PATENTS AND THE REGRESS OF USEFUL ARTS

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Patent systems are often justified by an assumption that innovation will be spurred by the prospect of patent protection, leading to the accrual of greater societal benefits than would be possible under non-patent systems. However, little empirical evidence exists to support this assumption. One way to test the hypothesis that a patent system promotes innovation is to simulate the behavior of inventors and competitors experimentally under conditions approximating patent and non-patent systems. Employing a multi-user interactive simulation of patent and non-patent (commons and open source) systems ("PatentSim"), this study

compares rates of innovation, productivity, and societal utility. PatentSim uses an abstracted and cumulative model of the invention process, a database of potential innovations, an interactive interface that allows users to invent, patent, or open source these innovations, and a network over which users may interact with one another to license, assign, buy, infringe, and enforce patents. Data generated thus far using PatentSim suggest that a system combining patent and open source protection for inventions (that is, similar to modern patent systems) generates significantly lower rates of innovation ($p < 0.05$), productivity ($p < 0.001$), and societal utility ($p < 0.002$) than does a commons system. These data also indicate that there is no statistical difference in innovation, productivity, or societal utility between a pure patent system and a system combining patent and open source protection. The results of this study are inconsistent with the orthodox justification for patent systems. However, they do accord well with evidence from the increasingly important field of user and open innovation. Simulation games of the patent system could even provide a more effective means of fulfilling the Constitutional mandate "to promote the Progress of . . . useful Arts" than does the orthodox assumption that technological innovation can be encouraged through the prospect of patent protection.

I. INTRODUCTION

Patent systems are usually justified by an assumption that they spur technological innovation. According to this orthodox view, the prospect of patent protection for new inventions should lead to higher rates of technological innovation, as well as greater attendant benefits to society, than would a commons "system" offering no patent protection. As an incentive to encourage the invention of new technologies, a "patent shall contain . . . a grant . . . of the right to exclude others from making, using, offering for sale, or selling the invention throughout the United States or importing the invention into the United States."[3] By conferring on patent owners a limited monopoly right to exclude others, a patent system should create incentives for technological innovation above and beyond any baseline incentives existing in a commons system. Specifically, prospective inventors should respond to this additional patent incentive by allocating correspondingly more time, energy, and other resources to the invention of "any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof."[4] Lawrence Lessig has summarized the conventional view of patents as spurs to technological innovation:

> The argument favoring patents is as old as the hills. If an inventor can't get a patent, then he will have less incentive to invent. Without a patent, his idea could simply be taken. If his idea could simply be taken, then others could benefit from his invention without the cost. They could, in other words, free-ride off the work of the inventor. If people could so easily free-ride, fewer would be inventors. And if fewer were inventors, then we would have less progress in "science and useful arts."
> Getting more progress is the constitutional aim of patents.[5]

However, despite the economic logic of the conventional view, there exists surprisingly little empirical evidence to support the key assumption that patents do actually spur technological innovation.[6]

Technological innovation has long been positively linked to economic growth.[7] In addition, research and development investment into technological innovation do tend

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[3] 35 U.S.C. §154(a)(1) (2006). Note that similar rights to exclude exist in the patent laws of most countries.

[4] 35 U.S.C. §101 (2006).

[5] Lawrence Lessig, The Future of Ideas 205 (2002).

[6] Comm. on Intell. Prop. Rts. in Knowledge-Based Econ., Nat'l Res. Council, Patents in the Knowledge-Based Economy 2 (Wesley M. Cohen & Stephen A. Merrill eds., 2003) [hereinafter Cohen & Merrill].

[7] Robert M. Solow, *Technical Change and the Aggregate Production Function*, 39 Rev. of Econ. & Stat. 312, 320 (1957).

to generate exceptionally high returns.[8] Thus, on the orthodox assumption that patents spur technological innovation, a patent system is considered to be a vital tool in economic policy, and even the United States Constitution itself grants Congress the power "To promote the Progress of Science and useful Arts, by securing for limited Times to . . . Inventors the exclusive Right to their . . . Discoveries."[9] However, as Lessig has suggested, "the question that must always be asked of any patent regime is whether we have good reason to believe that patents have that effect."[10]

Previous studies attempting to measure the additional quantum of technological innovation spurred by the availability of patent protection have taken two broad approaches. Some have relied upon theoretical economic frameworks.[11] Others have employed mathematical models of technological innovation,[12] attempted direct measurement of technological innovation in a single economy of interest,[13] or compared rates of technological innovation among countries offering different levels of patent protection.[14] The results of some of these studies have appeared to undermine the basic

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[8] Paul M. Romer, *Increasing Return and Long-run Growth*, 94 J. of Pol. Econ. 1002 (1986).

[9] U.S. Const. art. I, §8, cl. 8.

[10] Lessig, *supra* note 5, at 205.

[11] *See*, *e.g.*, William M. Landes & Richard A. Posner, The Economic Structure of Intellectual Property Law (2003).

[12] *See, e.g.*, Robert L. Basmann et al., *Patent Activity and Technical Change*, 139 J. Econometrics 355, 355-75 (2007) (analyzing the empirical effects of patent grants on changes in technology); Michael McAleer & Daniel Slottje, *A Simple New Measure of Innovation: The Patent Success Ratio*, 63 Scientometrics 421, 421-29 (2005) (introducing the patent success ratio as a measure of innovation); Edwin Mansfield, *Patents and Innovation: An Empirical Study*, 32 Mgmt. Sci. 173, 173-81 (1986); Petra Moser, *How Do Patent Laws Influence Innovation? Evidence from Nineteenth-Century World Fairs*, 95 Am. Econ. Rev. 1214 (2005).

[13] *See, e.g.*, Mark A. Lemley & Julie E. Cohen, *Patent Scope and Innovation in the Software Industry*, 89 Cal. L. Rev. 1 (2001) (examining the effects of patents on innovation in the computer software industry); Joshua Lerner, *Where Does State Street Lead? A First Look at Finance Patents, 1971-2000*, 57 J. Fin. 901, 901-30 (2002) (business method patents); Stuart J.H. Cohen & Matthew J. Higgins, *The Impact of Patenting on New Product Introductions in the Pharmaceutical Industry* (Munich Pers. RePEc Archive, Working Paper No. 4574, 2007), *available at* http://mpra.ub.uni-muenchen.de/4574/1/MPRA_paper_4574.pdf; Stuart J.H. Graham & Matthew John Higgins, *Comanor and Scherer Revisited: Do Patents Proxy for New Product Introductions?* (Sept. 27, 2007) (unpublished working paper, on file on Soc. Sci. Research Network), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1024572 (examining the utility of patents as a proxy for technological innovation in the pharmaceutical industry) .

[14] *See, e.g.*, Lee G. Branstetter, *Do Stronger Patents Induce More Local Innovation?*, 7 J. Int'l Econ. L. 359 (2004) (comparing the levels of innovation under Japanese and United States patent laws); Janice M. Mueller, *The Tiger Awakens: The Tumultuous Transformation of India's Patent System and the Rise of Indian Pharmaceutical Innovation*, 68 U. Pitt. L. Rev. 491 (2007); Mark Schankerman, *How Valuable is Patent Protection? Estimates by Technology Field*, 29 RAND J.

assumption that a patent system does indeed promote technological innovation, sometimes even suggesting that patents deter, rather than spur, such innovation.

One way to test the hypothesis that patent systems promote technological innovation is to employ an experimental approach to simulate the behavior of inventors and competitors under conditions approximating patent and non-patent systems. Employing a multi-user interactive simulation of patent, patent/open source, and commons systems ("PatentSim™"),[15] this study compares rates of innovation, productivity, and social utility across these three systems. PatentSim uses an abstracted and cumulative model of the invention process, a database of potential innovations, an interactive interface that allows users to invent, patent or open source these innovations, and a network over which users may interact with one another to license, assign, buy, infringe, and enforce patents.

Simulation games have been used effectively in a wide variety of contexts, from war games[16] to modeling building fires[17] to simulations of collaborative work.[18] However, no study has yet employed interactive simulation games to study the relationship between a patent system and technological innovation.[19] Simulation games differ from traditional mathematical model-based approaches by allowing multiple users to interact dynamically with a mathematical model. In the case of the patent system, this approach has several advantages, including the following:

> (1)   It involves the participation of actual humans, whose behavior may more accurately reflect the behavior of human inventors, patent owners, sellers, and infringers than can more static mathematical models;

Econ. 77 (1998) (examining patent protection and innovation in France);; Yi Qian, *Do National Patent Laws Stimulate Domestic Innovation in a Global Patenting Environment? A Cross-Country Analysis of Pharmaceutical Patent Protection, 1978-2002*, 89 Rev. Econ. & Stat. 436 (2007); John Baldwin et al., *Determinants of Innovative Activity in Canadian Manufacturing Firms: The Role of Intellectual Property Rights* (Statistics Can., Working Paper No. 122, 2000), *available at* http://www.statcan.gc.ca/pub/11f0019m/11f0019m2000122-eng.pdf.

[15] The authors possess certain trademark rights in the mark "PatentSim™." However, uses of this mark below lacks the "TM" notification for purely stylistic reasons.

[16] Robert C. Rubel, *The Epistemology of War Gaming*, Naval War C. Rev., Spring 2006, at 108, *available at* http://findarticles.com/p/articles/mi_m0JIW/is_2_59/ai_n16689840/pg_1?tag=artBody;col1.

[17] Richard Bukowski & Carlo Séquin, *Interactive Simulation of Fire in Virtual Building Environments*, 24 SIGGRAPH Conf. on Computer Graphics & Interactive Tech. 35 (1997), *available at* http://doi.acm.org/10.1145/258734.258757.

[18] Nathan Bos, N. Sadat Shami, Judith S. Olson, Arik Cheshin, & Ning Nan, *In-group/Out-group Effects in Distributed Teams: An Experimental Simulation*, 2004 ACM Conf. on Computer Supported Cooperative Work 429, *available at* http://doi.acm.org/10.1145/1031607.1031679.

[19] In fact, simulations games have rarely been employed to study intellectual property law.

(2)   One can model behavior of both users familiar with the patent system and those ignorant of its architecture and purpose, as well as track how users learn how to improve their use of a simulated patent system;

(3)   One can easily strengthen, weaken, turn on, or turn off specific features of a patent system, such as licensing, absolute novelty, and enforcement, allowing isolation of their influence on simulation outcomes;

(4)   One can track each and every event that occurs during any particular simulation, generating a comprehensive data set describing behavior both of individual users and of an entire simulated patent system.

Results thus far from data generated using PatentSim are striking. These results indicate that current patent systems (that is, systems combining patent and open source protection for inventions) may generate significantly lower rates of innovation ($p<0.05$), productivity ($p<0.001$), and social utility ($p<0.002$) than does a commons system.[20] This suggests that current patent systems may significantly deter, rather than spur, technological innovation compared to a commons system.

Part II of this article briefly reviews empirical evidence relevant to the role of patent systems in promoting technological innovation. Part III provides an overview of previous efforts to simulate patent systems. Part IV describes the architecture and functionality of the PatentSim patent simulation system. Part V presents the experimental methods employed in this study, the data resulting from these experiments, and statistical analyses of these data. Part VI compares the empirical results generated using PatentSim with evidence about the role of patents in generating technological innovation drawn from the emerging field of user and open innovation.[21] Finally, Part VII concludes by considering implications that the results of this study may have for the patent system, and outlines future research directions on patent systems and technological innovation using the PatentSim simulation game.

