ESSAYS

AUTOMATING CONTRACT LAW

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The study of contract law is undergoing a difficult transition as it moves from the theoretical to the empirical. Over the past few decades scholars have focused largely on developing economic theories that offer a normative approach to setting the legal rules governing voluntary exchange. The time has now come to test whether these theories provide a meaningful basis for choosing our laws—in other words, to ask whether empirical data supports the theoretical models that contracts scholars have posited. Unfortunately, this type of empirical analysis has proven exceptionally difficult to conduct, and some commentators are beginning to question whether it will ever be possible to test and revise our economic theories of contract in a meaningful manner. Yet the problem of harnessing information to support complex decisions is not unique to contract law. This Essay explores the possibility that recent technological developments from the field of organizational knowledge management—including advances in meaning-based computing algorithms—will soon make it easier to conduct empirical work in contract law on a much larger scale.

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Introduction

Early one morning in January 1956, Herbert Simon announced to his graduate class at Carnegie Mellon that "[o]ver Christmas, Al Newell and I invented a thinking machine."[1] His claim was a bit premature, but Simon did win the Nobel Prize in Economics twenty-two years later—not for creating a sentient computer, but rather "for his pioneering research into the decisionmaking process within economic organizations."[2] Simon's main contention was that all decisions had to be made under uncertainty because it was impossible to gather and process every bit of relevant information.

Despite these computational limits, Simon did not just throw up his hands and suggest that decisionmakers abandon the collection of information and resort to, say, flipping a coin. He concentrated instead on techniques that might improve our ability to muster information, such as finding patterns or organizational structures in data to manage information overload. Thus Simon famously studied master chess players, determining that they each could keep thousands of "chunks" of information on chess positions in their minds and draw on these chunks to plan their moves.[3] Or he told stories about the ability

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1 Carnegie Mellon University Libraries, Herbert Simon Collection, Exhibit, Problem Solving Research, http://shelf1.library.cmu.edu/IMLS/MindModels/problemsolving.html (last visited Jan. 20, 2008).

2 Press Release, The Royal Swedish Acad. of Scis., Studies of Decision-Making Lead to Prize in Economics (Oct. 16, 1978), *available at* http://nobelprize.org/nobel_prizes/economics/laureates/1978/press.html.

3 Herbert A. Simon & Kevin Gilmartin, *A Simulation of Memory for Chess Positions*, 5 Cognitive Psychol. 29, 43 (1973).

of a master watchmaker to increase production by dividing tasks into modular subassemblies instead of trying to put together a complete watch in one go.[4]

The concepts of chunking up information and modularizing complicated systems were helpful frames, but ultimately Simon became fascinated with the potential of technology and computer simulation to organize information beyond human capacity and to facilitate complex decisionmaking.[5] Simon was a polymath with diverse interests, spanning theories of artificial intelligence,[6] the social implications of computing,[7] and philosophical problems in epistemology and intelligence.[8] Yet in all of these areas, Simon had a singular quest: to uncover how computing might augment our ability to process information.[9]

The design of contract law is similar to the boardrooms and chessboards that Simon studied, in that the creation of contract law also involves difficult and complex tradeoffs.[10] And just as directors and chess players seek data to reduce uncertainty and to guide their choices, contract scholars have moved toward empiricism as a basis for selecting the rules that govern our agreements, promises, and contractual bargains.[11] This trend is not confined to contract law, of course; legal scholars of all stripes seek tangible data to evaluate their theories.[12] My interest in this Essay relates to the rules governing

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[4] HERBERT A. SIMON, THE SCIENCES OF THE ARTIFICIAL 188–90 (3d ed. 1996). Henry Smith recounts this story in more detail and relates it to contract design. Henry E. Smith, *Modularity in Contracts: Boilerplate and Information Flow*, 104 MICH. L. REV. 1175, 1179–81, 1191 (2006).

[5] HERBERT A. SIMON, MODELS OF MY LIFE 198–99 (1991).

[6] *Id.* at 189–97; *see also* Byron Spice, *CMU Legend Herbert Simon Dies at Age 84*, PITTSBURGH POST-GAZETTE, Feb. 10, 2001, at A1 (stating that Simon and Newell "launched the field of artificial intelligence").

[7] Herbert A. Simon, *Prometheus or Pandora: The Influence of Automation on Society*, COMPUTER, Nov. 1981, at 69, 69–70.

[8] SIMON, *supra* note 4, at 80–83.

[9] SIMON, *supra* note 5, at 198–99.

[10] *See, e.g.*, Richard Craswell, *In That Case, What Is the Question? Economics and the Demands of Contract Theory*, 112 YALE L.J. 903, 913–14 (2003) ("[Contract law] is extremely difficult, with lots of effects that we do not yet understand."); Smith, *supra* note 4, at 1187–90 (describing contractual complexity and use of modular design principles to simplify information interactions).

[11] *See, e.g.*, Ian Ayres, *Valuing Modern Contract Scholarship*, 112 YALE L.J. 881, 900 (2003) (predicting rise in empirical analysis of contract law); Russell Korobkin, *Empirical Scholarship in Contract Law: Possibilities and Pitfalls*, 2002 U. ILL. L. REV. 1033, 1037 (offering framework for classifying and pursuing future empirical scholarship in contract law); David V. Snyder, *Go Out and Look: The Challenge and Promise of Empirical Scholarship in Contract Law*, 80 TUL. L. REV. 1009, 1009–10 (2006) (reflecting on current state of contracts scholarship and on heightened interest in empirical analysis).

[12] Over the last decade, legal scholars from many fields have called for more empirical analysis. *See* RICHARD A. POSNER, OVERCOMING LAW 210–11 (1995) (urging greater

promise and exchange, however, and I will focus the discussion on contract law.

Unfortunately, engineering the springs and wheels of contract law with empirical data[13] presents some real challenges. For one thing, it simply takes a long time to do this work. Further, anyone studying the written opinions of judges or the executed agreements of private parties must limit her sample size, which raises questions about the general applicability of her conclusions.[14] Time and the volume of information also make it difficult to repeat or update studies.[15] Even more troubling are recent assertions that our theoretical models have grown so complex that scholars simply cannot collect or process the needed empirical information. Eric Posner, for example, has argued that while we could "make complex and interesting predictions about contract law if we had sufficient information about empirical conditions . . . it is . . . unlikely that we ever [will]."[16] Thus, while many are

scholarly attention to empiricism); Lee Epstein & Gary King, *The Rules of Inference*, 69 U. CHI. L. REV. 1, 2, 6–7 (2002) [hereinafter Epstein & King, *Rules of Inference*] (recognizing importance of empirical legal scholarship but warning that it must be performed more carefully); Michael Heise, *The Importance of Being Empirical*, 26 PEPP. L. REV. 807, 810–12 (1999) (advocating for use of empirical work); Richard A. Posner, *The Decline of Law as an Autonomous Discipline: 1962–87*, 100 HARV. L. REV. 761, 762–66 (1987) (offering historical explanation for scarcity of empirical scholarship); Thomas S. Ulen, *A Nobel Prize in Legal Science: Theory, Empirical Work, and the Scientific Method in the Study of Law*, 2002 U. ILL. L. REV. 875, 876 ("[R]ecent scholarly trends in the law show evidence of a movement toward an even more science-like discipline."). Likewise, scholars have considered institutional strategies for building the infrastructure needed to conduct this research. *See* Lee Epstein & Gary King, *Building an Infrastructure for Empirical Research in the Law*, 53 J. LEGAL EDUC. 311, 312 (2003) [hereinafter Epstein & King, *Building an Infrastructure*] (offering four concrete categories of suggestions for improving empirical legal research); Matthew Spitzer, *Evaluating Valuating Empiricism (at Law Schools)*, 53 J. LEGAL EDUC. 328 (2003) (responding to Epstein and King's suggestions); David E. Van Zandt, *Discipline-Based Faculty*, 53 J. LEGAL EDUC. 332, 335–39 (2003) (same). The 2006 annual meeting of the Association of American Law Schools also sought to promote empirical work. Program, Ass'n of Am. Law Schs., Empirical Scholarship: What Should We Study and How Should We Study It? (Jan. 3–7, 2006), *available at* http://www.aals.org/am2006/program/finalprogrammain2006.pdf.

13 In this Essay, I use the term empirical to refer to both qualitative and quantitative analysis, although some commentators focus mostly on a lack of quantitative work. *See* Epstein & King, *Rules of Inference*, *supra* note 12, at 2–3 (describing how term "empirical" refers broadly to "evidence about the world based on observation or experience"); Snyder, *supra* note 11, at 1012 (same).

14 *See* Korobkin, *supra* note 11, at 1051–52 ("None of the empirical contracts articles reviewed . . . present[s] data that makes up a truly representative sample of the population . . . . Consequently, critics will usually be able to raise legitimate questions about the extent to which descriptive conclusions or policy prescriptions can be inferred from empirical results.").

15 *See* Heise, *supra* note 12, at 816–24 (describing difficulties inherent in conducting empirical legal scholarship).

16 Eric A. Posner, *Economic Analysis of Contract Law After Three Decades: Success or Failure?*, 112 YALE L.J. 829, 864–65 (2003).

eager to see an empirical revolution,[17] the volume of work that has actually emerged in this area remains low.[18]

Of course, as Simon's work suggests, the problem of harnessing information to support complex decisions is not exclusive to contract scholars. In the corporate world, an entire market has emerged around building knowledge-management technology to help organiza-

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17 *See, e.g.*, Ayres, *supra* note 11, at 900 (joining Posner "in welcoming and predicting a shift from the theoretical to the empirical"); Russell Korobkin, *Possibility and Plausibility in Law and Economics*, 32 FLA. ST. U. L. REV. 781, 785 (2005) ("I certainly support the widespread drumbeat for legal scholars to conduct more empirical analysis than our corner of the academy has produced historically."); Snyder, *supra* note 11, at 1009 ("The opportune scholarly moment has arrived for empirical scholarship in contract law.").

