PATENT EXPERTISE AND THE REGRESS OF USEFUL ARTS

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I. INTRODUCTION

A traditional assumption underlying justification of patent systems is that the prospect of patent protection for new inventions should lead to higher rates of technological innovation, along with greater attendant benefits to society, than should a commons "system" offering no patent protection. Patents privilege their owners with "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 . . . ."[1] According to this traditional assumption, a limited monopoly right to exclude others should spur prospective inventors to allocate 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"[2] because patents provide those inventors with an enhanced ability to appropriate monopoly rents for the sale or licensing of their patented inventions. Lawrence Lessig explains the traditional logic linking patents to technological progress as follows:

> 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."
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> Getting more progress is the constitutional aim of patents.[3]

Despite the widespread adoption of patent systems throughout the world,[4] little empirical evidence actually links the prospect of patent protection for inventions to increased rates of invention.[5]

Participants in patent systems vary in the depth and accuracy of their knowledge of, and their level of experience with, patent systems, patent law, and alternative models of innovation, such as open and user innovation (for example, innovation subject to an open source license).[6] Some participants, such as individual inventors and small companies of modest means and limited legal sophistication, may know relatively little about patent law and open innovation. Others, such as patent attorneys, large corporations, and large research institutions, may possess relatively sophisticated expertise in patent law and open innovation; for the purposes of this article, these participants are hereafter referred to as "expert users". Despite the obvious possibility that expertise in patent law and open innovation could influence patterns of creating, using, and protecting inventions, little is known about patterns of innovation, productivity, and social utility generated by expert users.

This study relies upon empirical data generated using The Patent Game™[7], a dynamic multi-user interactive simulation of the patent system, to investigate the behavior of expert users. The Patent Game uses an abstracted and cumulative model of the invention process, a database of potential innovations, an interactive interface that allows users to make, invent, patent,

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3.   Lawrence Lessig, THE FUTURE OF IDEAS: THE FATE OF THE COMMONS IN A CONNECTED WORLD 205 (2002).

4.   *E.g.*, the Patent Cooperation Treaty ("PCT") had 139 contracting parties as of Feb. 12, 2009. http://www.wipo.int/treaties/en/ShowResults.jsp?lang=en&treaty_id=6 (last visited on Feb. 12, 2009).

5.   Wesley M. Cohen & Stephen A. Merrill, *Introduction* to PATENTS IN THE KNOWLEDGE-BASED ECONOMY 2 (Wesley M. Cohen & Stephen A. Merrill eds.) (2003) [hereinafter Cohen & Merrill].

6.   For simplicity, "open innovation" hereafter encompasses both open innovation and user innovation.

7.   Also referred to as SimPatent™ and PatentSim™. To minimize inelegance, the "TM" symbol is omitted from "The Patent Game" elsewhere in this article.

or open source innovations, and a network over which users may interact with one another to license, assign, buy, infringe, and enforce patents. Specifically, we explore the rates of innovation, productivity, and social utility generated by expert users by experimentally simulating the behavior of expert inventors and competitors under three sets of conditions designed to approximate patent and non-patent systems. Across (1) pure patent, (2) patent/open source, and (3) pure commons systems, we compare rates of innovation, productivity, and social utility generated by expert users.

We have previously presented empirical evidence suggesting that, for non-expert users, the availability of patent protection in either a pure patent or patent/open source system does not generate more innovation, productivity, or social utility than does a commons system.[8] Instead, non-expert users generated significantly more innovation, productivity, and social utility in a commons system than in a pure patent or patent/open source system.[9] The experimental population of non-expert users from whom these results were derived consisted of first-year law students who had never formally studied either intellectual property law, in general, or patent law or open innovation, in particular. In order to investigate the influence of expertise in patent law and open innovation on innovation, productivity, and social utility, this current study employed a population of expert users, who played The Patent Game immediately after having formally studied (and been evaluated on) patent law and open innovation. This article presents the experimental results derived from this second population of expert users.

For expert users, the data generated from The Patent Game are striking. The results indicate that expertise in patent law and open innovation does lead expert users to generate statistically significantly more (at a $p = 0.05$ level of statistical significance)[10] innovation in pure patent or patent/open source systems than they do in a pure commons system. In fact, there is no statistically significant difference in levels of innovation generated by expert users across the pure patent, patent/open source, and commons systems. By contrast, the results do show that expert users generate significantly different amounts of productivity and social utility across these three systems (with all possible pairwise comparisons of the pure patent, patent/open source, and pure commons systems statistically different at a $p = 0.05$ level of statistical

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8. Dr. Andrew W. Torrance & Dr. Bill Tomlinson, *Patents and the Regress of Useful Arts,* COLUM. SCI. & TECH. L. REV., Vol. X., 128 (2009 [hereinafter Torrance & Tomlinson].