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[20] These data also indicate that there is no statistical difference in innovation, productivity, or social utility between a pure patent system and a system combining patent and open source protection.

[21] This field is sometimes referred to as "open innovation." For the purposes of this article, the more inclusive phrase "user and open innovation" is employed.

II. PATENTS AND INNOVATION

Both theoretical and empirical approaches have attempted to test the hypothesis that availability of patent protection encourages higher levels of technological innovation than would occur in the absence of patent protection. Although neither approach has yielded decisive results thus far, they are reviewed below.

A. Theoretical Evidence

Mazzoleni and Nelson have constructed a useful framework for organizing theories about the patent system.[22] They suggest that the answer to the question, "What are the social benefits and costs of awarding patents for inventions?" is not simple or well settled, despite what "[m]any economists and patent lawyers seem to think."[23] They propose four broad theories about the purposes served by patents:

> The anticipation of patents provides motivation for useful invention: we weill [sic] call this the "invention motivation" theory.
>
> Patents induce inventors to "disclose" their inventions when otherwise they would rely on secrecy, and in this and other ways facilitate wide knowledge about and use of inventions: we will call this the "invention dissemination" theory.
>
> Patents on inventions induce the needed investments to develop and commercialize them: this we call the "induce commercialization" theory.
>
> Patents enable the orderly exploration of broad prospects: we call this the "exploration control" theory.[24]

Mazzoleni and Nelson recognize that these purposes are not necessarily mutually exclusive; not only may they overlap, but some versions of these theories may even conflict with one another. The first three theories have a long history, whereas the fourth theory is of relatively recent vintage.[25] Mazzoleni and Nelson also make the useful observation that theories about the costs and benefits of patents are often based on assumptions (not always explicit) about certain "context conditions":

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[22] Roberto Mazzoleni & Richard R. Nelson, *Economic Theories About the Benefits and Costs of Patents*, 32 J. Econ. Issues 1031, 1031 (1998).

[23] *Id.*

[24] *Id.* at 1033.

[25] *Id.*

1. The nature and effectiveness of means other than patents to induce invention and related activities. These "other means" may be as diverse as government grants and contracts or strong first mover advantages.
2. Whether the group of potential inventors is likely to work on diverse and non-competing ideas, or whether the group is likely to be focused on a single alternative or a set of closely connected ones. Basically the issue here is whether or not more inventing input yields more useful inventing output or mainly duplication of effort and waste.
3. The deterrent effect of the presence of patents on unauthorized use of a technology and on the transaction costs involved in licensing an invention.
4. Whether the multiple steps in the invention, development, and commercialization of a new technology tend to proceed efficiently within a single organization, or whether efficiency is enhanced if different organizations are involved at different stages of the process.
5. What we will call the topography of technological advance, by which we mean the manner in which inventions are linked to each other temporally, and as systems in use.

At least some of these conditions are partly endogenous to the nature of the patent system. They are themselves influenced by the strength and scope of the patent protection within a field of technology. . . . In any case, the implications of the theories are very sensitive to the assumed context conditions.[26]

These authors also admit that different theories will probably apply with more or less salience in different domains. In their formulation, "[t]he proposition we now want strongly to espouse is that the appropriate question about these diverse theories is not 'Which theory is the correct one?' but rather, 'Where do the different theories apply?'"[27] Empirical data and analyses would be useful for formulating answers to this latter question.

Other theoretical approaches have been taken to analyze the question of what effects patents have on promoting or retarding technological innovation. For example, Landes and Posner suggest a comparative theoretical approach that incorporates insights from other forms of intellectual property law: "a more illuminating way of thinking about the patent system is as a response to economic problems inherent in trade secrecy and market structure."[28] Much more work will be required before stronger causal links can be drawn between patents and technological innovation.

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[26] *Id.* at 1034.

[27] *Id.* at 1044.

[28] Landes & Posner, *supra* note 11, at 294.

B. Empirical Evidence

In 2003, the National Academies[29] published a report on the United States patent system, entitled "Patents in the Knowledge-Based Economy,"[30] based on one of the most comprehensive reviews of the patent system completed to date. Included in this report was a review of the evidence that the patent system stimulates technological innovation. Instead of concluding that patents do spur invention, the National Academies made the rather different suggestion that "[t]here are theoretical as well as empirical reasons to question whether patent rights advance innovation in a substantial way in most industries."[31] They offered a number of explanations for why patents might not spur technological innovation. For example, the report points out that the benefits of the patent monopoly might be outweighed by the costs of disclosure required to receive the patent grant,[32] and, that, "where technological advances build upon one another cumulatively, as is increasingly the case, broad patent protection on upstream discoveries may slow the rate of technical change by impeding subsequent innovations."[33] Despite abundant studies into patents and technological innovation, including theoretical work spanning more than a century and "[e]mpirical work by a number of economists over nearly fifty years,"[34] the National Academies concluded that the "literature on the impact of patents on innovation must be considered emergent."[35]

The National Academies determined that there has been "little systematic empirical analysis of the impact of patents on innovation."[36] This lack of empirical analysis may stem from two very different problems: the existence of limited data that links patents and innovation; and, the fact that "the effect of patent policy has many dimensions," making it challenging to determine how any particular aspect of patent policy actually affects innovation.[37] Thus, there is a strong need for empirical data and

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[29] The National Academies "perform an unparalleled public service by bringing together committees of experts in all areas of scientific and technological endeavor. These experts serve pro bono to address critical national issues and give advice to the federal government and the public." The National Academies, About, http://www.nationalacademies.org/about (last visited Dec. 1, 2008).

[30] Cohen & Merrill, *supra* note 6.

[31] Cohen & Merrill, *supra* note 6,at 2.

[32] *Id.* (citation omitted).

[33] *Id.* at 3 (citations omitted).

[34] *Id.*

[35] *Id.*

[36] *Id.* at 2.

[37] *Id.* at 3–4.

analysis to elucidate what role a patent system may play "[t]o promote the Progress of . . . useful Arts."[38]

In this article, we describe our efforts to provide such empirical data and analyses. By gathering empirical data using PatentSim, a dynamic interactive simulation of the patent system, we offer a novel approach to test the hypothesis that patents spur technological innovation.[39]

III. SIMULATION OF THE PATENT SYSTEM

Two major categories of simulations have been used to study intellectual property. The first involves the application of mathematical simulation techniques, most often employed in the economic studies of intellectual property.[40] The second makes use of human participants, and such simulations are sometimes described as "games."[41]

A. Mathematical Simulation

Mathematical simulations, particularly economic simulations, have been used to test various hypotheses about intellectual property systems, including patent systems. Some mathematical simulations have attempted to estimate the value of patent systems in general. For example, Lanjouw estimated the value to inventors of patent protection in different fields of technology.[42] Arora, Ceccagnoli, and Cohen analyzed how investments in research and development react when the value of patent protection changes.[43] Mathematical simulations have also been used to simulate how variations in the strength of intellectual property protection may affect rates or patterns of technological innovation, and, more generally, social welfare.[44]

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[38] U.S. Const. art. I, §8, cl. 8.

[39] PatentSim™ can be found on the Internet at www.patentgame.net.

[40] Mathematical simulations do not involve human participants, relying only on software algorithms and specified sets of parameters.

[41] Simulation games also involve algorithms and some specified sets of parameters, but additionally include human participants whose behaviors interact with the algorithms and parameters.

[42] Jean Olson Lanjouw, *Patent Protection in the Shadow of Infringement: Simulation Estimations of Patent Value*, 65 Rev. Econ. Stud. 671, 671 (1998).

[43] Ashish Arora, Marco Ceccagnoli, & Wesley M. Cohen, *R&D and the Patent Premium* 1 (Nat'l Bureau of Econ. Research, Working Paper No. 9431, 2003).

[44] *See* Max Boisot, Ian C. MacMillan, & Kyeong Seok Han, *Property Rights and Information Flows: A Simulation Approach*, 17 J. Evolutionary Econ. 63, 63 (2007) (simulating "the quantity and cost to society of new knowledge under different property right regimes"); Thomas Vallee &

Others have used mathematical simulations to study specific aspects of a patent system, such as patent terms,[45] or to compare effects of patenting in specific industries, such as pharmaceuticals.[46] Similar approaches have also considered the effects of damages in litigation[47] or of a post-grant opposition system.[48]

B. Simulation Games

Unlike mathematical simulations, whose results depend entirely on calculations made by algorithms, simulation games allow the possibility of more meaningful results by including more complicated elements of actual human behavior. It is reasonable that humans may be better at simulating human behavior than are computer algorithms alone. Simulation games – especially those carried out using computers - are increasingly important in the study of human systems, such as the law.

As long ago as 1984, Hazen and Hazen discussed "simulation gaming" as a valuable teaching tool:

Gaming has been described as a type of simulation involving the use of human decision makers in the simulation of a real life situation which involves conflicting interests. In gaming, the players form an integral part

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Murat Yildizoglu, *Social and Technological Efficiency of Patent Systems* abstract (May 2004) (unpublished manuscript, on file with the *Columbia Science and Technology Law Review*) (using "an evolutionary model of industry dynamics"); *see also* Andrew A. Toole & Dirk Czarnitzki, *Patent Protection, Market Uncertainty, and R&D Investment* 2 (Berkeley Ctr. for Law & Tech., Working Paper No. 24, 2006) (using Real Options analysis to find that patent protection "diminishes the patenting firm's sensitivity to market uncertainties and stimulates R&D investment").

[45] Francesca Cornelli & Mark Schankerman, *Patent Renewals and R&D Incentives*, 30 RAND J. Econ. 197, 197 (1999).

[46] Carsten Fink, *How Stronger Patent Protection in India Might Affect the Behavior or* [sic] *Transnational Pharmaceutical Industries* 29 (Dev. Research Group, World Bank, Working Paper No. 2352, 2000); *see also* Jason C. Hsu & Eduardo S. Schwartz, *A Model of R&D Valuation and the Design of Research Incentives* 1 (Nat'l Bureau of Econ. Research, Working Paper No. 10041, 2003) (finding that patent protection will not stimulate R&D in vaccines for diseases affecting developing countries); Eduardo S. Schwartz, *Patents and R&D as Real Options* 2 (Nat'l Bureau of Econ. Research, Working Paper No. 10114, 2003) (using Real Options to assess the value of patents in the pharmaceutical industry, though based on a model that has general application, and particularly looking at patent duration).

[47] Michael Abramowicz, *A Unified Economic Theory of Noninfringement Opinions*, 14 Fed. Cir. B.J. 241, 243 (2004).

[48] Jonathan Levin & Richard Levin, *Benefits and Costs of an Opposition Process*, *in* Patents in the Knowledge-Based Economy 120, 123 (Wesley M. Cohen & Stephen A. Merrill eds., 2003).

of the simulation, often filling those roles or elements of the simulations that cannot easily be programmed into a simulation model.[49]

Even earlier, in 1972, John Drobak discussed "[g]aming as a research device."[50] He observed that "one of the major problems of computer simulation is the difficulty of adequately representing and programming human attributes," and suggested that computer gaming, where humans participate in the simulation, could alleviate this problem.[51] However, he also pointed out that gaming has "unique limitations in addition to those inherent in computer simulation."[52] For example, individual players might not make decisions in the same way institutions would.[53]

Simulations of intellectual property processes, whether or not described as games, have been used to teach participants about intellectual property and patent systems. A common focus of such simulations has been what strategy businesses might use for exploiting their intellectual property. For example, Arnaud Gasnier has developed several variations on games that simulate business usage of patents.[54] One version allows a team (representing one of several kinds of entities) to choose between several patent strategies: research and development, manufacturing, obtaining one's own patents, exploiting one's own patents, defending one's own patents, or attacking others' patents.[55] A later version of Gasnier's simulation game is called *Patentopolis*.[56]

Simulation games have thus far tended to be in the form of board games rather than computer- or web-based games.[57] Such board games can be designed to provide business people or students with hands-on experience in how various strategies succeed or fail in practice. One version, developed by Gasnier, is intended to help businesses

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[49] Margret M. Hazen & Thomas Lee Hazen, *Simulation of Legal Analysis and Instruction on the Computer*, 59 Ind. L.J. 195, 202 (1984) (citations omitted).

