Real Options in Law: (Possibly, Frivolous) Litigation and Other Applications

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Introduction

I. (Possibly, Frivolous) Litigation Option Games

A. Models of Litigation

B. Models of Frivolous Litigation

II. Limitations of Strategic Litigation Options Analysis

A. Cognitive Limitations

B. Emotional and Psychological Factors

III. Other Legal Applications of Real Options

A. Rethinking the "Calculus" of Negligence and the Hand Formula

B. Legal Preclusions

Conclusions

Appendix: A Real Options Game-Theoretic Model of Litigation

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Abstract: This Article advances the thesis that real options are not only ubiquitous in law, but also provide novel insights about legal decision making, doctrines and rules. An introduction provides a brief a primer about financial options, real options, and real options in law. Part I of this Article develops implications of the fact that every lawsuit contains a sequence of real options for the plaintiff to unilaterally abandon that lawsuit. Part II of this Article appraises the limitations of game-theoretic analysis of the abandonment options embedded in litigation and some responses to such limitations. Part III of this Article illustrates how to apply real options analysis to provide insights over numerous legal areas, including the "calculus" of negligence and the Hand formula; collateral estoppel and res judicata; constitutional amendments; judicial minimalism; and marriage or divorce statutes. A conclusion summarizes the insights of the novel real options approach to law advanced in this Article. An appendix develops a general mathematical sequential real abandonment options game-theoretic model of (possibly, frivolous) litigation. This analytical model demonstrates how the real abandonment option values in (possibly, frivolous) litigation determine a set of necessary and sufficient conditions for the sequential credibility of (possibly, frivolous) litigation and derives Nash equilibrium settlement values.

Introduction

What do buying a house, having children, and recalling the governor of California have in common? These three seemingly unrelated experiences all involve not only sequential decision making,[1] but also exercising or preserving various options. House hunting may involve looking over many houses that differ along numerous dimensions.[2] These differences mean that it can be difficult for a buyer to compare houses in order to determine an optimal stopping rule for house shopping.[3] Passing on a particular house preserves options to buy other houses, but risks losing an option to buy that particular house later. Multiple potential buyers might express interest in a particular house and end up bidding against each other. A bidding contest over a house means that each potential buyer has fewer negotiating options because she may feel she has to make her initial bid her best offer instead of engaging in a series of negotiating rounds. Deciding to bid on and then possibly losing bids over houses can become an emotionally difficult roller coaster.[4] The purchase of a home is part of the American dream, but for most Americans, their home is or was their most expensive purchase (at least, until then). Thus, most (at least, first-time) home buyers finance part of the price of their purchase by taking out a mortgage. Virtually every home mortgage grants a homeowner the option to pay the mortgage off early without any penalties for prepayment.[5]

Whether and when to have children, as well as how many to have are various options that people have. Before (and even after) a child is conceived, there are numerous options regarding

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[1] *See generally*, ERIC V. DENARDO, DYNAMIC PROGRAMMING: MODELS AND APPLICATIONS 2-3 (Dover ed., 2003) (describing the ubiquitous nature of sequential decision making).

[2] *House Hunters* (HGTV television broadcast, Thursdays 10 and 10:30) (depicting the actual house search experiences of various first-time home buyers).

[3] ROBERT H. FRANK, MICROECONOMICS AND BEHAVIOR 288 (5th ed. 2003) (explaining that experienced realtors often show their clients two nearly identical houses, but with one that is both in better condition and less expensive than the other in order to provide their clients with the opportunity to make an easy decision).

[4] MARY FRANCES LUCE ET AL., EMOTIONAL DECISIONS: TRADEOFF DIFICULTY AND COPING IN CONSUMER CHOICE 2-9 (2001) (detailing emotional difficulties that consumers face in deciding among consumption alternatives).

[5] 15 U.S.C. § 1639(c)(1)(A) (2003).

birth control. Conception can be assisted by reproductive and genetic technologies.[6] Once a child is conceived, there are many options regarding prenatal care, whether to carry the child to full term, and methods of delivery. But, while a woman is pregnant, she does not have the option to become pregnant again until after her first pregnancy concludes. In addition, there are numerous adoption options.[7] After a child is born, parents have and feel they have fewer options in terms of alternative joint activities or purchases. Finally, there are numerous child rearing options. Of course, children have options to have their own children.

The October 7, 2003 recall election of California governor Gray Davis is the result of the California Constitution providing California voters with options to recall their elected officials.[8] Some social observers and political commentators fear that California's recall election sets a dangerous precedent because it can lead to voters exercising their options to hold recall elections of any elected officials who make unpopular decisions.[9] As a result, elected officials may come to engage in perpetual campaigning and elections might degenerate into no more than contests of personality or popularity. But, fifteen states, the District of Columbia, Guam, and the Virgin Islands already have laws that provide their voters with options to recall elected state officials, and thirty-six states have laws that provide their voters with options to recall various local officials.[10] In fact, a Gallup Organization poll conducted in 1987 found that sixty-seven percent of a nation-wide sample of one thousand and nine people supported amending the United States Constitution to provide for the recall of members of Congress and fifty-five percent of that same

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[6] *See, e.g.*, Peter H. Huang, *Herd Behavior in Designer Genes*, 34 WAKE FOREST L. REV. 639 (1999).

[7] *See, e.g.*, Elisabeth M. Landes & Richard A. Posner, *The Economics of the Baby Shortage*, 7 J. LEGAL STUD. 323 (1978).

[8] CA. CONST. art. II, §§ 13-18.

[9] *But see*, Richard Thompson Ford, *Love It: The Recall is Pure Democracy*, SAN JOSE MERCURY NEWS Aug. 14, 2003 (criticizing poor arguments against a recall of California's Governor Gray Davis).

[10] THOMAS E. CRONIN, DIRECT DEMOCRACY: THE POLITICS OF INITIATIVE, REFERENDUM, AND RECALL 125-27, tbl. 6.1 (1989).

sample supported a Constitutional amendment providing for the recall of the President.[11] Only a third of those polled opposed the idea of recalling nationally elected officials.[12]

Another common feature of buying a house, having children, and recalling the governor of California is risk. In fact, virtually every legal (and for that matter, non-legal) decision involves an element of risk. Attorneys, their clients, elected officials, judges, jurors, legislators, litigants, negotiators, regulators and voters face various risks, including those arising from appellate, contractual, electoral, financial, judicial, legislative, regulatory, statutory, and technological sources. It is increasingly critical for such decision-makers to respond effectively to such risks. Just as omnipresent as risks are the methods by which individuals, organizations, and institutions can employ to cope or deal with risks, including diversifying, hedging, insuring, and learning. In a sense, (payoff-relevant) information can be thought of as the reduction of risk or the negative of risk.

A particular method of handling risks is by utilizing options. An option provides its holder with a right, as opposed to an obligation, to choose some action in the future. The word option "comes from the medieval French and is derived from the Latin optio, optare, meaning to choose, to wish, to desire."[13] Options are valuable from a decision-theoretic perspective when there are yet unresolved risks because they provide the flexibility to be not locked into an irreversible course of action. In other words, options have no value if there is no risk & decisions are reversible.[14] After all, risks involve not only dangers, but also opportunities.[15] Options allow those facing risky environments to profit from the upside potential of, while truncating losses from the downside possibility of, the risks they face. Options thus offer

[11] *Id*. at 132, tbl. 6.2.
[12] *Id*. at 133, tbl. 6.2.
[13] MARION A. BRACH, REAL OPTIONS IN PRACTICE 1 (2003).
[14] ALEXANDER VOLLERT, A STOCHASTIC CONTROL FRAMEWORK FOR REAL OPTIONS IN STRATEGIC VALUATION 7-8 (2003).
[15] The Chinese character for crisis is composed of two ideograms, namely those for danger and opportunity.

asymmetric, kinked, or non-linear payoffs because options permit actors to make future decisions after learning relevant information concerning the risks they face.

This Article's major contribution is to develop the legal and policy implications of realizing that many legal doctrines and rules essentially regulate the numerous options that legal interactions provide. The first and second parts of this Article focus on the options that plaintiffs have to abandon lawsuits. In particular, part I and the appendix of this Article present a new theory of (possibly, frivolous) litigation.[16] The following hypothetical example of medical malpractice litigation illustrates the value of a plaintiff's option to abandon or drop litigation. Suppose that Portia sues her doctor, Daphne, for medical malpractice alleging negligence during a routine operation. Daphne knows that she did nothing improper during the surgical procedure. But, Portia was under anesthesia during surgery and feels that someone must be to blame for her suffering. Suppose that Portia's ex ante or initial expected probability of her prevailing at trial is 1/2. Suppose that the monetary judgment which Portia initially expects to win at trial is $1,000,000. Then, Portia's initial expected judgment at trial is (1/2)($1,000,000) or $500,000. Suppose that Portia's total expected litigation costs for proceeding to a trial are $550,000. Portia's lawsuit has a net expected value of $500,000-$550,000 = -$50,000 < 0.

But, now suppose the lawsuit consists of two stages: discovery and trial, each of which costs Portia $275,000. Also, suppose that discovery resolves all of the risks of Portia's litigation; so that, the posterior or ex post probability conditional upon discovery of Portia's prevailing in court is either 0 or 1. Portia would only proceed when she has a sure winner, and Portia would abandon a sure loser. Portia's revised initial expected value or her initial option value of the lawsuit is thus (1/2)($1,000,000-$275,000)-$275,000 = (1/2)($725,000)-$275,000 = $362,500-275,000 = $87,500 > 0. Notice that holding fixed the other values of the parameters in this hypothetical, as long as the monetary judgment from prevailing in court for Portia exceeds

[16] This novel theory was originally developed and introduced in Peter H. Huang, Litigation Options in Civil Procedure (1997) (unpublished J.D. thesis, Stanford University) (on file with the author) and reproduced in Joseph A. Grundfest & Peter H. Huang, *Real Options and the Economic Analysis of Litigation: A Preliminary Inquiry*, Stanford Law School Olin Program in Law and Economics Working Paper No. 131 (May 1996).

$825,000, this lawsuit has initial positive option value. Portia would initially file this Negative Expected Value (NEV) lawsuit, but after discovery Portia would choose to drop this lawsuit once Portia realizes that Daphne is not liable for Portia's misfortune. The appendix of this Article derives and solves a multi-period game-theoretic model of litigation that generalizes this hypothetical by incorporating not only litigation abandonment options, but also bilateral settlement bargaining.

A few legal scholars have already begun to apply options analysis to study legal rules and institutions.[17] But, financial economists and management scholars have been studying options theory and its applications in the practice of financial engineering and management science for over a quarter of a century.[18] Options are classified as financial or real.[19] Financial options are

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[17] *See, e.g.*, Peter H. Huang, *A New Options Theory for Risk Multipliers of Attorney's Fees in Federal Civil Rights Litigation*, 73 N.Y.U. L. REV. 1943 (1998); Peter H. Huang, *Teaching Corporate Law From An Option Perspective*, 34 GA. L. REV. 571 (2000); Mark Klock, *Is It "the Will of the People" or a Broken Arrow? Collective Preferences, Out-of-the-Money Options, Bush v. Gore, and Arguments for Quashing Post-Balloting Litigation Absent Specific Allegations of Fraud*, 57 U. MIAMI L. REV. 1 (2002); Michael S. Knoll, *Put-Call Parity and the Law*, 24 CARDOZO L. REV. 61 (2002); Michael S. Knoll, *Products Liability and Legal Leverage: The Perverse Effects of Stiff Penalties*, 45 U.C.L.A. L. REV. 99 (1997); Paul G. Mahoney, *Contract Remedies and Options Pricing*, 24 J. LEGAL STUD. 139 (1995); Richard A. Nagareda, *Autonomy, Peace, and Put Options in the Mass Tort Class Action*, 115 HARV. L. REV. 749, 755-58 (2002); Klaus M. Schmidt, *Contract Renegotiation and Options Contracts*, *in* 1 THE NEW PALGRAVE DICTIONARY OF ECONOMICS AND THE LAW 432 (Peter Newman ed., 1998); and Alexander J. Triantis & George G. Triantis, *Timing Problems in Contract Breach Decisions*, 41 J. L. & ECON. 163 (1998).

[18] *See generally* Martha Amram & Nalin Kulatilaka, *Disciplined Decisions: Aligning Strategy with the Financial Markets*, 77 HARV. BUS. REV. 95 (1999); MARTHA AMRAM & NALIN KULATILAKA, REAL OPTIONS: MANAGING STRATEGIC INVESTMENT IN AN UNCERTAIN WORLD (1999); F. Peter Boer, *Valuation of Technology Using Real Options*, July-Aug. RES. TECH. MGMT. 15 (2000); F. PETER BOER, THE REAL OPTIONS SOLUTION: FINDING TOTAL VALUE IN A HIGH-RISK WORLD 26 (2002); BRACH, *supra* note 13; RICHARD A. BREALEY & STEWART C. MYERS, PRINCIPLES OF CORPORATE FINANCE 268-76 (7th ed. 2003); RICHARD A. BREALEY & STEWART C. MYERS, CAPITAL INVESTMENT AND VALUATION 429-49 (2003); Michael J. Brennan & Eduardo S. Schwartz, *Evaluating Natural Resource Investments*, 58 J. BUS. 135 (1985); PROJECT FLEXIBILITY, AGENCY, AND COMPETITION (Michael J. Brennan & Lenos Trigeorgis eds., 2000); DON M. CHANCE & PAMELA P. PETERSON, REAL OPTIONS AND INVESTMENT VALUATION (2002); Andrew H. Chen et al., *Valuing Flexible Manufacturing Facilities as Options*, 38 QUART. REV. ECON. & FIN. 651 (1998); Thomas E. Copeland & Philip T. Keenan, *Making Real Options Real*, 3 MCKINSEY QUART. 128 (1998); TOM COPELAND & VLADIMIR ANTIKAROV, REAL OPTIONS: A PRACTITIONER'S GUIDE (2001); Peter Coy, *Exploiting Uncertainty*, BUS. WK. June 7, 1999, at 118; Avinash Dixit, *Investment and Hysteresis*, 6 AM. ECON. REV. 107 (1992); Avinash Dixit & Robert S. Pindyck, *The Options Approach to Capital Investment*, 73 HARV. BUS. REV. 105 (1995); AVINASH K. DIXIT & ROBERT S. PINDYCK, INVESTMENT UNDER UNCERTAINTY (1994); Keith J. Leslie & Max P. Michaels, *The Real Power of Real Options*, 3 MCKINSEY QUART. 4 (1997); Timothy A. Luehrman, *Investment Opportunities as Real Options: Getting Started on the Numbers*, 76 HARV. BUS. REV. 51 (1998); Timothy A. Luehrman, *Strategy as a Portfolio of Real Options*, 76 HARV. BUS. REV. 89 (1998); DAVID G. LUENBERGER, INVESTMENT SCIENCE 337-43 (1998); Scott Mason & Robert C. Merton, *The Role of Contingent Claims in Corporate Finance*, *in* RECENT ADVANCES IN CORPORATE FINANCE (Edward Altman & Marti G. Subrahmanyam eds., 1985); Robert McDonald & Daniel Siegel, *The Value of Waiting to Invest*, ? QUART. J. ECON. 707 (1986); Robert McDonald & Daniel Siegel, *Investment and the Valuation of Firms when There is An*

contracts that give their holders the right, but not an obligation, to buy (or sell) at a certain price on (or before) a certain date a particular quantity of some underlying financial asset.[20] Examples of underlying financial instruments on which options are written include bonds, stocks, commodities (such as corn, soybeans, wheat, gold, or silver) futures contracts, foreign currencies, or stock indices. There is a vast literature concerning the financial theory, institutional details, pricing models, regulation, and valuation of various financial options.[21]

Because options concepts, ideas, and terminology may not be familiar to some readers, this introduction offers a brief overview about options in general.[22] A call option provides its owner with the right, but not obligation, to buy a specified quantity of some underlying item at some price called the strike or exercise price. A put option provides its owner with the right, but not obligation, to sell a specified quantity of an underlying item at some price called the strike or exercise price. An option's price is called its premium to avoid confusion with exercise or strike prices. A European option provides its owner with the right to exercise that option only on the

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Option to Shut Down, 26 INT'L. ECON. REV. 331 (1985); JONATHAN MUN, REAL OPTION ANALYSIS: TOOLS AND TECHNIQUES FOR VALUING STRATEGIC INVESTMENTS AND DECISIONS (2002); Nancy A. Nichols, *Scientific Management at Merck: An Interview with CFO Judy* Lewent, 72 HARV. BUS. REV. 88 (1994); Robert S. Pindyck, *Irreversibility, Uncertainty, and Investment*, 29 J. ECON. LIT. 1110 (1991); REAL OPTIONS AND INVESTMENT UNDER UNCERTAINTY: CLASSICAL READINGS AND RECENT CONTRIBUTIONS (Eduardo S. Schwartz & Lenos Trigeorgis eds., 2001); Alex Triantis & Adam Borison, *Real Options: State of the Practice*, 14 J. APPL. CORP. FIN. 8 (2001); Alexander J. Triantis & James E. Hodder, *Valuing Flexibility as a Complex Option*, 45 J. FIN. 549 (1990); Lenos Trigeorgis, *Real Options and Interactions with Financial Flexibility*, 22 FIN. MGMT. 292 (1993); Lenos Trigeorgis & Scott P. Mason, *Valuing Managerial Flexibility*, 5 MIDLAND CORP. FIN. 14 (1987); REAL OPTIONS IN CAPITAL INVESTMENT – MODELS, STRATEGIES, AND APPLICATION (Lenos Trigeorgis ed., 1995); LENOS TRIGEORGIS, REAL OPTIONS: MANAGERIAL FLEXIBILITY AND STRATEGY IN RESOURCE ALLOCATION 227-71 (1998); and W. Carl Kester, *Today's Options for Tomorrow's Growth*, 62 HARV. BUS. REV. 153 (1984).