18 Russell Korobkin conducted an extensive review of five hundred law journals from 1985 to 2000 to collect articles that explicitly applied empirical analysis to contract doctrine. He uncovered fewer than thirty articles, some of which only briefly discussed issues related to contract law. Ultimately, Korobkin deemed "the empirical study of contract law . . . a very underdeveloped genre of legal scholarship." Korobkin, *supra* note 11, at 1036–37. Since Korobkin's article, it appears that interest in this type of work is rising, but most recent studies do not pursue normative recommendations for contract law, or do so only tangentially. *See generally* Omri Ben-Shahar & James J. White, *Boilerplate and Economic Power in Auto Manufacturing Contracts*, 104 MICH. L. REV. 953, 956–64 (2006) (analyzing supplier contracts in automotive industry); Larry A. DiMatteo & Bruce Louis Rich, *A Consent Theory of Unconscionability: An Empirical Study of Law in Action*, 33 FLA. ST. U. L. REV. 1067, 1068–70 (2006) (coding 187 unconscionability cases to empirically examine effects of selected case characteristics on judicial outcomes); Christopher R. Drahozal, *Contracting Out of National Law: An Empirical Look at the New Law Merchant*, 80 NOTRE DAME L. REV. 523, 536–42 (2005) (examining use and prevalence of arbitration clauses in transnational commerce); Theodore Eisenberg & Geoffrey Miller, *Ex Ante Choices of Law and Forum: An Empirical Analysis of Corporate Merger Agreements*, 59 VAND. L. REV. 1975, 1981 (2006) (examining choice-of-law provisions in corporate merger contracts); M.P. Ellinghaus & E.W. Wright, *The Common Law of Contracts: Are Broad Principles Better than Detailed Rules? An Empirical Investigation*, 11 TEX. WESLEYAN L. REV. 399, 408–19 (2005) (conducting three empirical experiments replicating judicial resolution of contractual disputes); Jason Scott Johnston, *The Return of Bargain: An Economic Theory of How Standard-Form Contracts Enable Cooperative Negotiation Between Businesses and Consumers*, 104 MICH. L. REV. 857, 864–76 (2006) (demonstrating empirically that standard-form consumer contracts often grant agents of drafting party discretion to deviate from negotiated terms); Benjamin Klein & Joshua D. Wright, *The Economics of Slotting Contracts*, 50 J.L. & ECON. (forthcoming 2007) (manuscript at 33–46), *available at* http://ssrn.com/abstract=773464 (examining shelf space contracts in retail industry); Florencia Marotta-Wurgler, *What's in a Standard Form Contract? An Empirical Analysis of Software License Agreements*, 4 J. EMPIRICAL LEGAL STUD. 677, 679, 702–12 (2007) (analyzing key terms in approximately 647 software licensing contracts to determine whether agreements present substantive unconscionability problems); Deborah A. Schmedemann, *Beyond Words: An Empirical Study of Context in Contract Creation*, 55 S.C. L. REV. 145, 154–70 (2003) (conducting empirical experiment relating to creation of employment contracts); Stewart J. Schwab & Randall S. Thomas, *An Empirical Analysis of CEO Employment Contracts: What Do Top Executives Bargain For?*, 63 WASH. & LEE L. REV. 231, 240–58 (2006) (examining 375 CEO employment contracts, reporting on key terms, and linking analysis to corporate law). I have surely missed some other important studies, but I still think it is fair to assert that there is a dearth of high-quality empirical research in this area.

tions deal with vast volumes of unstructured information.[19] Some of these tools are straightforward: more powerful databases, better search engines, or systematic processes for getting the right information in front of researchers and decisionmakers. Others, however, are more innovative, involving computer algorithms that couple information theory with statistics.[20] These developments are leading to more powerful systems for managing text, voice, and video information, which large corporations, government security agencies, and others are already using with some success.[21] It is unfortunate that Simon died in 2001[22]—the technological progress of the last six years undoubtedly would have intrigued him.

This Essay explores the possibility that innovation in organizational knowledge management may soon make it easier to conduct meaningful, large-scale empirical work in contract law. The general idea of using technology to augment legal research has a vast reach, and many of the concepts and tools that I will discuss could facilitate empirical projects in diverse areas of legal scholarship.[23]

I believe, however, that contract law is especially well suited to take advantage of knowledge management for two reasons. First, the choices that parties make when forming contracts often leave a data trail.[24] The principals typically record the terms of their agreement in a way that is less likely to happen within the context of, say, tort or criminal law. Second, large, centralized repositories of contract data are now available, including databases of historically executed contracts, litigated case law, and other relevant sources. Conceivably,

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[19] For a collection of introductory articles related to knowledge management, see HARVARD BUSINESS REVIEW ON KNOWLEDGE MANAGEMENT (Harvard Bus. Review ed., 1998). For a more comprehensive synthesis of work in this area, see KIMIZ DALKIR, KNOWLEDGE MANAGEMENT IN THEORY AND PRACTICE (2005).

[20] *See infra* Part II.C.1.

[21] *See infra* Part II.

[22] Spice, *supra* note 6.

[23] This is particularly true for doctrinal or descriptive research, and the analytical methods explored *infra* Part III.A should be applicable to help automate work in *any* legal discipline with a robust body of judicial or administrative opinions. The analogy is even tighter for areas of the law that produce other large collections of unstructured data, such as business organizations or securities regulation.

[24] I say "often" because some contracts, such as implied-in-fact contracts or quasi-contracts, leave little permanent record. It also may be hard to assemble historical data for some types of contracts, such as verbal agreements. It is worth noting, however, that the knowledge-management algorithms described in this Essay are successfully being used on voice recordings. *See, e.g.*, AUTONOMY SYS. LTD., AUDIO AND BROADCAST WHITE PAPER 5–10 (2003), http://www.autonomy.com/content/downloads/White%20Papers/index.en.html (follow "Autonomy Audio Broadcast White Paper 20031003" hyperlink; then fill out pop-up form for free customer membership; then reclick on same hyperlink) (last visited Mar. 3, 2008) (describing use of knowledge-management algorithms to manage voice and other digital multimedia data).

scholars could tap and systematically study each of these digital information troves.

My primary claim is that we can, and soon will, conduct meaningful empirical work in contract law using cutting-edge knowledge-management technology. Furthermore, it will be possible to automate much of this work to allow constant updating and refreshing of the empirical studies. I want to remain cautious because contract law is complex; certainly I am not suggesting that we will reach uncontested results that allow us to make law without subjective judgment. Knowledge management offers some intriguing possibilities, however, and it is worth discussing how the tools that organizations use to manage unstructured information can assist scholarly inquiry into the incentives and effects of contract law.

I have divided this Essay into four main parts. Part I briefly reviews the current state of contract law scholarship, with a focus on economic analysis and the thirst for empirical data. Part II turns to recent technological advances in organizational knowledge management, such as algorithms that blend information theory and statistical methods to process and synthesize unstructured information. Part III illustrates some possible applications of this technology to empirical contract law research—including descriptive analysis, normative analysis, and predictive modeling. Part IV acknowledges some practical obstacles, and a brief conclusion summarizes the Essay's claims.

I
Empiricism and the Design of Contract Law

A. The Cry for Empirical Analysis

Over the past few decades, much of contract law scholarship has focused on developing economic theories that offer a normative approach to setting the legal rules governing binding promises.[25] The literature in this area is well known and vast, and I will not try to review it here.[26] Suffice to say, the economic framework is powerful

[25] Some of this work also offers a descriptive understanding of contract law, but more recent emphasis has been placed on the normative (either explicitly or implicitly). *See* Craswell, *supra* note 10, at 903–07 (describing contemporary preference for normative work).

[26] For helpful discussions of economic analysis in contract law, see Robert Cooter & Thomas S. Ulen, Law and Economics, 188–294 (4th ed. 2004), Richard A. Posner, Economic Analysis of the Law §§ 4.1–.15 (6th ed. 2003), 3 Encyclopedia of Law and Economics §§ 4000–4800 (Boudewijn Bouckaert & Gerrit De Geest eds., 2000), and Benjamin E. Hermalin et al., *Contract Law*, *in* The Handbook of Law and Economics 7–128 (A. Mitchell Polinsky & Steven Shavell eds., 2007).

because it can conceivably provide lawmakers with a principled basis for preferring one rule over another.[27]

Standard economic analysis consists of examining a project that has potential benefits for both buyer and seller.[28] After picking a specific deal, a researcher develops an economic model that considers various contingencies and contract terms and uses that model to explore how—and whether—the parties will trade and invest under different legal default rules. Based upon the model's results, the researcher may suggest that a particular rule is economically superior to the alternatives under either the theoretical framework offered or the model's assumptions.[29]

For example, Judge Richard Posner considers how economic analysis might aid courts in contract interpretation.[30] He starts by stating an objective function for our legal system: "to minimize [contractual] transaction costs, broadly understood as obstacles to efforts voluntarily to shift resources to their most valuable use."[31] Judge Posner then develops a cost function for contract formation, which includes initial efforts to draft an agreement, the probability that litigation over an ambiguous or missing term will ensue, the costs of potential litigation, and the costs of judicial error (broadly defined).[32] After further analysis, he concludes that a formalist approach to contract interpretation, requiring that parties "do whatever is necessary" to avoid ambiguity, is inefficient because it will lead to excessive

27 *See, e.g.*, Craswell, *supra* note 10, at 910–11 (describing ability of economic analysis to assess "individual pieces of the normative puzzle" even when it fails to "recommend the most efficient rule"); Alan Schwartz & Robert E. Scott, *Contract Theory and the Limits of Contract Law*, 113 YALE L.J. 541, 543–44 (2003) (using economic contract theory to develop "normative theory to guide decisionmakers in the regulation of business contracts"). Of course, the economic framework is not the only vehicle for understanding contract law. Other theories of contract law consider moral and philosophical arguments for determining which promises should be legally binding. *See, e.g.*, Randy E. Barnett, *A Consent Theory of Contract Law*, 86 COLUM. L. REV. 269, 269–89 (1986) (describing alternative theories of contract law).

28 In other words, the buyer's valuation exceeds the seller's cost of production in at least some future states of the world. One or both parties may also be able to make relationship-specific investments at a future time to increase the gains from trade. This step provides additional justification for legal enforcement of time-deferred commitments in order to counter postreliance opportunism by the other party. *See* Schwartz & Scott, *supra* note 27, at 559–62 ("Enforcement . . . permits parties to make believable promises to each other when reputational or self-enforcement sanctions will not avail.").

29 Economic superiority is usually defined in terms of welfare maximization through Pareto efficiency. *E.g.*, Posner, *supra* note 16, at 833 n.8.

30 Richard A. Posner, *The Law and Economics of Contract Interpretation*, 83 TEX. L. REV. 1581, 1581–84 (2005).

31 *Id*. at 1583.

32 *Id*. at 1583–84.

upfront drafting costs.[33] Moreover, Judge Posner's economic analysis informs the appropriate use of the indefiniteness doctrine (which is sometimes used to invalidate half-baked agreements).[34] Similar use of economic theories and models to advance normative claims permeates the contracts literature.[35]

The challenge, of course, is to determine whether these economic models are accurate reflections—or at least partial reflections—of the way the world really works. Are the variables complete enough? Are all incentives identified? Are the assumptions reasonable? And so on. In other words, economic analysis offers a powerful theoretical basis for evaluating contract law, but scholars must test these theories to determine whether normative assertions comport with real-world observations. If they do, economic analysis may actually provide a meaningful basis for making choices about our laws.

In field after field of the social sciences, scholars have made intellectual progress by creating, testing, revising, and retesting their theories in this manner. Many academic commentators believe the time has now come for contract law to follow the same path. Thomas Ulen nicely captures this sentiment: "The newer theorizing in law tends to make predictions about the real-world consequences of legal rules and standards. . . . [But] ultimately their worth turns on the extent to which they are borne out by careful empirical and experimental work."[36] Other scholars have taken up this cry, eagerly heralding the promise of a new wave of empirical analysis in contract law.[37]

Yet I think it is fair to describe empirical contract scholarship as underdeveloped. Russell Korobkin surveyed the literature a few years ago and found a "surprising dearth of empirical research in contract law scholarship."[38] There have been additional studies in recent

33 *Id*.

34 Judge Posner does not explicitly say this, but a natural extension of his work might contend that courts should enforce vague contracts only when parties make efficient tradeoffs between the various costs of contract formation. *See id.* ("The object of judicial enforcement of contracts is to minimize the sum of . . . the drafting-stage costs and the litigation-stage costs, rather than, as might seem tempting, to insist that parties do whatever is necessary at the first stage to minimize the likelihood of litigation.").

35 Much of this work deals with economic analysis of contract remedies. *See, e.g.*, Posner, *supra* note 16, at 834–37 & 837 n.16 (discussing economic arguments related to remedies); Alan Schwartz, *The Case for Specific Performance*, 89 YALE L.J. 271, 274–78 (1979) (linking economic goals of contract law to alternative remedy regimes).

36 Ulen, *supra* note 12, at 878; *see also* Thomas S. Ulen, *The Unexpected Guest: Law and Economics, Law and Other Cognate Disciplines, and the Future of Legal Scholarship*, 79 CHI.-KENT L. REV. 403, 409–14 (2004) (explaining how legal scholarship is moving away from doctrinalism and toward "proto-scientific" method of inquiry).