[50] John N. Drobak, *Computer Simulation and Gaming: An Interdisciplinary Survey with a View Toward Legal Applications*, 24 Stan. L. Rev. 712, 719 (1972).

[51] *Id.* at 719–20.

[52] *Id.* at 720.

[53] *Id.*

[54] Arnaud Gasnier, The Patenting Paradox: A Game-based Approach to Patent Management, Presentation at Ph.D. Dissertation Defense at Delft University (Feb. 11, 2008), http://www.patenting-paradox.com/Presentation%20080211.pdf.

[55] *Id.*

[56] *Id.* at 16.

[57] *See* Patentopolis, http://cps.q42.net/projects/10 (last visited Feb. 1, 2009).

improve their internal processes for management and decision making about their patent portfolios.[58]

There have been several other uses of simulation games aimed at helping business users understand how to manage and exploit their intellectual property assets. For example, Jerome Haas developed a "computer-based business simulation that involves an ongoing series of strategic decisions related to a hypothetical manufacturing company in a competitive environment."[59] The University of Washington has used a simulation game in a continuing education certificate program.[60] The Scandinavian International Management Institute has also developed a computer-based simulation game, this one related to management practices.[61] Some law schools have even used simulation games to help teach principles of intellectual property law to law students.[62]

This Article presents empirical data generated using PatentSim, – a simulation game designed specifically to test hypotheses about patent systems, commons systems, and technological innovation.

IV. DESCRIPTION OF PATENSIM

PatentSim, a multi-user interactive simulation system, is used to test hypotheses of individual and societal benefits by varying incentives for such activities as invention, licensing, and infringement by creating a simplified model of the inventive process, and networking together multiple users so they can interact through this system. PatentSim uses an abstracted and cumulative model of the innovation process, a database of potential innovations, an interactive interface that allows users to invent, patent, or open source these innovations, and a network over which users may interact with one another to license, assign, buy, infringe, and enforce patents. Users can potentially cooperate or

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[58] *Id.*

[59] Cornell Management Game, http://www.cms-training.com/ (last visited Feb. 1, 2009).

[60] University of Washington, Certificate Class in Intellectual Property Strategies, http://depts.washington.edu/ventures/About_Us/Education/Certificate.php (last visited Dec. 1, 2008).

[61] Press Release, Scandinavian Int'l Mgmt. Inst., The Business of Intellectual Property – BIP, Program Description 2006 (2006), *available at* http://www.scanbalt.org/graphics/ScanBalt/databases/BIP%202%20page%20version.pdf.

[62] *See, e.g.*, William O. Hennessey, Intellectual Property Program of the Franklin Pierce Law Center - Past Developments, Current Situation, and Future Tasks, with particular emphasis on its Educational Methodology to Develop Human Resources Meeting Social Needs, ICS Seminar at Franklin Pierce Law Center 16 (Feb. 22 2004), *available at* http://www.ipmall.info/hosted_resources/pubspapers/hennessey_TOKYOICS.pdf ; University of Utah S.J. Quinney College of Law, Course Information: Intellectual Property Licensing, http://www.law.utah.edu/courseschedule/window_courseInformation.asp?courseID=122 (last visited Dec. 1, 2008).

compete by recombining simpler inventions into more complex and powerful combination inventions. PatentSim is used to test hypotheses regarding the benefits conferred on society, in general, and inventors and licensees, in particular, under patent and non-patent systems.

A. Interface Elements

1. Main Interface Screen

There are five main components to the main interface screen of PatentSim, two in the left column, two in the center column, and one in the right column (Figure 1). In the top left of the screen, the Score section and the money totals (and, optionally, a timer) for each user are displayed. The timer and money totals dynamically update, so that each player knows how long the game has been underway, and how much money the player and all other players currently have.

Figure 1. Main Interface Screen of PatentSim
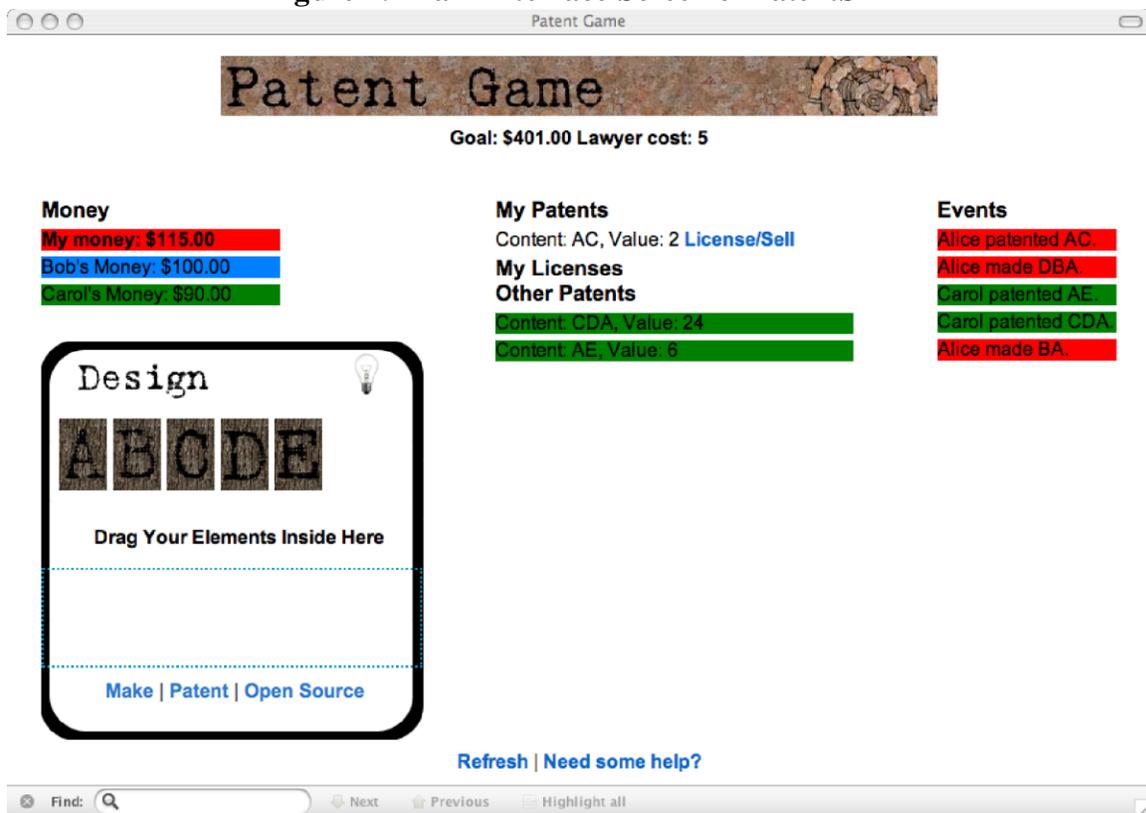
In the bottom left of the main screen is the Innovation section, where players can design and manufacture various virtual products. A product, in the PatentSim system, is a combination of one to five Widgets, represented here by the icons featuring the letters

"A," "B," "C," "D," and "E."[63] Each player may drag some or all of the Widgets into a "Creation Box" at the bottom of this section, arranging them in a specific order. Once the player has arranged the combination of Widgets into a pattern, the player may choose one of up to three buttons: "Make," "Patent," or "Open Source." The Make button appears in any of the three types of play ("Commons," "Patent," and "Patent/Open Source"). That button takes the player to the Make Product screen, through which a player can be given a specified amount of money, to simulate the production and sale of an item on the market. The amount of money that the player will receive varies based on the specific combination of Widgets in the box. However, if a player makes a product for which another player owns a corresponding patent, or exclusive license thereto, without acquiring the necessary license, that player runs the risk of becoming the subject of a patent enforcement action by any other player whose patent rights have been infringed. The Patent button appears in "Patent" and "Patent/Open Source" play, and takes the player to the Acquire Patent Screen, where the system gives the player the option to spend a specified amount of money or time to patent that combination and pattern of Widgets. If the player agrees, the relevant amount of money is deducted from the player's account (and, optionally, the interface displays a counter and prevents user interaction until the specified amount of time has elapsed). The Open Source button appears only in "Patent/Open Source" play, and takes the player to the Set Open Source screen, where the player is asked to decide whether or not to designate that combination and pattern of Widgets as open source, thus rendering it and all Widgets that contain it as henceforth unpatentable and freely usable by other players.

The center column contains two interface components, both relating to patents currently owned by players in the game. The top component shows a list of all the patents held by the player. Next to each patent is a "License/Sell" button that links to a separate web page where the player can specify license and sale parameters (e.g., availability, price) for the corresponding patent. The bottom component shows a list of all patents currently owned by other players. Each of these patents is accompanied by buttons that allow a player to license or purchase any of those patents if the patent owner has chosen to allow licensing or sale.
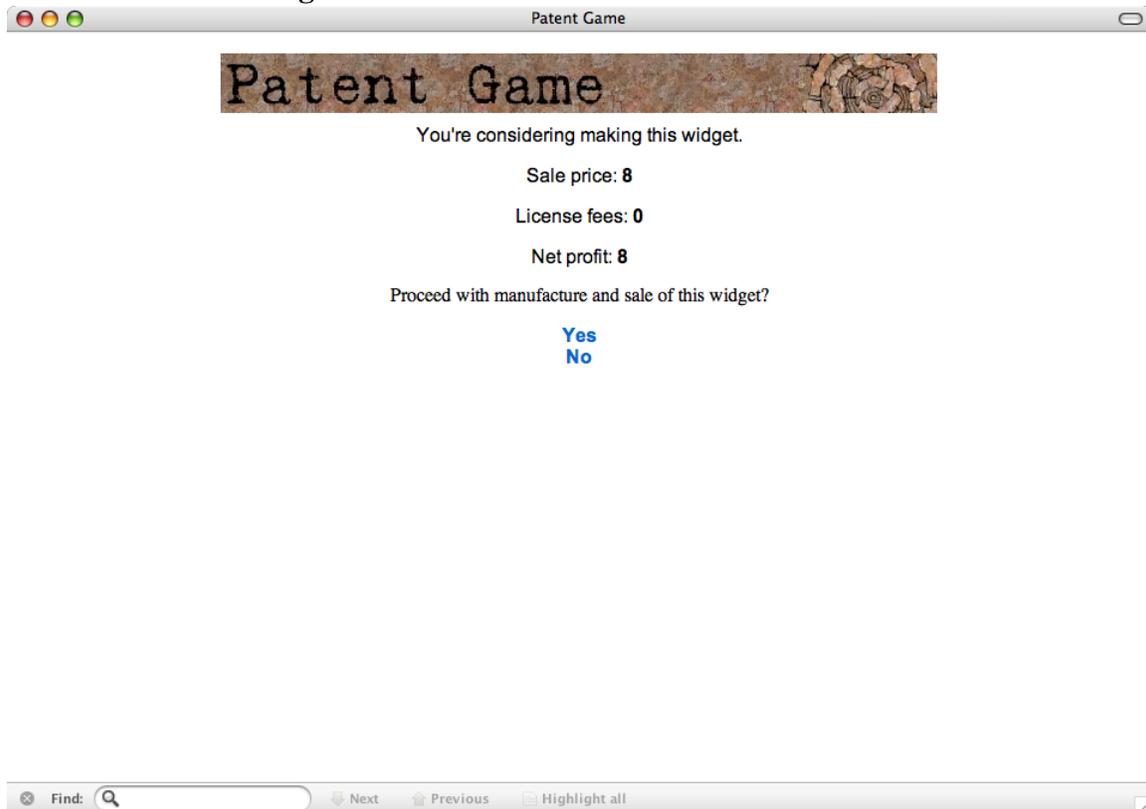
The right column provides a running list of all actions taken by all players. Each action includes the name of the player who took the action, the Widget combination and pattern used, and information about whether that combination and pattern was made, patented, or open sourced by that player. In addition, if the action of another player has potentially infringed a patent held by the player viewing the screen, an "Enforce?" web link appears. This link takes the player to a screen that provides the player with the option to enforce the patent by allocating a specified amount of legal effort into enforcement.