[19] BRACH, *supra* note 13, at 1.

[20] *See, e.g.*, WILLIAM L. MEGGINSON, CORPORATE FINANCE THEORY 226 (1997).

[21] For institutional details about financial options and their regulation, *see generally* Peter H. Huang, *A Normative Analysis of New Financially Engineered Derivatives*, 73 S. CAL. L. REV. 471 (2000); Roberta Romano, *A Thumbnail Sketch of Derivative Securities and Their Regulation*, 55 MD. L. REV. 1, 41-47 (1996). For the financial theory of and pricing models for stock options, *see generally* RICHARD A. BREALEY & STEWART C. MYERS, PRINCIPLES OF CORPORATE FINANCE 561-615 (7th ed. 2003); RICHARD A. BREALEY & STEWART C. MYERS, FINANCING AND RISK MANAGEMENT 181-208 (2003); JOHN C. COX & MARK RUBINSTEIN, OPTION MARKETS (1985); ESPEN GAARDER HAUG, THE COMPLETE GUIDE TO OPTION PRICING FORMULAS (1998); PETER RITCHKEN, OPTIONS: THEORY, STRATEGY, AND APPLICATIONS (1987); and SHELDON M. ROSS, AN INTRODUCTION TO MATHEMATICAL FINANCE: OPTIONS AND OTHER TOPICS (1999).

[22] *See, e.g.*, Peter H. Huang, *Teaching Corporate Law from an Option Perspective*, 34 GA. L. REV. 571 (2000) (providing a more detailed introduction about options). *See also*, JOHN D. AYER, GUIDE TO FINANCE FOR LAWYERS 325-248 (2001)

date it expires. An American option provides its owner with the right to exercise that option anytime before an including the date it expires. So, an American option provides it owner with all that a European option does and more. An option is at-the-money if the current price of the item equals the strike price. A call option is out-of-the-money (respectively, in-the-money) if the current price of the underlying item that the option is written on is less (respectively, greater) than its exercise price. Similarly, a put option is out-of-the-money (respectively, in-the-money) if the current price of the underlying item the option is written on is greater (respectively, less) than its exercise price.

The intrinsic value of a call (respectively, put) option is the difference between the current price of the underlying item that the option is written on and the strike price (respectively, the difference between the strike price and the current price of the underlying item that the option is written on). Even an option that is currently out-of-the-money has a positive (although possibly, very small) value because of its time value. The time value of an option will be positive (although possibly, very small) as long as the options has not yet expired because in the remaining time before its expiration, an option may finish in-the-money. It is of course true symmetrically that an option may finish out-of-the-money. But, because options do not require their owners to buy or sell the underlying items on which the options are written on, rational option holders will simply choose to not exercise options that are out-of-the-money. The option feature or nature of an option explains why intuitively an option always has a value that is non-negative, gross of the option premium.

Financial options permit decision-makers to hedge such financial types of risk as those arising from fluctuations in stock prices, interest rates, or currency rates.[23] Financial options are a type of state-contingent securities. Professor Kenneth J. Arrow, a recipient of the 1972 Nobel Prize in Economics, introduced the concept and theory of state-contingent securities in a paper

[23] *See generally*, Peter H. Huang, *Securities Price Risks and Financial Derivative Markets*, 21 NW. INT'L. L. & BUS. 589 (2001).

that he presented in 1952.[24] Many of today's exotic financial derivatives that Wall Street investment banks create, such as catastrophe bonds (whose payoffs are linked to such natural disasters as earthquakes and hurricanes) utilize Professor Arrow's work.[25] Professor Robert J. Shiller has proposed the creation of even more contingent securities markets to hedge aggregate income risks, home price risks, income distribution inequality risks, intergenerational risks, international risks, and livelihood risks.[26] Professor Stephen A. Ross proved that under certain assumptions, trading simple financial call and put options written on a single index of existing securities can realize any possible desired pattern of payoffs across contingencies and over time.[27]

Financial options have revolutionized modern financial markets by facilitating the reallocation of underlying financial market risks. The 1997 Nobel Prize in Economics recognized the path-breaking financial option pricing models of Professors Fisher Black, Robert C. Merton, and Myron S. Scholes.[28] Widely publicized huge losses from trading in financial options by such well-known corporations as Barrings Bank, Dell Computer, Gibson Greetings, and Procter & Gamble;[29] such municipalities as Orange County, California;[30] and such hedge

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[24] HAL R. VARIAN, INTERMEDIATE MICROECONOMICS: A MODERN APPROACH 219-20 (6th ed 2003).

[25] Kenneth Joseph Arrow, *Le Role des Valeurs Boursieres Pour la Repartition la Meillure des Risques*, 40 ECONOMETRIE COLLOQUES INTERNATIONAUX DU CENTRE NATIONAL DE LA RESERCHERCHE SCIENTIFIQUE 41 (1953), *translated in* Kenneth Joseph Arrow, *The Role of Securities in the Optimal Allocation of Risk Bearing*, 31 REV. ECON. STUD. 91 (1964).

[26] ROBERT J. SHILLER, MACRO MARKETS: CREATING INSTITUTIONS FOR MANAGING SOCIETY'S LARGEST ECONOMIC RISKS (1993) and ROBERT J. SHILLER, THE NEW FINANCIAL ORDER: RISK IN THE 21ST CENTURY (2003).

[27] Stephen A. Ross, *Options and Efficiency*, 90 QUART. J. ECON. 75, 84-86 (1976). *See also*, Fred Arditti & Kose John, *Spanning the State Space with Options*, 15 J. FIN. & QUANTITATIVE ANALYSIS 1 (1980) and Kose John, *Efficient Funds in a Financial Market with Options: A New Irrelevance Proposition*, 36 51 J. FIN. 685 (1981) (extending and generalizing Ross' theorem). *See also*, Rolf W. Banz & Merton H. Miller, *Prices for State-Contingent Claims: Some Estimates and Applications*, 51 J. BUS. 653 (1978) and Douglas T. Breeden & Robert H. Litzenberger, *Prices of State-Contingent Claims Implicit in Option Prices*, 51 J. BUS. 621 (1978) (applying Ross' theorem). *See generally*, Huang, *supra* note 21, at 477 (explaining the financial engineering implications of Ross' theorem).

[28] *See, e.g.*, Fischer Black & Myron S. Scholes, *The Pricing of Options and Corporate Liabilities*, 81 J. POL. ECON. 637 (1973) and Robert C. Merton, *Theory of Rational Option Pricing*, 4 BELL J. ECON. 141 (1973). *See also*, AYER, *supra* note 22, at 369-80 (providing an exposition for law students of the Black-Merton-Scholes option model and its application to equity pricing) and Robert A. Jarrow, *In Honor of the Nobel Laureates Robert C. Merton and Myron S. Scholes: A Partial Differential Equation That Changed the World*, 13 J. ECON. PERSP. 229 (1999) (explaining the many contributions and ramifications of Black-Merton-Scholes option pricing theory).

[29] Brandon Becker & Jennifer Yoon, *Derivative Financial Losses*, 21 J. CORP. L. 215 (1995).

funds as Long-Term Capital Management (LTCM);[31] illustrated the potential dangers from speculation in financial options.[32] These spectacular debacles generated two major government studies examining such financial derivatives as financial options.[33] Recently, many commentators have questioned whether incentive compensation in the form of executive stock options contributed to the series of corporate fraud and mismanagement scandals, and whether, and if so, how companies should expense their executive stock options.[34]

Real options involve decisions concerning activities whose risks have not been completely reduced to financial assets or financial commodities.[35] Real options are so named to differentiate them from such financial options as well-known executive stock options.[36] The phrase, real options, is utilized in corporate finance to refer to options that managers have in their investment projects, such as the option to abandon unprofitable projects;[37] alter capacity, output levels, or scale of operations; break up, divide, or partition investment opportunities; defer before (further) investing; switch inputs, outputs, or production methods; and grow from a pilot project.[38] Indeed, any dynamic investment opportunity presents a sequence of real options.[39] For example, business deal making negotiations entail numerous real options.[40]

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[30] PHILLIPE JORION, BIG BETS GONE BAD: DERIVATIVES AND BANKRUPTCY IN ORANGE COUNTY (1995).

[31] Franklin R. Edwards, *Hedge Funds and the Collapse of Long-Term Capital Management*, 13 J. ECON. PERSP. 189 (1999); ROGER LOWENSTEIN, WHEN GENIUS FAILED: THE RISE AND FALL OF LONG-TERM CAPITAL MANAGEMENT (2000); and NICHOLAS DUNBAR, INVENTING MONEY: THE STORY OF LONG-TERM CAPITAL MANAGEMENT AND THE LEGENDS BEHIND IT (2000).

[32] Peter H. Huang et al., *Derivatives on TV: A Tale of Two Derivatives Debacles in Prime-Time*, 4 GREEN BAG 2d. 257 (2001).

[33] Financial Derivatives: Market Overview and Supervisory Concerns, A Report prepared by the House Banking Committee Minority Staff, Nov. 1993 and Financial Derivatives: Actions Needed to Protect the System, U.S. General Accounting Office, May 18, 1994

[34] *See, e.g.*, FRANK PARTNOY, INFECTIOUS GREED: HOW DECEIT AND RISK CORRUPTED THE FINANCIAL MARKETS 156-60 (2003).

[35] Stewart C. Myers, *Determinants of Corporate Borrowing*, 5 J. FIN. ECON. 147 (1977) (coining the phrase "real options").

[36] *See* Don M. Chance, *A Derivative Alternative as Executive Compensation*, Mar./Apr. FIN. ANALYSTS J. 6 (1997) (questioning the ability of executive stock options, at least as they are typically granted, to align the interests of executives with those of shareholders) and RON S. DEMBO & ANDREW FREEMAN, THE RULES OF RISK: A GUIDE FOR INVESTORS, 207-22 (1998) (discussing the possibly unexpected and perverse incentive effects of utilizing stock options in employee compensation).

[37] AYER, *supra* note 22, at 359-67.

[38] *See generally*, BRACH, *supra* note 13, at 67-103; BREALEY & MYERS, *supra* note 18, at 616-41; DIXIT & PINDYCK, *supra* note 18, at 6-25; and TRIGEORGIS, *supra* note 18, at 1-4, 9-20, and 121-50 (1996).

In describing a generic decision-making setting, the phrase real option implies that options theory is applicable to analyzing the sequential choices that are inherent in such a dynamic and uncertain environment. Real options have a fascinating history.[41] Familiar (and perhaps, some unfamiliar) examples of real options include the options to: abandon, perhaps temporarily (i.e. mothball) a project;[42] become delinquent in property tax payments;[43] breach a contract and pay liquidated or expectation damages;[44] build or develop real estate property versus delaying construction;[45] continue with education;[46] declare corporate or personal bankruptcy;[47] delay a project;[48] dissolve a business arrangement, marital or corporate union, merger, partnership, or any other form of on-going or steady relationship;[49] drill, develop, or start production from oil wells;[50] engage in venture capital start-up investing;[51] exchange one asset for another;[52] heat new construction with electricity, heating oil, or natural gas;[53] lease airplanes,

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[39] *See, e.g.*, Frank T. Magiera & Robert A. McLean, *Strategic Options in Capital Budgeting and Program Selection under Fee-For-Service and Managed Care*, 21 HEALTH CARE MGMT. REV. 7 (1996) (explaining how to apply real options analysis to healthcare management).

[40] *See generally* RICHARD RAZGAITIS, DEALMAKING USING REAL OPTIONS AND MONTE CARLO ANALYSIS (2003) (introducing a real options approach to valuing and negotiating business projects).

[41] BRACH, *supra* note 13, at 13-15.

[42] Brennan & Schwartz, *supra* note 18; Stewart C. Myers & Saman Majd, *Abandonment Value and Project Life*, 4 ADVANCES IN FUTURES AND OPTIONS RESEARCH 1 (1990).

[43] Brendan O'Flaherty, *The Option Value of Tax Delinquency: Theory*, 28 J. URBAN ECON. 287 (1990).

[44] Mahoney, *supra* note 17.

[45] *See, e.g.*, Paul D. Childs et al., *Mixed Uses and the Redevelopment Option*, 24 REAL ESTATE ECON. 317 (1996); David Geltner, *On the Use of the Financial Option Price Model to Value and Explain Vacant Urban Land*, 17 AM. REAL ESTATE & URBAN ECON. ASSOC. J. 142 (1989); Steven R. Grenadier, *The Strategic Exercise of Options: Development Cascades and Overbuilding in Real Estate Markets*, 51 J. FIN. 1653 (1996); and Sheridan Titman, *Urban Land Prices under Uncertainty*, 75 AM. ECON. REV. 505 (1985).

[46] Uri Dothan & Joseph Williams, *Education as an Option*, 54 J. BUS. 117 (1981).

[47] Douglas G. Baird & Edward R. Morrison, *Bankruptcy Decision Making*, 24 J. L. ECON. & ORG. 356, 358-66 (2001).

[48] Jonathan E. Ingersoll, Jr. & Stephen A. Ross, *Waiting to Invest: Investment and Uncertainty*, 65 J. BUS. 1 (1992) and Saman Majd & Robert S. Pindyck, *Time to Buiild, Option Value, and Investment Decisions*, 18 J. FIN. ECON. 7(1987).

[49] Dixit, *supra* note 18, at 127 & n.13.

[50] *See, e.g.*, Jeff Strnad, Taxes and Nonrenewable Resources: The Impact on Exploration and Development (unpublished manuscript, July 1996) (analyzing the effects of tax laws on the last three options).

[51] Pascal Botteron & Jean-Francois Casanova, Start-ups Defined as Portfolios of Embedded Options, International Center for Financial Asset Management and Engineering Research Paper No. 85 (May 2003) (unpublished manuscript, on file with the author).

[52] William Margrabe, *The Value of an Option to Exchange One Asset for Another*, 33 J. FIN. 177 (1978).

[53] BRACH, *supra* note 13, at 7-8. *See also*, Nalin Kulatilaka, *The Value of Flexibility: The Case for a Dual-Fuel*

assets, copiers, power plants, real estate, satellites, trucks, or zoo animals;[54] maintain academic employment under faculty tenure;[55] make a movie from a script and follow-up sequels if the original movie is a box office success;[56] purchase assets, items, or properties;[57] threaten to employ fewer workers if a firm has a flexible production technology;[58] throw away food obtained from an all-you-care-to-eat buffet or freely dispose of items generally; try predatory pricing or to leverage monopoly power in one market into monopoly power in another market;[59] and utilize (export or import) quota licenses.[60]

Real options theory applies financial option pricing models to derive qualitative, if not (yet) quantitative, estimates of real option values.[61] Continuous time quantitative option pricing models usually assume that the stochastic process of underlying asset price risks is represented by geometric Brownian motion with drift.[62] While such a distributional assumption does not describe litigation generally, other discrete time quantitative option pricing models, such as the binomial or two state option pricing model, may approximately describe a particular lawsuit.[63] More generally, qualitative as opposed to quantitative option valuation models apply to litigation

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Industrial Steam Boiler, 22 FIN. MGMT. 271 (1993) (explaining the value of an industrial facility which can be fueled by gas or oil).

[54] *See, e.g.*, Steven R. Grenadier, *Valuing Lease Contracts: A Real-Options Approach*, 38 J. FIN. ECON. 297 (1995) and Stephen E. Miller, *Economics of Automobile Leasing: The Call Option Value*, 29 J. CONSUMER AFFAIRS 199 (1995).

[55] John G. McDonald, *Faculty Tenure as a Put Option: An Economic Interpretation*, 55 SOC. SCI. QUART. 362 (1974).

[56] ZIV BODIE & ROBERT C. MERTON, FINANCE 448-50 (2000).

[57] *See, e.g.*, John E. Stonier, *What is an Aircraft Purchase Option Worth? Quantifying Asset Flexibility Created Through Manufacturer Lead-Time Reductions and Product Commonality*, *in* HANDBOOK OF AIRLINE FINANCE 231 (Gail F. Butler & Martin R. Keller eds., 1999).

[58] Nalin Kulatilaka & Stephen Gary Marks, *The Strategic Value of Flexibility: Reducing the Ability to Compromise*, 78 AM. ECON. REV. 574 (1988).

[59] Peter H. Huang, *Still Preying on Strategic Reputation Models of Predation, A Review of John R. Lott, Jr., Are Predatory Commitments Credible? Who Should the Courts Believe?* 3 GREEN BAG 2D. 437, 442-43 (2000).

[60] James E. Anderson, *Quotas as Options: Optimality and Quota License Pricing under Uncertainty*, 23 J. INT'L. ECON. 21 (1987).

[61] MEGGINSON, *supra* note 20, at 292 n.42 (1997).

[62] *See, e.g.*, J. MICHAEL STEELE, STOCHASTIC CALCULUS AND FINANCIAL APPLICATIONS 29-40 (2001) and LARS TYGE NIELSEN, PRICING AND HEDGING OF DERIVATIVE SECURITIES 13 (1999).