37 *See* sources cited *supra* note 17.

38 Korobkin, *supra* note 11, at 1061; *see also* D. Gordon Smith, *The "Branding Effect" of Contracts*, 12 HARV. NEGOT. L. REV. 189, 191 (2007) ("Instead of focusing on contract

years,[39] but this work typically takes one of two approaches, neither of which provides direct empirical guidance for the development or reform of contract law.

The first approach focuses on understanding particular terms within a specialized collection of contracts. For example, recent studies have analyzed CEO compensation agreements[40] or corporate merger contracts[41] to identify the fundamental similarities and differences among individual agreements in these categories. Given its descriptive focus, this brand of empirical analysis rarely pursues normative recommendations for contract law (or does so only tangentially). This is not to say that such work is not valuable (it is) but rather that it may have more to say about other issues—such as labor law or corporate governance—than it does about contract law.

The second approach to empirical contract research uses empirical analysis to raise a puzzle or to motivate a primary research question. For example, Robert Scott has empirically examined cases involving incomplete contracts and shown that courts frequently annul these agreements under the indefiniteness doctrine.[42] Scott's finding leads into his primary question: Why do parties continue to write these potentially nonbinding agreements?[43] To take another recent example, Jason Scott Johnston has empirically demonstrated that employees often enjoy discretion to bargain around standard-form contracts, a fact he uses to launch into several theories of contractual interpretation and enforcement.[44] Again, this is a valid and powerful use of empiricism, and I do not mean to denigrate it. But I am more interested in the possibility that we can use empirical analysis to explicitly test positive or normative claims about contract doctrine, rather than simply to motivate research.

Of course, there are exceptions to generalizations about the use of empirics in contract scholarship, and some scholars are indeed con-

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doctrine or relationship management, legal scholars could have elected to study contract documents. For the better part of the last three decades, however, such studies have been performed primarily by economists and a smattering of others who work outside of the legal academy.").

39 *See* sources cited *supra* note 18.

40 Schwab & Thomas, *supra* note 18, at 232–33 (analyzing 375 employment contracts between CEOs and large public companies).

41 Eisenberg & Miller, *supra* note 18, at 1981–85 (analyzing 412 public corporate merger agreements filed with SEC in 2002).

42 Robert E. Scott, *A Theory of Self-Enforcing Indefinite Agreements*, 103 COLUM. L. REV. 1641, 1652–53, 1692 (2003). This work is discussed in more detail *infra* notes 117–20 and accompanying text.

43 Scott, *supra* note 42, at 1660.

44 *See* Johnston, *supra* note 18, at 865–76 (presenting data from hospital industry, credit card industry, and other consumer contexts).

ducting empirical analysis with the direct and explicit goal of reforming contract doctrine.[45] Furthermore, assertions of an "empirical drought" focus mostly on a lack of quantitative empirical work, excluding a large body of doctrinal analysis that we might also consider empirical.[46] In addition, there is a growing collection of work, sometimes conducted outside the legal academy, that empirically studies executed contracts.[47] Again, however, this research typically focuses on how parties structure their agreements when the law is taken as a given rather than on using empirical analysis to decide what the law should be.[48]

B. Addressing the Indeterminacy Problem

Seizing upon the slow rate of progress in empirical contract law analysis, Eric Posner raises another pessimistic thought: Maybe this type of work just can't be done. In a provocative and widely read essay in the *Yale Law Journal*, Posner argues that there are two fundamental barriers damming a much-needed flood of empirical contracts research. First, data required to assess some economic theories of contract law are simply not available.[49] As described above, economic

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[45] *See, e.g.*, Ben-Shahar & White, *supra* note 18, at 954–55 (studying automotive supply contracts and arguing that "the way the form contracts are drafted gives a detailed understanding of how and when tailoring of terms takes place and how internal organizational features are harnessed to affect the outcome of negotiations over contract terms"); Marotta-Wurgler, *supra* note 18, at 678–81 (examining collection of terms in roughly 650 standard-form software-licensing contracts to shed light on what rules should govern such agreements).

[46] In other words, the analysis in a judicial opinion is itself an assessment of how the world works based on observation or experience, and thus it meets the definition of qualitative empirical research. *Cf.* Korobkin, *supra* note 11, at 1035 ("[Empiricism] include[s] any attempt to collect and analyze a set of data for more than anecdotal purposes . . . .").

[47] *See, e.g.*, ROGER D. BLAIR & FRANCINE LAFONTAINE, THE ECONOMICS OF FRANCHISING 54–81 (2005) (analyzing franchise contracts); Stephen J. Choi & G. Mitu Gulati, *Innovation in Boilerplate Contracts: An Empirical Examination of Sovereign Bonds*, 53 EMORY L.J. 929, 931–32 (2004) (analyzing sovereign bond contracts); Marcel Kahan & David Yermack, *Investment Opportunities and the Design of Debt Securities*, 14 J.L. ECON. & ORG. 136, 136–37 (1998) (analyzing bond indentures); Steven N. Kaplan & Per Stromberg, *Characteristics, Contracts, and Actions: Evidence from Venture Capital Analyses*, 59 J. FIN. 2177, 2177 (2004) (analyzing venture capital contracts).

[48] While it is an important question, I do not want to spend too much time asking why there has not been more empirical work in contract law. Plenty of other thoughtful articles explore the challenges of that work, which include the need for training in statistics and quantitative methods, time delays arising from data collection or from painstaking efforts to code and analyze this data, and other institutional and logistical factors. *See, e.g.*, Epstein & King, *Rules of Inference*, *supra* note 12, at 114–33 (advocating for development of infrastructure to support empirical research in legal scholarship); Heise, *supra* note 12, at 810–24 (suggesting reasons for "dearth" of empirical research in legal scholarship).

[49] *See* Posner, *supra* note 16, at 837 ("[T]he relevant variables are too complex and too hard to determine. We do not observe doctrine incorporating them, nor do we have

models evaluating alternative contract rules might make assumptions about buyer-valuation distributions, seller cost curves, specialized investment opportunities, the willingness to negotiate around information asymmetries, transaction costs, judicial administration costs, and other nuanced variables.[50] Posner doubts that empirical data can be found to challenge (or support) these assumptions.[51]

Second, even if it is possible to get at some (or all) of the necessary data, Posner contends that it will be difficult to sum up the effects of numerous variables into probabilistic choice models that might coherently suggest the superiority of a particular legal rule.[52] In other words, even if we can empirically support assumptions for the most important variables in an economic analysis, how can we possibly model the complex interactions among these variables to arrive at an optimal normative prescription for courts or legislators?[53] Further, how should we evaluate situations in which the variables point in different directions? Ultimately, Posner claims that these modeling and evaluation limitations render economic models of contract law indeterminate[54]—a damning accusation.

I agree with Posner that empirical analysis is taxing and that it can be difficult to gather and aggregate the information necessary to reach sound conclusions.[55] But I would also argue that the future of empirical contracts analysis need not be so bleak. While Posner's con-

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enough empirical data to be able to guess which rule is based on assumptions that are closer to reality.").

[50] *See supra* notes 28–35 and accompanying text.

[51] *See* Posner, *supra* note 16, at 880 ("Models that have been proposed . . . make optimal doctrine a function of variables that cannot realistically be observed, measured, or estimated.").

[52] *Id.* at 853–54.

[53] Richard Craswell nicely synthesizes Posner's concerns:

> [W]e cannot decide which remedy is "best" in any overall sense . . . unless we have some way of measuring the relevant effects, both good and bad, and then summing them to come up with a combined score for each of the possible remedies. But if we lack empirical data to measure the magnitudes of the various effects, any such sum will be difficult—or even impossible—to construct, so we will never know which remedy is truly the most efficient.

Craswell, *supra* note 10, at 908.

[54] *See* Posner, *supra* note 16, at 880 (concluding that economic analysis leaves decisionmaker with "little guidance" as to how best to reform contract law).

[55] I have tried to conduct some of it myself and have had to qualify most of the conclusions because certain variables are grounded in assumptions. *See* George S. Geis, *Empirically Assessing* Hadley v. Baxendale, 32 FLA. ST. U. L. REV. 897, 921–49 (2005) [hereinafter Geis, *Empirically Assessing* Hadley] (modeling and testing *Hadley* rule barring unforeseeable consequential damages); George S. Geis, *An Experiment in the Optimal Precision of Contract Default Rules*, 80 TUL. L. REV. 1109, 1139–47 (2006) [hereinafter Geis, *Optimal Precision*] (extending *Hadley* analysis into sample economy comprised of five diverse markets).

cerns about a dearth of information may once have been accurate, we are now entering an era where more and more data on variables related to contractual choice—including human preferences and economic cost structures—are becoming available. In fact, two sources of such data are close at hand: collections of published court opinions and digital aggregations of executed contracts.

The availability of full-text court opinions through Westlaw, Lexis, and other avenues is familiar. Some may be less aware, however, that as the cost of data storage decreases, more organizations are building centralized databases of executed contracts for public research. For example, the Digital Contracts Library, hosted by the Contracting and Organizations Research Institute (CORI), has amassed an impressive collection of over 440,000 contracts.[56] CORI gathers these contracts from both public and private organizations (much of the data comes from filings with the Securities and Exchange Commission[57]), and they are freely available for research purposes. The breadth of coverage is impressive—sports stadium leases, container shipping agreements, physician/HMO provider agreements, and so on—and CORI adds thousands of contracts daily. Moreover, there are many other contract collection initiatives underway.[58] I believe that the data now available through these sources can help jump-start empirical research.

56 Contracting and Organizations Research Institute, Digital Contracts Library, http://cori.missouri.edu/pages/ksearch.htm (last visited Jan. 28, 2008).

57 Public firms are required to file material contracts with the SEC when they register securities under the Securities Act of 1933, 15 U.S.C. § 77aa (2000). The public can easily access these contracts through EDGAR, through Lexis, or, increasingly, through third-party aggregators who collect, update, and host full-text contract databases. One organization, ONECLE, http://www.onecle.com (last visited Jan. 28, 2007), lists over ten thousand business contracts from SEC filings, sorted by industry and transaction type. This information is worth studying, but it is important to note two selection-bias concerns. First, most "nonmaterial" contracts are not disclosed. *See, e.g.*, Michael P. Vandenbergh, *The New Wal-Mart Effect: The Role of Private Contracting in Global Governance*, 54 UCLA L. Rev. 913, 936–37 (2007) (describing how SEC filing obligations only extend to material contracts). Second, there is likely to be an underrepresentation of contracts involving private companies.

58 The World Intellectual Property Organization is compiling a database of contracts related to biodiversity. World Intellectual Property Organization, Contracts Database, http://www.wipo.int/tk/en/databases/contracts/index.html (last visited Jan. 28, 2007). The University of California, Berkeley has a project collecting labor contracts. Institute for Research on Labor and Employment, Labor Contracts Database, http://www.irle.berkeley.edu/library/index.php?page=3 (last visited Jan. 28, 2008). The Kansas City Regional Purchasing Cooperative, a partnership of regional councils and local governments, gathers full-text versions of government purchase contracts. Kansas City Regional Purchasing Cooperative, Contract Database, http://www.marc.org/kcrpc/contracts.htm (last visited Jan. 28, 2008).

Similarly, I am optimistic that scholars can use analytical techniques, such as random sampling and simulation, to combine the most important variables underlying economic models of contract law—and to move us beyond the indeterminate results that Posner describes. As I discuss below, engineers have developed a number of new computer applications over the past several years that have revolutionized our ability to process and analyze vast amounts of data.[59] The methods underlying these applications provide a principled way to aggregate the effects of many different variables; applying them to contract analysis may allow us to develop new insights into the potential superiority of one approach to a contract problem over another. Indeed, some have argued that we are rapidly moving toward a world where more of our decisions will be guided by empirical efforts to gather and crunch massive amounts of data.[60] By tapping into recently amassed contract data and harnessing the power of new analytical technology, I believe we can launch such an effort in contract law scholarship. In doing so, we may be able to improve both our descriptive analysis of the law and our ability to provide meaningful normative solutions.