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[63] Widgets can be any set of symbols. For example, they could be "1," "2," "3," "4," and "5," a set of clock gears, a set of shapes, or a set of colors. In addition, Widgets can be composed of 2-dimensional strings of characters or symbols or 3-dimensional patterns of characters or symbols.

2. Make Product Screen

This screen informs a player about how much money will be made if the player opts to manufacture and sell one unit of the product (i.e., a single combination and pattern of Widgets) (Figure 2). The amount of money the player will earn depends on the specified value of the product, as well as on any license fees that the player is legally obligated to pay to the owner of a licensed patent. Each product has a fixed sale value, specified at the beginning of the game (see DATABASE section below for the algorithm that specifies the price), and which is unknown to the players until they decide to make or patent a unit of that product. The license fees that an individual player will need to pay depend on what patent rights (i.e., ownership or license) the player currently owns, and what licensing arrangements the player has already negotiated with other players for rights to their patents. Patent owners set license fees in PatentSim, sometimes in response to the success of previously set prices. The simulation contemplates the possibility that license fees could be greater than the sale price of the product. The player considering acquiring a license is given the option of proceeding with the licensing transaction, or canceling it. PatentSim allows an iterative negotiating process of offer and nonacceptance, eventually leading to an acceptable licensing fee, to occur.

Figure 2. Make Product Screen of PatentSim

Patent Game

Patent Game

You're considering making this widget.

Sale price: **8**

License fees: **0**

Net profit: **8**

Proceed with manufacture and sale of this widget?

Yes
No

3. Acquire Patent Screen

If a player clicks the Patent button on the main screen, and the product has not yet been made, patented, or open sourced (i.e., there is no prior art), the player is given the option of patenting that combination and pattern (Figure 3). The player is informed of the sale price of that product, as well as of the legal fee (and, optionally, the time delay (i.e., prosecution time)) for acquiring a patent on that particular combination and pattern. The player may then choose to proceed with the patenting process, or to cancel and return to the main interface screen. If, however, the product that a player is seeking to patent has already been patented, or is currently the subject of a patent application by another player, the first player is notified that patenting is not possible.

**Figure 3. Acquire Patent Screen of PatentSim**
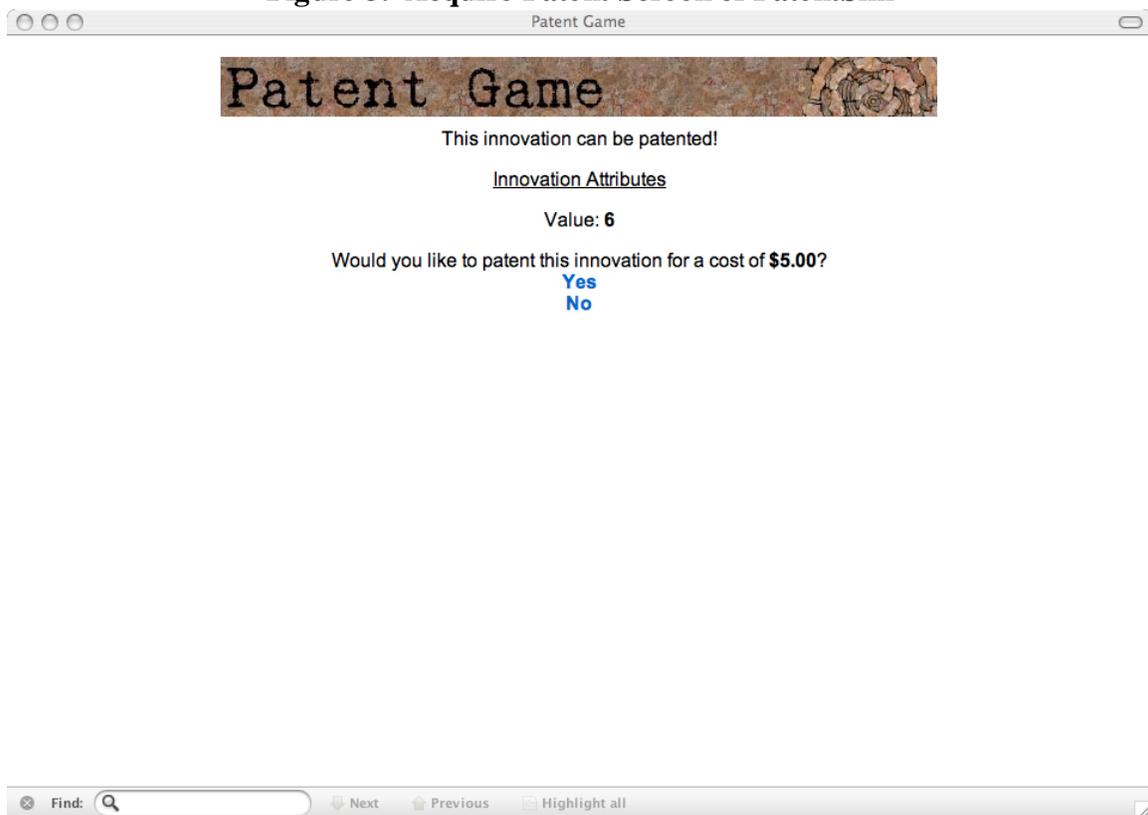
4. Set Open Source Screen

If a player clicks the Open Source button on the main screen, and there is no prior art for that product, the player is given the option of open sourcing it (Figure 4). The player is informed of the sale price of that product. The player may then choose to proceed with the open sourcing process, or cancel and return to the main interface screen. If, however, the product that a player is seeking to open source has already been protected, or is currently the subject of a patent application or open sourcing process by

another player, the first player is notified that open sourcing is not possible, and then allowed to return to the main game screen.

Figure 4. Set Open Source Screen of PatentSim
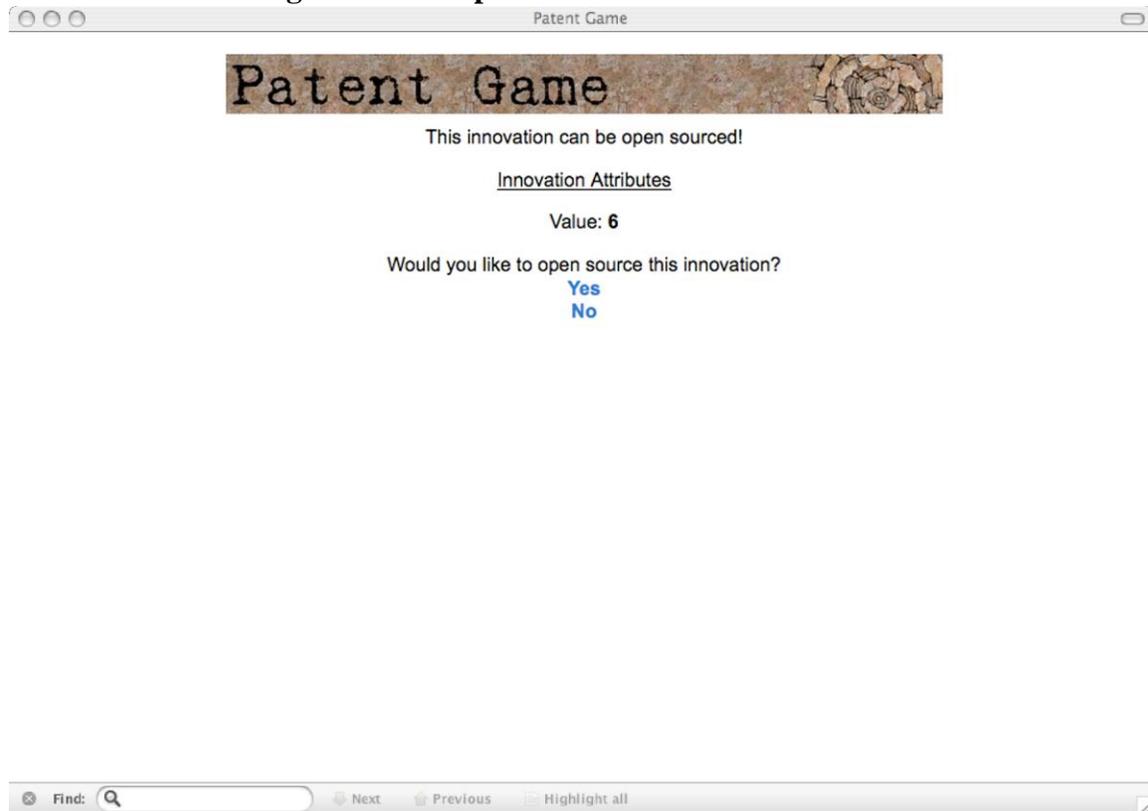
5. Patent Attributes Screen

Once a player owns a patent, the player can click on the button next to the patent and be taken to a screen where rights in the patent may be transferred, either in full or in part, to other players desiring such rights (Figure 5). Specifically, the patent may be made available for sale, or not, and made available for licensing, or not. If a player decides to make the patent available for sale or licensing, the player can specify prices for either of those transactions.