[63] AYER, *supra* note 22, at 349-58; COX & RUBINSTEIN, *supra* note 21, at 166-85; James Cox, Stephen A. Ross, & Mark Rubinstein, *Option Pricing: A Simplified Approach*, 7 J. FIN. ECON. 229 (1979) and Richard J. Rendleman & Brit J. Barter, *Two-State Option Pricing*, 34 J. FIN. 1093 (1979).

abandonment options because qualitative option valuation models do not make any distributional assumptions regarding the stochastic process of underlying risks.[64] Qualitative option valuation models provide upper and lower bounds for option values.[65]

The rest of this Article is organized as follows. Part I of this Article introduces the options approach to litigation, including quite possibly, frivolous litigation. This part of the Article explains that (possibly, frivolous) lawsuits will be filed and settled when their embedded abandonment option values exceed the costs of purchasing those litigation abandonment options. Part II of this Article addresses limitations of a real abandonment options game-theoretic model of litigation.[66] In particular, there is reason to believe that people have cognitive limitations in their ability to reason backwards in sequential games.[67] There is also empirical and experimental evidence that emotions affect how people make decisions.[68] Finally, recent psychological experiments indicate that decision makers often overvalue options and over-invest in keeping options alive, even if those options present little intrinsic value.[69] Part III of this Article demonstrates how and why a real options viewpoint alters the standard negligence "calculus" of tort law as captured by the Hand rule. Finally, part III of this Article demonstrates that many laws and judicial doctrines effectively preclude specific real options in legal settings. These include the collateral estoppel, res judicata, judicial minimalism, and family law statutes imposing conditions on marriage or divorce.

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[64] *See, e.g.*, John C. Cox & Stephen A. Ross, *A Survey of Some New Results in Financial Option Pricing Theory*, 31 J. FIN. 383, 384-89 (1987) (presenting option pricing results that are distribution and preference free).

[65] Merton, *supra* note 28, at 142-60 (deriving restrictions on option pricing formulae based upon the assumption that investors prefer more wealth to less wealth) and Hal R. Varian, *The Arbitrage Principle in Financial Economics*, J. ECON. PERSP. 55, 62-64 (1987) (deriving bounds for option prices based upon the no-arbitrage condition).

[66] *See also*, VOLLERT, *supra* note 14, at 42-44 (discussing drawbacks to real options analysis in general).

[67] *See, e.g.*, Robert Rosenthal, *Games of Perfect Information, Predatory Pricing and the Chain-Store Paradox*, 25 J. ECON. THEORY 92 (1981).

[68] *See, e.g.*, Wilco W. van Dijk et al., *Emotional Reactions to the Outcomes of Decisions: The Role of Counterfactual Thought in the Experience of Regret and Disappointment*, 75 ORG. BEHAV. & HUMAN DECISION PROCESSES 117 (1998).

[69] Jiwoong Shin & Dan Ariely, Keeping Doors Open: The Effect of Unavailability on Incentives to Keep Options Viable, presented at the Society for the Advancement of Behavioral Economics (July 31, 2003) (unpublished manuscript, on file with the author).

I. (Possibly, Frivolous) Litigation Option Games

A litigation explosion is merely a descriptive phrase, devoid of any particular normative content. Legal sociologist Professor Marc Galanter argued that an explosion in litigation is not only foreseeable, but also socially desirable.[70] But, Walter Olson, a senior fellow of the Manhattan Institute, argued that an explosion in litigation is both man-made and socially undesirable.[71] Although the quantity of litigation in the United States in comparison with other countries and over time has always been a subject of much debate and controversy, there is a more recent and related but more specific concern regarding the nature or quality of litigation in particular areas, including medical malpractice, product liability lawsuits, derivative shareholder lawsuits, so-called strike lawsuits, and nuisance lawsuits in general.[72] Many legal and social commentators feel that America is and has been experiencing an explosion in frivolous litigation.

An explosion in frivolous litigation is not normatively neutral. A perceived rise in frivolous lawsuits alleging securities fraud was a major impetus for California's Proposition 211 and the provisions imposing strict pleading requirements contained in the Private Securities Litigation Reform Act of 1995, which Congress enacted over President Clinton's veto.[73] The politics of American litigation reform and specific anti-litigation campaigns is an interesting reflection of American culture, history, and society that is beyond the scope of this Article.[74]

Whether there has been such a frivolous litigation explosion is a descriptive and historical question, which is empirically challenging to resolve because nearly all lawsuits settle with many of the settlements often involving confidentiality agreements. But, positive theoretical

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[70] Marc Galanter, *The Day After the Litigation Explosion*, 46 MD. L. REV. 3, 38 (1986).
[71] WALTER K. OLSON, THE LITIGATION EXPLOSION: WHAT HAPPENED WHEN AMERICA UNLEASHED THE LAWSUIT (1991) and WALTER K. OLSON, THE RULE OF LAWYERS: HOW THE NEW LITIGATION ELITE THREATENS AMERICA'S RULE OF LAW (2003).
[72] *See, e.g.*, REGULATION THROUGH LITIGATION (W. Kip Viscusi ed., 2002).
[73] Pub. L. No. 104-67, 109 Stat. 737 (1995); the strict pleading requirements are codified at 15 U.S.C. §78u-4(b)(2).
[74] *See generally*, THOMAS F. BURKE, LAWYERS, LAWSUITS, AND LEGAL RIGHTS: THE BATTLE OVER LITIGATION IN AMERICAN SOCIETY (2002).

economics can provide insights to frivolous litigation by providing analytical, formal, rigorous, and systematic models.[75] What procedural and/or substantive reforms would reduce frivolous litigation is a normative question, which raises difficult concerns involving procedural fairness, both outcome-based and process-based, in addition to questions regarding the nature and limits of substantive rights. But, normative theoretical economics can help answer this question by identifying and comparing the various error and process costs of alternative reforms.[76] The rest of this part of the Article first analyzes models of litigation in general and then analyzes models of frivolous litigation in particular.

A. Models of Litigation

The application of microeconomics to litigation has a distinguished and relatively long history in the field of law and economics.[77] There also is a rich literature analyzing civil procedure utilizing microeconomics.[78] Three path-breaking models set the standard for the formal economic analysis of the settlement of litigation.[79] First, Professor William Landes explained why most criminal cases involve negotiated sentences instead of trial.[80] Second, Professor Richard Posner explained why the FTC and other administrative agencies settle most regulatory disputes via out-of-court settlements.[81] Third, Professor John Gould explained why

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[75] *See, e.g.*, A. Mitchell Polinsky & Daniel L. Rubinfeld, *Sanctioning Frivolous Suits*, 82 GEO. L.J. 397, 426-35 (1993) (providing a formal economic model of how optimally to sanction frivolous lawsuits).

[76] *See, e.g.*, ROBERT G. BONE, CIVIL PROCEDURE: THE ECONOMICS OF CIVIL PROCEDURE 125-57 (2003).

[77] For excellent surveys of this literature, see Cooter & Rubinfeld, *supra* note 113; ROBERT D. COOTER & THOMAS S. ULEN, LAW AND ECONOMICS, 388-444 (4th ed. 2004); Bruce L. Hay & Kathryn E. Spier, *Settlement of Litigation*, *in* 3 THE NEW PALGRAVE DICTIONARY OF ECONOMICS AND THE LAW 442 (Peter Newman ed., 1998); and Steven Shavell, *Basic Theory of Litigation*, in FOUNDATIONS OF ECONOMIC ANALYSIS OF LAW (forthcoming, 2003).

[78] *See, e.g.*, John M. Olin Program in Law and Economics Conference on Economic Analysis of Civil Procedure 23 J. LEGAL STUD. 303 (1994) (providing a representative selection of such research).

[79] THOMAS J. MICELI, ECONOMICS OF THE LAW: TORTS, CONTRACTS, PROPERTY, LITIGATION 156-80 (1997) (providing an excellent mathematical exposition of the economics of litigation and settlement). *See also*, COOTER & ULEN, *supra* note 77, at 413-17 (providing a less technical exposition of an economic theory of settlement bargaining).

[80] William M. Landes, *An Economic Analysis of the Courts*, 14 J.L. & ECON. 61 (1971).

[81] Richard A. Posner, *An Economic Approach to Legal Procedure and Judicial Administration*, 2 J. LEGAL STUD. 399 (1973).

most civil cases are settled before trial.[82] The Landes-Posner-Gould (LPG) single-person decision theory expected value approach to settlement of litigation culminated in Professor Steven Shavell's model comparing the incentives to sue and settle under the American and British rules for allocating legal costs.[83] Some legal practitioners utilize the powerful tools of single-person decision theory and risk analysis to help facilitate the settlement of their clients' legal disputes.[84]

The standard approach in law and economics models to how people deal with risk is to assume that legal decision-makers maximize their expected utilities of wealth. This general assumption is often then reduced to assuming that legal decision-makers maximize the net present discounted values of their expected wealth levels. In other words, neoclassical models assume that legal decision-makers have as their utility function over wealth, the net present discounted value of wealth. This can be more accurately termed an expected value of wealth approach to risk.

An expected value approach to the risks in litigation is appropriate if legal decision-makers in litigation were locked into their initial decisions. What an expected value approach to risks ignores are the opportunities to make future choices after learning more concerning the payoff-relevant risks. In the lawsuit context, an expected value approach neither incorporates, nor reflects the value of the flexibility provided by a plaintiff's options to abandon litigation after learning unfavorable information regarding the legal merits of her case. The values of the abandonment real options embedded within litigation lead to qualitatively different implications concerning the incentives to sue, settle, or go to trial than under the usual expected value approach to lawsuits and can be quite large quantitatively.

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[82] John P. Gould, *The Economics of Legal Conflicts*, 2 J. LEGAL STUD. 279 (1973).

[83] Steven Shavell, *Suit, Settlement, and Trial: A Theoretical Analysis under Alternative Methods for the Allocation of Legal Costs*, 11 J. LEGAL STUD. 55 (1982).

[84] *See, e.g.*, David P. Hoffer, *Decision Analysis as a Mediator's Tool*, 1 HARV. NEGOTIATION L. REV. 113 (1996); Marjorie C. Aaron, *The Value of Decision Analysis in Mediation Practice*, 11 NEGOTIATION J. 123-33 (1995); and Marc B. Victor, *The Proper Use of Decision Analysis to Assist Litigation Strategy*, 40 BUS. LAWYER 617 (1985).

Professor Bradford Cornell was the first scholar to observe that plaintiffs have options to drop a lawsuit before incurring the cost of a full blown trial.[85] Professor Cornell showed the option to drop a lawsuit increases the expected payoff to a lawsuit and hence the incentive to file a lawsuit. Professor Cornell's analysis extends the LPG model in which litigation decisions were based solely on the (present discounted) value of a lawsuit's costs and expected benefits by introducing an explicit options approach to litigation. William J. Blanton applied Cornell's insights to evaluate the impact on a plaintiff's incentive to file a lawsuit of changes in evidentiary rules.[86] In particular, Blanton focuses on changes in the admissibility of expert scientific testimony resulting from the Supreme Court's decision in *Daubert v. Merrell Dow Pharmaceuticals, Inc*.[87] Blanton identified four principal ways in which any evidentiary, procedural, or substantive rule (or change in a rule) can reduce the value of a plaintiff's option to unilaterally drop litigation, namely: 1) increasing plaintiff's litigation costs; 2) front-loading plaintiff's litigation costs; 3) enhancing trial precision; and 4) obfuscating plaintiff's ability to predict a trial outcome.[88] Frederick Dunbar, et al. provided an options-based approach to nuisance lawsuits; plaintiffs' attorneys' behavior under contingent fee arrangements in securities litigation; securities litigation reform; and testable hypotheses about observed settlements in shareholder class actions.[89]

Professor Peter H. Huang introduced an options model of contingency multipliers for attorneys' fees in public interest and civil rights litigation.[90] Professor Steven Shavell raised a set of related concerns in his affidavit for a civil rights case where attorney's fees were hotly

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[85] Bradford Cornell, *The Incentive to Sue: An Option-Pricing Approach*, 19 J. LEGAL STUD. 173 (1990).
[86] William J. Blanton, *Reducing the Value of Plaintiff's Litigation Option in Federal Court: Daubert v. Merrell Dow Pharmaceuticals,, Inc.*, 2 GEO. MASON U. L. REV. 159 (1995).
[87] 113 S. Ct. 2786 (1993).
[88] Blanton, *supra* note 86, at 160-61; 182-90.
[89] Frederick C. Dunbar et al., Shareholder Litigation: Deterrent Value, Merits and Litigants' Options, John M. Olin School of Business, Washington University Working Paper 95-07-a 26-30 (1995).
[90] Peter H. Huang, *A New Options Theory for Risk Multipliers of Attorney's Fees in Federal Civil Rights Litigation*, 73 N.Y.U. L. REV. 1943 (1998).

contested.[91] But, Professor Shavell did not frame his argument explicitly in terms of the language of a real options approach to litigation. Also related are Professor Huang's proposal to incorporate real options in (teaching) corporate law;[92] and Professor Huang's suggestion advocating a real options approach to understanding why a firm could rationally choose to engage in predatory pricing.[93]

Professor Lucian Bebchuk provided a theory of NEV lawsuits where threats to go to trial are credible due to divisibility over time of plaintiffs' litigation costs.[94] The real options model of litigation in this Article differs from Professor Bebchuk's model because in his model litigants face certainty over expected trial outcomes and legal fees, while litigants in this Article's model face uncertainty over expected judgments and/or litigation costs. The plaintiffs in the model of this Article have opportunities to not only learn about expected judgments and/or litigation costs during the litigation process, but also to drop litigation conditional on information they learn during the course of that litigation. The divisibility of legal costs also forms the basis for Professor William Landes' model of unitary versus sequential trials.[95] Professor Landes demonstrated that bifurcating liability and damages reduces expected litigation costs (because there is no need to litigate damages if there is no liability), which in turn increases the incentives to sue and the minimum acceptable settlement as well as decreases the maximum settlement offer.

There is a vast literature about optimal sequential decision-making, both for single-person decision-makers playing against (probabilistic laws of) nature and for multi-person decision-

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[91] Affadavit of Steven M. Shavell, *In re Burlington Northern, Inc., Employment Practices Litigation*, Nos. MDL 374, 78 C269, 1985 WL 1808 (N.D. Ill. May 31, 1985).
[92] Huang, *supra* note 17, at 593-96 (2000).
[93] Huang, *supra* note 59.
[94] Lucian A. Bebchuk, *A New Theory Concerning the Credibility and Success of Threats to Sue*, 25 J. LEGAL STUD. 1 (1996).
[95] William M. Landes, *Sequential Versus Unitary Trials: An Economic Analysis*, 22 J. LEGAL STUD. 99 (1993). *See also*, DOUGLAS G. BAIRD, GAME THEORY AND THE LAW 251-60 (1994) (extending Landes' model to cases where litigants possess unverifiable information) and William M. Landes, *Sequential and Bifurcated Trials*, *in* 3 THE NEW PALGRAVE DICTIONARY OF ECONOMICS AND THE LAW 438 (Peter Newman ed., 1998) (discussing the sequential nature of litigation).

makers playing against each other in a so-called game. A lawsuit is more accurately described by a multi-person decision-making environment or game than by a single-person decision-making environment because of the interactive nature of litigation. Scholars have applied multi-person decision theory or game theory to analyze settlement negotiations in litigation.[96] Game theory's origins date back at least two thousand and five hundred years and can be found in classic Chinese philosophical texts.[97] Multi-person decision theory, as it is more accurately described, is a branch of applied mathematics,[98] having numerous applications in biology,[99] economics,[100] everyday life,[101] management,[102] and politics.[103] It has become standard practice to apply game theory to analyze legal rules and institutions.[104] The programs of the annual meetings of the American Law and Economics Association since its inception in 1991 document how pervasive game-theoretic models have become in legal scholarship. Additional proof of the acceptance of game-theoretic reasoning in the legal scholar's toolkit is found in the pages of the five law and economics journals.[105] Finally, game theory played a crucial role in designing the Federal Communications Commission (FCC) auctions for assigning licenses to wavelengths for such personal communication services as cell phones and wireless computer access services. Professor John McMillan provides an excellent account of this case study in the success of modern game theory applied to policy.[106] He explains how the features of the auction format the

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[96] *See, e.g.*, ROBERT H. MNOOKIN ET AL., BEYOND WINNING: NEGOTIATING TO CREATE VALUE IN DEALS AND DISPUTES 106-26 (2000).
[97] *See, e.g.*, SUN TZU, THE ART OF WAR (140 - 118 B.C).
[98] *See, e.g.*, HAROLD W. KUHN, LECTURES ON THE THEORY OF GAMES (2003).
[99] *See, e.g.*, JOHN MAYNARD SMITH, EVOLUTION AND THE THEORY OF GAMES (1982).
[100] *See, e.g.*, AVINASH DIXIT & SUSAN SKEATH, GAMES OF STRATEGY (1999).
[101] *See, e.g.*, AVINASH DIXIT & BARRY NALEBUFF, THINKING STRATEGICALLY: THE COMPETITIVE EDGE IN BUSINESS, POLITICS, AND EVERYDAY LIFE (1991).
[102] *See, e.g.*, JOHN MCMILLAN, GAMES, STRATEGIES, AND MANAGERS (1992).
[103] *See, e.g.*, JAMES D. MORROW, GAME THEORY FOR POLITICAL SCIENTISTS (1994).
[104] *See, e.g.*, Peter H. Huang, *Strategic Behavior and the Law: A Review of* GAME THEORY AND THE LAW *and A Guide to Game Theory for Legal Scholars*, 36 JURIM. J.L. SCI. & TECH. 99 (1995) (providing a review of this book and an annotated tour of many other leading game theory texts).
[105] AM. L. ECON. REV., J.L. & ECON., J. LEGAL STUD., INT'L REV. L. & ECON., and J.L. ECON. & ORG.
[106] John McMillan, *Selling Spectrum Rights*, 8 J. ECON. PERSP. 145 (1994). *See also*, John McMillan, *Market Design: The Policy Uses of Theory*, 93 AM. ECON. REV. 139, 139-42 (2003) (discussing other successful applications of modern sophisticated game theory to the optimal design of economic policy).