C. Limits of an Automated Solution

Unfortunately, the techniques described in this Essay are not perfect, and they are unlikely to prove helpful for all avenues of empirical inquiry or for all problems related to the design of contract law. It is important, therefore, to acknowledge at the outset several limitations to the solutions I am proposing.

1. Methodological Limitations

First, contract law is a social and linguistic construct, as well as an instrument for the regulation and promotion of exchange. No computer on Earth can plumb the depths of human society or language, and there will always be limits on the use of computer-aided empiricism to survey the contours of contract.

Consider one example: Richard Brooks, in an interesting and thoughtful essay, challenges the economic justification for the efficient-breach hypothesis.[61] Under this hypothesis, the option of nonperformance is awarded to the promisor, who is free to substitute

[59] *See infra* Part II.C.1.

[60] *See, e.g.*, IAN AYRES, SUPER CRUNCHERS: WHY THINKING-BY-NUMBERS IS THE NEW WAY TO BE SMART 9–13 (2007) (describing use of large empirical databases as basis for reaching better decisions in wide variety of contexts).

[61] Richard R.W. Brooks, *The Efficient Performance Hypothesis*, 116 YALE L.J. 568, 573–74 (2006).

a payment of expectation damages to the promisee in lieu of performance.[62] Brooks questions why the entitlement should run this way and proceeds to demonstrate that an alternative rule—one allowing the promisee to demand performance or to compel breach and receive the promisor's cost of performance—is also economically efficient.[63]

If Brooks has removed the efficiency basis for preferring one remedy over the other, deciding where to place the entitlement may depend on the answer to a different empirical question: What did the parties intend by their promise? Did they mean to include the option for efficient breach, or was this simply a naked promise to perform? Brooks regrets that scholars have made little effort to identify empirically the social meaning of contractual promises, leaving us with no intention-based grounds for preferring an efficient-breach or an efficient-performance hypothesis.[64]

An empirical journey into the social meaning of contractual promises is certainly possible,[65] but nothing I discuss in this Essay can directly help with such an effort. Likewise, computer-aided empiricism may not have much to add to moral or philosophical frameworks for selecting contract rules.

A second and different sort of problem arises from the perfect-rationality assumption that underlies many economic theories of contract law. Most normative arguments in favor of a given contract rule hinge upon a fundamental belief: Contracting parties will respond rationally to the incentives created through legal rules. Yet experiment after experiment suggests that our actual behavior may not

62 For further implications of the options framework in contract law, see Robert E. Scott & George G. Triantis, *Embedded Options and the Case Against Compensation in Contract Law*, 104 COLUM. L. REV. 1428, 1429–30 (2004).

63 Brooks, *supra* note 61, at 581–84. This is true because both rules cause one party to internalize the marginal costs and benefits of performance. *Id.* It is interesting to ask, however, whether distortions from a promisee's incentive to overrely with expectation damages (because he sets the probability of breach at zero) might differ from distortions caused by promisor incentives to take inadequate precautions against breach (because she sets the probability of actually performing at less than one).

64 Given this efficiency toss-up, Brooks goes on to advocate the efficient-performance hypothesis by turning to moral and philosophical reasoning. *Id.* at 591–95. An alternative approach, in the face of multiple equilibria, might be to conduct further inquiry into the relative administrative costs of each alternative—for example, will it cost more to figure out seller cost or buyer valuation? *See* Eric A. Posner, *What the Efficient Performance Hypothesis Means for Contracts Scholarship*, 116 YALE L.J. POCKET PART 438, 439–40 (2007), http://yalelawjournal.org/2007/07/23/posner.html (discussing significance of administrative costs given multiple equilibria).

65 Lisa Bernstein, for example, has explored the underlying intentions of promisors in the diamond industry. *See* Lisa Bernstein, *Opting Out of the Legal System: Extralegal Contractual Relations in the Diamond Industry*, 21 J. LEGAL STUD. 115, 115–16 (1992) (outlining possible reasons why diamond trade has unique system of private governance).

come close to perfect rationality.[66] If this is true, it poses concerns both for economic models themselves and for the empirical work seeking to reform them. In short, it will be difficult to form an economic basis for advancing any given rule when the parties may not respond as expected to the incentives it creates.

Despite the shortcomings just described, I believe that it is important to pursue computer-aided empirical analysis of contract law. As I show in the remainder of this Essay, such efforts have the potential to provide powerful insights into the ways that we do—and should—structure our contractual relationships. We should not disregard this potential simply because it will not address every problem we may confront.

2. *Informational Limitations*

Beyond its theoretical limitations, economic analysis of contract law faces some practical problems related to data. Eric Posner is surely correct that it will be difficult (and maybe impossible) to get at some of the variables that are important to economic models of contract law. The ideas presented in this Essay depend upon data availability; they will not be applicable in situations where necessary information is lacking. Of course, as discussed above, we already have access to more than enough contract data to get started; there is no reason to wait until we have covered every possible variable.

Empirical scholars should also be concerned about an entirely different data issue that has received much less attention in the contract-law literature: There is an extraordinary amount of data available on the collective choices we make in our contractual trades.[67] As the volume (and availability) of information grows, it may become more difficult to whittle it down to what really matters. Thus, while we should heed Posner's concern about data limitations,

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[66] Indeed, I argue throughout this Essay that it is rarely possible to gather enough information to lift decisional ambiguity like a stage curtain and reveal the "rational" decision. *See infra* notes 69–70 and accompanying text.

[67] The diversity of this information can most easily be seen in the marketing literature. *See, e.g.*, Randolph E. Bucklin & Catarina Sismeiro, *A Model of Web Site Browsing Behavior Estimated on Clickstream Data*, 40 J. MARKETING RES. 249 (2003) (examining browsing behavior of 5000 random visitors to the website of an Internet automotive reseller); Ganesh Iyer, *Coordinating Channels Under Price and Nonprice Competition*, 17 MARKETING SCI. 338, 352–53 (1998) (exploring how sellers should coordinate distribution channels when retailers compete on both price and nonprice terms); Sanjeev Swami et al., *SilverScreener: A Modeling Approach to Movie Screens Management*, 18 MARKETING SCI. 352, 354–58 (1999) (offering a decision support system based on media industry data).

we should also be mindful that there is—or may soon be—too much information on some subjects.[68]

Of course, fears that decisionmakers might drown in a sea of data are not new. Limits on the human cognitive ability to absorb information have led to interesting experiments in bounded rationality,[69] which behavioral theorists seize upon to argue that we are forced to resort to "mental shortcuts" in decisionmaking.[70] Information overload also gets some play in the popular press,[71] which often emphasizes how too much information can doom consumers to less meaningful choices—or even decision paralysis.[72]

While I am skeptical of this "freezing-up" phenomenon,[73] I do worry about the ability of organizational decisionmakers—including the lawmakers establishing contract law—to make the best use of all the information that is out there. There are an awful lot of economic theories about contract law and millions of contracts that might be examined to test the impact of these theories. Similarly, as the

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68 Both of these concerns can be seen as relating to the problem of obtaining *relevant* data to analyze and evaluate economic models of contract law.

69 For some helpful collections of this work, see CHOICES, VALUES, AND FRAMES (Daniel Kahneman & Amos Tversky eds., 2000), and JONATHAN BARON, THINKING AND DECIDING (2000).

70 *See* JUDGMENT UNDER UNCERTAINTY: HEURISTICS AND BIASES (Daniel Kahneman et al. eds., 1982) (arguing that people rely on heuristics as aids in decisionmaking). There are some examples of these ideas being applied in contract law. *See* Melvin Aron Eisenberg, *The Limits of Cognition and the Limits of Contract*, 47 STAN. L. REV. 211, 225–48 (1995) (exploring links between cognitive bias and contractual decisions across wide range of issues, including liquidated damages, form contracts, and express conditions); Robert A. Hillman, *The Limits of Behavioral Decision Theory in Legal Analysis: The Case of Liquidated Damages*, 85 CORNELL L. REV. 717, 718–19 (2000) (describing various forms of cognitive bias and using this work to inform judicial treatment of liquidated-damages provisions in contract law); Russell Korobkin, *Bounded Rationality, Standard Form Contracts, and Unconscionability*, 70 U. CHI. L. REV. 1203, 1255–78 (2003) (examining impact of cognitive bias on unconscionability doctrine).

71 See, for example, BARRY SCHWARTZ, THE PARADOX OF CHOICE: WHY MORE IS LESS 1–6 (2004), bemoaning modern-day anxieties such as choosing a pair of jeans at clothing retailer The Gap: "I just want regular jeans. You know, the kind that used to be the only kind."

72 *See, e.g.*, Naresh K. Malhotra, *Reflections on the Information Overload Paradigm in Consumer Decision Making*, 10 J. CONSUMER RES. 436, 437 (1984) ("[L]imited processing capacity can become cognitively overloaded if [consumers] attempt to process 'too much' information in a limited time, and this can result in confusion, cognitive strain, and other dysfunctional consequences.").

73 *See* David M. Grether et al., *The Irrelevance of Information Overload: An Analysis of Search and Disclosure*, 59 S. CAL. L. REV. 277, 279 (1986) (arguing that consumers are more likely to "satisfice" than to freeze up); Robert E. Scott, *Error and Rationality in Individual Decisionmaking: An Essay on the Relationship Between Cognitive Illusions and the Management of Choices*, 59 S. CAL. L. REV. 329, 331 (1986) ("[T]he traditional model of rational choice remains a useful norm for evaluating consumer behavior in market settings.").

volume of published legal opinions grows exponentially, it may become more difficult to determine how courts are really applying a given rule. Without some means of effectively processing or sorting through all this information, decisionmakers may make poorly informed choices or may simply throw up their hands in despair and abandon data analysis altogether.

Fortunately, the challenge of managing massive quantities of information arises in many different contexts, and some well-funded organizations have profit motives for inventing sophisticated data-management tools to aid sound decisionmaking. It is therefore worth asking whether some of the recent innovations in organizational knowledge management might also be helpful for studying and testing our theories of contract law; it is to this inquiry that I now turn.

II
Recent Technological Advances in Knowledge Management

We live in an uncertain world, and every day we are bombarded with information related to our decisions. Some of this information is structured—that is, placed in a database or other format that can be readily defined, accessed, and manipulated at an atomic level. More and more, however, we must wade through unstructured information: the management memo from last month, the video news clip from Tuesday night, this morning's phone call, or the collection of emails lingering in our inboxes.

Constant streams of information—whether structured or unstructured—can often complicate decisionmaking: We face greater uncertainty about what information to consider when deciding and greater risk that we will consider the wrong thing. By gathering, processing, and synthesizing information, however, we can improve decisionmaking by reducing that uncertainty and risk to a collection of probabilistic assessments.[74] Difficult questions cannot be answered with mathematical certainty, of course, and we will always need social context, subjective judgment, and intuition. But the disciplined tools of decision analysis—and their focus on identifying relevant variables and on gathering the empirical facts necessary to attach probabilities and payoffs to these variables—can help us seek sound results. In this regard, the last five years have led to some remarkable innovations in

[74] For helpful overviews of probability theory, see Paul Goodwin & George Wright, Decision Analysis for Management Judgment (2004), and Howard Raiffa, Decision Analysis: Introductory Lectures on Choices Under Uncertainty (1997).

knowledge-management technology. This Part considers how these new tools are changing the way decisionmakers harness unstructured information.