9. These results were statistically significant at the $p = 0.05$ level of significance.

10. Throughout this article, 5% is used as the threshold for statistical significance. Thus, data are considered to be statistically significantly different if the p-value resulting from a statistical analysis is less than 0.05.

significance): the lowest amounts in the pure patent system, intermediate amounts in the patent/open source system, and the highest amounts in the commons system. These results suggest that patents in pure patent or patent/open source systems fail to spur technological innovation above the level found in a commons system. In addition, they suggest that levels of productivity and social utility are lowest in a highly proprietary system (pure patent), intermediate in a system that mixes proprietary with open innovation (patent/open source), and highest in a non-proprietary system (commons).

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 Patent Game 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 considers implications that the results of this study may have for patent systems and open innovation systems. Finally, Part VII concludes with a summary of the results and their implications, and outlines future research directions on patent and open innovation systems using The Patent Game.

II. PATENTS AND INNOVATION[11]

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.[12] 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

11. This section is adapted from Dr. Andrew W. Torrance & Dr. Bill Tomlinson, *Patents and the Regress of Useful Arts*, COLUM. SCI. & TECH. L. REV., Vol. X, 128, 134–37 (2009).
12. Roberto Mazzoleni & Richard R. Nelson, *Economic Theories About the Benefits and Costs of Patents*, 32 J. ECON. ISSUES 1031 (1998).

and patent lawyers seem to think."[13] They propose four broad theories about the purposes served by patents:

> 1. The anticipation of patents provides motivation for useful invention: we weill [sic] call this the "invention motivation" theory.
>
> 2. 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.
>
> 3. Patents on inventions induce the needed investments to develop and commercialize them: this we call the "induce commercialization" theory.
>
> 4. Patents enable the orderly exploration of broad prospects: we call this the "exploration control" theory.[14]

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.[15] The first three theories have a long history, whereas the fourth theory is of relatively recent vintage.[16] 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":

> 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.
> 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.

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13.   *Id*. at 1031.
14.   *Id*. at 1033.
15.   *Id*.
16.   *Id*.

2. The deterrent effect of the presence of patents on unauthorized use of a technology and on the transaction costs involved in licensing an invention. 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.

3. 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.

4. 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.[17]

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?'"[18] 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."[19] Much more work will be required before stronger causal links can be drawn between patents and technological innovation.

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17. *Id*. at 1033–34.
18. *Id*. at 1044.
19. William M. Landes & Richard A. Posner, THE ECONOMIC STRUCTURE OF INTELLECTUAL PROPERTY LAW 294 (2003).

B. Empirical Evidence

In 2003, the National Academies[20] published a report on the United States patent system, entitled "Patents in the Knowledge-Based Economy,"[21] 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."[22] 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,[23] 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."[24] 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,"[25] the National Academies concluded that the "literature on the impact of patents on innovation must be considered emergent."[26]

The National Academies determined that there has been "little systematic empirical analysis of the impact of patents on innovation."[27] 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.[28] Thus,

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20. 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 http://www.nationalacademies.org/about (last visited Dec. 1, 2008).
21. Cohen & Merrill, *supra* note 5.
22. Cohen & Merrill, *supra* note 5, at 2.
23. *Id*.
24. *Id*. at 3.
25. *Id*.
26. *Id*.
27. *Id*. at 2.
28. *Id*. at 3–4.

there is a strong need for empirical data and analysis to elucidate what role a patent system may play "[t]o promote the Progress of . . . useful Arts."[29]

In this article, we describe our efforts to provide such empirical data and analyses. By gathering empirical data using The Patent Game, a dynamic interactive simulation of the patent system, we offer a novel approach to test the hypothesis that patents spur technological innovation.[30]

III. SIMULATION OF THE PATENT SYSTEM[31]

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.[32] The second makes use of human participants, and such simulations are sometimes described as "games."[33]

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.[34] Arora, Ceccagnoli, and Cohen analyzed how investments in research and development react when the value of patent protection changes.[35] 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.[36]

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29. U.S. CONST. art I, § 8, cl. 8.
30. The Patent Game can be found on the Internet at www.patentgame.net.
31. Torrance & Tomlinson, *supra* note 8, at 137–40.
32. Mathematical simulations do not involve human participants, relying only on software algorithms and specified sets of parameters.
33. Simulation games also involve algorithms and some specified sets of parameters, but additionally include human participants whose behaviors interact with the algorithms and parameters.
34. Jean Olson Lanjouw, *Patent Protection in the Shadow of Infringement: Simulation Estimations of Patent Value*, 65 REV. ECON. STUD. 671 (1998).
35. Ashish Arora, et al., *R&D and the Patent Premium* 1 (Nat'l Bureau of Econ. Research, Working Paper No. 9431, 2003).
36. *See* Thomas Vallee & 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"); Max Boisot, et al., *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

Others have used mathematical simulations to study specific aspects of a patent system, such as patent terms,[37] or to compare effects of patenting in specific industries, such as pharmaceuticals.[38] Similar approaches have also considered the effects of damages in litigation[39] or of a post-grant opposition system.[40]

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 of the simulation, often filling those roles or elements of the simulations that cannot easily be programmed into a simulation model.[41]

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regimes). *See also* Andrew A. Toole & Dirk Czarnitzki, *Patent Protection, Market Uncertainty, and R&D Investment* 2 (Berkeley Center for Law & Technology, 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).