Figure 5. Patent Attributes Screen of PatentSim
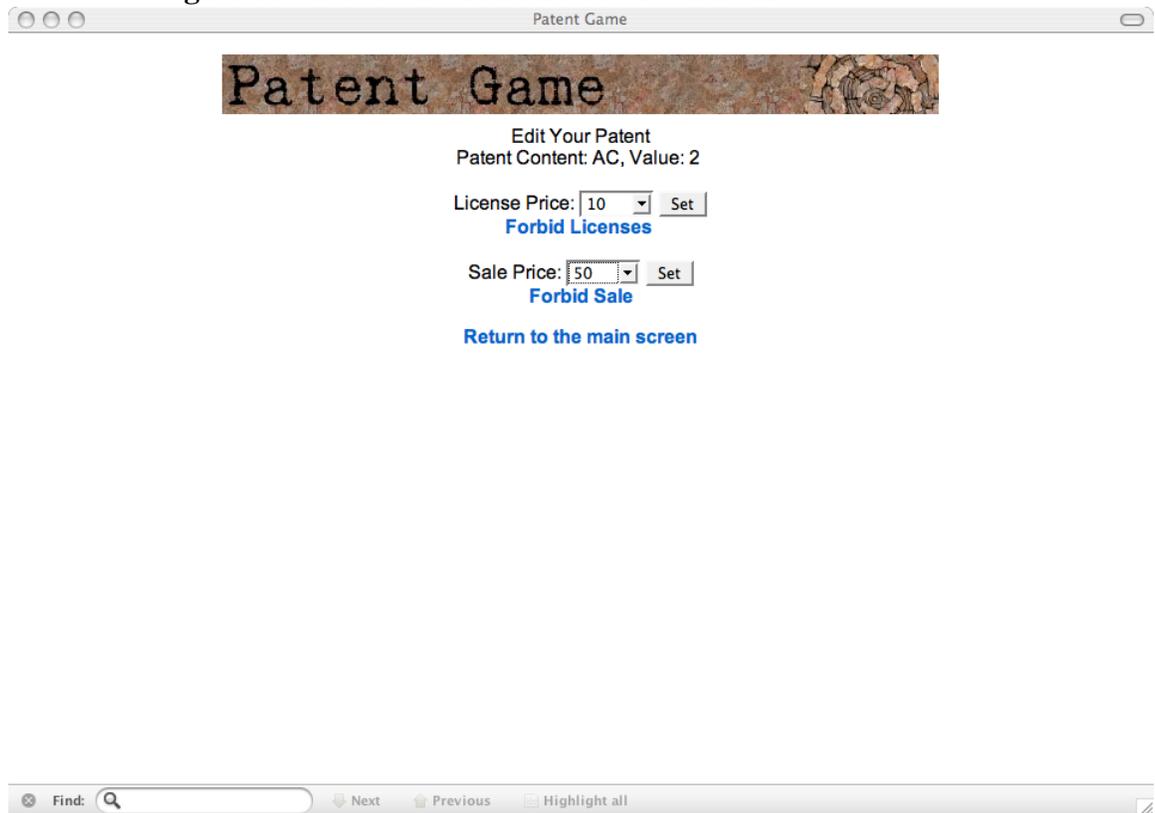
6. License/Buy/SELL Patent Screens

If a player wishes to license or buy a patent owned by another player, and the other player has made that patent available for licensing or sale, the player wishing to purchase rights in the patent may click on the License or Buy buttons situated next to the patent.   The purchasing player is then taken to a screen where the price for that transaction is specified. The player may either proceed with the transaction, or cancel and return to the main interface screen. The patent owner has the ability to change the prices set for licensing or buying the player's patent, so there is an opportunity for a form of iterative bargaining to reach a mutually agreeable price. Alternatively, PatentSim can allow bids, counterbids, and even dynamic auctions to facilitate the purchase or licensing of a patent.

7. Enforce/Defend Screens

If a sequence of Widgets for which the player holds a patent is included in a product manufactured by another player lacking a license, the patent owner will be presented with an Enforce link in the right-hand side list on the main screen (Figure 6). The Enforce link appears alongside the report that another player has manufactured and sold a product that may infringe the sequence of Widgets protected by one of the patent

owner's patents. This link takes the patent owner to a page where the amount of legal effort to allocate to an enforcement action (represented by a pull-down menu wherein one can choose to hire a number of attorneys) can be specified. Potentially, PatentSim could be run whether attorneys are considered a count noun (e.g., hire five attorneys at $5 each) or a mass noun (e.g., hire $25 of attorney), with the default set to the count noun approach.

Figure 6. Enforce Patent Screen of PatentSim

Once the enforcement effort is specified by the patent owner (plaintiff player), the alleged infringer (defendant player) is presented with a similar screen that provides notice of the legal action filed against the defendant player as a result of the allegedly infringing manufacturing and selling action, and asks the defendant player to allocate effort to the legal defense of the infringement action using an equivalent pull-down menu of attorneys to that the plaintiff player previously used (Figure 7).

Figure 7. Infringement Defendant Screen of PatentSim
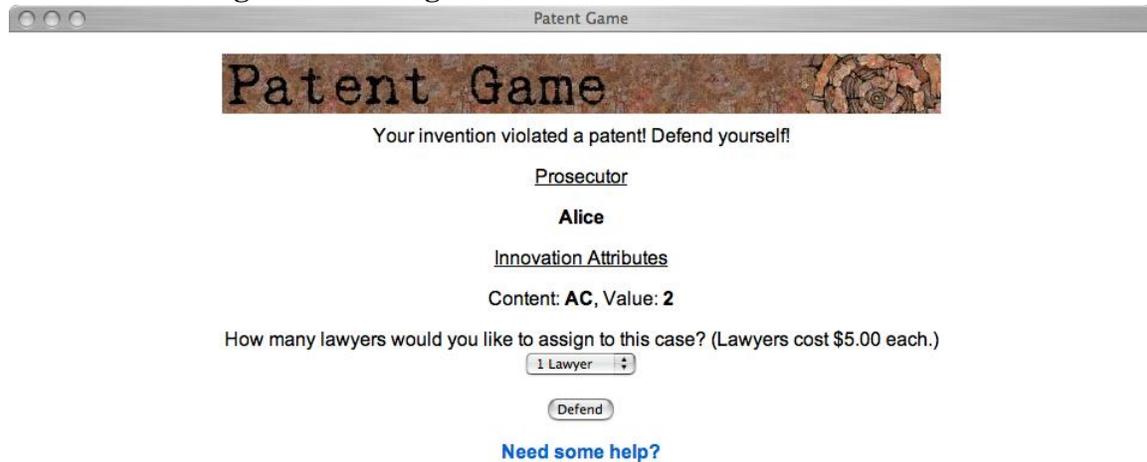
8. End Game Screen

Once the game has concluded (see the END OF GAME section below), a final set of statistics (including, optionally, a ranked order of players' resulting money) is displayed.

B. Database Elements

1. Database Overview

The PatentSim system uses a MySQL database[64] to store the underlying data representations for the different games. The basic structure of a database consists of one or more tables, each of which stores groups of similarly-structured information. Each table has one or more columns, each of which stores a particular piece of information in a specified format. A row in a table is made up of a matched set of values for each column. Each piece of data at a specific row and column is called a field. For example, a table of "Attorneys" might have columns for name, practice area, and salary, and rows for each of several different attorneys. The salary for a particular attorney would be stored in the field specified by the salary column and the row for that attorney.

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[64] MySQL, http://www.mysql.com/ (last visited Oct. 9, 2008).

2. Database Tables

This section describes the tables that provide the data storage and manipulation for the PatentSim system.

a. Game

Each game has an accompanying entry in the database's "Game" table. This entry includes the type of game (e.g., patent system versus non-patent system), the goal-state (e.g., end at a fixed time, end when a player obtains a specified amount of money), the number of Widgets in the game, the cost for acquiring a patent, the cost for hiring a attorney, and any other parameters that might be tested among different games. Each of the tables below contains a Game ID column that specifies which game that particular row is connected to. This Game ID provides the connection between the various elements in the same game.

i. Player

Each entry in the Player table has a unique login name and an amount of money.

ii. Innovation

The innovation table contains a column for the sequence of Widgets in that innovation, one for the value of that sequence, and a column to store an indication of whether a patent application is pending on that particular Widget.

The value of the sequence is determined prior to the beginning of the game by the following algorithm:

(1) First, all of the single widgets (e.g., A, B, C . . .) are randomly assigned a value from 0 to 4.
(2) Then, all of the two digit sequences (e.g., AB, AC, AD, BA, etc.) are assigned a value, calculated as the value of the first digit times a random number from 0 to 4. Note that the value of a two-Widget sequence is not the product of the first Widget's value times the second Widget's value.
(3) Thereafter, all of the three digit sequences are given a value that is the value of the two-Widget sequence that it starts with times a random value from 0 to 4. Values for the four and five Widget sequences are then calculated in an analogous manner. This algorithm causes the value of a single Widget to be from 0 to 4 with a mean of 2, a two-Widget sequence to be from 0 to 16 with a mean of 4, a three-Widget sequence to be from 0 to 64 with a mean of 8, a four-Widget sequence to be from 0 to 256 with a mean of

16, and a five-Widget sequence to be from 0 to 1024 with a mean of 32.

This algorithm is used because it creates a set of values in which certain innovations are very valuable, but difficult to invent. In addition, it makes it possible to locate valuable innovations if one is willing to go through the rigorous process of testing the single Widgets to see which are most valuable, then testing all of the two-Widget sequences that start with those Widgets to find any that are of high value, and proceeding up through the orders of complexity. Having a discoverable pattern to the assignment of value (rather than, for example, randomly assigning values in the same range to all Widget sequences) helps to provide another potentially successful strategy that players may employ. This algorithm is also an attempt to represent the systematic, experimental nature of the process of invention.

Other algorithms can also be used, depending upon which features of patenting and the patent system one wishes to emphasize. PatentSim has the advantage of being capable of incorporating features or assumptions of the patent system derived either from theoretical models or from empirical observations.

iii. Patent

The patent table includes a player ID to identify and store who owns each patent, an innovation ID to specify which innovation each patent relates to, a time of discovery, flags for whether each patent is licensable and/or available for sale, and sale and license prices set by each patent owner. By default, patents are not available for licensing or sale until the patent owner takes affirmative action to enable the licensing or sale functions.

iv. License

The license table stores all of the licenses that are purchased throughout each game. It includes columns for the player ID, the innovation ID, and the cost paid for a license.

v. Enforcement

The enforcement table stores the identity of any player who has engaged in enforcement of patent rights against an alleged infringing player, the allegedly infringing player who has defended against the allegation, the number of attorneys for the plaintiff, the number of attorneys for the defendant, a flag for whether or not the prevailing party has yet been decided, and the amount of money damages owed to the plaintiff should the plaintiff prevail.

vi. Event

Finally, there is an event table that keeps track of every action players take. Specifically, it stores the player's ID, a timestamp, and a string that records what specific action the player took at the timestamped point in time. This archiving of all events

allows for the recreation of every element of every game, thereby opening the door for a wealth of *a posteriori* analyses. Through data-mining, it may be possible to conduct detailed meta-analyses of the individual data sets recorded for each specific simulation run.

C. Example of a PatentSim Game

This section provides a walk-through of the user experience in the PatentSim system, in order to provide an overview of, and insight into, the system's operation.

Five players, Alice, Bob, Carol, David, and Eloise, are recruited to play PatentSim. At an appointed time, an administrator sets up the conditions of the game, specifying that it will be a Patent type game, last for 25 minutes, and have various other characteristics, and each of the five players logs into a web browser, accessing the system via its URL. The players enter a game number into a web form, so that they are all connected to the same game instance. Each player chooses a login name, so that he or she is identifiable throughout the game. Once the players are all waiting in the game's digital "lobby," they are informed that they will be playing a simulated business game, and that the goal is to make as much money as possible before the game is over. They are told that the game will conclude at a time randomly chosen between 25 and 35 minutes after they begin.[65] Thereafter, they are instructed to begin playing by clicking the "Begin Game" button.

Upon entering the game, all players see the main interface screen. Alice catches on quickly, and starts dragging Widgets into the "creation box." When she does this, she sees the Make and Patent buttons, clicks on Make, and notices that her money begins to increase. The other players see her action appear in the right column, and start to experiment with the interface. Before long, all of the players are making and patenting sequences of Widgets.