FCC essentially adopted were those that were proposed by Professors Preston McAfee, Paul R. Milgrom and Robert Wilson and experimentally tested by Professor Charles Plott.[107] As Professor McMillan stated, "[w]hen the theorists met the policy-makers, concepts like Bayes-Nash equilibrium, mechanism design, incentive-compatibility constraints, and order-statistic theorems came to be discussed in the corridors of power."[108]

B. Models of Frivolous Litigation

Both the positive and normative analysis of frivolous litigation depends on the definition of frivolous litigation. Defining a frivolous lawsuit is more complicated than one might initially think. Professor Robert Bone thoughtfully discusses the problems in defining frivolous litigation.[109] An obvious definition of a frivolous lawsuit is a case in which the plaintiff does not expect initially to prevail at trial. In other words, the plaintiff of a frivolous lawsuit suffered no legally recoverable damages because she either suffered no harm or if she did suffer harm, she cannot recover for them from the defendant, under existing legal precedent. Her case lacks any legal merit because her expected judgment from proceeding to a trial is zero.

A more inclusive approach to defining frivolous litigation includes cases involving a plaintiff lacking the credibility to go to trial. In other words, frivolous litigation can be defined as litigation where the expected judgment is greater than zero, but still remains less than the plaintiff's costs of proceeding to trial. Such negative expected value (NEV) litigation appears to be irrational for plaintiffs to file and for defendants to settle. But, such a comprehensive

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[107] Paul R. Milgrom, *Game Theory and the Spectrum Auctions*, 42 EUR. ECON. REV. 771 (1998) and PAUL R. MILGROM, PUTTING AUCTION THEORY TO WORK (2003).

[108] *Id.* at 146. *See generally* DAVID M. KREPS, GAME THEORY AND ECONOMIC MODELLING (1987) (presenting a non-technical introduction to the strengths and weaknesses of non-cooperative (asymmetric information) game theory). *But see*, Robert J. Aumann, *What is Game Theory Trying to Accomplish?*, *in* FRONTIERS OF ECONOMICS (Kenneth J. Arrow & Seppo Honkapohja eds., 1987) (questioning whether the goal of game theory is or should be prediction); and ARIEL RUBINSTEIN, *The Rhetoric of Game Theory*, *in* ECONOMICS AND LANGUAGE 71-88 (2000) (doubting the practical applicability of game theory).

[109] BONE, *supra* note 76, at 41-43 and Robert G. Bone, *Modeling Frivolous Suits*, 145 U. PA. L. REV. 519, 529-33 (1997).

definition of frivolous litigation as NEV litigation includes cases which seek to establish new legal theories that differ from existing legal precedent. Many people, including the author of this Article, believe and feel that novel test cases in such legal areas as civil rights actions, e.g. subconscious gender discrimination or unconscious racial discrimination, should not be considered as frivolous litigation.

Professor Bone decides to define a frivolous lawsuit as one for which a plaintiff either: (1) actually knows the case completely (or virtually completely) lacks any merit under the legal theories being alleged; or (2) fails to conduct a reasonable investigation before filing, where had a plaintiff conducted a reasonable investigation before filing, the lawsuit would have been frivolous under the first prong of this definition.[110] This definition of frivolous litigation differs from negative expected value litigation, where the total costs of litigation exceed the expected value of judgment at trial. As Professor Bone details, positive net expected value litigation explanations of frivolous litigation are unconvincing.[111]

A number of law and economics models address the dual questions of why plaintiffs file frivolous lawsuits and why defendants agree to settle frivolous lawsuits.[112] Existing models demonstrate that frivolous litigation can be credible if litigants possess different probability estimates of the plaintiff prevailing at trial;[113] courts make legal errors;[114] parties' litigation costs are incurred sequentially;[115] asymmetries exist between litigants in the size or timing of litigation costs;[116] plaintiffs have private information concerning their cases;[117] or plaintiffs have the

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[110] BONE, *supra* note 76, at 43 and Bone, *supra* note 109, at 533.

[111] BONE, *supra* note 76, at 44-45 and Bone, *supra* note 109, at 534-37.

[112] For excellent summaries of economic analyses of frivolous lawsuits, see Lucian A. Bebchuk, *Suits with Negative Expected Value*, *in* 3 THE NEW PALGRAVE DICTIONARY OF ECONOMICS AND THE LAW 551 (Peter Newman ed., 1998); BONE, *supra* note 76, at 20-68; Bone, *supra* note 109, at 534-77; MICELI, *supra* note 79, at 181-200 (1997); Eric B. Rasmusen, *Nuisance Suits*, *in* 2 THE NEW PALGRAVE DICTIONARY OF ECONOMICS AND THE LAW 690-93 (Peter Newman ed., 1998); and Steven Shavell, *Extensions of the Basic Theory of Litigation*, in FOUNDATIONS OF ECONOMIC ANALYSIS OF LAW (forthcoming 2003).

[113] Robert D. Cooter & Daniel L. Rubinfeld, *Economic Analysis of Legal Disputes and Their Resolution*, 27 J. ECON. LIT. 1067, 1083-84 (1989).

[114] Keith N. Hylton, *Costly Litigation and Legal Error Under Negligence*, 6 J.L. ECON. & ORG. 433, 441 (1990).

[115] Bebchuk, *supra* note 94.

[116] David Rosenberg & Steven Shavell, *A Model in which Suits Are Brought for Their Nuisance Value*, 5 INT'L REV.

ability to (pre)commit to litigation, e.g. by having lawyers on retainer and paying for legal services in advance, whether or not plaintiffs undertake litigation to a trial.[118]

The questions of why a plaintiff would choose to file a frivolous lawsuit and why a defendant would agree to settle a frivolous lawsuit are troublesome both intellectually and practically. Asymmetric information game-theoretic models answer both questions, but as the phrase asymmetric information suggests, these models assume that just one side of the litigation realizes the litigation is frivolous.[119] In other words, either the plaintiff or the defendant knows her or his actual type (frivolous or non-frivolous plaintiff or defendant) and there is no credible mechanism for communication or truthful revelation of such private information besides litigation. The 2001 Nobel Prize in Economics recognized the pioneering research and seminal concepts in the economics of asymmetric information due to Professors George Akerlof, Andrew Michael Spence, and Joseph E. Stiglitz.[120] Such concepts as lemons, pooling, separation, and signaling games play crucial roles in asymmetric information game-theoretic models of frivolous litigation.[121]

This Article allows for the realistic possibility that initially neither side of the litigation knows whether they are part of a frivolous lawsuit or perhaps more importantly the possibility that initially neither side of the litigation knows for certain whether a court will hold they are part of a frivolous lawsuit. For example, medical malpractice plaintiffs often file a lawsuit in part from a motivation to find out what really happened with a medical procedure that went awry.

L. & ECON. 3 (1985).

[117] Avery Katz, *The Effect of Frivolous Litigation on the Settlement of Legal Disputes*, 10 INT'L REV. L. & ECON. 3 (1990).

[118] HERBERT GINTIS, GAME THEORY EVOLVING: A PROBLEM-CENTERED INTRODUCTION TO MODELING STRATEGIC INTERACTION 100-02 (2000).

[119] BONE, *supra* note 76, at 54 and Bone, *supra* note 109, at 542, 598-99.

[120] *See, e.g.*, George Akerlof, *The Market for Lemons: Qualitative Uncertainty and the Market Mechanism*, 84 QUART. J. ECON. 488 (1970); A. Michael Spence, *Job Market Signaling*, 87 QUART. J. ECON. 355 (1973); and Michael Rothschild & Joseph E. Stiglitz, *Equilibrium in Competitive Insurance Markets: An Essay in the Economics of Imperfect Information*, 80 QUART. J. ECON. 629 (1976).

[121] BONE, *supra* note 76, at 59-64 and Bone, *supra* note 109, at 552-66.

Although doctors would indeed know whether they operated negligently, they may still be unsure as to whether an empathetic jury will nonetheless find in favor of a sympathetic plaintiff.

The model in the appendix of this Article captures litigation that is only possibly frivolous despite having negative initial expected value. The adjective possibly reflects the realistic feature of litigation that during its course or process, litigants and their attorneys revise their expected values to and expected costs of proceeding to a trial. In other words, parties and their lawyers will only learn if a lawsuit is frivolous after the lawsuit commences. Frivolous litigation is not rational for plaintiffs to file and for defendants to settle if litigation costs are incurred up front, all-at-once or if the expected value of litigation does not change over the course of litigation. But, possibly frivolous litigation can be rational for plaintiffs to file and for defendants to settle if litigation costs are incurred sequentially and if the expected value of litigation changes over the course of litigation.

This Article develops a new theory of the conditions under which (possibly, frivolous) litigation is credible for plaintiffs to file and for defendants to settle.[122] This novel theory of (possibly, frivolous) litigation is based upon two central features of litigation. The first aspect of litigation is that once a plaintiff makes the initial decision to file a lawsuit, that plaintiff faces a sequence of additional decisions about whether to drop that lawsuit. State and federal rules of civil procedure provide parties to a lawsuit with specific opportunities to make further decisions at various points during litigation. A by-product of state and federal rules of civil procedure is they naturally divide a lawsuit into a series of stages, at each of which plaintiffs and their attorneys have unilateral options to abandon the litigation.

The second feature of litigation is that parties and their attorneys learn information concerning their litigation over the course of that litigation. An important benefit of acquiring information to a decision-maker is the opportunity to make additional choices after obtaining that information. Such potentially valuable opportunities are precisely what decision-makers gain

[122] *See infra* Appendix, proposition 1.

from having options.[123] This central and fundamental insight underlies Professors C. Frederick Beckner and Steven Salop's multi-stage decision model of sequential legal procedure, which computes the optimal standards of summary disposition (those minimizing the sum of information and error costs) and the optimal sequence of legal and factual issues which a court should take up;[124] Professor Landes' model about when a court should hold separate trials for liability versus damages as opposed to a unified trial which considers both issues;[125] and Professor Warren F. Schwartz's demonstration that separating determinations of damages from determinations of liability could reduce litigation costs.[126]

This Article fills a niche in the literature about (possibly, frivolous) litigation.[127] This Article demonstrates how to harmoniously blend a real options approach to lawsuits with a strategic approach to pre-trial settlement bargaining. The analytical model in the appendix of this Article builds upon and combines two major influences. The first is research about real options, both in law and more generally, in strategic management. The second is the literature consisting of game-theoretic models of litigation. The model in the appendix of this Article integrates these related, but distinct strands of the literature about litigation into a unified game-theoretic real options model of litigation. Strategic real options models have only recently begun to appear in the financial and management literatures.[128] These models can become quite mathematically complicated rather quickly.[129]

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[123] Ronald A. Howard, *Options*, *in* WISE CHOICES: DECISIONS, GAMES, AND NEGOTIATIONS 81 (Richard J. Zeckhauser, et al. eds., 1996).

[124] C. Frederick Beckner, III & Steven C. Salop, *Decision Theory and Antitrust Rules*, 67 ANTITRUST L. J. 41 (1999).

[125] Landes, *supra* note 95.

[126] Warren F. Schwartz, *Severance - A Means of Minimizing the Role of Burden and Expense in Determining the Outcome of Litigation*, 20 VAND. L. REV. 1197 (1967).

[127] Bone, *supra* note 109, at 542 n.81 (noting that existing options approach to litigation fails to incorporate strategic interaction between litigants).

[128] *See generally*, BRACH, *supra* note 13, at 33-74 (providing an introduction to games involving shared real options) and Han T. J. Smit & L. A. Ankum, *A Real Options and Game-Theoretic Approach to Corporate Investment Strategy Under Competition*, Autumn FIN. MGMT. 241 (1993).

[129] *See generally*, GAME CHOICES: THE INTERSECTION OF REAL OPTIONS AND GAME THEORY (Steven Grenadier ed., 2000) (presenting selected papers that provide theoretical foundations for and practical, state-of-the-art applications of strategic real options models). *See also*, Steven R. Grenadier, *Option Exercise Games: The Intersection of Real Options and Game Theory*, 13 J. APPL. CORP. FIN. 99 (2000); Grenadier, *supra* note 45; VOLLERT, *supra* note 14.

The model in the appendix of this Article clarifies how and why real options analysis explains when (possibly, frivolous) litigation can be nonetheless credible for plaintiffs to file and for defendants to settle. Of course, not all possibly, frivolous lawsuits are going to be credible for plaintiffs to file and for defendants to settle. In fact, the appendix of this Article proves that only lawsuits, including possibly frivolous ones, with positive net (of their expected option premia) abandonment real option values are credible for plaintiffs to file and for defendants to settle.[130] In other words, the gross real abandonment option values for each stage of litigation must exceed the cost of that stage of litigation. The model in the appendix of this Article demonstrates that lawsuits that have positive net expected values will also have positive net real option values. Thus, any lawsuit with positive expected value (PEV), will be credible for a plaintiff to file and for a defendant to settle.[131]

The key intuition for why any lawsuit, including NEV lawsuits, must have positive gross real abandonment option value is that any random variable's abandonment option value is larger than or equal to its expected value. This is true because the abandonment option value of a random variable can be thought of as being equal to that random variable's expected value when all of the negative value realizations of that random variable are replaced by zero. Such a conceptualization of the abandonment option value of a random variable insightfully captures the pragmatic and valuable feature that real abandonment options provide, namely the flexibility to avoid negative outcome realizations of the underlying random variable. Thus, the abandonment option value of any random variable, including that of a plaintiff's expected judgment at litigation, must be non-negative by definition.

Several economists developed a concept of an option value or quasi-option value in the particular context of environmental preservation and in the more general setting of decision

[130] *See infra* Appendix, proposition 1.
[131] *See infra* Appendix, proposition 2.

making under conditions of risk.[132] The relationship of such option values to real options has caused some confusion in the literature.[133] By the phrase, the option value of a random variable, this Article simply means the expected value of that random variable, but with all of its negative value realizations replaced by zero. From this definition of the option value of a random variable, it follows that at every date, the option value of any random variable exceeds the expected value of any random variable.

The model in the appendix of this Article provides four principal ways in which any evidentiary, procedural, or substantive rule (or change in such a rule) can increase the value of a plaintiff's litigation abandonment option, namely: 1) increasing the variance of trial judgment awards;[134] 2) increasing the divisibility of plaintiff's legal costs;[135] 3) back-loading plaintiff's litigation costs;[136] and 4) decreasing plaintiff's total litigation costs.[137]

The real options game-theoretic model of litigation in the appendix of this Article differs from expected value game-theoretic models of litigation in terms of its predictions. For example, a mean-preserving increase (or decrease) in the variance of judgment at trail has no impact on the incentives to file or the Nash equilibrium settlement amounts in expected value game-theoretic models of litigation involving risk-neutral parties. But, a mean-preserving increase (respectively, decrease) in the variance of judgment at trail increases (respectively, decreases) the incentives to file and the Nash equilibrium settlement amounts in the real options game-theoretic model of litigation involving risk-neutral parties.[138] The intuition and reason for this difference in the

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[132] *See, e.g.*, Kenneth J. Arrow & Anthony C. Fisher, *Environmental Preservation, Uncertainty, and Irreversibility*, 88 QUART. J. ECON. 312, 315 (1974); W. Michael Hanemann, *Information and the Concept of Option Value*, 16 J. ENVIRON. ECON. & MGMT. 23, 27 (1989); and Claude Henry, *Investment Decisions under Uncertainty: The 'Irreversibility Effect,'*" 64 AM. ECON. REV. 1006, 1007 (1974).

[133] Anthony C. Fisher, *Investment under Uncertainty and Option Value in Environmental Economics*, 22 RESOURCE & ENERGY ECON. 197, 202-03 (2000) (offering a unifying framework); and Paul Mesnick & Till Requate, *The Dixit Pindyck and the Arrow-Fisher-Hanemann-Henry Option Values Are Not Equivalent*, RESOURCE & ENERGY ECON. (forthcoming 2003).

[134] *See infra* Appendix, proposition 6.

[135] *See infra* Appendix, proposition 10.

[136] *See infra* Appendix, proposition 12.

[137] *See infra* Appendix, proposition 14.

[138] *See infra* Appendix, proposition 6.

predictions of expected value game-theoretic models of litigation versus the real options game-theoretic model of litigation is that risk-neutral litigants only care about expected values and not variance in expected value game-theoretic models of litigation. But, in a real options game-theoretic model of litigation, the option values of the settlement amounts from litigation depend not only upon expected values, but also variances of random variables even with even risk-neutral litigants. An application of this that filing of (possibly, frivolous) litigation is more likely under the English rule than under the American rule for allocating legal costs.

While the appendix of this Article develops a multi-period real options model of lawsuits, this general approach to litigation can be illustrated by making the simplifying assumption that litigation consists of two stages only, namely discovery and trial. Filing a lawsuit and surviving a defendant's motion to dismiss it for failure to state a claim[139] (modern liberal rules of pleading allow the survival of a fairly broad class of claims) allows a plaintiff's lawyers to engage in discovery. Thus, before discovery, the plaintiff has filed suit and initial motions, but has not yet engaged in any real discovery. Legal fees up to then are usually small in comparison with the sizable and irreversible amounts incurred by discovery. In fact, an empirical survey of attorneys found lawyers reporting that about fifty percent of the aggregate costs of litigation are discovery costs.[140] A plaintiff must decide whether to incur those significant discovery costs.

But, a plaintiff is not locked into proceeding with a trial even if she decides to have her attorney engage in discovery. In fact, discovery results in the gathering of information and the updating of probability beliefs over the plaintiff prevailing at trial. The various federal and state rules governing discovery confer upon parties legal rights to obtain information from other parties before trial via document requests, interrogatories, and the deposition of witnesses. But, attorney-client privilege and the work product doctrine both limit what information another party

[139] Fed.R.Civ.P. 12(b)(6).