37. Francesca Cornelli & Mark Schankerman, *Patent Renewals and R&D Incentives*, 30 RAND J. ECON. 197 (1999).

38. Carsten Fink, *How Stronger Patent Protection in India Might Affect the Behavior or* [sic] *Transnational Pharmaceutical Industries* 29 (Development Research Group, World Bank, Working Paper No. 2352, 2000). *See also* 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); 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).

39. Michael Abramowicz, *A Unified Economic Theory of Noninfringement Opinions*, 14 FED. CIR. B.J. 241, 243 (2004).

40. 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).

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

Even earlier, in 1972, John Drobak discussed "[g]aming as a research device."[42]   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.[43] However, he also pointed out that gaming has "unique limitations in addition to those inherent in computer simulation."[44] For example, individual players might not make decisions in the same way institutions would.[45]

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.[46] 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.[47] A later version of Gasnier's simulation game is called *Patentopolis*.[48]

Simulation games have thus far tended to be in the form of boardgames rather than computer or web-based games.[49] Such boardgames 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 improve their internal processes for management and decision-making about their patent portfolios.[50]

There have been several other uses of simulation games aimed at helping business users understand how to manage and exploit their intellectual property assets, either directly or indirectly through related management

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42.   John N. Drobak, *Computer Simulation and Gaming: An Interdisciplinary Survey with a View Toward Legal Applications*, 24 STAN. L. REV. 712, 719 (1972).

43.   *Id*. at 719–20.

44.   *Id*. at 720.

45.   *Id*.

46.   Arnaud   Gasnier,   ISAGA   2004   presentation   (2004),   *available   at* h t t p : / / w w w . t b m . t u d e l f t . n l / w e b s t a f / a r n a u d g / I S A G A % 2 0 2 0 0 4 % 2 0 - %20A%20Gasnier%20presentation%20(5Sept04).ppt (last visited Aug. 27, 2008).

47.   Arnaud   Gasnier,   ISAGA   2004   presentation   (2004),   *available   at* h t t p : / / w w w . t b m . t u d e l f t . n l / w e b s t a f / a r n a u d g / I S A G A % 2 0 2 0 0 4 % 2 0 - %20A%20Gasnier%20presentation%20(5Sept04).ppt (last visited Aug. 27, 2008).

48.   A r n a u d   G a s n i e r ,   I S A G A   2 0 0 5   p r e s e n t a t i o n ,   *a v a i l a b l e   a t* h t t p : / / w w w . t b m . t u d e l f t . n l / w e b s t a f / a r n a u d g / I S A G A % 2 0 2 0 0 4 % 2 0 - %20A%20Gasnier%20presentation%20(5Sept04).ppt (last visited Aug. 27, 2008)

49.   *See* "Patentopolis," http://cps.q42.net/projects/10 (last visited Aug. 27, 2008).

50.   *Id*.

decisions. 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."[51] The University of Washington has used a simulation game in a continuing education certificate program.[52] The Scandinavian International Management Institute has also developed a computer-based simulation game, this one related to management practices.[53] Some law schools have even used simulation games to help teach principles of intellectual property law to law students.[54]

This article presents empirical data generated using The Patent Game, a simulation game designed specifically to test hypotheses about patent systems, commons systems, and technological innovation.

V. DESCRIPTION OF THE PATENT GAME[55]

The Patent Game, 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. The Patent Game 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 compete by recombining simpler inventions into more complex and powerful combination inventions. The Patent Game is used to test hypotheses regarding the benefits conferred on society, in

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51.   The Cornell Management Simulation, http://www.cms-training.com/ (last visited Aug. 27, 2008).

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

53.   Press Release, Scandinavian International Management Institute, The Business of Intellectual Property – BIP, Program Description (2006), http://www.scanbalt.org/graphics/ScanBalt/databases/BIP%202%20page%20version.pdf. (last visited Dec. 1, 2008).

54.   *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* 16 (Franklin Pierce Law Center, Working Paper, Feb. 22, 2004)), http://www.ipmall.info/hosted_resources/pubspapers/hennessey_TOKYOICS.pdf (last visited Dec. 1, 2008); Univ. of Utah S.J. Quinney Coll. of Law, Course Information: Intellectual Property Licensing, http://www.law.utah.edu/courseschedule/window_courseInformation.asp?courseID=122 (last visited Dec. 1, 2008).

55.   Torrance & Tomlinson, *supra* note 8, at 140–57.

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 The Patent Game, 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 under way, and how much money the player and all other players currently have.