Once the players each own a few patents, they begin to sense the complexity of the game, and start developing various strategies for increasing their money. Alice decides to make and sell simple Widgets as quickly as possible, opting for the first strategy for making money that she has noticed. Bob notices that Widgets made from different sequences are worth differing amounts of money, and so he explores different Widgets in search of high value Widgets. Carol decides to acquire patent protection for several Widgets she believes possess important sequences, hoping to make money by enforcing those patents against infringers. David and Eloise take hybrid approaches, blending making and selling, patenting, licensing, and enforcement.

Players begin to develop relationships with other players. Carol sees that Alice rarely pays her license fees and chooses to target her for enforcement actions. Bob watches all the other players' actions to see if anyone makes a certain product repeatedly, hoping that his scrutiny will thereby reveal additional high money-value combinations. Other players form implicit cross-licensing relationships, choosing not to enforce

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[65] If appropriate, having the game end at exactly minute 25 might prevent players from engaging in various "end game" strategies.

violations against each other. All players seem more inclined to enforce their patent rights against infringers with relatively high amounts of money.

The end of the game comes suddenly, right at the 25-minute mark. The various players have different amounts of money and different portfolios of patents.[66] These data, as well as data recording all other actions that took place in this session of PatentSim, are recorded in the database.

D. Technology

The PatentSim system was created using an open source platform for developing database-backed web applications called Ruby on Rails.[67] This platform enables the creation of multi-user interactive systems using standard web browsers as the interface. Because it uses the same technologies that are used for e-commerce and social networking sites, many of the challenges of networking, synchronization, interface design, and other elements are handled using standard protocols. Players may take actions asynchronously from each other, and the MySQL database back-end ensures avoidance of conflicts (e.g., two players attempting to patent the same sequence of Widgets).[68]

E. Interactive Simulation

Involving human players in a simulation of the patent system adds tremendous complexity to the behavior of the system and the interpretation of that system. Alternatively, a simulation system run without human participation (i.e., a mathematical simulation) could run many iterations much faster than is possible with human involvement. PatentSim could be run without direct human participation, using computational agents to play against each other. However, one important reason for involving people in a patent simulation is that understanding the behavior of people interacting with a simulated patent system under different circumstances can enable findings based on real human behavior, rather than idealized, hyperrational computational systems. It is hoped that embracing the complexity, variability, rationality, and irrationality that humans exhibit may provide novel, and perhaps unpredictable, insights into how patent systems function embedded within broader human social systems.

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[66] At the end of the game, players could be rewarded, either financially or otherwise, based on their performance in the game.

[67] Ruby on Rails, http://www.rubyonrails.org/ (last visited Oct. 9, 2008).

[68] Of course, such complications may occur in the real world, and PatentSim™ is capable of enabling a variety of complications of interest to occur, if so desired.

1. Mapping of Real World into Simulation

In order to create a viable interactive simulation that could shed light on the role of patent systems in the real world, it is necessary to consider how aspects of the real world could be mapped onto structures in the simulation. This section describes various facets of that mapping.

2. Individuals and Businesses

A player of PatentSim serves as the simulated equivalent of an individual or business in the real world. Individuals and businesses may pursue identifiable dominant strategies regarding innovation, patenting, manufacturing, selling, licensing, and enforcement. Money is a metric by which many individuals, and most businesses, measure success. Both individuals and businesses may own, buy, sell, and license patents protecting inventions. Players serve to represent the various entities that engage in businesses involving innovation.

3. The Inventive Process

The process of innovation in the real world involves the interaction of numerous human motives and actions with numerous aspects of the surrounding physical and social environments. The process of invention itself can be influenced by a number of factors. One potential influence involves education and experience, as reflected in the adage "chance favors the prepared mind."[69] Invention can also involve, at least in part, flashes of Archimedean "Eureka!" insight, such as Newton's serendipitous (and possibly apocryphal) collision with an apple. Expenditure of time, money, and effort are the many other potential factors influencing invention. As Thomas Edison famously said, "What [invention] boils down to is one percent inspiration and ninety-nine percent perspiration."[70] By allowing the participation of human players, PatentSim attempts to probe the effects these human characteristics can have on inventive outcomes.

The manner in which people manufacture and invent products of value in the simulation seeks to involve each of these elements, allowing people to gain experience by exploring the values assigned to various sequences, allowing them to experience "Eureka!" moments of discovering the sequences of valuable Widgets, and enabling them to allocate their time, money, and efforts in ways they find most valuable. Even serendipity is possible in PatentSim, because a player is more likely to understand the structure of the embedded valuation system for Widgets if the player happens across some of the higher-valued sequences (e.g., those based on powers of 2, such as 256, 512,

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[69] Wikiquote, *Louis Pasteur*, http://en.wikiquote.org/w/index.php?title=Louis_Pasteur&oldid=830712 (Oct. 9, 2008, 15:26 EST).

[70] James D. Newton, Uncommon Friends 24 (1987).

and 1024). By allowing people to discover islands of value in a sparsely populated opportunity space, the PatentSim system provides a simplified version of the real world process of invention.

4. Ways of Doing Business

The digital interface maps onto an individual's or business's way of doing business. It provides a means for manufacturing, communicating with others, and engaging in legal maneuvers, such as licensing, selling, and enforcing. It also provides multiple pathways for success, thereby paralleling the similar availability of multiple pathways to success in the real business world, where different entities may pursue their goals by following a diversity of strategies.

The user interface is also the gatekeeper by which PatentSim can control the degree of perfect information that is given to players. For example, it might be relevant to have players know approximately, but not exactly, how much money each other player has. Just as there may not be full transparency in the real world of business, it may be useful to obscure various information channels intentionally in the PatentSim system.

5. Patents

The PatentSim patent system provides a simplified mapping of a real-world patent system. Its features enable business entities to patent their inventions, to accept money for licenses or sales of patents, and to attempt to enforce their patent rights by suing other players for infringement. Certainly, PatentSim cannot capture the full complexity of a real-world patent system. Notably, PatentSim has yet to attempt to incorporate principles of international patent law or many of the regulatory, legal, or negotiating complexities involved in the patent prosecution, licensing, selling, buying, and litigation processes. For example, litigation is currently represented by a relatively quick and decisive process involving little more than choosing whether or not to enforce one's patent rights, and then allocating a proxy for legal effort (i.e., hiring a specified number of attorneys) and awaiting the roll of the algorithmic dice. Nevertheless, PatentSim does attempt to capture the fundamental and meaningful elements common to most patent systems.

6. Encouraging Innovation

The goal of patent systems in the real world is to encourage innovation. In simulation, we can measure various attributes of players' behaviors, including the number of times a Widget is manufactured, the number of patents acquired, the range of sequences manufactured or patented, and all instances of licensing, selling, and enforcement. While these data are based only on discrete and objectively trackable events, they may provide insight into the motivations and strategies of producers and consumers of innovation, as well as evidence of their responses to variations in incentives patent systems provide.

Since various parameters of PatentSim can be deliberately varied, the simulation system can also be used to isolate and change specified parameters in order to map their influences on simulation outcomes. For example, while holding all other variables constant, one could run separate trials in PatentSim in each of which the patent term is set to a different length, and then compare the effect of different patent terms on simulation outcomes. By conducting such an experiment, one might uncover tipping points at which one set of patent strategies begin consistently to outperform other sets of strategies. Such results could then be used to construct hypotheses about the real world patent system and be compared to real world empirical data. Because PatentSim allows finer control than is possible in the real world, patterns revealed in the patent simulation have the potential to reveal real world patterns obscured by the complexity and roughness of real world data.

7. Impediments to Innovation

Numerous forces serve to stifle innovation in the real world. Notable among these are lacunae of money, time, effort, and enthusiasm. Inventors have been known to balk at patenting their work out of sheer dread of interacting with patent attorneys, let alone paying their fees. The PatentSim system cannot capture all of these impediments, but it does include financial costs and time delays as impediments to certain activities. By doing so, it helps to add a sense of realism to the process of patenting and innovation.

8. Measuring Social Utility

Usually, the professed ultimate goal of encouraging innovation is to enhance social utility or well-being. PatentSim uses money as a proxy by which to measure these variables. While not a perfect proxy, money is widely used as the default utility proxy. Even given an acceptable proxy for utility, measuring the distributive consequences of innovation presents a difficult challenge. Under various versions of Pareto efficiency, a positive societal result occurs when (1) society as a whole is better off even though some of its constituent members are worse off, (2) society as a whole is better off and none of its constituent members are worse off, or (3) society and all of its constituent members are better off.[71] PatentSim allows the comprehensive measurement of utility (as represented by money, points, or other currencies) across society as a whole (the aggregate of all players' utilities) and for each and every constituent member (each individual player). This approach may shed light on the effects that different rates of innovation may have on social and individual utility.

Furthermore, exit surveys can ask players to rate such alternative measurements of utility as how they enjoyed playing the simulation, how they valued their interactions with other players, or how satisfied they were with the outcome of the simulation.

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[71] Thomas J. Miceli, The Economic Approach to Law 4–6 (2004).

9. Constraints of Simulation

There are a number of inevitable constraints that accompany the creation of an interactive simulation. One significant constraint is that the simulation must usually begin and end at defined points in time. In the real world, there is often no clear beginning or end to the business process. As Rosencrantz states in *Rosencrantz and Guildenstern are Dead*, "The only beginning is birth and the only end is death-if you can't count on that, what can you count on?"[72] Individuals and companies tend to enter and leave the business world dynamically, their entries and exits are staggered, and the resources they have available to them vary over time, are different in kind, and may confer competitive advantages unequally. Thus, among the challenges and questions that a simulation game must confront are the following:

> Should all the players start and end at the same time?
> Should some players be given directions, while others are left to find their own way?
> Should players know ahead of time when, or under what conditions, the game will end, or should they be kept ignorant of such details to avoid the use of "end game" strategies?

If designed carefully, simulations can provide insight into the workings of the real world, but they must attend to these types of issues to enable their results to transfer effectively into real-world insights.

10. Long-Term Deployment

An area of potential future work involves the deployment of the PatentSim system as a long-term online game that players can dynamically enter and leave. Technologically, it would require little additional effort to enable players to add themselves to, and remove themselves from, the simulation, and login at various different times. The system is designed to scale readily to large numbers of players. The popularity of massively multiplayer online games (MMOGs), such as World of Warcraft (>11 million players),[73] suggests that many people are willing to engage with multi-player online systems over long periods of time. While user bases of such magnitude are difficult to attract, even a few hundred people playing over an extended period of time (e.g., a few weeks or months) could provide a wealth of data for understanding the relative merits of various patent processes over longer periods of time.

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[72] Tom Stoppard, Rosencrantz & Guildenstern are Dead 39 (1st ed. 1967).

[73] Press Release, Blizzard Entm't, World of Warcraft Surpasses 11 Million Subscribers Worldwide (Oct. 28, 2008), *available at* http://www.blizzard.com/us/press/081028.html.

V. METHODS, DATA, AND ANALYSIS

A. Experimental Methods

The data presented here were generated using individual human players ("Subjects"). Groups of Subjects competitively played PatentSim[74] against one another in games whose parameters were strictly controlled ("Trials"). A series of Trials were conducted under three distinct Treatments: (1) a Treatment approximating a pure patent system ("Pure Patent"), (2) a Treatment approximating a system allowing both patents and open source ("Patent/Open"), and (3) a Treatment approximating a pure commons system ("Pure Commons").