A. The Challenge Presented by Unstructured Information

For a long time now, we have used technology to organize and process structured information, including the use of database fields or tabular data that can be manipulated in a predetermined manner. This is the type of information that ancient punch-card computers accepted; each punched-out chad corresponded to a predefined data format. Address fields in a contact management program or billing records in a firm's financial software are also good examples of structured data. Both contain singularly defined fields specifying an enforced composition of relationships that can be used to print mailing labels or to compile financial reports.

As we empower computers to handle richer forms of content, however, more and more of our information becomes unstructured. This might include free-form text with no data-type definition, such as an email or a memo drafted in a word-processing program. This Essay itself is an example of unstructured—perhaps very unstructured—information. Digitized voice and video are still other forms of unstructured information.[75]

While the proliferation of unstructured information is not necessarily a bad thing (we enjoy using this richer content), it does complicate life for organizational decisionmakers seeking to use data to reduce uncertainty and risk. A string of old emails, for example, is harder to process and synthesize than a financial database. A collection of research papers scattered throughout remote corporate outposts is hard to incorporate into new product design decisions. There are various ways to finesse the problem, such as tagging unstructured data elements with keywords in an attempt to "force" the data into more structured formats, but these classification schemes present some obvious concerns. Most importantly, they might miscategorize data or exclude important information.[76]

In response to the challenges created by unstructured data, researchers are developing new algorithms, blending information theory, statistical inference, and other ideas to provide deci-

[75] For more on the difference between structured and unstructured information, see Geoffrey Weglarz, *Two Worlds of Data—Unstructured and Structured*, DM REV., Sept. 2004, at 19, 19.

[76] *See infra* Part II.C.2.

sionmakers with better tools for taming information.[77] This field is a close cousin to Internet search, which also entails the daunting task of organizing and categorizing unstructured information.[78] Therefore, it is helpful background to consider briefly how web-search algorithms have evolved over the past fifteen years.

B. *Search Versus Knowledge Management*

The rapid expansion of the Internet in the mid-1990s led to an exponential increase in unstructured information and created a need for search engines to navigate this universe of data. Early products were crude, focusing on webpage titles or URLs for content-based classification and retrieval.[79] The next generation of search engines improved results, however, by using web crawlers to scan the entire text of a webpage and score the document on various keyword-relevance metrics.[80] This worked well for a while, but spammers soon started to sabotage search engines by embedding unrelated words throughout their pages.[81]

In response, search engines grew more sophisticated, turning to webpage links and cross-references in order to increase accuracy and relevance. Lycos, a once-popular search engine, analyzed the anchor text around a webpage's outbound links in order to determine that referring page's content.[82] For example, if I publish a website with the phrase "Here is a terrific academic article discussing contract law" next to a hyperlink, then Lycos might use that information to infer that my site deals with contract law scholarship.

Google's celebrated PageRank algorithm took the hyperlink concept one step further with the idea of linking sites as a way to retrieve meaningful search results.[83] In a nutshell, Google crawls the web to

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77 *See, e.g.*, Miguel Helft, *Xerox's Strategy Pays Off with a New Search Venture*, N.Y. Times, Feb. 9, 2007, at C3 (describing recent advances in search algorithms); Javed Mostafa, *Seeking Better Web Searches*, Sci. Am., Feb. 2005, at 66, 67 (same).

78 The two disciplines can be distinguished, however. *See infra* notes 86–87 and accompanying text.

79 John Battelle, The Search: How Google and Its Rivals Rewrote the Rules of Business and Transformed Our Culture 39–41 (2005).

80 AltaVista and Excite were two pioneers in this type of search technology. Notably, Excite conducted statistical analysis of word relationships to evaluate a webpage's underlying concepts. *Id.* at 45–47, 55.

81 As search expert John Battelle describes, "spammers . . . could capture traffic for high-traffic keywords like 'cars' by hiding those keywords all over their sites (often in small white letters on a white background . . .)." *Id.* at 104.

82 *Id.* at 53–54.

83 *See* Sergey Brin & Lawrence Page, The Anatomy of a Large-Scale Hypertextual Web Search Engine (1998), http://infolab.stanford.edu/~backrub/google.html (explaining concepts of PageRank and other components of original Google search algorithm). PageRank is just one of many different algorithms used by Google to determine search

determine how many other sites link to a given webpage. Yet not all links are created equal: Google has devised a mathematical formula for weighing the importance of each linking site based on the number of links attached to it.[84] Google then assigns each webpage a ranking score for keywords in Google's index. Overall, the Google system produces famously relevant search results.[85]

The ability to search and classify a linked system of information, such as the relation of one website to another, is useful for knowledge management.[86] Organizations are successfully adapting web-search technologies to manage information in a closed organizational

relevancy, but the firm maintains that PageRank continues to "play a central role in many of [its] web search tools." Our Search: Google Technology, http://www.google.com/technology/ (last visited Jan. 28, 2008).

84 BATTELLE, *supra* note 79, at 69–76 (describing history of and rationale for PageRank algorithm); Brin & Page, *supra* note 83 (explaining that PageRank does not count all links equally in approximating page importance). This description is a slight simplification of the PageRank algorithm, but the main focus is on the number and quality of inbound links. For example, after setting up a webpage, I might wonder, "How many people link to my site?" Before Google, there was no way to know the answer. But with access to Google's internal data, I can now find out because Google has crawled the entire web to determine who is linking to each site. Furthermore, Google assigns weights to the linking sites based, again, on the number of links coming in to those sites. So my high school friend's website linking to my site might get a low hypothetical score of 10 (if no one links to him), my home city newspaper's website linking to my site might garner a score of 1000, and the U.S. Supreme Court's website linking to my site might earn an additional score of 10,000. My total score of 11,010 could then be compared to the scores of all other sites dealing with, say, contract law, and the results would be served up in ranked order (after any paid search ads) to an interested searcher.

85 Of course, the Google search system has also produced a cottage industry dedicated to farming links and using other methods to boost a site's PageRank score, which is one reason why Google constantly updates its algorithms to exclude certain parts of the Internet. *See* BATTELLE, *supra* note 79, at 156–63 (describing growth of both optimization industry and search-engine marketing and noting Google's responses).

86 As an aside, there is a very interesting research (and perhaps business) opportunity involving the "Googleization" of all U.S. published court opinions and legal scholarship. As discussed above, Google's PageRank algorithm relies on linked citations—and on the relative importance of the citing source—to return the most relevant pages for a given keyword. Intriguingly, this is the same format used in case law: Court opinions cite (or link) to one another to support their claims, and the linking opinions are then cited with differing frequency in support of various legal doctrines. Thus, it should be possible to create a program that crawls the entire digital collection of published court opinions and uses Google's algorithm to calculate a "CaseRank" for each case. This would allow scholars, practicing lawyers, or other researchers to type in search keywords and, presumably, retrieve the most relevant and authoritative cases on point (although the accuracy of the search results is an empirical question that would need to be tested). I will present some similar ideas *infra* Part III.A, but Googleization is different because it relies on the networked web of legal citations instead of on the use of meaning-based computing to "understand" and cluster court opinions. Either approach is likely to be better than our current, awkward framework for legal research.

system.[87] Unstructured information often stands alone, however, independent from a web of interlinking documents like the Internet. Thus, the broader field of knowledge management seeks to organize and muster both discrete and linked information in order to improve organizational decisions.

One of the most recent innovations in knowledge management involves meaning-based computing. The general idea is to organize unstructured information in a way that does not depend on keyword tagging, anchor-text references, or linking citations. In other words, meaning-based computing goes beyond most search algorithms in that it tries to estimate (I won't say understand) what the information actually *means*. How is this possible, and what does it look like in practice? To answer these questions, let me turn to the theories underlying meaning-based computing and then to some of its applications.

C. Meaning-Based Computing Algorithms

1. Theoretical Underpinnings

Many path-breaking firms are working to create technology that can help organizations manage unstructured information.[88] These projects' primary goals are to uncloak important data and to enable informed decisionmaking, both by forming contextual understandings of the key ideas contained in individual units of communication and

87 For example, Google offers a corporate appliance in which its search technology queries and retrieves organizational information from multiple business applications. *See* Google Enterprise: Google Search Appliance, http://www.google.com/enterprise/gsa/#utm_medium=et&utm_source=bizsols&utm_campaign=gsa (last visited Jan. 28, 2008) (describing Google's corporate appliance).

88 One leader in this area is a British firm named Autonomy, founded by Cambridge graduate Michael Lynch. *See* Autonomy's Board of Directors, http://www.autonomy.com/content/Autonomy/Management/index.en.html (last visited Jan. 23, 2008) (describing Lynch's background); *see also Business by Numbers: Algorithms*, ECONOMIST, Sept. 15, 2007, at 94, 94 (quoting Lynch in story on increasing use of algorithms by consumers and corporations to make sense of unstructured data). Some of the discussion in this section comes from an analysis of Autonomy's technological algorithms. *See, e.g.*, AUTONOMY SYS. LTD., TECHNOLOGY WHITE PAPER 3–7, http://www.autonomy.com/content/downloads/White%20Papers/index.en.html (outlining Autonomy's technologies). The Xerox Palo Alto Research Center lab is also researching technology for natural-language information retrieval. Helft, *supra* note 77 (discussing Xerox's business strategy in researching natural-language search technology). Oracle Corporation's purchase of Hyperion Solutions signals its eagerness to compete in this space. *See* Vauhini Vara, *Oracle Adds Business-Intelligence Firm Hyperion*, WALL ST. J., Mar. 2, 2007, at B3 (describing Oracle's acquisition of Hyperion as part of strategy of "snapping up players in fast-growing niches" like business-intelligence software). And Microsoft, perhaps not surprisingly, also has some dogs in the fight. *See* Mostafa, *supra* note 77, at 70 (noting rumors of Microsoft's planned release of implicit speech function).

by relating disparate units to each other. Knowledge management's complex algorithms draw upon ideas from linguistics, information theory, statistics, and other disciplines to achieve these goals. Two of its most important concepts are Shannon's information theory and Bayesian inference.

In 1948, Claude Shannon, a mathematician in AT&T's Bell Labs, wrote an important paper on the efficient communication of information.[89] His main contention is counterintuitive because it equates information with disorder. Nonetheless, Shannon's paper is a foundational work in the field of information theory, and his ideas have been used to analyze topics as diverse as psychology, philosophy, biology, physics, and economics.[90]

The easiest way to understand Shannon's theory is to consider his diagram of the essential elements in a communication system (portrayed in Figure 1).[91] The system breaks down communication streams into four main pieces: the information source; the transmitter (encoding and dispatching the information along a channel of communication);[92] the receiver (obtaining and decoding); and the destination. Along the way, there might also be a noise source that threatens to corrupt the signal carrying the information.

Within this model, Shannon's challenge was to encode information so that it could be communicated accurately and efficiently, meaning that a message could still get through even if noise altered the signal. Shannon recognized that a great deal of information is redundant.[93] We can get the gist of a newspaper article by skimming a few sentences. Students can keep up with a law school class without hanging on the professor's every word. He wondered, therefore, whether it was possible to quantify certain units of communication as more important for conveying meaning than others. The answer was

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[89] C.E. Shannon, *A Mathematical Theory of Communication* (pts. 1 & 2), 27 BELL SYS. TECH. J. 379, 623 (1948).