Figure 1. Main Interface Screen of The Patent Game
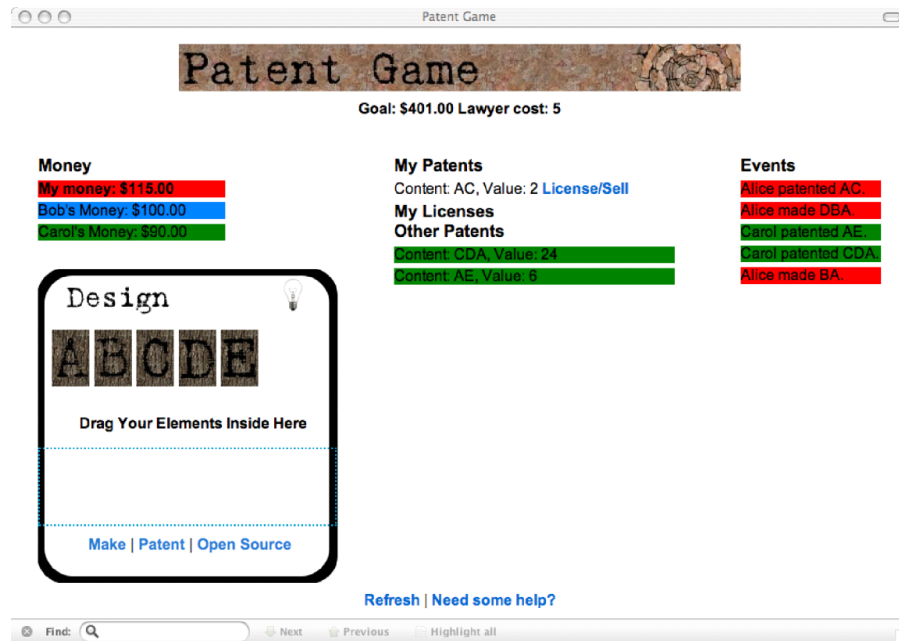
In the bottom left of the main screen is the Innovation section, where players can design and manufacture various virtual products. A product, in the The Patent Game system, is a combination of one to five Widgets, represented here by the icons featuring the letters "A," "B," "C," "D," and "E."[56] Each 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

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56.   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.

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 which 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.

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. License fees in The Patent Game are set by the patent owner, 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. The Patent Game allows an iterative negotiating process of offer and nonacceptance to occur, eventually leading to an acceptable licensing fee.

Figure 2. Make Product Screen of The Patent Game

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 The Patent Game
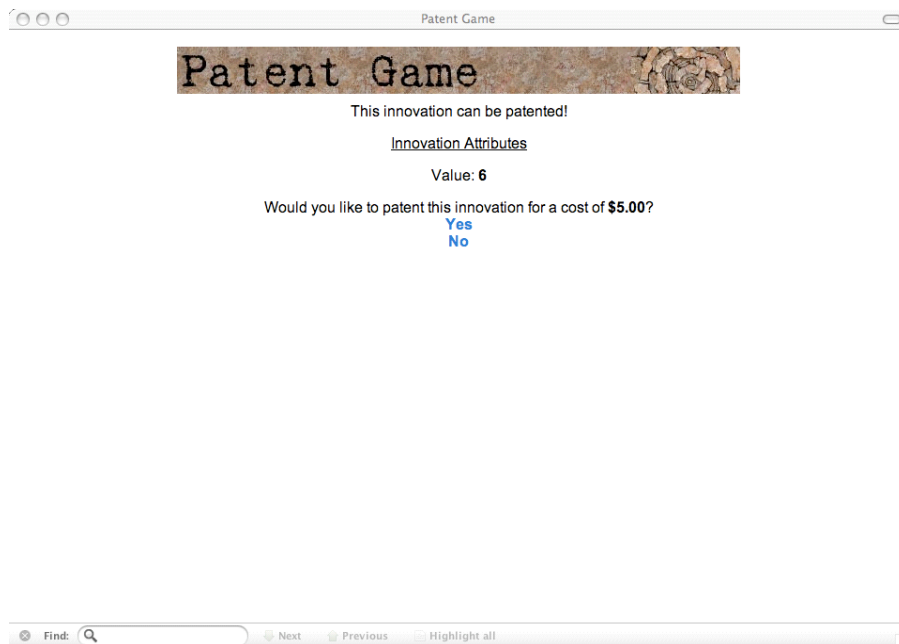
4. Set Open Source Screen

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 The Patent Game
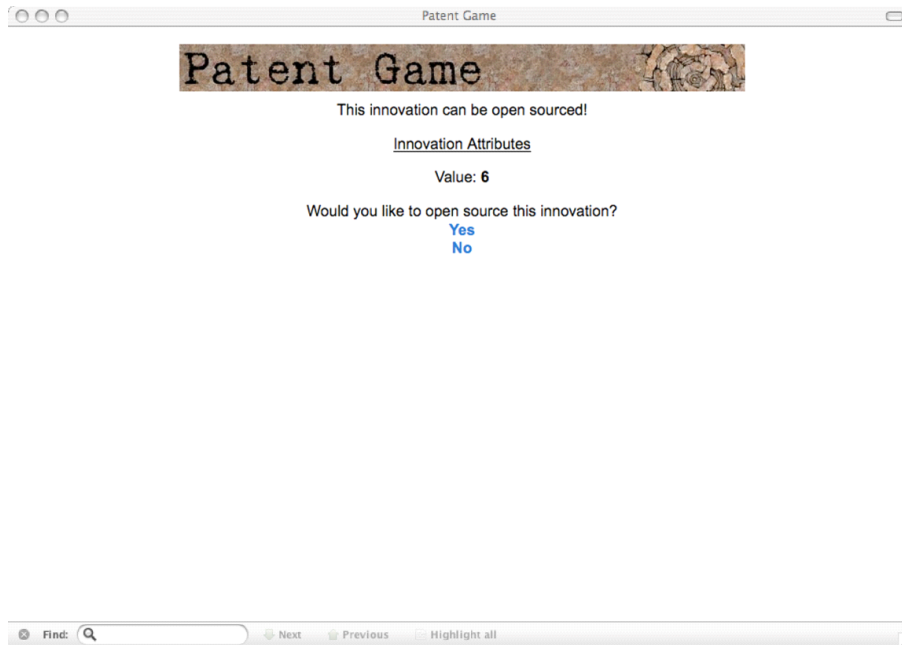
5. *Patent Attributes Screen*

