age was also observed to decrease over time, while the mean number of references was seen to increase over time.[110] These trends illustrate fundamental changes in the patent system that must be accounted for in the model by conditioning patent generality and normalizing the number of patent references and patent age.[111] Table 3 above provides the new factor weights for the model corrected for these effects associated with the migration of the patent system.

Portfolio valuations were conducted for the sample of patents from the general population. Like the results of the technology subpopulation model, the assignees on the list owning the most valuable patents are not surprising. In total value, unassigned patents have the greatest value, because of the sheer number of patents that are unassigned. Next are the perennially prolific corporate R&D leaders such as IBM, Toshiba, Motorola, GE, Sony, General Electric, Kodak, and Du Pont. These companies have amassed large portfolios of patents that are highly valuable in aggregate, but value is not achieved solely by bulk. These same corporate assignees also own the highly valuable patents on average, patents valued well above the average population value.[112] Intel was found to have the highest average patent value at 5.32 and followed by companies including: IBM, Texas Instruments, Hewlett

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[110] *See The NBER Patent Citations Date File*, *supra* note 21, at 424–25. The observation of an increasing number of references made by patents over time and the simultaneous decreasing average reference age has previously been identified. *Id.*

[111] The revised model accounting for these effects becomes: 6.0548 -0.0183 * normalized citations -0.0211 * normalized references - 1.67677 * conditioned generality + 0.1407 * reference age. Under the new model, the mean value of the population sample is 1.99 and the value of the aggregated essential patents is 6.30.

[112] *See* discussion *supra* Part II.B.2. The top twenty-five companies were found to have a mean value of 3.03, while the sample of the general population was found to have a mean value of 1.58. *Id.*

Assignee	Total Value	Average Value
Intel	616.9	5.32
IBM	3111.7	5.22
DEC	376.2	4.23
AT&T	1089.5	4.01
Texas Inst.	810.8	3.39
Motorola	1267.5	3.19
Fujistu	886.9	3.12
Sony	882.7	3.12
Toshiba	1551.3	3.12
Hitachi	1617.6	3.03
HP	491.5	2.94
NEC	987.4	2.94
Xerox	627.2	2.90
Ricoh	498.9	2.90
Sharp	527.2	2.72
Canon	1384.8	2.64
Matsushita	760.8	2.57
Mitsibushi	1084.1	2.52
3M	539.8	2.41
Bosch	369.9	2.33
Du Pont	462.8	2.29
Phillips	670.0	2.28
Fuji	750.8	2.22
GE	974.3	2.20
Kodak	768.5	2.14
Siemmens	467.1	2.01
Unassigned	8727.3	1.04

Table 6: Top Assignees by Average Patent Value in the Sample of the General Population

Packard, and Xerox. Table 6 summarizes the portfolio valuation analysis.

In view of the foregoing results, some observations on model performance must be addressed. Achieving consistent valuation across diverse technologies with a model is a consideration to bear in mind, but variation should not present a substantial issue because the need to value patents in highly diverse technology sectors simultaneously will occur infrequently. Observed differences in average patent value across technology sectors may be a modeling artifact, a result of differences in patent drafting and prosecution across the sectors, or a true difference in average patent value. First, the underlying basis of the model is that essential patents are a proxy for patent value.[113] The essential patents were drawn from fields where standardization has primarily occurred, communications and electronics. Thus, an inherent model bias may exist to cause more favorable valuation for patents within like technology classes compared to patents outside those technologies. Such a conclusion depends on the presence of fundamental differences in patent characteristics across the technology sectors.[114] On the other hand, the differences may reflect the relative difference in average value of patents among technology sectors. For instance, the model yields an average value for patents in the electronics, communications, and computer technology classes that is significantly greater than the average value for patents in the food, photography, and land vehicle classes.[115] This result may be a manifestation of model bias but intuitively, patents granted from 1986 to 1999 in the electronics and communications industries are quite likely to be of a greater average value than those patents among the latter technology classes.

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[113] *See* discussion *supra* Part II.B.

[114] Allison, et al., *supra* note 21, at 455–56. There are differences in the average of the characteristics such as claims, citations, references, originality, and generality that do exist among the technology sectors. *Id.*

[115] Patents of the first group, consisting of electronics and communications in United States PTO classes 345, 370, and 379, have an average value ranging from 3.5 to 6.0. Patents of the second group of food, photography, and packaging, in classes 380, 396, and 426, have an average value ranging from 1.05 to 1.8.

III. Conclusion

Patents are an essential asset for a technology company and it is critical that business leaders are adequately informed when making decisions that involve patents. Patent transactions and corporate R&D planning are two scenarios where an efficient means of providing illuminating and quantitative assessment to appropriately drive the decision making process is necessary. A methodology for quantifying valuing patents and patent portfolios has been presented to meet this need.

A valuation model has been developed on the hypothesis that status as an essential patent of a technical standard is a suitable proxy for patent value. It has been shown that the characteristics of essential patents such as citations, citation age and reference age, and forward and backward technology spread, differ significantly from the general population of patents. These differences have been exploited to develop a universal and technology specific analytical patent valuation model. Application of the model provides reasonable valuation results, thereby satisfying the hypothesis that essential patents are a suitable proxy for patent value and successfully creating an effective means of quantitative patent valuation. The practitioner may apply the principals and formulations presented in assessing the value of patents and patent portfolios of interest.