[140] THOMAS E. WILLGING ET AL., DISCOVERY AND DISCLOSURE PRACTICE, PROBLEMS, AND PROPOSALS FOR CHANGE 15 (Federal Judicial Center 1997).

can discover.[141] The process of discovery provides a plaintiff's attorney with the opportunity to conduct research into a case and develop it further if it looks promising (in terms of an expected judgment or a settlement), but recommend that a plaintiff drop the case if the case does not look promising (in terms of an expected judgment or a settlement). For simplicity, assume that discovery completely resolves the uncertainty over the actual merits of a case. Then, after discovery, both sides of the case will know the probability of plaintiff prevailing at trial is either zero or one. In the second period, a plaintiff will be willing to incur the sizable and irreversible costs of trial if she learns that she has a sure winner, while a plaintiff will drop the case unilaterally if she learns that she has a sure loser.

There are many sophisticated game-theoretic models of discovery;[142] discovery rules;[143] and efficient discovery.[144] Discovery generates benefits and costs that differ significantly between plaintiff and defendant.[145] When the plaintiff is an individual and the defendant is a doctor, corporation, or even just another individual, for example; the cost for that defendant of complying with a plaintiff's discovery requests for non-privileged, relevant documents can be quite substantial.[146] There is a clear potential for discovery abuse because of the externality involved where plaintiffs receive the informational benefits of discovery, but defendants bear its costs.[147] So, even if the discovery request will likely produce benefits which exceed its costs,

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[141] Ronald J. Allen et al., *A Positive Theory of the Attorney-Client Privilege and the Work Product Doctrine*, 19 J. LEGAL STUD. 359 (1990) (offering an economic model of the procedural limits on discovery based upon their incentive effects).

[142] *See, e.g.*, Robert D. Cooter & Daniel L. Rubinfeld, *An Economic Model of Legal Discovery*, 23 J. LEGAL STUD. 435, 438 (1994) (providing a general strategic analysis of discovery). *See also*, Bruce L. Hay, *Civil Discovery: Its Effects and Optimal Scope*, 23 J. LEGAL STUD. 481 (1994) (extending Cooter & Rubinfeld's analysis).

[143] Joel Sobel, *An Analysis of Discovery Rules*, 52 L. & CONTEMP. PROB. 133 (1989).

[144] Robert Mnookin & Robert Wilson, *A Model of Efficient Discovery*, 25 GAMES & ECON. BEHAV. 219 (1998).

[145] Fed.R.Civ.P. 26(b)(2)(iii) limits discovery to requests whose compliance does not impose a burden that is likely to outweigh the benefits. Fed.R.Civ.P. 26(g)(3) allows courts to impose appropriate sanctions for violations.

[146] Fed.R.Civ.P. 26(b)(1) provides a broad scope for discovery, including information that need not be admissible at trial so long as the information requested "appears reasonably calculated to lead to the discovery of admissible evidence."

[147] Frank H. Easterbrook, *Discovery as Abuse*, 69 B.U. L. REV. 635, 636 (1989) (expressing judicial concern over discovery abuse). *But see*, Linda S. Mullenix, *Discovery in Disarray: The Pervasive Myth of Pervasive Discovery Abuse and the Consequences for Unfounded Rulemaking*, 46 STAN. L. REV. 1393, 1432-42 (1994) (noting the anecdotal and survey nature of evidence about discovery abuse).

one party receives the benefits from, while another party bears the costs of, discovery.[148] Thus, even if a discovery request is socially desirable (in the sense that its benefits exceed its costs); it can provide a small plaintiff an advantage over a large defendant as in Professors David Rosenberg & Steven Shavell's analysis of NEV lawsuits.[149] Although both sides to a lawsuit can make discovery requests, a plaintiff does not incur much cost in complying with discovery requests when she lacks "truckloads of documents."[150] The costs of complying with discovery requests illustrates how litigation abandonment options may create problems akin to a strategy of raising rival's costs in the context of business competition and the game-theoretic industrial organization literature.[151]

More generally, any lawsuit consists of not just discovery and trial stages, but also at least several of these stages: the plaintiff's lawyer files a complaint; the defendant's lawyer files a pre-answer motion to dismiss the plaintiff's complaint, e.g. under the federal rules of civil procedure, a motion to "for failure to state a claim upon which relief can be granted";[152] the defendant's lawyer answers the compliant by making admissions,[153] making denials,[154] raising affirmative defenses,[155] or filing counterclaims or cross claims;[156] the lawyers file third party complaints;[157] the lawyers amend or supplement their pleadings;[158] the lawyers make any required automatic disclosures;[159] the lawyers conduct, object to, and respond to discovery

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[148] John K. Setear, *The Barrister and the Bomb: The Dynamics of Cooperation, Nuclear Deterrence, and Discovery Abuse*, 69 B.U. L. REV. 569, 581 (1989) (differentiating between informational benefits and impositional benefits of discovery requests).
[149] Rosenberg & Shavell, *supra* note 116.
[150] *See also*, COOTER & ULEN, *supra* note 77, at 412 (illustrating how "[e]xternalizing compliance costs provides an incentive for discovery abuse."). *But see*, CLASS ACTION (20th Century Fox, 1991) (depicting how a defendant's lawyer can bury a plaintiff's attorney with literally truckloads of documents in complying with a discovery request).
[151] *See, e.g.*, William P. Rogerson, *A Note on the Incentive for a Monopolist to Increase Fixed Costs as a Barrier to Entry*, 99 QUART. J. ECON. 399 (1984).
[152] Fed.R.Civ.P. 12(b)(6).
[153] Fed.R.Civ.P. 8(b).
[154] Fed.R.Civ.P. 8(b).
[155] Fed.R.Civ.P. 8(c).
[156] Fed.R.Civ.P. 13.
[157] Fed.R.Civ.P. 14.
[158] Fed.R.Civ.P. 15.
[159] Fed.R.Civ.P. 26(a).

requests for the production of documents;[160] the lawyers send and answer interrogatories;[161] the lawyers take oral depositions;[162] the lawyers request and comply with court orders for independent medical physical or mental examinations;[163] the lawyers promulgate and respond to requests for admissions;[164] the lawyers file and respond to motions for summary judgment;[165] the lawyers proceed to trial by among other things, conducting opening arguments, examining and cross-examining witnesses,[166] presenting non-testimonial evidence, and making closing arguments; the lawyers file and respond to motions for judgment as a matter of law before a verdict (also known under some state rules of civil procedure as motions for summary judgment);[167] the lawyers file and respond to motions for judgment as a matter of law after the verdict (also known under some state rules of civil procedure as motions for j.n.o.v., which stands for judgment non obstante veredicto);[168] the lawyers file and respond to motions for a new trial;[169] and finally, the lawyers file and respond to motions to alter or amend a judgment.[170]

Thus, litigation is a multi-stage process that provides plaintiffs not just a single option, but instead a sequence of abandonment options analogous to those found in sequential investment. Litigation abandonment options have several interesting features. First, plaintiffs do not pay litigation abandonment option premia to defendants, but instead to plaintiffs' attorneys. If plaintiffs are not paying clients, but instead suing under contingency fee arrangements or attorney fee award statutes, then plaintiff's attorneys incur litigation abandonment option premia up front. Second, defendants provide these litigation options to plaintiffs by virtue of their activity choices and relevant substantive and procedural laws. Third, plaintiffs' abandonment

[160] Fed.R.Civ.P. 34.
[161] Fed.R.Civ.P. 33.
[162] Fed.R.Civ.P. 30.
[163] Fed.R.Civ.P. 35.
[164] Fed.R.Civ.P. 36.
[165] Fed.R.Civ.P. 56.
[166] Fed.R.Civ.P. 44(b).
[167] Fed.R.Civ.P. 50(a).
[168] Fed.R.Civ.P. 50(b).
[169] Fed.R.Civ.P. 59(a).
[170] Fed.R.Civ.P. 59(e).

options are similar to the real options, which a natural resources company, oil refinery, pharmaceutical company, petrochemical firm, or in fact any business that is engaged in research and development (R&D) has to abandon product or process innovation.[171] But, a very important difference between a plaintiff's litigation abandonment options and those in R&D is that lawsuits are wasteful from the joint perspective of plaintiffs, defendants, and perhaps, society as a whole if the costs imposed upon a court, a judge, and jury, if there is one, exceed the precedent and process values from adjudication of the litigation. On the other hand, a corporation engaging in R&D, its employees, its equity owners, its debt holders, its current and future customers, the surrounding community, and possibly other third-parties all serve to gain from the development and sale of a new product. In litigation, the plaintiff and the defendant will jointly lose if they make investments in a lawsuit as opposed to resolve their differences via some alternative dispute resolution method.

II. Limitations of Strategic Litigation Option Analysis

This part of the Article appraises limitations of a real options game-theoretic approach to litigation. Some of these limitations in the particular context of litigation are the result of general behavioral limitations to game-theoretic analysis.[172] First, there are cognitive limitations in how people conceptualize, frame, make, process, and understand choices over time.[173] Second, traditional or non-psychological game-theoretic models assume that people do not experience

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[171] *See, e.g.*, Terrence W. Faulkner, *Applying 'Options Thinking' to R&D Valuation*, 39 RES. TECH. MGMT. 50 (1996); HARIOLF GRUPP & SHLOMO MAITAL, *Innovation Investment as Doors to the Future: A Real Options Approach*, *in* MANAGING NEW PRODUCT DEVELOPMENT AND INNOVATION: A MICROECONOMIC TOOLBOX 39-53 (2001); and Graham R. Mitchell & William F. Hamilton, *Managing R&D as a Strategic Option*, May-June RES. TECH. MGMT. 15 (1988).

[172] *See generally* COLIN F. CAMERER, BEHAVIORAL GAME THEORY: EXPERIMENTS ON STRATEGIC INTERACTION (2003) (providing an excellent overview to experimental research about how people actually play games).

[173] *See generally*, TIME AND DECISION: ECONOMIC AND PSYCHOLOGICAL PERSPECTIVES ON INTERMPORAL CHOICE (George Loewenstein et al. eds., 2003) (presenting a fascinating interdisciplinary collection of articles about the philosophical, evolutionary, and neurobiological underpinnings; theoretical perspectives; and practical applications of the psychology and economics of time preference) and CHOICE OVER TIME (George Loewenstein & Jon Elster eds., 1992) (presenting articles about how people actually make choices over time).

any emotions or feelings. Both of these limitations are particularly serious in litigation settings because most litigation is quite time-consuming and emotionally draining, if not protracted and contentious. Fortunately, even if litigants themselves are myopic and overly emotional, their lawyers might be more farsighted and less emotional. Unfortunately, lawyers may exacerbate cognitive and emotional issues due to conflicts of interests and repeat play considerations involving developing a reputation for being tough or playing hardball in pre-trial settlement negotiations.[174] This part of the Article considers these limitations in turn and possible responses.

A. Cognitive Limitations

The standard procedure for solving dynamic games of complete information utilizes a technique known as backward induction.[175] This method for calculating an equilibrium solution to an extensive form game of perfect information starts by determining the optimal choice for the player who moves last; then determining the optimal course of action for the player who moves penultimately, and so forth until determining the optimal decision for the player who moves first. An alternative way to understand backward induction focuses on the sequential rationality of players' strategies. The requirement of sequential rationality is related to another intuitive notion, that of credibility of threats. Professor Bebchuk systematically applied the credibility constraint in his approach to NEV lawsuits.[176]

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[174] *See, e.g.*, Ronald J. Gilson & Robert H. Mnookin, *Disputing Through Agents: Cooperation and Conflict Between Lawyers in Litigation*, 94 COLUM. L. REV. 509, 514-15 (1994) (illustrating the possibility of a prisoner's dilemma situation where both litigants withhold information from each other and their lawyers file motions to compel disclosure). *But see, e.g.*, A. Mitchell Polinsky & Daniel L. Rubinfeld, *Aligning the Interests of Lawyers and Clients*, 5 AM. L. & ECON. REV. 165 (2003) (proposing a variation of the standard contingent fee system for compensating lawyers that overcomes the conflict of interest between clients and their lawyers).

[175] Robert Gibbons, *An Introduction to Applicable Game Theory*, 11 J. ECON. PERSP. 145 (1994).

[176] Bebchuk, *supra* note 94, at 1-2, 4, 7-8, 14-15, 23-24.

As Professor Bebchuk noted, backward induction arguments have become standard in studying multi-period strategic environments.[177] The history of backward induction arguments dates back (at least) to Zermelo's demonstration that in chess, either white or black can ensure itself a draw regardless of how the other side plays.[178] Later, the philosopher, Kierkegaard said, "[i]t is perfectly true, as philosophers say, that life must be understood backwards. But they forgot the other proposition, that it must be lived forwards."[179] Similarly, backward induction arguments presume that decision-makers have the computational ability to and in fact do correctly forecast all of the future choices that are to be made in a game.[180] The longer and/or more complex that a game is, the more descriptively problematic is the assumption of rational expectations about strategic decisions.[181]

Numerous experiments demonstrate that people are quite limited in their ability to perform backwards induction for even relatively simple game situations.[182] The inconsistency between empirical experimental play results and backward induction based solutions for a famous game called the centipede game illustrates the predictive limitations of using backward induction arguments for sufficiently lengthy games.[183] Even in only two-stage or three-stage sequential bargaining experimental games, subjects actually play very differently from backward induction based equilibrium solutions for those games.[184] One way to resolve these and related backward induction paradoxes is to "introduce some uncertainty into the players' knowledge of

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[177] *Id.*, at 6 & n. 7.
[178] E. Zermelo, *Uber eine Anwendung der Mengenlehre auf die Theorie des Schachspiels*, 2 PROC. FIFTH INT'L CONG. MATHEMATICIANS 501 (1913).
[179] SOREN KIERKEGAARD, THE JOURNALS OF SOREN KIERKEGAARD (1938).
[180] MORROW *supra* note 103, at 157.
[181] DAVID M. KREPS, GAME THEORY AND ECONOMIC MODELLING 77-82, 147-48 (1990).
[182] *See, e.g.*, THEODORE C. BERGSTROM & JOHN H. MILLER, EXPERIMENTS WITH ECONOMIC PRINCIPLES 395 (1997).
[183] The technical term for backward induction based solutions to an extensive form game of perfect information is that of subgame perfect (Nash) equilibria.
[184] BERGSTROM & MILLER, *supra* note 182, at 374-76, 394-96.

each other's payoffs."[185] Such a resolution, however, voids the assumption of common knowledge of rationality which underlies the method of backward induction.

The game-theoretic analysis of litigation real options in the appendix of this Article utilizes backward induction arguments to analyze lawsuits despite the above concerns being disturbing and convincing. In defense of using backward induction arguments in analyzing lawsuits, litigants have financial and psychological incentives to be sequentially rational. Litigants are more likely to be sequentially rational than experimental subjects, who may face artificial time constraints and might lack the motivations of greed and emotional responses more often than not found in litigation.[186] Also, even if the litigants themselves fail to be sequentially rational due, for example, to cognitive difficulties, they hire lawyers who provide not only legal knowledge and expertise, but also negotiating experience and professionalism. Presumably, part of being a professional is not making incredible threats. In a sense, then, litigation involves professionals who have reasons to be sequentially rational. Of course, both defendants' and plaintiffs' attorneys are often repeat players and their behavior might be rational across cases as opposed to within any given case. A final defense is the often-made hand waving argument that market reputation and competition discipline lawyers who fail to be sequentially rational.

B. Emotional and Psychological Factors

Almost all formal economic models of litigation focuses primarily on the monetary incentives to sue, settle or proceed to a trial. An exception is provided by Professors Huang & Ho-mou Wu's psychological game-theoretic models of litigation. Their models demonstrate how such emotions as anger, outrage, and shock can prevent or delay settlement in litigation by

[185] MORROW *supra* note 103, at 158.
[186] Peter H. Huang & Ho-Mou Wu, *Emotional Responses in Litigation*, 12 INT'L REV. L. & ECON. 31 (1992).

changing the incentives of parties to sue, settle, or go to trial.[187] In addition, the U.S. Supreme Court described and endorsed the wide-ranging rights of parties to control and participate in their litigation based upon a psychological theory of process-based value to precluding feelings of unjust treatment.[188] Empirical and experimental psychological research demonstrates that people are more likely to accept an adverse outcome and to believe that an adjudicatory process is fair if they have the opportunity to personally participate in that process, have their day, and have the adjudicator hear their stories and their voice.[189] Emotional considerations usually predominate in particular (legal) areas, including, but not necessarily limited to battery, child custody, criminal offenses, defamation, divorce, false imprisonment, intentional infliction of emotional distress, invasion of privacy, medical malpractice, products liability (especially involving bodily injury), and worker's compensation.

Whether a lawsuit has a positive or negative expected value to a plaintiff, a lawsuit always has net negative expected value to a defendant (ignoring the filing of counterclaims) because of a defendant's litigation costs. Indeed, avoiding the incurring of such costs is often the rationale for settlement. In reality, it is not just legal costs, but also the opportunity costs and harms to a defendant's reputation of having to deal with a lawsuit which might lead a defendant to settle a lawsuit by effectively purchasing the plaintiff's litigation continuation options. An often used pejorative term is that of vexatious litigation. In a well-known quotation from a securities fraud lawsuit, the Chief Justice of the Supreme Court, William Rhenquist, spoke of the danger of "vexatious litigation" which could result from the prosecution of "a complaint which

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[187] *Id. See also*, William G. Morrison, *Instincts as Reflex Choice: Does Loss of Temper Have Strategic Value?*, 31 J. ECON. BEHAV. & ORG. 335 (1996) (demonstrating in games based upon biological conflict models that subordinate players can benefit from losing their temper in asymmetric contests with dominant opponents and that such instinctual temper can be robust against evolutionary pressures and persist over time) and Glenn Feltham & William G. Morrison, Civil Disputes, the Allocation of Legal Costs and Emotional Litigation (1995) (unpublished manuscript, on file with author) (modeling the possibility of a plaintiff reacting emotionally to a defendant's low pre-trial settlement offer by becoming insulted, losing her temper and making a reflex choice to proceed to trial instead of settle, regardless of the monetary consequences to her of doing so).