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 The Patent Game**

6. License/Buy/SELL Patent Screens

If a player wishes to license or buy a patent owned by another player, and that patent has been made available for licensing or sale by the other player, 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, The Patent Game 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, The Patent Game 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 The Patent Game
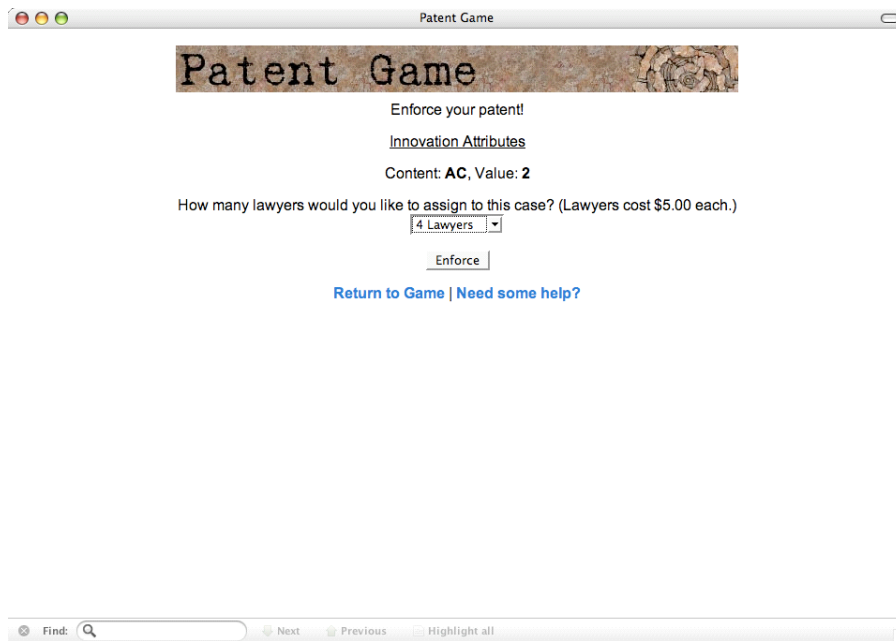
Once the enforcement effort is specified by the patent owner (plaintiff player), the alleged infringer (defendant player) is presented with a similar screen that provides notice of the legal action filed against the defendant player as a result of the allegedly infringing manufacturing and selling action. The game 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 previously used by the plaintiff player (Figure 7).

Figure 7. Infringement Defendant Screen of The Patent Game
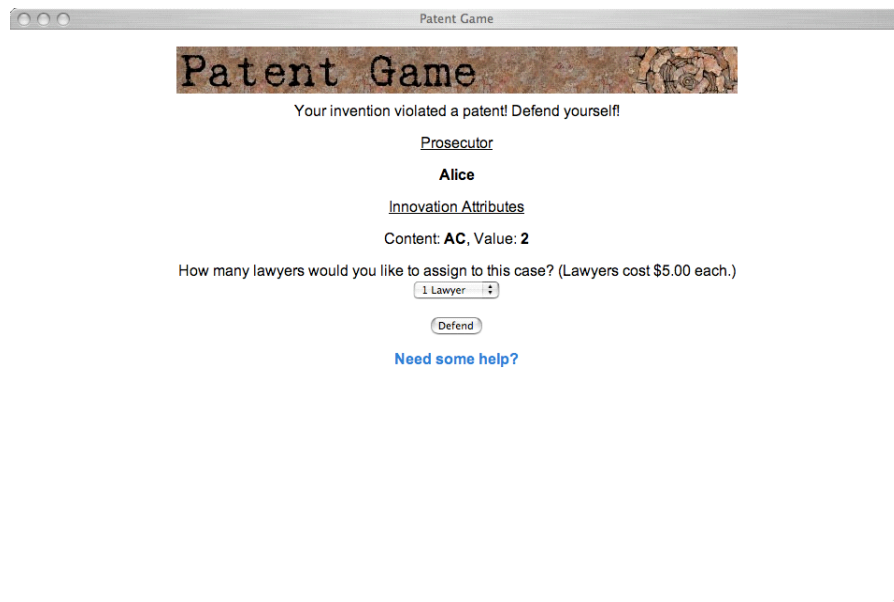
8. End Game Screen

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 Patent Game system uses a MySQL database[57] 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

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

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.