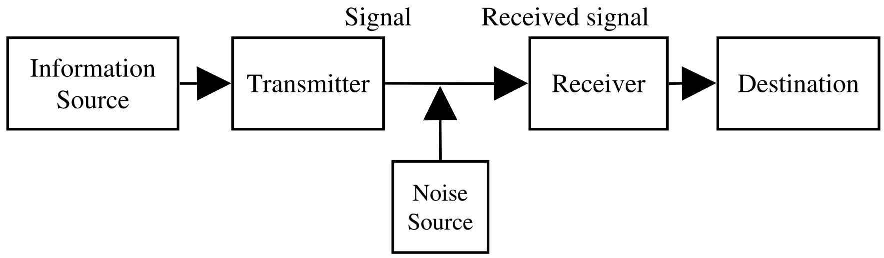
[90] L. DAVID RITCHIE, COMMUNICATION CONCEPTS 2: INFORMATION 7 (Steven H. Chaffee ed., 1991) (describing influence of Shannon's essay). Shannon's work has appeared less frequently in legal scholarship, although some creative articles address it. *See, e.g.*, Alan L. Durham, *Copyright and Information Theory: Toward an Alternative Model of "Authorship*,*"* 2004 BYU L. REV. 69, 73–92, 111–23 (using information theory to offer alternative conception of authorship in copyright law); Paul H. Edelman, *The Dimension of the Supreme Court*, 20 CONST. COMMENT 557, 557–63 (2003) (reviewing use of information theory to analyze voting patterns on second Rehnquist Court).

[91] Figure 1 is adapted from the diagram used in CLAUDE E. SHANNON & WARREN WEAVER, THE MATHEMATICAL THEORY OF COMMUNICATION 34 fig.1 (1964).

[92] This channel might consist of a phone line, but it could also refer to letters on a piece of paper, laser signals in an optical network, or any other medium for sending a message. *See* Durham, *supra* note 90, at 75 (discussing encoded symbols).

[93] *Id.* at 74–76.

FIGURE 1
ELEMENTARY COMMUNICATION SYSTEM



surprising: The most disordered, or unexpected, term will often denote the most meaning.[94]

Suppose, for example, you are standing in the middle of a noisy cocktail party trying to decide which of three conversations to join. The room is buzzing, and you can hear only snippets of the discussions:

"Yesterday . . . Iraq . . . disheartening"
"Believe . . . NASDAQ . . . lately"
"Arizona . . . see . . . Super Bowl"

With these fairly limited—and distorted—units of communication, you can still probably get a decent sense of each group's conversation topic. Sure, you do not know exactly what they are talking about (does the second speaker, for example, believe the stock market will rise or fall?), but you can still orient yourself toward a discussion on politics, business, or sports—even when noise tattoos the full communication.

Furthermore, within snippets of conversation, a few words convey more meaning than others. "Iraq," "NASDAQ," and "Super Bowl" all present strong clues. According to Shannon, this is because infrequently occurring words convey greater meaning than common ones.[95] He goes on to provide a basis for quantifying the level of meaning that a given unit of communication provides.[96]

So how does Shannon's information theory help programmers write knowledge-management algorithms? Essentially, algorithms that incorporate Shannon's ideas weigh rarer words more heavily when determining a communication's meaning. For example, in the sentence "I'm flying to Arizona tomorrow to see the Super Bowl," the words "Arizona," "Super," and "Bowl" probably occur most infre-

94 SHANNON & WEAVER, *supra* note 91, at 51. For further discussion of this insight, see Durham, *supra* note 90, at 73–92.
95 SHANNON & WEAVER, *supra* note 91, at 48–53.
96 Durham, *supra* note 90, at 76–81.

quently.[97] Thus, the algorithm would treat them as more indicative of the sentence's meaning.[98] Knowledge-management software uses this concept on a much grander scale to estimate the most important terms in a piece of unstructured information.

Yet even infrequently occurring words can be ambiguous and subject to multiple meanings.[99] In the sentence quoted in the last paragraph, for example, is the speaker talking about a football game or her grandmother's terrific china? To help with this problem, meaning-based algorithms use a second important concept: the statistical notion of Bayesian inference.

I will not spend as much time discussing Bayesian inference, as it should be more familiar.[100] In a nutshell, this is a statistical technique used to update the probability that a prior belief is true in light of newly received information. One obvious application of Bayesian inference is to the law of evidence. If a jury is sixty percent sure that a criminal defendant is guilty, how should it update this belief when the prosecution presents new physical evidence showing the defendant's fingerprints in the victim's apartment? Bayesian inference provides a mathematical framework for answering this and other questions—though not one that is free from controversy.[101]

In the field of knowledge management, Bayesian inference is used to calculate probabilistic relationships between multiple variables and to determine how one variable impacts or relates to another.[102] These relationships are important in two ways. First, within a bundled communication such as a letter or phone call, they

[97] This would need to be determined in the overall context of the body of information under analysis.

[98] To take a related example, Amazon.com employs technology to identify "statistically improbable phrases" that may convey a sense of a book's subject matter. *See* Amazon.com Statistically Improbable Phrases, http://www.amazon.com/gp/search-inside/sipshelp.html (last visited Jan. 23, 2008) (discussing process by which "statistically improbable phrases" are identified).

[99] Another problem arises when there are no rare words in a search phrase. BATTELLE, *supra* note 79, at 24.

[100] For more background on Bayesian inference, see ANDREW GELMAN ET AL., BAYESIAN DATA ANALYSIS (2d ed. 2004), and Ulen, *supra* note 12, at 888–93.

[101] *See, e.g.*, Ronald J. Allen & Brian Leiter, *Naturalized Epistemology and the Law of Evidence*, 87 VA. L. REV. 1491, 1507–10 (2001) ("Naturalized epistemology . . . recommends considerable skepticism about Bayesianism for thinking seriously about evidence."); Ronald J. Allen & Michael S. Pardo, *The Problematic Value of Mathematical Models of Evidence*, 36 J. LEGAL STUD. 107, 114–28 (2007) (discussing epistemological limitations of mathematical models of evidence); Roger C. Park & Michael J. Saks, *Evidence Scholarship Reconsidered: Results of the Interdisciplinary Turn*, 47 B.C. L. REV. 949, 988–95 (2006) (summarizing views of Bayesian "skeptics and enthusiasts" regarding evidence law).

[102] *See* AUTONOMY SYS. LTD., *supra* note 88, at 4–5 (explaining Bayesian inference).

can help us to refine or deduce the meaning of the message. Second, researchers can apply Bayesian inference to a larger universe of data in order to estimate which parcels of unstructured information are likely to deal with similar concepts or messages.

Let me illustrate these applications of Bayesian inference by returning to our earlier sentence: "I'm flying to Arizona tomorrow to see the Super Bowl." We might have a prior belief that any time the word "bowl" is used, it refers to something you would use to eat soup or cereal sixty percent of the time; a form of casual recreation involving ten pins and a heavy ball thirty percent of the time; and a forum for a football game just ten percent of the time.[103] But using Bayesian inference, we might modify that prior belief from a 60-30-10 split to a 10-10-80 split once we discover that the word "super" occurs in close proximity to "bowl" and to a 1-1-98 split when the word "Arizona" (the 2008 location of the contest) appears in the same sentence.

Once it has been determined that our message probably relates to a championship football game, an algorithm can then use Bayesian inference to find other parcels of unstructured information that probably relate to the same concept. By examining the multivariate relationships across many documents, the algorithm can determine that communications relating to the NASDAQ or Iraq are less relevant than ones discussing the quarterback prospects of the New York Giants or the New England Patriots.

2. *Knowledge-Management Applications*

Assuming that knowledge-management technology really works—that a combination of Shannon's information theory, Bayesian inference networks, and other techniques can estimate the meaning of unstructured information—what is it good for? One likely application is a better search engine. Imagine how much more relevant search results might become when users query on the meaning of the data, instead of on keywords or the frequency of inbound links.[104]

The applications of knowledge management transcend search techniques, however. Once a universe of data is processed, it becomes possible to conduct clustering analyses or to obtain especially relevant

[103] These numbers are merely illustrative; I have no idea how often "bowl" refers to each of these three concepts.

[104] There is, however, a potential concern with using meaning-based technology to build a search engine in an open universe like the Internet: Because there are commercial incentives to attract attention, spammers may again seek to undermine the algorithm by hiding irrelevant keywords throughout a webpage. Fortunately, I suspect that this problem is less likely to emerge in the analysis of information related to contract law.

information automatically. If I am writing an article on contract remedies, for example, my computer can scan everything I have ever downloaded on the topic and habitually present the most relevant results in a sidebar window as I type.[105] Or I might program my computer to cluster all previous academic articles on the topic in order to determine the different analytical approaches to remedy selection. This type of knowledge management is proving useful in a wide variety of fields.[106]

Further, meaning-based computing is becoming popular with organizational decisionmakers because the technology is more accurate and efficient than other methods of processing unstructured information, such as keyword searches or manual tagging schemes. Most keyword search engines simply scan an information index—which technicians must manually seed and update—looking for documents where the keyword occurs frequently.[107] Typically, these systems also require users to write more complex and syntax-specific queries in order to weed out irrelevant results. Similarly, while manually tagging each document with predefined taxonomies[108] can help force some structure around information, human inconsistency may create accuracy problems. Manual tagging also takes a lot of time and does not scale.

The relative advantages of meaning-based computing offer some intriguing possibilities for empirical legal research. Contract law, in particular, may lend itself to this sort of analysis because private agreements generate a great deal of unstructured information, more and more of which is becoming available for examination. Yet I am unaware of any previous attempt to use this technology to study the law. I will try to fill this gap by sketching out some ways in which knowledge-management tools may be able to facilitate meaningful empirical contract analysis.

III
Some Possibilities for the Empirical Analysis of Contract Law

As I discussed earlier, gathering the unstructured information necessary to automate empirical analysis of contract law seems like a daunting task. The availability of databases of court opinions and exe-

[105] Several recent Microsoft projects (codenamed "Stuff I've Seen," "PowerScout," and "Watson") seek to accomplish this type of implicit search. Mostafa, *supra* note 77, at 70.

[106] *See* sources cited *supra* notes 19, 88.

[107] *See* Autonomy Sys. Ltd., *supra* note 88, at 26–28 (describing some limitations of keyword searching and Boolean query).

[108] Technology standards such as XML facilitate this sort of information tagging.

cuted contracts, however, opens the door to an immense store of information. Processing this information will not allow us to test every economic theory of contract law,[109] but it is a good place to start.

While Lexis, Westlaw, and other avenues for retrieving the full text of judicial opinions have been available to legal scholars for decades, we have yet to fully exploit their empirical potential. I devote much of this section to exploring some ideas for using this information. For the moment, however, I want to focus on CORI, which now contains the full text of nearly half a million contracts—each of which can be sorted by SIC code, date range, transaction type, and other key attributes. In addition, other private databases, while potentially harder to access, may provide meaningful information on buyer valuation, seller cost, and additional variables of interest to contracts scholars.[110] Within these databases, some contracts are tagged with simple descriptors, such as the date and type of contract or the industry involved. But these tags do not always cluster contract types precisely,[111] nor do they provide enough structure to easily analyze and compare key terms.

How, then, might scholars combine this data with knowledge-management algorithms to better study contract theory and contract law? There are three broad possibilities. First, we might use meaning-based computing to improve our descriptive analysis of contract doctrine. Second, data-gathering technology could help us operationalize or revise normative economic theories of contract law. And finally, the information we generate might help us to conduct what I call predictive modeling—that is, to run massive computer simulations on various economic models of contract law in an attempt to derive a pretty good, though not necessarily perfect, rule.

Hopefully, these ideas will become clearer as we go. I will take them on in order of difficulty, from the least to the most ambitious

[109] *See infra* Part IV.

[110] *See supra* notes 56–58 and accompanying text.