First, approval was obtained for human subjects research from the University of Kansas Institutional Research Board ("IRB"). In June 2008, volunteer Subjects were chosen from among the 2008 "summer starters" class at the University of Kansas School of Law. These Subjects were in their first semester of law school, and none of them had previously studied intellectual property or patent law. All Subjects were paid $10 per hour for the time they were involved in this study.[75]

All Subjects attended an introductory meeting at which the "Introductory Statement Regarding The Patent Game™"[76] was read to them and then each student signed his or her name to indicate that he or she heard and understood the introductory statement.

All Subjects were then introduced to The Patent Game interface. Subjects learned how to use all of the functions of The Patent Game. Finally, Subjects played a series of practice games to ensure that they understood how to use the functions of The Patent Game. Subjects were provided with answers to questions about how to use the functions of The Patent Game. In response to inquiries about the purpose of Subjects' participation in The Patent Game, Subjects were provided with an answer derived from the "Introductory Statement Regarding The Patent Game™": "We are conducting this study to better understand the patent system. The information obtained from this study will help us gain a better understanding of the patent system."

Eight Trials were run for each of the Pure Patent, Patent/Open, and Pure Commons Treatments; in The Patent Game, these were represented in the Game Type function as Patent, Patent/Open Source, or Commons, respectively. During every Trial the following settings were used in The Patent Game:

Use Lesser Included Strings = Yes

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[74] During the empirical trials, PatentSim was consistently referred to as "The Patent Game." The graphical user interface of PatentSim also includes the title "The Patent Game." PatentSim and The Patent Game are synonymous.

[75] The authors plan to extend this initial study by later studying the behavior of other groups of players, such as law students who have already formally studied patent law, engineers, business managers, scientists, entrepreneurs, politicians, regulators, and venture capitalists, each of which groups will vary in sophistication and motivations.

[76] The text of the introductory statement is in appendix A.

Time Limit = 30 minutes
Winning Goal = Unlimited
Patent Cost = $20.00
Patent Expiration Time = Unlimited
Lawyer Cost = $20.00
Number of Elements = 5 Elements

The Use Lesser Included Strings function ensures that patented and open sourced inventions are both accounted for, even if the inventions are only a subset of the Subject's new or sought after claim. This same function also keeps track of subsets of characters that are included in strings of characters that are made, patented, or open sourced. The Number of Elements refers to the maximum number of characters a Subject can use to make any particular invention.

Each Trial involved five Subjects and lasted exactly 30 minutes. For each Treatment different groups of Subjects played in each Trial. During each Trial, Subjects were requested not to speak with one another or to make any other avoidable noises or physical gestures. If a Subject did speak or make any avoidable noise or gesture, that Subject was immediately reminded and requested to desist. Each Subject used a laptop computer wirelessly connected to the Internet to play The Patent Game on the www.patentgame.net website. All Subjects were informed ahead of time that the winner of each Trial (that is, the Subject who ended that Trial with the most money) would receive a prize.

B. Data

Pure Patent Treatment. The mean number of unique inventions created was 84.2, with a variance of 23.0. The mean number of total inventions created or made was 316.0, with a variance of 53.4. The mean amount of money with which each Subject ended each Trial was $7,703, with a variance of $4,650.
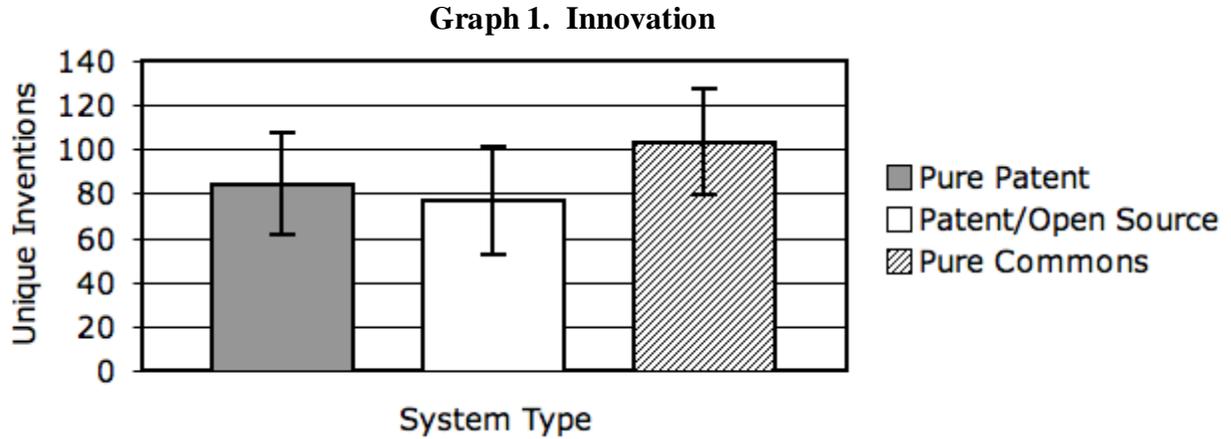
Patent/Open Source Treatment. The mean number of unique inventions created was 76.8, with a variance of 24.5. The mean number of total inventions created or made was 323.0, with a variance of 124.0. The mean amount of money with which each Subject ended each Trial was $10,210, with a variance of $7,994.

Pure Commons Treatment. The mean number of unique inventions created was 103.0, with a variance of 24.3. The mean number of total inventions created or made was 659.0, with a variance of 34.5. The mean amount of money with which each Subject ended each Trial was $41,230, with a variance of $18,220.

C. Analysis

Innovation. The mean number of unique inventions can represent the rate of innovation. Graph 1 illustrates the relative amounts of innovation generated in the Pure Patent, Patent/Open Source, and Pure Commons Treatments. A Student's t-test reveals that there is no significant difference in innovation (p=0.538) between the Pure Patent

and Patent/Open Source Treatments, a nearly significant difference in innovation (p=0.128) between the Pure Patent and Pure Commons Treatments, and a significant difference in innovation (p=0.046) between the Patent/Open Source and Pure Commons Treatments.

Graph 1. Innovation

Productivity. The mean number of total inventions created or made can represent the rate of productivity. Graph 2 illustrates the relative amounts of productivity generated in the Pure Patent, Patent/Open Source, and Pure Commons Treatments. A Student's t-test reveals that there is no significant difference in innovation (p=0.886) between the Pure Patent and Patent/Open Source Treatments, a highly significant difference in productivity (p=0.0000000004) between the Pure Patent and Pure Commons Treatments, and a highly significant difference in productivity (p=0.000003) between the Patent/Open Source and Pure Commons Treatments.

Graph 2. Productivity
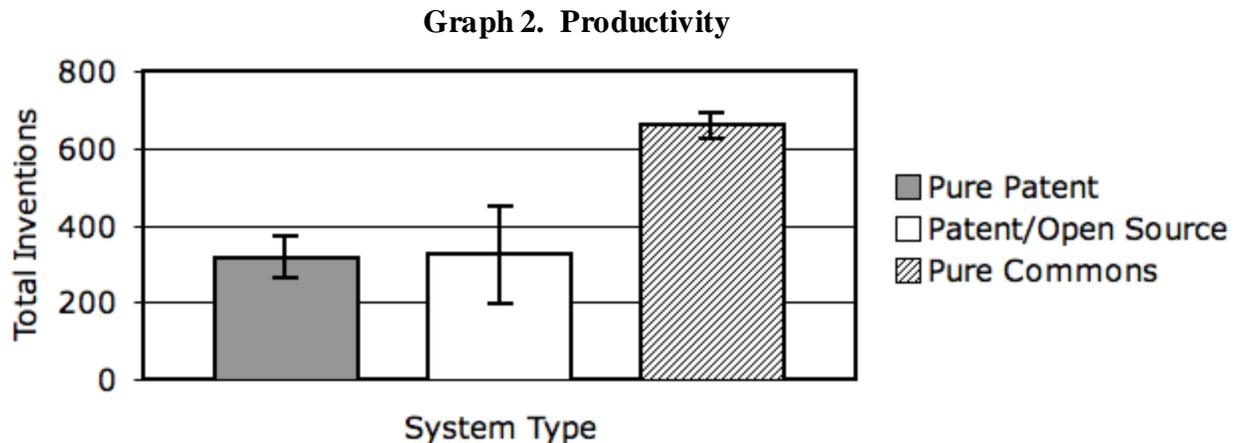
Social Utility. The mean amount of money with which each Subject ended each Trial can represent wealth or social utility. Graph 3 illustrates the relative amounts of social utility generated in the Pure Patent, Patent/Open Source, and Pure Commons Treatments. A Student's t-test reveals that there is no significant difference in social utility (p=0.454) between the Pure Patent and Patent/Open Source Treatments, a highly

significant difference in social utility (p=0.0002) between the Pure Patent and Pure Commons Treatments, and a significant difference in social utility (p=0.0006) between the Patent/Open Source and Pure Commons Treatments.

Graph 3. Social Utility
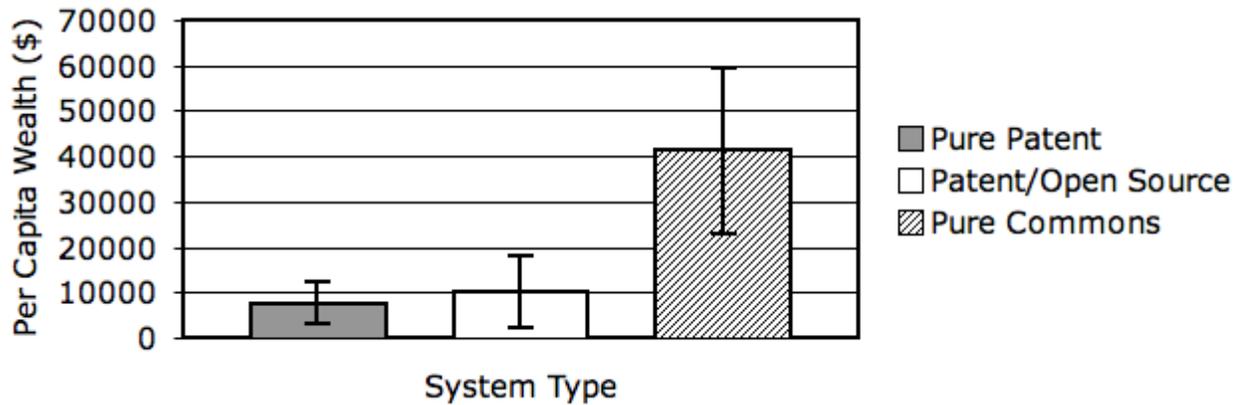
The empirical data generated using The Patent Game suggest that a system combining patent and open source protection for inventions (that is, similar to modern patent systems) generates significantly lower rates of innovation (p<0.05), productivity (p<0.001), and social utility (p<0.002) than does a commons system. These data also indicate that there is no statistical difference in innovation, productivity, or social utility between a pure patent system and a system combining patent and open source protection.

VI. USER AND OPEN INNOVATION

Empirical data generated using The Patent Game suggest that commons systems can generate significantly greater amounts of innovation, productivity, and social utility than currently predominating patent systems that combine both patent and open source protection for inventions. These results represent a marked departure from the orthodox view that patent systems can be justified because they spur technological innovation. However, these same results are consistent with much of the research generated by the increasingly important field of user and open innovation.

As Lawrence Lessig, a prominent advocate of user and open innovation, has explained, "[g]etting more progress is the constitutional aim of patents."[77] However, Lessig also points out that "the question that must always be asked of any patent regime is whether we have good reason to believe that patents have that effect."[78] Lessig answers this question in the negative, stating that "[t]he strongest conclusion one can

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[77] Lessig, *supra* note 4, at 205.