2. Database Tables

This section describes the tables that provide the data storage and manipulation for The Patent Game 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 to which game that particular row is connected. This Game ID provides the connection between the various elements in the same game.

i. Player

Each entry in the Player table has a login name and an amount of money. The login name must be uniquely different from all other login names used in the same Game.

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 by 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, 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. The Patent Game 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 defended 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. Open Source

The open source table includes a player ID to identify and store who performed the open source action, an innovation ID to specify which innovation each open source action relates to, and a time of discovery.

vii. Event

Finally, there is an event table that keeps track of every action taken by players. 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 Using the Patent Game

This section provides a walk-through of the user experience in The Patent Game 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 The Patent Game. 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. Each of the five players

logs into a web browser, accessing the system via its URL. Each player enters 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 all of them are able to identify each other throughout the game. Once they 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.[58] 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 each of the players own a few patents, the players 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 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

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

patents.[59] These data, as well as data recording all other actions that took place in this session of The Patent Game are recorded in the database.

D. Technology

The Patent Game system was created using an open source platform for developing database-backed web applications called Ruby on Rails.[60] 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).[61]

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. The Patent Game 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, by 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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59. At the end of the game, players could be rewarded, either financially or otherwise, based on their performance in the game.
60. Ruby on Rails, http://www.rubyonrails.org/ (last visited Oct. 9, 2008).
61. Of course, such complications may occur in the real world, and The Patent Game 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 The Patent Game 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."[62] 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."[63] By allowing the participation of human players, The Patent Game 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,

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62.   Wikiquote, *Louis Pasteur*, http://en.wikiquote.org/w/index.php?title=Louis_Pasteur&oldid=830712 (last visited Feb. 24, 2009).

63.   James D. Newton, UNCOMMON FRIENDS 24 (Harcourt Brace Jovanovich, Publishers 1987).

allowing them to experience "Eureka!" moments of discovering the sequences of valuable Widgets, and enabling them to allocate their time, money, and efforts in which ways they find most valuable. Even serendipity is possible in The Patent Game, 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, and 1024). By allowing people to discover islands of value in a sparsely populated opportunity space, The Patent Game 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 The Patent Game 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 Patent Game system.

5. *Patents And Open Source*

The Patent Game patent system provides a simplified mapping of a real-world patent and open source systems. The patent features enable users playing 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. The open source features enable them explicitly to exempt specified innovations from eligibility for patent protection. Certainty, The Patent Game cannot capture the full complexity of real-world patent and open source systems. Notably, The Patent Game 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, The Patent Game does attempt to capture the fundamental and meaningful elements common to most patent and open source 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 incentives provided by patent systems.

Since various parameters of The Patent Game 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 The Patent Game 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 The Patent Game 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 lack 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 Patent Game 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 thereby to enhance social utility or well-being. Measuring such a variable in the correct unit of currency is an elusive goal. Money is usually used as the default currency of utility, and money can be used as the default currency by The Patent Game.

Even given an acceptable currency of 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.[64] The Patent Game 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.

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 *Rosencratz 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?"[65] 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:

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64. Thomas J. Miceli, THE ECONOMIC APPROACH TO LAW 4–6 (2004).
65. Tom Stoppard, ROSENCRANTZ & GUILDENSTERN ARE DEAD 39 (1967).

1. Should all the players start and end at the same time?
2. Should some players be given directions, while others are left to find their own way?
3. 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 Patent Game 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),[66] suggests that many people are willing to engage with a 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.

V. METHODS, DATA, AND ANALYSIS[67]

A. Experimental Methods

The data presented here were generated using individual human players ("Subjects"). Groups of Subjects competitively played The Patent Game[68] against one another in games whose parameters were strictly controlled ("Trials"). A series of Trials were conducted under three distinct Treatments:

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66. Blizzard Entertainment, World of Warcraft Surpasses 11 Million Subscribers Worldwide (Oct. 28, 2008), *available at* http://www.blizzard.com/us/press/081028.html.

67. Torrance & Tomlinson, *supra* note 8, at 157–61.

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

(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, the University of Kansas Institutional Research Board ("IRB") approved human subject research. In November 2008, volunteer Subjects were chosen from among the 2008 Intellectual Property (Law 968) class at the University of Kansas School of Law. These Subjects were advanced law students, in either their second or third years of law school, all of whom had formally studied patent law and open innovation (including open source) in an "Intellectual Property" class. Therefore, these Subjects were used to represent expert users of patent and open innovation systems. All Subjects were paid $10 per hour for the time they were involved in this study.

Prior to participating in the Trials, all Subjects had the following "Introductory Statement Regarding The Patent Game" read to them:

> 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.

Next, each Subject signed his or her name to indicate that the "Introductory Statement Regarding The Patent Game." had been heard and understood.

All Subjects were then introduced to The Patent Game interface. Subjects learned how to use all of the functions of The Patent Game. Finally, a series of practice games were played by Subjects to ensure that all Subjects 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."