[111] For example, the ONECLE database, described *supra* note 57, lumps several thousand service contracts into a single group. Within this cluster are contracts as diverse as a large business outsourcing project, a small website development contract, and a telecom-services arrangement. *See, e.g.*, Framework Agreement Between BP Amoco PLC and Exult, Inc. (Dec. 7, 1999), http://contracts.onecle.com/exult/bpamoco.svc.1999.12.07.shtml (last visited Jan. 8, 2008) (business outsourcing contract); Website Services Agreement Between iVillage, Inc. and Hearst Communications, Inc. (Dec. 19, 2003), http://contracts.onecle.com/ivillage/hearst.svc.2003.12.19.shtml (last visited Jan. 8, 2008) (website development contract); SynchroNet Service Agreement Between Southern/South Central Bell Telephone Company and InterCept Systems, Inc., http://contracts.onecle.com/intercept/bellsouth.svc-synchronet.shtml (last visited Jan. 8, 2008) (telecom-services contract).

(although this is a matter of degree, and a fair-minded critic might still term all three sections "excessively ambitious").

A. Descriptive Analysis

1. Supercharged Doctrinal Analysis (Without Tagging)

Doctrinal research involves examining published court decisions in order to determine how judges implement legal principles. A contracts scholar, for example, might read several hundred cases on the mistake doctrine to study how courts differentiate between unilateral and bilateral mistakes and to clarify the conditions necessary to excuse contractual liability.[112]

There are a variety of approaches to doctrinal scholarship. The most ambitious work seeks to glean legal principles from an analysis of the cases.[113] Less ambitious studies simply conduct doctrinal analysis as a legal reasoning exercise where various cases are harmonized, distinguished, or criticized in light of earlier precedent. A third approach uses doctrinal analysis to present a puzzle—that is, to show that courts are deciding certain cases in a manner inconsistent with prevailing conventional wisdom.

All three types of doctrinal research present some methodological concerns,[114] and focusing on doctrine seems to have fallen out of favor in recent years.[115] After all, the fact that a lot of courts *are* deciding cases in a certain way does not necessarily mean that they *should* be doing so.[116]

But criticisms of doctrinal analysis are often overstated, and this work can provide important insights into our legal system. For example, in a recent article on the indefiniteness doctrine, Robert Scott gathered, coded, and analyzed 238 indefiniteness cases in state

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[112] *E.g.*, Melvin A. Eisenberg, *Mistake in Contract Law*, 91 CAL. L. REV. 1573, 1576–78 (2003) (analyzing cases to present functional approach to mistake doctrine).

[113] One example of this is Farnsworth's derivation of a "dependence" principle in contract law. *See* E. ALLAN FARNSWORTH, CHANGING YOUR MIND: THE LAW OF REGRETTED DECISIONS 89–96 (1998) (examining distinction between dependence based on promise and dependence based on conduct).

[114] For example, there is a potential problem with selection bias because the analysis is based only on the results of decided and published cases. All data on settled or unpublished disputes are excluded by necessity—even though inclusion of this information might change the results. *Cf.* Epstein & King, *Rules of Inference*, *supra* note 12, at 110–12 (describing how selection of which cases to study automatically introduces bias into analysis).

[115] *See* Craswell, *supra* note 10, at 904–07 (discussing decline of descriptive hypotheses in law and economics); Posner, *supra* note 16, at 877–78 (considering whether scholars should return to doctrinal analysis).

[116] As Craswell puts it, it is hard to find a useful null hypothesis to test empirically with descriptive analysis. Craswell, *supra* note 10, at 905–06.

and federal court.[117] He concluded that the conventional wisdom—which condemns the indefiniteness doctrine as dead-letter law—is entirely wrong.[118] According to Scott's analysis, courts often continue to invalidate agreements when contracts are too uncertain to be legally enforced.[119] Having offered evidence of the persistent risk that courts will annul contracts for indefiniteness, Scott goes on to explore why parties might continue to make indefinite agreements.[120] Scott's work shows that it is important to know what courts are really doing in order to develop and test hypotheses on the incentives that contract law creates. Or, as Stephen Smith puts it: "Legal scholarship is done with various purposes in mind, but the basic aim of legal scholarship is to understand the law better. Even if our ultimate goal is law reform, we need first to understand what it is we are trying to reform."[121]

Unfortunately, any scholar launching a doctrinal study runs into hurdles: There are an awful lot of court decisions out there, and it is hard to unearth all of the cases that matter.[122] Furthermore, because this information is primarily unstructured, comprehensive analysis typically requires intensive tagging, coding, and interpretation. Random sampling could help reduce the caseload and simplify the work, but it introduces questions of accuracy and replication. Put differently, doctrinal analysis does not always scale efficiently.

Meaning-based computing algorithms could help doctrinal scholars in two different ways. First, they might make it easier to identify relevant cases. Go back, for a moment, to Scott's indefiniteness study. To identify cases involving the indefiniteness doctrine, Scott queried a Westlaw Key number[123] related to the requirements for contractual certainty.[124] I am sure West does a decent job tagging legal cases with subject-matter descriptors, but some cases involving this rule might use different terms or concepts—such as "preliminary

117 Scott, *supra* note 42, at 1652–53.

118 *Id.* at 1659 (discussing cases in which courts have invalidated agreements due to indefiniteness).

119 *Id.* at 1653.

120 Scott's hypothesis is that some parties may be motivated by a behavioral sense of reciprocal fairness and that an ambiguous agreement can serve as a type of signal. *Id.* at 1660–63.

121 Stephen A. Smith, *Taking Law Seriously*, 50 U. Toronto L.J. 241, 249 (2000).

122 For example, a recent Westlaw search for the phrase "contract" in the ALLCASES database for every state and federal opinion in the past ninety days located 7897 results as of February 2, 2008.

123 Westlaw Key numbers organize cases by general and specific legal topics.

124 Specifically, Scott used Westlaw's 95k9(1) database: "Contracts: Requisites and Validity: Nature and Essentials in General: Certainty as to Subject Matter: In General." He then chose a random subset of these cases in order to construct a manageable dataset. Scott, *supra* note 42, at 1652–53.

agreements," "incomplete contracts," "partial deals," or "agreements to agree." If West employees neglect any of these possibilities, then they may miss relevant opinions.[125] This will not necessarily lead to bias, but it would be more powerful to scan every single case involving contract law with meaning-based algorithms that can look for all cases involving annulment by indefiniteness—even those using unorthodox terminology.[126] Scholars could also use this technology to find relevant cases for legal questions or concepts where West has not yet established a key number taxonomy.

Second, meaning-based computing can help synthesize the key factors that influence courts in borderline cases. Ultimately, everyone conducting this type of research must simplify large amounts of unstructured information into manageable distinctions; prior contextual understanding will usually shape this synthesis. Compounding the problem, research assistants and professors working on the same project might analyze cases in a slightly different manner.

In contrast, unleashing the statistical objectivity of meaning-based computing might lead to a more consistent synthesis of contract doctrine. How would this work? In theory, we could add every contracts case to a centralized database and process each case with a meaning-based algorithm in order to develop an initial subject-matter impression. This sounds like a lot of work, but organizational knowledge-management systems routinely process hundreds of thousands or millions of documents. From here, researchers could cluster the information according to key concepts, and perhaps tune the results by "teaching" the algorithm which connections are the most important.[127]

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125 This concern is less important for Scott's claim that a meaningful number of courts still use the indefiniteness doctrine, which his analysis clearly demonstrates. *See id.* (discussing results of search for use of indefiniteness doctrine by courts). But missing cases would be potentially more damaging to any work asserting a more comprehensive claim on the exact contours of a rule in contract law.

126 Taking this idea to its extreme, researchers might conceivably scan every single court opinion ever published in the United States with a meaning-based computing algorithm to look for interesting connections across disciplines.

127 By "teaching," I mean updating the Bayesian networks that reflect the strength of links between words and concepts (either through human understanding and intervention or through automated review of additional, related content). Many knowledge-management programs allow users to tune systems in this manner. *See, e.g.*, AUTONOMY SYS. LTD., *supra* note 88, at 24 (describing "learning" capabilities of knowledge-management software). For example, after scanning all court opinions on contract law, I might tell the computer that "consideration" is less likely to be associated with "kindness" and more likely to involve bargained-for contractual requirements of detriment and benefit. Or, even better, I might scan several dozen casebooks and treatises on the topic and use this information to retroactively update the Bayesian linkages between words and concepts in the case database.

After that, there are multiple ways to proceed. One option is to seed an analysis with a leading case or treatise discussion on, say, indefiniteness and ask the computer to return all relevant cases. We could then cluster these results on two, three, or more dimensions and use the analysis to refine theories on how and why courts are deciding cases. This sort of analysis might suggest, hypothetically, that courts enforce indefinite agreements when it would be hard to specify clear, verifiable metrics for a key contingency, but not when, in hindsight, such a task would have been easy.[128] Thus, by automatically clustering all relevant court opinions across many dimensions, computer systems might help scholars synthesize doctrinal results.

Let me give another illustration of how automated analysis could assist scholars studying a familiar event—the circuit split. Consider a specific example from contract law: Federal circuit courts have taken a divided approach in applying the elusive concept of unconscionability, a doctrine used to invalidate outrageously lopsided contracts. Many courts require the demonstration of both procedural and substantive unconscionability before they will annul a contract.[129] Other jurisdictions, however, find that just one type of unconscionability corrupts the agreement.[130] How extensive is this schism? And why are courts coming out differently?

One possible way to answer these questions is to gather every historical case on unconscionability and manually code the facts of interest—including the judicial test (procedural, substantive, both, something else), the holding (contract voided, contract upheld, contract reformed), the parties' demographics (sophisticated, educated, poor), and so on.[131] This might convey useful information, but it is unlikely to capture everything that matters.[132]

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[128] I borrow here from Scott's musings on the topic. *See* Scott, *supra* note 42, at 1659 ("[T]he indefiniteness was endogenous to the contract, and the courts appear to infer from that fact that the parties either do not intend or do not deserve legal enforcement.").

[129] Procedural unconscionability represents a flaw in the bargaining process, while substantive unconscionability goes to the outrageousness of specific terms. E. ALLAN FARNSWORTH, CONTRACTS § 4.28 (4th ed. 2004). For the origins of the procedural/substantive distinction, see Arthur Allen Leff, *Unconscionability and the Code—The Emperor's New Clause*, 115 U. PA. L. REV. 485, 489–93 (1967).

[130] *E.g.*, Maxwell v. Fid. Fin. Servs., 907 P.2d 51, 59 (Ariz. 1995) (holding that unconscionability can be established without procedural flaws but also recognizing that many courts require both).

[131] Other factors might include whether the contract involves a consumer or commercial transaction, the nature of the disputed term (price, an arbitration clause, or something else), and the term of the contract. For one recent study presenting some variables to consider, see DiMatteo & Rich, *supra* note 18, at 1093–94.

[132] A recent study, for example, attempts this sort of exercise by coding unconscionability cases across ten different dimensions. While this is an impressive effort, the authors have almost certainly left out some important factors. *See* DiMatteo & Rich, *supra* note

Now, imagine how knowledge-management technology might improve the analysis. With a meaning-based algorithm in place, it would be possible to run a consistent review of every single case.[133] After completing this review, we could automatically sort and cluster the unstructured cases on any number of dimensions—including jurisdiction, date, outcome, legal test, contractual subject matter, and anything else—to clarify the scope and substance of the circuit split. Furthermore, the algorithm could search for notable factors relating to the doctrinal split that we may have overlooked. And, importantly, there would be no need for human recoding if we needed to extract another variable from the cases. In other words, automated analysis eliminates the need to predetermine which factors will be included in the tagging taxonomy for doctrinal review.