[78] *Id.*

draw is that whatever benefit patents provide (except in industries such as pharmaceutics), it is small."[79]

Eric von Hippel, a founder of the field of user and open innovation, has observed that patent systems offer not just benefits to society, but significant costs as well:

> The fundamental reason that societies grant intellectual property rights to innovators is to increase private investment in innovation. At the same time, economists have long known that there will be social welfare losses associated with these grants: owners of intellectual property will generally restrict the use of their legally protected information in order to increase private profits. In other words, intellectual property rights are thought to be good for innovation and bad for competition.[80]

As with Lessig, von Hippel is skeptical of the orthodox justification of patent systems, observing that "[s]tudies find that innovators in many fields view patents as having only limited value,"[81] "most innovators do not judge patents to be very effective [in spurring innovation], and . . . the availability of patent grant protection does not appear to increase innovation investment in most fields."[82] Furthermore, von Hippel has warned that "the characteristics of present-day intellectual property regimes as actually experienced by innovators are far from the [beneficial] expectations of theorists and policy makers."[83] In summarizing the last 40 years of research on "the real-world value of patent protection,"[84] von Hippel concludes that "with a few exceptions, innovators do *not* think that patents are very useful either for excluding imitators or for capturing royalties in most industries."[85]

Economists Steven Shavell and Tanguy van Ypersele have argued that "there is no necessity to marry the incentive to innovate to conferral of monopoly power in innovations."[86] von Hippel has gone even further, suggesting that, though "[t]he

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[79] *Id*. at 206.

[80] Eric von Hippel, Democratizing Innovation 112–13 (2005), *available at* http://web.mit.edu/evhippel/www/democ1.htm [hereinafter von Hippel, Democratizing Innovation].

[81] *Id*. at 10.

[82] *Id.* at 112.

[83] *Id.*

[84] *Id.* at 84.

[85] *Id.*

[86] Steven Shavell & Tanguy van Ypersele, *Rewards versus Intellectual Property Rights* 27 (Nat'l Bureau of Econ. Research, Working Paper No. 6956, 1999), *available at* http://www.nber.org/papers/w6956.

consensus view has long been that the good [of intellectual property protection for innovations] outweighs the bad, [s]ome – not all – are beginning to think that intellectual property rights are bad for innovation too in many cases."[87]

A growing body of empirical research appears to support the view that patent systems do not necessarily "promote the Progress of . . . useful Arts."[88] As far back as 1988, von Hippel concluded that "empirical data seem to suggest that the patent grant has little value to innovators in most fields."[89] More recently, Bessen and Hunt have identified empirical evidence that, in the software industry at least, "on average, as firms' investments in patent protection go up, their investments in research and development actually go down."[90] In their review of the empirical evidence of free-riding, patents, and innovation, Bessen and Meurer conclude that, "it is not clear that the entry of imitators is necessarily detrimental to innovation as in the canonical reward theory model. If firms can obtain some rents even when competing against a limited number of other firms, then competition might actually increase innovation."[91] Bessen and Meurer interpret the available empirical evidence as "suggest[ing] that much innovation is not dependent on patenting,"[92] and that "innovators have grown frustrated with the failings of the American patent system."[93] They suggest that "patents are neither the only nor even the most important means of encouraging innovation. On average, patents make a rather small contribution in this regard."[94] Similarly, in her historical study of nineteenth century technological innovation, Moser found that countries that offered patent protection to inventions did not have higher rates of innovation than countries that offered no such protection.[95] Bessen and Meurer conclude that "[o]ur empirical analysis indicates that the patent system provides little innovation incentive to most public firms; these are the

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[87] Von Hippel, Democratizing Innovation, *supra* note 80, at 113.

[88] U.S. Const. art. I, §8, cl. 8.

[89] Eric von Hippel, Sources of Innovation 48–51 (1988), *available at* http://web.mit.edu/evhippel/www/sources.htm [hereinafter von Hippel, Sources of Innovation].

[90] von Hippel, Democratizing Innovation, *supra* note 80, at 114 (citing James E. Bessen & Robert M. Hunt, *An Empirical Look at Software Patents* 2 (Fed. Reserve Bank of Philadelphia, Working Paper No. 03-17, 2004), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=461701).

[91] James Bessen & Michael J. Meurer, Patent Failure 89 (2008).

[92] *Id.* at 90.

[93] *Id.* at 2.

[94] *Id.* at 118.

[95] Petra Moser, supra note 12, at 1220.

firms that perform the lion's share of R&D. So it seems unlikely that patents today are an effective policy instrument to encourage innovation overall."[96]

Heller and Eisenberg have long suggested that too much patenting may result in an inefficient "tragedy of the anticommons."[97] In some particular instances, Bessen and Meurer have found evidence that patents can actually harm innovation. Notably, they interpret the aggregate empirical evidence as "suggest[ing] that during the late 1990s, patents provided a net disincentive to innovation outside the chemical and pharmaceutical industries."[98] In general, Bessen and Meurer conclude that "our evidence implies that patents place a drag on innovation. Without this drag, the rate of innovation and technological progress might have been even greater, perhaps much greater."[99] This is consistent with research by Josh Lerner, who, based on a large study of patent reforms in sixty countries over a period of a century and a half, observed that strengthening of available patent protection tended to yield *less* patenting of new innovations by domestic inventors, a result that may correlate with lowered rates of technological innovation.[100]

Yochai Benkler offers an explanation for why patent protection might yield less, rather than more, innovation than commons systems: "Increasing patent protection . . . increases the costs that current innovators have to pay on existing knowledge more than it increases their ability to appropriate the value of their own contributions."[101] He elaborates that

> in the mainstream analysis, exclusive rights always cause static inefficiency – that is, they allow producers to charge positive prices for products (information) that have a zero marginal cost. Exclusive rights have a more ambiguous effect dynamically. They raise the expected returns from information production, and thereby are thought to induce investment in information production and innovation. However, they also increase the costs of information inputs. If existing innovations are more likely covered by patent, then current producers will more likely have to pay for innovations or uses that in the past would have been available freely from the public domain. Whether, overall, any given regulatory change that increases the scope of exclusive rights improves or

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[96] Bessen & Meurer, *supra* note 91, at 216.

[97] *See, e.g.*, Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 Sci. 698, 698–701 (1998).

[98] Bessen & Meurer, *supra* note 91, at 142.

[99] *Id.* at 146.

[100] Yochai Benkler, Wealth of Networks 39 (2006), *available at* http://www.benkler.org/Benkler_Wealth_Of_Networks.pdf (citing Josh Lerner, *Patent Protection and Innovation over 150 Years* 2 (Nat'l Bureau of Econ. Research, Working Paper No. 8977, 2002), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=315327).

[101] *Id.* at 39.

undermines new innovation therefore depends on whether, given the level of appropriability that preceded it, it increased input costs more than or less than it increased the prospect of being paid for one's outputs.[102]

In addition, Benkler suggests that patents may result in a drop in productivity.[103] As an alternative to proprietary protection for inventions, Benkler has proposed "commons-based strategies" to spur innovation in software, agriculture, and drug development.[104]

Research on user and open innovation does not necessarily prove that our data generated using PatentSim are accurate or meaningful.[105] However, we do consider the concordance between the results of our empirical simulation game and the rapidly growing body of research flowing out of user and open innovation to be highly suggestive.

VI. CONCLUSIONS

Bessen and Meurer have characterized the Patent Clause[106] as a "Constitutional mandate to 'promote the Progress of . . . the [sic] Useful Arts.'"[107] In keeping with this mandate, patent systems in the United States and most other countries are often justified by an assumption that the prospect of patent protection will spur innovation, leading to the accrual of greater societal benefits than would be possible under non-patent systems. However, little empirical evidence exists to support this assumption. One method of testing the hypothesis that a patent system promotes innovation is to simulate the behavior of inventors and competitors under experimental conditions approximating patent and non-patent systems.

Employing PatentSim, a multi-user interactive simulation of patent and non-patent (commons and open source) systems, this study compares rates of innovation, productivity, and societal utility. PatentSim uses an abstracted and cumulative model of the invention process, a database of potential innovations, an interactive interface that allows users to invent, patent, or open source these innovations, and a network over which users may interact with one another to license, assign, buy, infringe, and enforce patents.

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[102] *Id.* at 49.

[103] *Id.* at 49–50.

[104] *Id.* at 317–55.

[105] In fact, sources of error could include the failure of PatentSim™ to simulate real legal systems accurately, unsound selection of experimental parameters, or poor selection of research subjects.

[106] U.S. Const. art. I, §8, cl. 8.

[107] Bessen & Meurer, *supra* note 91, at 6–7.

Data generated thus far using PatentSim suggest that a system combining patent and open source protection for inventions (that is, similar to modern patent systems) generates significantly lower rates of innovation ($p<0.05$), productivity ($p<0.001$), and societal utility ($p<0.002$) than does a commons system. These results are inconsistent with the orthodox justification for patent systems. However, they do accord well with evidence from the increasingly important field of user and open innovation.

In the future, the authors plan to expand on the results presented in this article, using PatentSim to explore how patterns of technological innovation vary based on strength, duration, and cost of the patent grant, characteristics of individual users, numbers of players, strategies, fields of technology, and iterative trials. Even though the evidence in this study is derived from simulation games, rather than real-world empirical evidence, it is strongly suggestive that a patent system may not always maximize innovation, productivity, and social utility. Future studies will also investigate the conditions under which a patent system might best provide benefits to individuals, in particular, and society, in general. Otherwise, there is cause for concern that the United States patent system may contravene the United States' Constitutional mandate "to promote the Progress . . . of useful Arts."[108]

The simulation game approach employed in this study could even have an affirmative and salutary effect by allowing investigation into whether a more dynamic patent system, in which the parameters of protection (or lack thereof) could be continuously adjusted, might improve social utility more effectively than does the current, more static, patent system. Empirical evidence from simulation games may provide a more rational basis for guiding public policy to accomplish the Constitutional mandate "to promote the Progress of . . . useful Art"[109] than do artifacts of a centuries-old, and potentially incorrect, orthodox assumption about how patents affect technological innovation.

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[108] U.S. Const. art. I, §8, cl. 8.

[109] *Id.*

APPENDIX A—"INTRODUCTORY STATEMENT REGARDING THE PATENT GAME™"

The School of Law at the University of Kansas supports the practice of protection for human subjects participating in research. The following information is provided for you to decide whether you wish to participate in the present study. You should be aware that even if you agree to participate, you are free to withdraw at any time without penalty.

We are conducting this study to better understand the patent system. This will entail your playing The Patent Game, a videogame that is an online simulation of the patent system. The Patent Game™ is expected to take approximately 60 minutes to play.

The Patent Game™ should cause no more discomfort than you would experience in your everyday life. Although participation may not benefit you directly, other than payment of $10 per hour for your time, we believe that the information obtained from this study will help us gain a better understanding of the patent system. The researcher may ask for your social security number in order to comply with federal and state accounting regulations. Your participation is solicited, although strictly voluntary. Your name will not be associated in any way with the research findings. If you would like additional information concerning this study before or after it is completed, please feel free to contact us by phone or mail.

Playing The Patent Game™ indicates your willingness to participate in this project and that you are at least age eighteen. If you have any additional questions about your rights as a research participant, you may call (785) 864-7429 or write the Human Subjects Committee Lawrence Campus (HSCL), University of Kansas, 2385 Irving Hill Road, Lawrence, Kansas, 66045-7563, email dhann@ku.edu.