Ten Trials were run of the Pure Patent Treatment, and eight Trials for each of the Patent/Open and Pure Commons Treatments;[69] 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
> 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 they occur as a subset of the characters in a string of characters that is made or for which patent or open source protection is sought by a Subject. 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.

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69.   Results of two each of the Pure Patent Treatment and Patent/Open Trials were discarded due to technical difficulties that arose during those Trials.

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 77.0, with a standard deviation of 18.1. The mean number of total inventions created or made was 198.1, with a standard deviation of 93.9. The mean amount of money with which each Subject ended each Trial was $4,890.30, with a standard deviation of $3,032.90.

Patent/Open Source Treatment. The mean number of unique inventions created was 67.5, with a standard deviation of 26.7. The mean number of total inventions created or made was 416.2, with a standard deviation of 195.6. The mean amount of money with which each Subject ended each Trial was $21,440.40, with a standard deviation of $17,409.60.

Pure Commons Treatment. The mean number of unique inventions created was 64.4, with a standard deviation of 19.2. The mean number of total inventions created or made was 699.5, with a standard deviation of 87.0. The mean amount of money with which each Subject ended each Trial was $67,566.20, with a standard deviation of $24,685.30.

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-t Test reveals that there is no significant difference in innovation ($p=0.441$) between the Pure Patent and Patent/Open Source Treatments, no significant difference in innovation ($p=0.197$) between the Pure Patent and Pure Commons Treatments, and no significant difference in innovation ($p=0.802$) between the Patent/Open Source and Pure Commons Treatments.

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Graph 1. Innovation
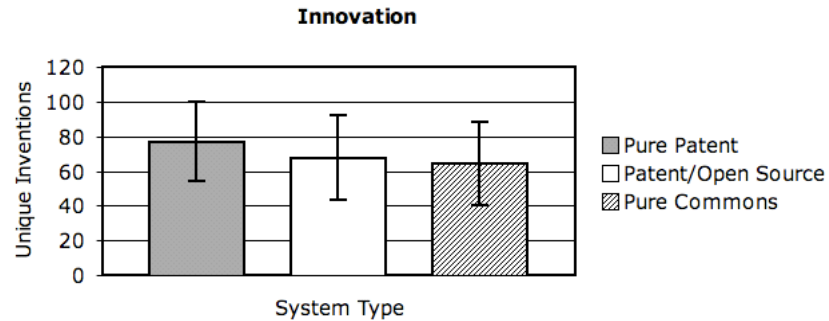
Productivity. The mean number of total inventions created or made can represent the rate of productivity. Graph 2 illustrates the relative amounts of productivity generated in the Pure Patent, Patent/Open Source, and Pure Commons Treatments. A Student-t Test reveals that there is a significant difference in innovation (p=0.017) between the Pure Patent and Patent/Open Source Treatments, a highly significant difference in productivity (p=0.0006) between the Pure Patent and Pure Commons Treatments, and a highly significant difference in productivity (p=0.0032) between the Patent/Open Source and Pure Commons Treatments.

Graph 2. Productivity
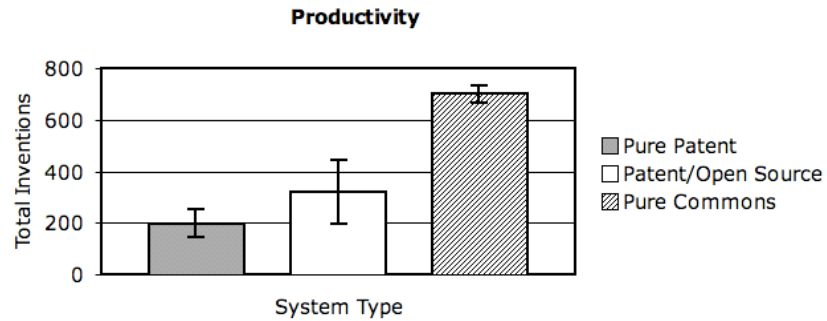
Social Utility. The mean amount of money with which each Subject ended each Trial can represent wealth or social utility. Graph 3 illustrates the relative amounts of social utility generated in the Pure Patent, Patent/Open Source, and Pure Commons Treatments. A Student-t Test reveals that there is a significant difference in social utility (p=0.020) between the Pure Patent and Patent/Open Source Treatments, a highly significant difference in innovation (p=0.0000051) between the Pure Patent and Pure Commons Treatments, and a significant difference in innovation (p=0.0021) between the Patent/Open Source and Pure Commons Treatments.