[188] *Carey v. Piphus*, 435 U.S. 247, 260-61 (1978).

[189] *See, e.g.*, E. ALLAN LIND & TOM R. TYLER, THE SOCIAL PSYCHOLOGY OF PROCEDURAL JUSTICE 26-40, 61-83, 93-127 (1988) (presenting this research).

by objective standards may have very little chance of success at trial" because, among other reasons, "the very pendency of the lawsuit may frustrate or delay normal business activity of the defendant which is totally unrelated to the lawsuit."[190] Exactly what constitutes a vexatious lawsuit is debatable in the same manner as precisely what constitutes a frivolous lawsuit. But, certainly examples of non-monetary aspects of vexatious litigation include heated emotional considerations motivating a plaintiff's use of a lawsuit out of anger to harass a defendant.

A recent set of psychological experiments indicate that decision makers generally overvalue their options and exhibit a willingness to invest greater effort and larger sums of money to keep options viable, even when such options have little intrinsic value.[191] The tendencies uncovered experimentally were robust with regard to information regarding outcomes, more experience, and saliency about option costs.[192] In other words, options may offer subjective values exceeding their decision-theoretic value for two psychological reasons. First, people sometimes derive pleasure from just "having the right to choose."[193] This phenomenon is perhaps related to a desire for or illusion of control.[194] Second, people sometimes experience loss aversion and a type of endowment effect for options.[195] This phenomenon is related to the phenomenon of litigants experiencing framing effects as described by prospect theory causing frivolous litigation and lack of settlement during pre-trial bargaining.[196]

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[190] *Blue Chip Stamps v. Manor Drug Stores*, 421 U.S. 723, 729 (1975).

[191] Shin & Ariely, *supra* note 69.

[192] *Id*.

[193] *But see*, Ziv Carmon et al., *Option Attachment: When Deliberating Makes Choosing Feel Like Losing*, 30 J. CONSUMER RES. 15 (2003) (presenting experimental evidence that considering options more closely may induce consumers to become attached to choice options and feel discomfort after choice) and Sheena S. Iyengar & Mark R. Lepper, *When Choice is Demotivating: Can One Desire Too Much of a Good Thing*, 79 J. PERSONALITY & SOC. PSYCHOL. 995 (2000) (providing both field and laboratory experimental evidence of participants reporting higher satisfaction when their options were limited).

[194] Ellen J. Langer, *The Illusion of Control*, 32 J. PERSONALITY & SOC. PSYCHOL. 311 (1975).

[195] *Id*.

[196] *See, e.g.*, Chris Guthrie, *Framing Frivolous Litigation: A Psychological Theory*, 67 U. CHI. L. REV. 163 (2000) and Jeffrey J. Rachlinski, *Gains, Losses, and the Psychology of Litigation*, 70 S. CAL. L. REV. 113 (1996).

III. Other Legal Applications of Real Options

This Article has thus far analyzed some elements and rules of civil procedure from the perspective of regulating the sequence of embedded real options to continue, drop, modify, or settle litigation. There are many other litigation real options arising in civil procedure. For example, real options analysis can inform procedural rules governing class actions.[197] A well-known result in option valuation is that a call option written on a portfolio of assets must cost less than the corresponding portfolio consisting of individual options written on those individual assets.[198] One can think of a class action as a portfolio made up of the lawsuits of the individual members of the class action. The above option valuation result implies the option value of a class action is less than the sum of the option values of the individual member lawsuits.

The practice of remittitur, in which a trial court denies a defendant's motion for a new trial conditional on a plaintiff accepting an award smaller than issued by a jury, provides further examples of litigation real options.[199] If a plaintiff rejects the lower amount and faces a new trial, that plaintiff can appeal the grant of the second trial after its conclusion. But, should a plaintiff accept such a lower award, that plaintiff cannot appeal the conditional ruling of the trial court.[200] In the language of real options, remittitur involves a court presenting a plaintiff with an option to accept less than a jury award in exchange for a defendant not being permitted to exercise it option for a new trial. Some states allow for the practice of additur, in which a court symmetrically denies a plaintiff's motion for a new trial conditional on a defendant accepting more liability than a jury awarded. But, the United States Supreme Court prohibited additur in federal practice as being in violation of the Seventh Amendment.[201] From a real options

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[197] Fed.R.Civ.P. 23.
[198] *See, e.g.*, RICHARD M. BOOKSTABER, OPTION PRICING AND INVESTMENT STRATEGIES 26-27, tbl. 2-3 (3d ed. 1991) and Merton, *supra* note 28, at 148 theorem 7.
[199] *Gasperini v. Center for Humanities, Inc*, 518 U.S. 415 (1996).
[200] *Donovan v. Penn Shipping Co.*, 429 U.S. 648 (1977).
[201] *Dmick v. Schiedt.*, 293 U.S. 474 (1935).

perspective, additur involves a court presenting a defendant with an option to accept more liability than a jury award in exchange for a plaintiff not being permitted to exercise her option for a new trial.

Real options theory provides not only descriptive or positive analysis, but also prescriptive or normative analysis, of legal behavior. For example, a manufacturer should factor into the price of her product a per unit amount for covering the option values of products liability cases, which are larger than merely expected litigation costs or damage awards from defending or settling products liability cases.[202] Another example is realizing that, ceteris paribus, the deterrence impact of settlements or trials based upon the option values of litigation exceed the deterrence impact of settlements or trials based upon their expected monetary damage awards.[203] This relative comparison applies equally forcefully to deterrence of harms from accidents, contract breaches, governmental takings of private property, and nuisances.[204] A final example is to analyze how litigation abandonment real options affect Professors George Priest and Benjamin Klein's selective litigation hypothesis that a non-random sample of all cases filed result in trial.[205]

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[202] *See also*, Blanton, *supra* note 86, at 185 n.135, 186 n.137; COOTER & ULEN, *supra* note 77, at 345 -6 (noting "the cost of liability will be captured in the price"); MICELI, *supra* note 79, at 29-32; A. MITCHELL POLINKSY, AN INTRODUCTION TO LAW AND ECONOMICS , 97-98, tbl. 11 (providing a hypothetical numerical example of the price of a product including expected accident losses).

[203] *See, e.g.*, A. Mitchell Polinsky & Daniel L. Rubinfeld, *The Deterrent Effects of Settlements and Trials*, 8 INT'L REV. L. & ECON. 109 (1988).

[204] Robert D. Cooter, *Unity in Tort, Contract, and Property: The Model of Precaution*, 73 CAL. L. REV. 1 (1985).

[205] George L. Priest & Benjamin Klein, *The Selection of Disputes for Litigation*, 13 J. LEGAL STUD. 1 (1984). *See also*, Theodore Eisenberg, *Testing the Selection Effect: A New Theoretical Framework with Empirical Tests*, 19 J. LEGAL STUD. 337 (1990); Keith N. Hylton, *Asymmetric Information and the Selection of Disputes for Trial*, 22 J. LEGAL STUD. 187 (1993); MICELI, *supra* note 79, at 158-59; George L. Priest, *Reexamining the Selection Hypothesis: Learning from Wittman's Mistakes*, 14 J. LEGAL STUD. 215 (1985); L. Stanley & Don Coursey, *Empirical Evidence on the Selection Hypothesis and the Decision to Litigate or Settle*, 19 J. LEGAL STUD. 145 (1990); R. Thomas, *The Trial Selection Hypothesis without the 50 Percent Rule: Some Experimental Evidence*, 24 J. LEGAL STUD. 209 (1995); Joel Waldfogel, *The Selection Hypothesis and the Relationship Between Trial and Plaintiff Victory*, 103 J. POL. ECON. 229 (1995); Joel Waldfogel, *Selection of Cases for Trial*, *in* 3 THE NEW PALGRAVE DICTIONARY OF ECONOMICS AND THE LAW 419 (Peter Newman ed., 1998); Donald Wittman, *Is the Selection of Cases for Trial Biased?* 14 J. LEGAL STUD. 185 (1985); and Donald Wittman, *Dispute Resolution, Bargaining, and the Selection of Cases for Trial: A Study of the Generation of Biased and Unbiased Data*, 17 J. LEGAL STUD. 313 (1988).

This final part of the Article applies real options analysis to negligence in torts; preclusion law; constitutional law; and family law. Constraints of space and time only permit a brief glimpse of the full potential of these applications of real options to law. For example, in the medical malpractice area, Professor Jeffrey O'Connell and several co-authors have proposed a reform plan under which a physician has the option to make a plaintiff an early offer to pay for economic losses in the form of medical expenses and lost wages.[206] In exchange for accepting such an offer, a plaintiff relinquishes her option to sue for non-economic harms unless that plaintiff can prove the physician was guilty of gross criminal negligence. Applying real options theory provides qualitative if not quantitative analysis of both a physician's option to make such early offers and the forgone value of a patient's option to sue for pain and suffering.[207] Although all the possible applications below only pertain to civil actions, there are numerous legal options in the areas of criminal law and procedure, such as prosecutorial discretion and plea bargaining.

A. Rethinking the "Calculus" of Negligence and the Hand Formula

A number of scholars have applied microeconomics to analyze the common law of torts in general and of negligence in particular.[208] Judge Learned Hand provided the most eminent articulation of the legal standard of negligence.[209] Judge Hand stated that perhaps "it serves to

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[206] *See, e.g.*, Jeffrey O'Connell & Andrew S. Boutros, *Treating Medical Malpractice Claims Under a Variant of the Business Judgment Rule*, 77 NOTRE DAME L. REV. 373 (2002); Jeffrey O'Connell & Patrick B. Bryan, *More Hippocrates, Less Hypocrisy: "Early Offers" as a Means of Implementing the Institute of Medicine's Recommendations on Malpractice Law*, 15 J.L. & HEALTH 23 (2000-01); Jeffrey O'Connell & Geoffrey Paul Eaton, *Binding Early Offers as a Simple, if Second-Best, Alternative to Tort Law*, 78 NEB. L. REV. 858 (1999); and Jeffrey O'Connell & James F. Neale, *HMO's, Cost Containment, and Early Offers: New Malpractice Threats and A Proposed Reform*, 14 J. CONTEMP. HEALTH L. POL'Y. 287 (1998).

[207] Peter H. Huang, A Real Options Analysis of Medical Malpractice: Plaintiffs' Litigation Abandonment Options (Aug. 2003) (unpublished manuscript, on file with author).

[208] *See, e.g.*, GUIDO CALABRESI, THE COST OF ACCIDENTS: A LEGAL AND ECONOMIC ANALYSIS (1970); RICHARD A. EPSTEIN, A THEORY OF STRICT LIABILITY: TOWARD A REFORMULATION OF TORT LAW (1980); WILLIAM M. LANDES & RICHARD A. POSNER, THE ECONOMIC STRUCTURE OF TORT LAW (1987); and STEVEN SHAVELL, ECONOMIC ANALYSIS OF ACCIDENT LAW (1987).

[209] *United States v. Carroll Towing Co.*, 159 F.2d 169 (2d Cir. 1947).

bring this notion into relief to state it in algebraic terms: if the probability be called P; the injury L; and the burden B; liability depends on whether B is less than L multiplied by P; i.e., whether B < PL."[210] Thus, the famous "Hand formula" is a simple inequality. Hand's formulation suggests that a reasonable person will take a precaution against injury when the burden from so doing is exceeded by the loss if the injury occurs multiplied by the probability of that injury occurring. The American Law Institute adopted the negligence calculus that motivates the Hand formula in various Restatements of the Law of Torts.[211]

Of course, to be unambiguous and correct, Hand's formula must be stated in a form that compares marginal precaution costs and marginal expected injury.[212] It would seem that the Hand formula captures in a succinct and parsimonious way a simple test for determining socially efficient precautions.[213] But, Hand never conceived of his formulation as being a mechanical tool for determining reasonable behavior. In fact, Hand later suggested that it is impossible to quantify the variables in his formula.[214] The Hand formula's most important contribution might be that it conjures up a balancing thought process.

But, as helpful an impressionistic and intuitive heuristic as the Hand formula is, or perhaps because of its Spartan simplicity, the Hand formula clearly takes an expected value approach to injury by multiplying the loss if an injury occurs by the probability of injury. The Hand formula does not account for any possibilities for undertaking such real options as permanently or temporarily abandoning the risky conduct in question. Similarly, precaution usually does not involve a lump-sum once-and-for-all burden, but instead a sequence of incremental burdens. Thus, a real options version of the Hand formula would replace B < PL by

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[210] *Id.* at 173.

[211] RESTATEMENT OF TORTS § 291(1) (1934); RESTATEMENT (SECOND) OF TORTS §§ 291-293 (1965); RESTATEMENT (THIRD) OF TORTS: LIABILITY FOR PHYSICAL HARM BASIC PRINCIPLES (1998).

[212] *See, e.g.*, COOTER & ULEN, *supra* note 77, at 333-37; RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 168 n.2 (6th ed. 2003).

[213] Richard A. Posner, *A Theory of Negligence*, 1 J. LEGAL STUD. 29 (1972). *But see*, Richard W. Wright, *Hand, Posner, and the Myth of the "Hand Formula."* 4 THEORETICAL INQUIRIES IN LAW 1 (2003) (arguing that judicial opinions and jury instructions do not make use of the Hand formula).

[214] *Moisan v. Loftus*, 178 F.2d 148, 149 (2d Cir. 1949).

a series of inequalities, namely for all t = 1, …, n; $b_t < OV_t(L)$, where b_t denotes the cost of precaution in period t and $OV_t(L)$ denotes the option value in period t of the injury.

The option value in period t of the injury L, $OV_t(L)$, differs from PL, the expected value of the injury L in at least two ways. First, a real options approach permits for the probability of injury being revised or updated over time in light of additional precautions. Second, the real options perspective allows for the undertaking of real options, including additional precautions. Notice that for all t = 1, …, n; $PL = EV_1(L) < OV_t(L)$, where P is the initial probability of the injury and $EV_1(L)$ denotes the initial expected value of the injury. Assume, as is plausibly the case, that $B = \sum_1^n b_t$ and for all t = 1, …, n; $b_t \geq 0$. If B < PL, then $B < OV_t(L)$ and so $b_t < OV_t(L)$. This reasoning demonstrates that any cost-justified precaution under the Hand formula remains a cost-justified precaution under a real options version of the Hand formula. But, the converse is false. In other words, some behavior that is negligent under the Hand formula would not be negligent under a real options version of the Hand formula.

B. Legal Preclusions

This Article demonstrates that many legal procedural and substantive rules provide options that are valuable because they provide flexibility. It is well-known conversely that inflexibility can be advantageous in strategic bargaining.[215] Economists and game-theorists often speak of people utilizing (pre)commitment devices to improve their bargaining position. Automobile salespeople, one member of a couple, and employers often claim their hands are tied. A real options perspective about law also reveals that numerous legal doctrines and rules increase the price of, if not preclude, certain other legal options. For example, both the model code of professional responsibility and the model rules of professional conduct preclude certain behavior available to lawyers as options. For another example, both state and federal sovereigns

[215] *See. e.g.*, MCMILLAN. *supra* note 102, at 53-57.

have developed a number of self-limitation doctrines and statutes that decline to exercise their full adjudicatory Constitutional authority over non-local cases.[216] Most prominent among these subconstitutional restrictions on geographic forum selection are the law of venue and forum nonconveniens.[217]

The judicially created doctrines of collateral estoppel and res judicata are part of preclusion law, which regulates how a judgment in one lawsuit governs future litigation.[218] Res judicata, also known as claim preclusion, bars any party from suing again for the same underlying occurrence or transaction.[219] For example, if Paula Plaintiff sued her Doctor Defendant for negligence during the delivery of her baby, then Paula is barred from suing for breach of contract for the delivery of her baby whether Paula wins or loses her first medical malpractice litigation. Res judicata thus prevents new litigation motivated by different legal theories or types of relief that should have been, but were not, litigated initially. The rationale for res judicata is to encourage plaintiffs to get it right initially by collecting all of the facts and related legal theories in just a single lawsuit.

Collateral estoppel, also known as issue preclusion, proscribes the same issues to be litigated again in subsequent lawsuits. For example, suppose Baker buys two identical wood-burning pizza ovens from their manufacturer, Acme. One of these ovens blows up and Baker sues Acme for her injuries. If Acme loses on the issue of negligence to Baker in a lawsuit for negligent design, then Baker can bind Acme to its adverse determination in another lawsuit for negligent design of the second oven if that oven also explodes a month later. Collateral estoppel prevents the litigation of issues that have already been litigated to a judgment by a court. Collateral estoppel thus avoids duplicative litigation of the same issue. For the doctrine of collateral estoppel to preclude an issue, that issue must have been the same as in a prior lawsuit,

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[216] *See, e.g.,* KEVIN M. CLERMONT, CIVIL PROCEDURE: TERRITORIAL JURISDICTION AND VENUE 27 (1999).
[217] *Id.,* at 27-30.
[218] *See, e.g.,* DAVID SHAPIRO, PRECLUSION IN CIVIL ACTIONS (2001) (discussing the legal structure and history of preclusion law).
[219] RESTATEMENT (SECOND) OF JUDGMENTS §24 (1982).

actually litigated in that prior lawsuit, decided in that prior lawsuit, and usually necessary for the court's judgment in that prior lawsuit.[220]

The doctrine of mutuality only allows parties who were parties in the lawsuit in which an issue was decided to invoke collateral estoppel of that issue. All of the federal courts have substantially eroded the doctrine of mutuality. The doctrine of non-mutual collateral estoppel permits a third party to bind a party in a prior action who lost on an issue in that action. For example, if Defendant Drugs loses on the issue of deficiency to Phirst Plaintiff in a lawsuit for a defective warning, then under the doctrine of non-mutual collateral estoppel, other future plaintiffs can bind Defendant Drugs to its adverse determination from Phirst's lawsuit. The above hypothetical exemplifies offensive non-mutual estoppel, in which "the plaintiff seeks to foreclose the defendant from litigating an issue the defendant has previously litigated unsuccessfully in an action with another party."[221]

Applying offensive non-mutual estoppel raises concerns of protecting defendants' Seventh Amendment rights to a trial by jury in civil cases.[222] The United States Supreme Court has neither categorically endorsed nor categorically rejected offensive non-mutual estoppel, holding instead that a lower court should consider whether a defendant would be unfairly prejudiced from permitting offensive non-mutual estoppel by considering various factors.[223] In that case, the plaintiffs in a class action lawsuit against Parklane Hosiery invoked collateral estoppel on the issue of whether a proxy statement was false and misleading because a court had already held that same proxy statement was indeed false and misleading in a prior lawsuit brought by the Securities and Exchange Commission.

In contrast, defensive non-mutual estoppel "occurs when a defendant seeks to prevent a plaintiff from asserting a claim the plaintiff has previously litigated and lost against another

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[220] RESTATEMENT (SECOND) OF JUDGMENTS §27 (1982).

[221] *Parklane Hosiery v. Shore*, 439 U.S. 322, 326 n.4 (1979).

[222] U.S. CONST. amend. VII.

[223] *Id*. at 332 n.17. *See generally* RESTATEMENT (SECOND) OF JUDGMENTS §29 (1982) (detailing the factors that should be considered in analyzing non-mutual collateral estoppel).

defendant."[224] The California Supreme Court first endorsed the doctrine of defensive non-mutual estoppel in a case where a Mrs. Bernhard alleged that certain funds held by the estate's executor, Cook, belonged to the estate.[225] Cook replied the funds should not be included in the estate's assets because they had been a gift from the decedent. Mrs. Bernhard challenged Cook's assertion in a probate hearing during settlement of the estate. A court held that the funds were indeed a gift from the decedent to Cook. Then, Bernhard sued Bank of America because it had held the funds and paid them to Cook, claiming again the funds were part of the estate's assets and not Cook's. Bank of America pleaded collateral estoppel. Justice Traynor emphasized that Bernhard was a party in the first action and already had a full and fair opportunity to litigate the issue there.[226]

The United States Supreme Court first approved the doctrine of defensive non-mutual estoppel in case where the University of Illinois Foundation sued a defendant for patent infringement, but lost on the grounds that it had an invalid patent.[227] The University of Illinois Foundation then brought suit against another defendant for infringement of the same patent. The second defendant pleaded collateral estoppel and the Supreme Court held for the defendant, noting the unfairness of waste of judicial resources from permitting "repeated litigation of the same issue as long as the supply of unrelated defendants holds out."[228] Like the California Supreme Court, the United States Supreme Court emphasized that defensive non-mutual estoppel is only appropriate when the precluded party already had a full and fair opportunity to litigate the issue in the first action.[229]

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[224] *Id*.
[225] *Bernhard. v. Bank of America National Trust & Savings Ass'n*, 122 P.2d 892 (Cal. 1942).
[226] *Id*. at 895.
[227] *Blonder-Tongue Laboratories, Inc. v. University of Illinois Foundation*, 402 U.S. 313 (1971).
[228] *Id*. at 329.
[229] *Id*. at 332-34.

The standard first-year of law school civil procedure casebook's explanation for collateral estoppel and res judicata is achieving finality or the repose of judgments.[230] Another traditional rationale for both collateral estoppel and res judicata is judicial economy.[231] Finally, decisional consistency is often cited as an additional benefit of collateral estoppel and res judicata.[232] But, collateral estoppel and res judicata both also influence the settlement values to litigation. Professor Bruce L. Hay argues that collateral estoppel and res judicata both function to better align the settlement values of lawsuits with their merits.[233] The few economic analyses of collateral estoppel and res judicata do not explicitly analyze these judicial doctrines from the vantage point of real options as clearly proscribe future litigation options.[234] The perspective of this Article suggests analyzing the preclusion rules of collateral estoppel and res judicata specifically from a real options perspective.

The United States Constitution requires that at least two-thirds of the members of both Houses of Congress vote to propose a constitutional amendment.[235] Alternatively, two-thirds of the state legislatures must petition Congress to call a constitutional convention.[236] The second method of proposing a constitutional amendment has never been utilized. In addition, the United

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[230] BARBARA J. ALLEN BABCOCK & TONI M. MASSARO, CIVIL PROCEDURE: CASES AND PROBLEMS 1087 (2d ed. 2001); Bruce L. Hay, *Some Settlement Effects of Preclusion*, 21 U. ILL. L. REV. 21, 23 n.8 (1993); ALLAN IDES & CHRISTOPHER N. MAY, CIVIL PROCEDURE: CASES AND PROBLEMS 1093 (2003); LINDA SILBERMAN & ALAN R. STEIN, CIVIL PROCEDURE: THEORY AND PRACTICE 725 (2001); STEPHEN N. SUBRIN ET AL., CIVIL PROCEDURE: DOCTRINE, PRACTICE, AND CONTEXT 884 (2000); and STEPHEN C. YEAZELL, CIVIL PROCEDURE 797 (5th ed. 2000).

[231] Hay, *supra* note 230, at 23 n.10.

[232] BONE, *supra* note 76, at 233-34.

[233] Hay, *supra* note 230, at 31-51.

[234] Hay, *supra* note 230; Note, *Exploring the Extortion Gap: An Economic Analysis of the Rules of Collateral Estoppel*, 105 HARV. L. REV. 1940 (1992); POSNER, *supra* note 212, at 593-95; Stephen J. Spurr, *An Economic Analysis of Collateral Estoppel*, 11 INT'L. REV. L. & ECON. 47 (1991); Stephen J. Spurr, *Collateral Estoppel*, *in* 1 THE NEW PALGRAVE DICTIONARY OF ECONOMICS AND THE LAW 289 (Peter Newman ed., 1998). RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 593-95 (6th ed. 2003). *But see*, Brainerd Currie, *Mutuality of Collateral Estoppel: Limits of the* ***Bernhard*** *Doctrine*, 9 STAN. L. REV. 281, 285 (1957) (criticizing "the multiple claimant anomaly" that can arise with non-mutual offensive collateral estoppel utilizing a hypothetical involving fifty potential plaintiffs injured by a train wreck); and Jack Ratliff, Offensive Collateral Estoppel and the Option Effect, 67 TEX. L. REV. 63, 74, 77-95 (1988) (discussing the unfairness of the litigation options that plaintiffs have under offensive non-mutual collateral estoppel).

[235] U.S. CONST. art. V.

[236] *Id*.

States Constitution requires three-quarters of the state legislatures or state conventions to ratify a Constitutional amendment.[237] The only amendment ratified by state conventions was the Twenty-first Amendment, which repealed Prohibition.[238] Although there have been over eleven thousand constitutional amendments introduced in Congress since 1793, only thirty-three of these have received the requisite two-thirds vote of Congress to be submitted to the states for ratification.[239] Of those, six were never ratified, including most notably, the Equal Rights Amendment proposed in 1972 and most recently, the D.C. Voting Rights Amendment proposed in 1978.[240]

The political value of precluding some amendment options helps to explain the above super-majoritarian requirements for the proposal and ratification of constitutional amendments.[241] The constitutional amendment process "guards equally against that extreme facility, which would render the Constitution too mutable; and that extreme difficulty, which might perpetuate its discovered faults."[242]

A similar concern about precluding judicial and legislative options helps explain why the current United States Supreme Court engages in judicial minimalism.[243] Deciding a particular case not only decides that case on its merits, but it affects future activity, behavior and cases via precedent and the resulting effects on incentives. In addition, the principles of analogical reasoning and the demands of logical consistency mean that any judicial decision may constrain or preclude future related legal options.

Finally, as Professors Dixit and Pindyck suggested in their book, "[m]arriage entails significant costs of courtship, and divorce has its own monetary and emotional costs. Happiness or misery within the marriage can be only imperfectly forecast in advance, and continues to

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[237] *Id*.
[238] U.S. CONST. amend. XXI.
[239] LINDA R. MONK, THE WORDS WE LIVE BY: YOUR ANNOTATED GUIDE TO THE CONSTITUTION 116 (2003).
[240] *Id*.
[241] DIXIT & PINDYCK, *supra* note 18, at 25.
[242] THE, FEDERALIST No, 43 (James Madison).
[243] *See e.g.*, CASS R. SUNSTEIN, ONE CASE AT A TIME: JUDICIAL MINIMALISM ON THE SUPREME COURT (1999).

fluctuate stochastically even after the event. Therefore waiting for a better match has an option value."[244] The perspective of this Article suggests analyzing family law statutes in terms of how they regulate the options to marry or divorce. For example, the family law statutes of many states require couples to wait for a specified period of time after the issuance of a marriage certificate before they can marry.[245] Symmetrically, some of these states also stipulate that a couple may not divorce until after the passage of a mandatory waiting period, that usually exceeds the mandatory prenuptial waiting period.[246] One can understand both types of such family law statutes as raising the waiting time or non-monetary price of, if not precluding, certain marriage or divorce options. The debate over whether a state will recognize legally the marriage of gay and lesbian couples effectively concerns whether a state will preclude legal marriage options and the attendant legal rights (themselves options) that follow. In fact, legal rights in general are real options their owners may choose not to exercise because of too low payoffs or too high strike prices.

Conclusions

This Article advocates a new real options perspective to analyzing legal doctrines and rules. In particular, this Article introduces a new real options game-theoretic model of (possibly, frivolous) litigation. This novel theory is a hybrid approach that combines a real options approach to litigation incentives and game-theoretic models of pre-trial settlement negotiations. This Article derives a set of necessary and sufficient conditions for the credible filing of (possibly, frivolous) litigation based on whether the real abandonment option values from

[244] DIXIT & PINDYCK, *supra* note 18, at 24.
[245] *See, e.g.*, 23 PA. C.S.A. § 1303 ("No marriage license shall be issued prior to the third day following the making of application therefor.").
[246] *See, e.g.*, 23 PA. C.S.A. § 3301 (stating that a married couple must allege that their marriage is irretrievably broken, file affidavits that each party consents to a divorce, and wait ninety days after commencing such action before the court may grant a divorce).

continuing litigation exceed the cost of those litigation abandonment options. In other words, plaintiffs only credibly file and correspondingly, defendants only settle those (possibly, frivolous) lawsuits with initial positive net (of the cost of litigation) real abandonment option values. This Article also considers limitations of strategic litigation options analysis. Finally, this Article very briefly introduces other applications of real options analysis to law, including reevaluating the "calculus" of negligence in torts by restating a real options version of the Hand formula, and pointing out preclusions of real options in various areas of law.

Appendix: A Real Options Game-Theoretic Model of Litigation

This appendix introduces a real options model of (possibly, frivolous) litigation under the assumption that defendants and plaintiffs maximize their expected net wealth and initially have incomplete but, common knowledge regarding all information concerning their litigation. This appendix adopts these quite strong assumptions to focus attention on the additional and novel insights provided by viewing litigation through the lens of real options theory. This Article demonstrates that real options analysis generates different conclusions and implications from those of expected value analysis under an identical set of assumptions. Litigation costs are stochastic processes in the real options game-theoretic model in this appendix. More generally, litigants might choose the levels of litigation expenditures as endogenous variables as opposed to facing litigation costs that are exogenously distributed random variables. It is left for another day to model endogenous litigation expenditures in a strategic real options analysis of litigation.

A. Notation

The following notation is used in the formal model. Denote the plaintiff's total litigation costs by P. Denote the defendant's total litigation costs by D. Divide the number of stages in pre-trial bargaining by the index t = 1, ..., n. All money values at periods t > 1 are denominated in terms of their present discounted values at t = 1 (using a common discount rate or factor). Let I_t represent the plaintiff's litigation costs at stage t. Thus, by definition, $P = \sum_1^n I_t$. Let C_t represent the defendant's litigation costs at stage t. Then, by definition, $D = \sum_1^n C_t$. Let P_t denote the plaintiff's remaining litigation costs after stage t. Then, by definition, $P_t = \sum_t^n I_k$. Let $E_1(P_t)$ denote the initial expected present value of plaintiff's remaining litigation costs once stage t is reached. Let D_t denote the defendant's remaining litigation costs once stage t is reached. Then, by definition, $D_t = \sum_t^n C_k$. Let $E_1(D_t)$ denote the initial expected present value of

defendant's remaining litigation costs once stage t is reached. Let α denote the relative bargaining strength of the plaintiff; so that, $0 \leq \alpha \leq 1$.

At stage t, the size of the dollar amount of judgment expected at trial is J_t. At stage t, the subjective probability of the plaintiff prevailing at trial is denoted p_t. At stage t, the expected value of the judgment expected at trial is defined as $x_t = p_t J_t$. Denote by $E_1(s_t)$ the initial net present discounted expected value of the settlement if the litigation settles at stage t. Solving recursively via backwards induction, $E_1(s_t) = x_1 + \alpha E_1(D_t)-(1-\alpha)E_1(P_t)$. Let $OV_1(s_t)$ be the initial abandonment option value of the settlement at stage t. Finally, let $E_1(I_t)$ be the initial present expected value of the plaintiff's litigation cost at stage t.

The following real options model of lawsuits assumes that $\{J_t\}$, $\{I_t\}$ and $\{C_t\}$ are stochastic processes, whose distributions are agreed upon and common knowledge among the litigants and their attorneys. Recall the litigants are assumed to be risk-neutral, share a common discount rate and face no effective wealth constraints. Finally, J_t, I_t and C_t are assumed to be independent random variables at each t.

B. Necessary and Sufficient Conditions for the Credible Filing of Litigation

This characterization of the incentives to file lawsuits illustrates the power of backwards induction.

<u>Proposition 1</u>: A necessary and sufficient condition for a lawsuit to be filed is that the initial value of all the **<u>abandonment options</u>** exceed the initial value of their expected costs or premia. In other words, for all t = 1, ..., n; these inequalities hold at date 1:

$$OV_1(s_t) \geq E_1(I_t)$$

Proof: (a) Necessity: If for any $t \leq n$, $OV_1(s_t) < E_1(I_t)$; then both parties expect at stage 1 that the plaintiff will not continue the lawsuit at stage t. Thus, reasoning backwards, both parties expect at stage 1 that the plaintiff's threat at stage t to continue the lawsuit is not credible.
(b) Sufficiency: Conversely, if for all $t \leq n$, $OV_1(s_t) \geq E_1(I_t)$, then both parties expect at stage 1 that the plaintiff will at each stage t be able to credibly threaten to continue the lawsuit for its abandonment option value at that stage. ■

It is straightforward to show that any Positive-Expected-Value (PEV) lawsuit will always satisfy the above condition.

Proposition 2: If a lawsuit has PEV, then all of the abandonment options will have initial values that exceed their initial expected cost.

Proof: A PEV lawsuit by definition satisfies $x_1 \geq E_1(P)$. Because $P = \sum_1^n I_t^i$ and $I_t \geq 0$ for all t, it follows that $x_1 \geq E_1(I_t) + E_1(P_t)$ for all t. So, $\alpha x_1 \geq \alpha E_1(I_t)$ and $(1-\alpha)x_1 \geq (1-\alpha)E_1(I_t)+(1-\alpha)E_1(P_t)$ for all t. Adding these last two inequalities together results in the inequality, $x_1 - (1-\alpha)E_1(P_t) \geq E_1(I_t)$ for all t. This implies that $x_1 + \alpha E_1(D_t)-(1-\alpha)E_1(P_t) \geq E_1(I_t)$ for all t because $\alpha E_1(D_t) \geq 0$. But, $E_1(s_t) = x_1 + \alpha E_1(D_t)-(1-\alpha)E_1(P_t)$ by definition. So, for all t; $E_1(s_t) \geq E_1(I_t)$. Finally, by the definition of abandonment option value, we conclude that for all t; $OV_1(s_t) \geq E_1(s_t) \geq E_1(I_t)$. ■

Thus, a lawsuit having PEV is a sufficient, but not necessary condition for a lawsuit to be credibly filed by a plaintiff. The last step in the proof of the above corollary, namely that for all t; $OV_1(s_t) \geq E_1(s_t)$ is merely an instance of the more general proposition that at every date, the abandonment option value of a random variable is greater than its expected value. This is true because the abandonment option value of a random variable can be thought of as being equal to its expected value with all of its negative value realizations replaced by zero.

C. Real Option Values and Equilibrium Settlement Amounts

In the LPG model of legal disputes, the parties compare their deterministic cash outflows from the costs of litigation with their probability weighted expected monetary payoffs to litigation. If the parties have the same expected values for trial, they will settle rather than go to court in order to save on trial costs (even if they are risk-neutral) or because they are risk-averse (even if trial costs are zero). Parties only go to trial if they have sufficiently different beliefs over the probability that the plaintiff will prevail at trial and/or the size of the judgment if the plaintiff should win at trial. In the LPG models, different expected values for the outcome of trial are necessary, but not sufficient for trial.[247] Settlement occurs if and only if there is a range of mutually acceptable settlement amounts. This interval will be non-empty if and only if the difference between the plaintiff's expected gain and the defendant's expected loss from going to trial is less than the sum of their litigation costs. The parties will settle immediately at an amount in the range of mutually acceptable settlement amounts. The precise settlement amount in that range is determined by the values of the parties' relative bargaining strengths. A similar immediate settlement result holds true in this real abandonment options model of lawsuits, the difference being the value of the settlement amount.[248]

<u>Proposition 3</u>: If the parties to litigation share the same initial common probability beliefs $\{p_t\}$ and have common knowledge over $\{J_t\}$, $\{I_t\}$ and $\{C_t\}$, then both parties will agree to settle the litigation in period 1 for the Nash equilibrium amount $S^* = OV_1(s_1) \geq E_1(s_1)$.