Graph 3. Social Utility
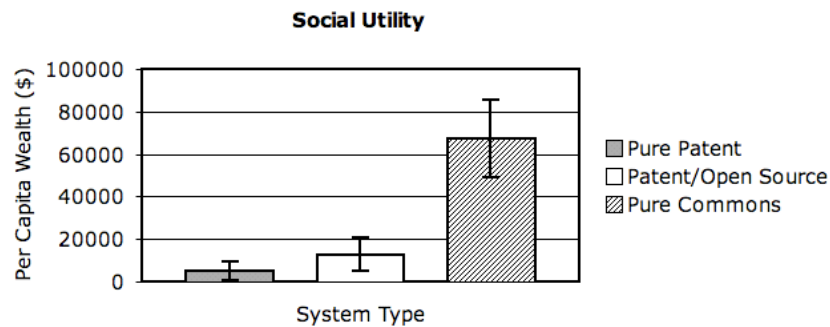
Summary of Statistical Results. The empirical data generated using The Patent Game suggest that, where Subjects have a formal knowledge of patent law and open and user innovation (including open source), there is no statistically significant difference in rates of innovation among a pure patent system, a system combining patent and open source protection, and a commons system.   In contrast, the empirical data does suggest that there are statistically significant differences in rates of productivity and social utility among all three systems, with both metrics lowest in a pure patent system, intermediate in a system combining patent and open source protection, and highest still in a pure commons system.

VI. EXPERTISE AND INNOVATION

The Subjects in this study all possessed detailed and specific knowledge of patent law and open innovation (including open source). The empirical data generated using The Patent Game allow a number of observations to be made about this population of expert users.

Innovation.   Based on results generated using The Patent Game, expertise in patent law and open innovation does not generate a statistically significant difference in rates of innovation among pure patent, patent/open source, and pure commons systems. Thus, the traditional assumption that

patents "promote the Progress . . . of useful Arts"[70] appears to be falsified with respect to expert users.

Productivity and Social Utility. Unlike rates of innovation, rates of productivity and amounts of social utility are statistically significantly different among all three systems, being highest for a pure commons system, intermediate for a system combining patent and open innovation protection, and lowest for a pure patent system. This pattern of productivity and social utility suggests that availability of open source protection may hold the potential to improve outcomes for both these metrics without eliminating the availability of patent protection for inventions. Although a commons system appears to outperform both other systems at generating productivity and social utility, the improved performance that a patent/open source system also offers over a pure patent system suggests the advantages of semi-open models of innovation over purely closed and proprietary models of innovation.

Furthermore, by combining availability of patent protection with availability of open source protection, a patent/open source system may offer a relatively familiar transitional stage on the pathway towards more open, and commons-like, systems of innovation. This kind of transitional stage may be important in facilitating the adoption of new ideas. Moving away from a more proprietary system of innovation, such as a patent system, would likely be difficult. Existing property entitlements, reliance on traditional ways of conducting business and trade, and uncertainty regarding how a more open, and less proprietary, system of innovation might function would all contribute to resistance to change. However, a system that retained certain familiar aspects of the more proprietary innovation paradigm, such as availability of patent protection, while simultaneously offering nonproprietary "protections", such as open source licenses, might facilitate experimentation with more open innovation. In addition, the prospect of significant improvements in productivity and social utility, along with no significant decline in rates of innovation, could create incentives to change.

Like our previous empirical results indicating advantages of a commons system over both pure patent and patent/open source systems, the results of this study represent a marked departure from the orthodox view that patent systems can be justified because they spur relatively more technological innovation than do commons. Furthermore, the results of this study are consistent with much of the research generated by the increasingly important field of open innovation.[71] Furthermore, we consider the concordance between the results of this empirical simulation game and the rapidly growing

70.   U.S. CONST. art. I, § 8, cl. 8.
71.   Torrance & Tomlinson, *supra* note 8.

body of research flowing out of open innovation to be highly suggestive of the advantages that open innovation may have over more closed and proprietary models of innovation, such as patent systems.

VI. CONCLUSION

One of the first lessons a law student learns when studying the patent system is that the United States Constitution grants to Congress the right to offer patent protection to inventors "to promote the Progress . . . of useful Arts."[72] In a previous study, we presented empirical evidence that patent systems may not accomplish the goal of technological progress as well as a commons system, at least in terms of innovation, productivity, and social utility.

Employing The Patent Game, a multi-user interactive simulation of patent and non-patent (commons and open source) systems, this current study also compares rates of innovation, productivity, and social utility, but does so with expert users deliberately selected to possess formal expertise in patent law and open innovation. We present results indicating that there is no statistically significant difference in rates of innovation among a pure patent system, a patent/open source system, and a commons system. By contrast, there are statistically significant differences in rates of productivity and social utility among all three systems, with both productivity and social utility lowest in a pure patent system, higher in a patent/open source system, and highest in a pure commons system. As in our previous study,[73] the results of this study are inconsistent with the orthodox assumption that patent systems generate more "Progress" than do more open models of innovation, such as patent/open source or pure commons systems, and are more consistent with predictions and observations from the burgeoning field of open innovation.[74]

In the future, the authors plan to expand on the results presented in this article, using The Patent Game to explore how patterns of technological innovation vary based on additional characteristics of individual users. As we have emphasized previously,[75] empirical evidence from simulation games may prove useful in helping public policy to accomplish more effectively the Constitutional mandate of "promot[ing] the Progress of . . . useful Arts".[76]

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72.   U.S. CONST. art. I, § 8, cl. 8.
73.   Torrance & Tomlinson, *supra* note 8.
74.   *See id*.
75.   *Id*.
76.   *Id*.