<u>Proof</u>: If the litigants share common priors regarding the distributions of the relevant random variables, then they also will agree on the values of $OV_1(s_t)$ and $E_1(I_t)$ and the inequality

[247] *See, e.g.* MICELI, *supra* note 79, at 157-58 for an exposition of the differing perceptions model.
[248] *See also*, Cornell, *supra* note 85, at 180-81.

conditions in Proposition 1 being satisfied for all $t \leq n$. Thus, they will agree to settle immediately to avoid incurring litigation costs. In other words, the defendant will effectively agree to buy the plaintiff's initial abandonment option for its value $OV_1(s_1)$ which is at least as large as the net present discounted expected value of the lawsuit, $E_1(s_1)$. ■

In this real options game-theoretic model, all lawsuits are settled immediately in the case of homogeneous probability beliefs $\{p_t\}$ between the plaintiff and defendant and common knowledge regarding the distributions of $\{J_t\}$, $\{I_t\}$ and $\{C_t\}$. As with settlement in the LPG model, the settlement amount in this real options model is constructed iteratively period by period from the last period backwards. If a lawsuit were to be credibly filed and not settled immediately due to differing beliefs $\{p_t\}$ or lack of common knowledge over the distributions of $\{J_t\}$, $\{I_t\}$ and $\{C_t\}$, it might settle nonetheless at some later period, e.g., after discovery, due to convergence of probability beliefs $\{p_t\}$ or common knowledge about $\{J_t\}$, $\{I_t\}$ and $\{C_t\}$. In particular, optimism or self-serving biases can generate lack of immediate settlement, as is the case in the LPG model.[249] Finally, notice that higher than expected actual realized litigation costs may cause a plaintiff to unilaterally drop her lawsuit (because the premium of the abandonment option at that stage is greater than its value).

D. Qualitative Comparative Statics or Sensitivity Analysis

A real options game-theoretic model of lawsuits has different implications for how various policies or shifts in the underlying legal random variables change the incentives to file lawsuits and the size of Nash equilibrium settlement amounts than those that are predicted by expected value game-theoretic model of lawsuits. Economists utilize the phrase comparative

[249] Linda Babcock & George Loewenstein, *Explaining Bargaining Impasse: The Role of Self-Serving Biases*, 11 J. ECON. PERSP. 109, 111-16 (1997).

statics analysis to refer to a comparison of how equilibrium behavior differs for different parameter values.[250] Another way to think of a comparative statics result is that it analyzes how sensitive behavior endogenously determined in equilibrium is to changes in exogenous variables. Thus, comparative statics results are forms of sensitivity analysis. In the litigation abandonment real options model, many of these comparative statics results are driven by the fact that the option value of a random variable increases with its variance because of the option to avoid downside risk, while a random variable's expected value does not necessarily increase with its variance.

The first comparative statics result concerns the awarding of punitive damages, a practice in certain areas of the law such as treble damages in antitrust,[251] punitive multiples in certain tort actions,[252] or willful contract breach.[253] Punitive damages increase the incentive to file lawsuits because such damages increase the amount of expected judgments. But, above and beyond the mean-increasing effect on judgments, punitive damages also increase the variance of judgments and hence they not only increase the net present discounted values, but also the real abandonment option values, of settlement.

Proposition 4: Holding all other variables fixed, punitive damages increase the incentives to file lawsuits and equilibrium settlement amounts more that just a variance-preserving increase in judgments by the same factor as the punitive multiple does.

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[250] *See, e.g.*, ALPHA C. CHIANG, FUNDAMENTAL METHODS OF MATHEMATICAL ECONOMICS 127-28 (3d ed. 1984) (explaining the method of comparative statics); LIONEL W. MCKENSZIE, CLASSICAL GENERAL EQUILIBRIUM THEORY 133-64 (2002) (presenting a detailed and rigorous treatment of comparative statics); and PAUL A. SAMUELSON, FOUNDATIONS OF ECONOMIC ANALYSIS 20 (enlarged ed 1983) (defining comparative statics).

[251] Clayton Act, ch. 323, §4(a), 38 Stat. 730 (1914).

[252] *See, e.g., Milwaukee and St. Paul R.R. Co. v. Arms et al.*, 91 U.S. 489, 492 (1875) (holding that punitive damages were "too well-settled now to be shaken, that exemplary damages may in certain cases be assessed.").

[253] *See generally*, A. Mitchell Polinsky & Steven Shavell, *Punitive Damages: An Economic Analysis*, 111 HARV. L. REV. 869 (1998) and CASS R. SUNSTEIN ET AL., PUNITIVE DAMAGES: HOW JURIES DECIDE (2002). *See also*, John E. Calfee & Richard Craswell, *Some Effects of Uncertainty on Compliance with Legal Standards*, 70 VA. L. REV. 965, 994-97 (1984); Richard Craswell, *Damage Multipliers in Market Relationships*, 25 J. LEGAL STUD. 463 (1996); and Richard Craswell, *Deterrence and Damages: The Multiplier Principle and Its Alternatives*, 97 MICH. L. REV. 2185 (1999); and Richard Craswell & John E. Calfee, *Deterrence and Uncertain Legal Standards*, 2 J.L. ECON. & ORG. 279, 292-97 (1986).

Proof: All other things being equal, punitive damages increase the variance of x_t for all t and thus increase $OV_1(s_t)$ for all t. Thus, the necessary and sufficient conditions for filing lawsuits are more likely to hold than before and compared to merely a variance-preserving increase in judgments by the same factor as the punitive multiple. ■

The other side of the above result concerns the frequently suggested policy of capping the damages which juries can award. Although these proposals usually lament both the unpredictability and seemingly random nature of jury awards, the argument behind these reforms focuses on the absolute magnitude of the punitive component of jury awards. A real abandonment options model of lawsuits makes clear that not only the size of expected punitive damages, but also the variance of punitive damages affects the incentives to sue and settle. This is because above and beyond the mean-decreasing effect on judgments, damage caps also decrease the variance of judgments and hence they not only decrease the net present values, but also the real abandonment option values of settlement.

Proposition 5: Holding all other variables fixed, damage caps decrease the incentives to file lawsuits and equilibrium settlement amounts more that just a variance-preserving decrease in judgments by the same factor as the punitive multiple does.

Proof: All other things being equal, damage caps decrease the variance of x_t for all t and thus decrease $OV_1(s_t)$ for all t. Thus, the necessary and sufficient conditions for filing lawsuits are less likely to hold than before and compared to merely a variance-preserving decrease in judgments by the same factor as the punitive multiple. ■

The above two results concerning effects on incentives to file lawsuits of substantive or procedural reforms are special cases of the next general comparative statics result about how the

real abandonment option value of a lawsuit changes as the variance of the trial judgment award changes.

Proposition 6: Holding all other variables fixed, an increase (respectively, decrease) in the variance of the trial judgment award increases (respectively, decreases) the incentives to file lawsuits and equilibrium settlement amounts.

Proof: All other things being equal, higher (respectively, lower) variance in the trial judgment award increases (respectively, decreases) $OV_1(s_t)$ for all t. Thus, the necessary and sufficient conditions for filing a lawsuit are more (respectively, less) likely to hold than before. ■

The next proposition explains how the option value of a lawsuit changes as the variance of the defendant's litigation costs changes, all other things being equal. More (respectively, less) risk over the defendant's legal costs at any given stage increases (respectively, decreases) a plaintiff's incentive to file a lawsuit because of the increased (respectively, decreased) savings in defendant's avoided legal costs from settling before that stage.

Proposition 7: Holding all other variables fixed, increasing (respectively, decreasing) the variance of defendant's litigation costs at any stage $k \leq n$, increases (respectively, decreases) the incentives to file lawsuits and equilibrium settlement amounts.

Proof: Holding all other variables fixed, more (respectively, less) variance in the defendant's litigation costs at stage $k \leq n$ increases (respectively, decreases) $OV_1(s_t)$ for all $t \leq k$. Thus, the necessary and sufficient conditions for filing a lawsuit are more (respectively, less) likely to hold than before. ■

Because changing the variance of the plaintiff's litigation costs also generally changes the mean of the plaintiff's litigation costs; changing the variance of the plaintiff's litigation costs affects both sides of the inequalities from the necessary and sufficient conditions for the (credible) filing of a lawsuit. To isolate the impact of changing the variance of the plaintiff's litigation costs upon the option value of lawsuit, the next proposition analyzes how the option value of a lawsuit changes as the variance of plaintiff's litigation costs changes in a mean-preserving manner.

Proposition 8: Holding all other variables fixed, a mean-preserving increase (respectively, decrease) in the variance of plaintiff's litigation costs at any stage $k \leq n$, increases (respectively, decreases) the incentives to file lawsuits and equilibrium settlement amounts.

Proof: All other things being equal, higher (respectively, lower) variance in the plaintiff's litigation costs at stage k increases (respectively, decreases) $OV_1(s_t)$ for all $t \leq k$. Thus, the necessary and sufficient condition for filing a lawsuit is more likely to hold than before. ■

The next proposition analytically demonstrates that initially NEV lawsuits due to non-negative values of litigation real options generalizes Bebchuk's model of NEV litigation.

Proposition 9: The set of parameter values for which initially NEV lawsuits are brought is larger than in Bebchuk's model of NEV litigation.[254] The difference between the set of parameter values for which NEV lawsuits are filed in a real options model and Bebchuk's model is a function of the difference between $OV_1(s_t)$ and $E_1(s_t)$, which in turn depends on the ability to subdivide the litigation into stages and the opportunities to learn more information.

[254] Bebchuk, *supra* note 94, at 14.

Proof: Bebchuk's conditions for the filing of a lawsuit can be thought of as t, $E_1(s_t) > I_t$. Bebchuk's model describes the situation of a lawsuit in which the values of all of the variables are known with certainty by the litigants. Under symmetric uncertainty, Bebchuk's conditions become $E_1(s_t) > E_1(I_t)$. Because the lawsuit can be dropped t, $OV_1(s_t) \geq 0$ and moreover $OV_1(s_t) \geq E_1(s_t)$. Thus, whenever $E_1(s_t) > E_1(I_t)$, $OV_1(s_t) > E_1(I_t)$ also holds. But, $OV_1(s_t) > E_1(I_t)$ can hold even though $E_1(I_t) > E_1(s_t)$. ■

Interpreting a comparison between the relative sizes of the set of parameter values in Bebchuk's non-stochastic model that satisfy the necessary and sufficient conditions for the credible filing of NEV lawsuits with that of the set of parameter values in the stochastic real abandonment options model that satisfy the necessary and sufficient conditions for the credible filing of NEV lawsuits requires a bit of care. When any non-stochastic model is embedded in another stochastic model involving the same variables as in the non-stochastic model, the whole parameter space of the non-stochastic model is only a single point in the parameter space of the stochastic model. In other words, for most economically and legally relevant choices of topologies and measures, the entire parameter space of the non-stochastic model will only be a small or negligible set in the parameter space of the stochastic model. [255] Thus, any proper subset of the parameter space of the non-stochastic model is a fortiori a small and negligible proper subset in the parameter space of the stochastic model. It is thus comes as no surprise that a real options model of NEV litigation generalizes Bebchuk's non-stochastic model of NEV litigation

[255] The precise notion of small depends on how we measure risk. For example, if risk involves a family of normal distributions, the parameter space of the stochastic model is that of the mean and variance of normally distributed random variables and the non-stochastic model is described by a point, which is a closed set of measure zero in the non-negative quadrant of Euclidean plane. If the risk involves a family of smooth distributions restricted to have finite variance, then a natural parameter space of the stochastic model is the infinite dimensional function space L^2 and the non-stochastic model is described by a set consisting of a single point, which is a small or negligible set for most economically, legally, and mathematically relevant or appropriate choices of topologies and measures. For technical details, see RALPH ABRAHAM ET AL., MANIFOLDS, TENSOR ANALYSIS, AND APPLICATIONS 2, 399, 551 (1983) (defining closed set, L^p spaces, and measure zero).

because any stochastic model generalizes any non-stochastic model involving the same variables in the sense that stochastic random variables generalize non-stochastic random variables.

The next two results analyze the impact of changes in a plaintiff's litigation costs on that plaintiff's incentive to file litigation and the resulting equilibrium settlement amount. Increased or greater divisibility of a plaintiff's legal costs only bolstered the credibility of a plaintiff's threats to continue a lawsuit in Bebchuk's non-stochastic model,[256] and Cornell's non-game-theoretic model.[257] A similar proposition holds in this Article's game-theoretic stochastic model.

Proposition 10: A finer partition of a plaintiff's legal costs can only bolster the credibility of that plaintiff's threats to continue a lawsuit and therefore increase equilibrium settlement amounts.

Proof: Let a finer partition of the plaintiff's legal costs be formed by at least subdividing some stage k into two substages: i and j. By construction, the plaintiff's legal costs in stage k can be decomposed into two component legal costs in stage i and stage j: $I_k = I_i + I_j$. If the plaintiff initially had credible threats for continuing the lawsuit through to trial, then by proposition 1, option values of settlement at each stage are larger than the initial expected premia of those continuation options. In other words, for all $t \leq n$; these inequalities hold at date 1: $OV_1(s_t) \geq E_1(I_t)$. In particular, at stage 1 it is expected that at stage k, $OV_1(s_k) \geq E_1(I_k) = E_1(I_i) + E_1(I_j)$. By definition of the random variables s_t, $s_k = s_i = s_j$ because there is no intermediate bargaining between stages k and k+1. Thus, $OV_1(s_i) = OV_1(s_k) \geq E_1(I_k) > E_1(I_i)$ and $OV_1(s_j) = OV_1(s_k) \geq E_1(I_k) > E_1(I_j)$. By proposition 1, this means that all of the plaintiff's threats for continuing the lawsuit through to trial remain credible.

[256] Bebchuk, *supra* note 94, at 15 and n.11. *See also*, Lucian A. Bebchuk, On Divisibility and Credibility: The Effects of the Distribution of Litigation Costs Over Time on the Credibility of Threats to Sue, John M. Olin Center for in Law, Economics, and Business Discussion Paper No. 190, Harvard Law School (August 1996) (unpublished manuscript).
[257] Cornell, *supra* note 85, at 184.

If the plaintiff initially did not have a credible threat at stage k for continuing the lawsuit through to trial, then by proposition 1, $OV_1(s_k) < E_1(I_k) = E_1(I_i) + E_1(I_j)$. As noted above, $s_k = s_i = s_j$ because there is no intermediate bargaining between stages k and k+1. It is now possible that both $OV_1(s_k) \geq E_1(I_i)$ and $OV_1(s_k) \geq E_1(I_j)$. Of course, that is not guaranteed because it is also possible that $OV_1(s_k) < E_1(I_i)$ yet $OV_1(s_k) \geq E_1(I_j$ or $OV_1(s_k) \geq E_1(I_i)$ yet $OV_1(s_k) < E_1(I_j)$ or $OV_1(s_k) < E_1(I_i)$ and $OV_1(s_k) < E_1(I_j)$. If any one of these three possibilities holds, then the plaintiff is initially expected not to have a credible threat at stage i or j or both for continuing the lawsuit through to trial. ■

In Cornell's non-game-theoretic model, front-loading a plaintiff's legal costs, meaning increasing that plaintiff's expected litigation costs at earlier stages while preserving the plaintiff's total expected litigation costs, reduced that plaintiff's litigation abandonment option value.[258] A similar proposition holds in this Article's game-theoretic stochastic model.

<u>Proposition 11</u>: Holding all other variables fixed, front-loading a plaintiff's litigation costs decreases the incentives to file lawsuits and equilibrium settlement amounts.

<u>Proof</u>: All other things being fixed, front-loading a plaintiff's litigation costs increases $E_1(I_t)$ for initial values of t = 1, 2, …. Thus, the necessary and sufficient conditions for initially filing lawsuits are less likely to hold than before. ■

Conversely, back-loading a plaintiff's legal costs, meaning decreasing that plaintiff's expected litigation costs at earlier stages while preserving the plaintiff's total expected litigation costs, increases that plaintiff's litigation abandonment option value.

[258] Blanton, *supra* note 86, at 161, 186.

Proposition 12: Holding all other variables fixed, back-loading a plaintiff's litigation costs increases the incentives to file lawsuits and equilibrium settlement amounts even preserving the plaintiff's total expected litigation costs.

Proof: All other things being held equal, back-loading a plaintiff's litigation costs decreases $E_1(I_t)$ for initial values of t = 1, 2, …. Thus, the necessary and sufficient conditions for initially filing lawsuits are more likely to hold than before. ■

In Cornell's non-game-theoretic model, increasing a plaintiff's total legal costs reduced that plaintiff's litigation abandonment option value.[259] A similar proposition holds in this Article's game-theoretic stochastic model.

Proposition 13: Holding all other variables fixed, increasing a plaintiff's total expected litigation costs decreases that plaintiff's incentives to file lawsuits and equilibrium settlement amount.

Proof: All other things being held fixed, increasing a plaintiff's total expected litigation costs increases $E_1(I_t)$ for some value(s) of t. Thus, at least one of the necessary and sufficient conditions for initially filing lawsuits is less likely to hold than before. ■

Conversely, decreasing a plaintiff's total legal costs increases that plaintiff's litigation abandonment option value.

Proposition 14: Holding all other variables fixed, decreasing a plaintiff's total expected litigation costs increases that plaintiff's incentives to file lawsuits and equilibrium settlement amount.

[259] *Id*.

Proof: All other things being equal, decreasing a plaintiff's total expected litigation costs decreases $E_1(I_t)$ for some value(s) of t. Thus, at least one of the necessary and sufficient conditions for initially filing lawsuits is more likely to hold than before. ■