Knowledge management's ability to eliminate factor predetermination could improve all sorts of doctrinal analyses, and thus merits additional emphasis beyond the circuit split context. One frequent criticism of empirical work is that researchers have incentives to form hypotheses based on the data, instead of gathering data to test a given hypothesis.[134] Or by analogy, they throw all the darts and then draw the bull's-eye wherever the missiles land. This tendency is understandable (though unfortunate) because researchers hate to report insignificant findings after conducting copious research. Automation, therefore, could free researchers to boldly state and test various hypotheses, as they can easily run a different inquiry if proven wrong.

Moreover, even if the results of an empirical study are significant, automation makes it easier to introduce another explanatory variable after the fact. Suppose, for instance, that after the above-mentioned unconscionability study is published, the authors have an "ah-ha" moment, in which they stumble upon another potential explanatory variable. A diligent researcher might return to the cases and reread every opinion to search out and code for this new factor. Some of us more indolent scholars, however, might simply mark the notion as an interesting postscript and move on to the next project. By making it

18, app. A (listing factors considered). These factors include the ones mentioned above, *see supra* note 131 and accompanying text, along with whether the parties were represented by an attorney, whether other legal doctrines such as good faith and fraud were discussed, whether the contract involved goods, and a few other issues. DiMatteo & Rich, *supra* note 18, app. A.

133 DiMatteo and Rich seek consistency by having two different coders analyze each case, and they arrive at an impressive ninety-three percent agreement rate. *Id.* at 1094. But how should the discrepancies be handled?

134 *See, e.g.*, Epstein & King, *Rules of Inference*, *supra* note 12, at 76–80 (discussing failure to consider rival hypotheses and related problem of searching only for data to confirm, but not refute, given hypothesis).

easy to process data, automated analysis simplifies reevaluation, which should encourage scholars to refine earlier hypotheses in search of a more robust explanation for doctrinal outcomes.

To be sure, even with automation, doctrinal analysis will not yield normative conclusions. We still don't know which court is doing it best. Nonetheless, it is always important to better understand the rules with which we work, and we should be eager to embrace new technologies that might further the pursuit of such knowledge.

To finish this discussion of computer-aided descriptive analysis, consider one final application: the replication (or automation) of doctrinal research over multiple periods in time.

2. *Time-Series Analysis*

In 1969, Stanley Henderson completed a landmark study on promissory estoppel—an alternative legal basis for enforcing promises in the event of reasonable detrimental reliance.[135] Henderson decided to examine how courts had handled every single case from the previous decade that involved section 90 of the Restatement (which famously sets out the requirements for promissory estoppel).[136] His work led to a surprising set of insights, including that courts primarily used promissory estoppel in situations where the parties also faced contractual liability for bargain promises—and not in other circumstances that also apparently met section 90's less stringent requirements.[137]

Henderson's results were puzzling, and sixteen years later Daniel Farber and John Matheson decided to update his analysis.[138] As before, the authors examined every single case from the previous ten years that involved promissory estoppel. Their work led to a very different set of conclusions: Courts were applying promissory estoppel in a wider range of contexts, rather than simply using it as a fallback

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135 Stanley D. Henderson, *Promissory Estoppel and Traditional Contract Doctrine*, 78 YALE L.J. 343 (1969).

136 RESTATEMENT (SECOND) OF CONTRACTS § 90 (1981).

137 Henderson, *supra* note 135, at 343–44. In other words, these older section 90 cases were often unwilling to enforce unilateral promises (without mutual consideration) even when they created the type of significant detrimental reliance contemplated by section 90. For further evaluation of Henderson's insights, showing that most promises upheld under section 90 involved commercial exchange, not gratuitous promises, see Ulen, *supra* note 12, at 902–05. For a discussion of the economics of promissory estoppel in which the author links the efficient normative use of promissory estoppel in prenegotiations to bargaining power, see Avery Katz, *When Should an Offer Stick? The Economics of Promissory Estoppel in Preliminary Negotiations*, 105 YALE L.J. 1249, 1253–59 (1996).

138 Daniel A. Farber & John H. Matheson, *Beyond Promissory Estoppel: Contract Law and the "Invisible Handshake*,*"* 52 U. CHI. L. REV. 903, 904–06 (1985) (surveying over two hundred cases and finding expanded judicial acceptance of promissory estoppel).

provision for consideration.[139] Richard Craswell, Robert Hillman, and others have continued the analysis in more recent work.[140] But we still lack consensus on the scope and limits of promissory estoppel, and more doctrinal analysis is clearly necessary.

These promissory estoppel studies demonstrate that contract law is an evolving creature. They also highlight the benefits of repeating doctrinal projects over time to refine earlier analysis and assess the breadth and pace of adaptation. Yet repeated time-series analysis is an arduous task, and it is hard to know whether scholars are reading the cases consistently across the decades.

Fortunately, meaning-based computing again offers a way to assist scholars, this time by providing a technological framework for automatically replicating and updating intertemporal doctrinal analysis. The first step is to build a database of historical cases, as described above, and use knowledge-management algorithms to process, cluster, and synthesize them across a variety of dimensions. After that, as courts issue new opinions, scholars can process them with the same algorithms to unleash a constant stream of doctrinal studies. In fact, once a framework is established, scholars could automatically refresh standing studies every one, two, or five years—or even in real time to get immediate feedback on judicial treatment of the rule.

Thus, meaning-based computing algorithms might help us to conduct a wide variety of time-series studies, even when the number of cases is voluminous. The obvious advantage of this methodology is speed; we would no longer need to wait ten years for new insights related to the shifting glaciers of common law. Another less obvious advantage is consistency. Using the same technological algorithm to process each case ensures uniform analysis. We cannot comfortably say the same thing about the evaluation of multiple generations of legal scholars (and their research assistants). Furthermore, scholars may be reluctant to revisit a given issue if they feel that an article

[139] *Id.* at 904–05. More specifically, they argued that reliance was becoming less important in promissory estoppel claims and that estoppel was being used to enforce many promises that were made in furtherance of economic activity. *Id.* at 925–29.

[140] Craswell suggests that one important variable in the judicial resolution of these cases is whether the promise is made under circumstances in which it would be efficient to engage in precontractual reliance. Richard Craswell, *Offer, Acceptance, and Efficient Reliance*, 48 STAN. L. REV. 481, 503–04 (1996). Hillman questions whether promissory estoppel has really changed much. *See* Robert A. Hillman, *Questioning the "New Consensus" on Promissory Estoppel: An Empirical and Theoretical Study*, 98 COLUM. L. REV. 580, 580–84 (1998) (finding that, contrary to "new consensus," courts still consider reliance as substantive element of promissory estoppel). Eric Holmes suggests that the doctrine has gone through four evolutionary phases. Eric Mills Holmes, *The Four Phases of Promissory Estoppel*, 20 SEATTLE U. L. REV. 45, 49–51 (1996).

cornered the topic a decade earlier. Automated time-series analysis—and the possibility of standing queries on doctrinal issues—makes this a nonissue.

For practitioners and judges, automated time-series analysis might prove a potent legal research tool. For academics, it offers an intriguing methodological framework for understanding, critiquing, and comparing case law on an unprecedented scale.[141] If successful, either application might lead to recurring insights that confirm or challenge our conventional understanding of how courts implement contract law.

Of course, as mentioned earlier, doctrinal analysis—even what I have called supercharged doctrinal analysis—can only go so far in helping us reform contract law. Knowing how courts *are* deciding cases does not tell us how they *should be* deciding cases. Ultimately, therefore, I believe that meaning-based computing's descriptive applications will be less important than its normative ones. Let me turn, then, to some possibilities for normative assessment.

B. Normative Analysis

If we accept that economic efficiency is normatively relevant to the design of contract law[142] (and while I do, some certainly do not[143]), then the issue confronting us is how to use meaning-based computing to uncover the incentives and economic effects of alternative rules. To this end, it is helpful to consider two different philosophies of the design and role of contract law. The first approach, incomplete-contracting theory, is taken by economists who treat contract law as a simple regime for specifically enforcing verifiable terms in an agreement.[144] Work in this area considers how parties can write intelligent contract terms to maximize the economic benefits of trade

141 It might be powerful, for instance, to cluster contract cases with tort, property, or agency cases in order to look for previously undeveloped linkages in the common law. Or it might be useful to cross-check the various ways in which courts or agencies deal with key constitutional or administrative principles.

142 *See, e.g.*, Richard Craswell, *Contract Law, Default Rules, and the Philosophy of Promising*, 88 MICH. L. REV. 489, 489–91 (1988) (defending economic approach as uniquely suited to offer fine-grained rules); Schwartz & Scott, *supra* note 27, at 550–56 (justifying efficiency theory of contract).

143 *See, e.g.*, CHARLES FRIED, CONTRACT AS PROMISE: A THEORY OF CONTRACTUAL OBLIGATION 5–6, 74–85 (1981) (arguing that contract law should be guided by moral principles instead of social policies such as economic efficiency); Seana Valentine Shiffrin, *The Divergence of Contract and Promise*, 120 HARV. L. REV. 708, 729–39 (2007) (discussing areas where morality and contract law diverge and advancing theory designed to accommodate "moral agency").

144 *See* Posner, *supra* note 16, at 855–59 (discussing premises and objectives of incomplete-contracting theory).

and investment.[145] The second approach, pursued more often by legal scholars, takes a very different tack: It assumes very simple contracts and asks what legal rules will promote efficient outcomes.[146] This approach is often termed default-rule theory, because it asks how courts should fill contractual gaps in the absence of stated intent.[147]

Both approaches simplify reality—incomplete-contracting theory assumes simple law, and default-rule theory assumes simple contracts. Nonetheless, they provide useful bookends for considering how meaning-based computing might assist in normative analysis. I will start with the incomplete-contracting approach.

1. *Incomplete-Contracting Theory*

The full scope of incomplete-contracting theory is beyond this Essay, but its goal is similar to that of default-rule theory: to determine how parties can form agreements that provide efficient incentives to trade and invest. For efficient trade, parties should go through with a deal only if the buyer's valuation exceeds the seller's cost at the time of exchange.[148] For efficient investment, the parties should invest in a way that maximizes payoffs from performance—the classic example involves a seller building her factory next door to the buyer in order to minimize transportation costs. But the parties should also take into consideration the probability of breach in order to avoid inefficient overinvestment in reliance on the contract.[149]

Economists in this area have come up with a variety of creative contracting solutions.[150] One typical trick is to ignore most substan-

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145 *Id.* at 856–58.

146 *Id.* at 832–34 (setting out typical premises of legal approach to economic analysis).

147 *See* Ian Ayres & Robert Gertner, *Filling Gaps in Incomplete Contracts: An Economic Theory of Default Rules*, 99 YALE L.J. 87, 87–91 (1989) (providing background on concept and theory of default rules).

148 Posner, *supra* note 16, at 856.

149 *See* A. MITCHELL POLINSKY, AN INTRODUCTION TO LAW AND ECONOMICS 32–35 (1983) (explaining concept of inefficient overreliance and when we can expect it to arise). These two goals can conflict. For instance, a remedy that fully compensates the buyer's valuation in the event of breach (thus giving the seller incentives to trade when efficient) may cause the buyer to ignore the probability of breach and subsequently overinvest. Posner, *supra* note 16, at 834–36, 856.

150 *See generally* PATRICK BOLTON & MATHIAS DEWATRIPONT, CONTRACT THEORY 489–641 (2005) (aggregating and analyzing work in this area under wide range of contexts); Philippe Aghion et al., *Renegotiation Design with Unverifiable Information*, 62 ECONOMETRICA 257 (1994) (analyzing how possibility of ex post renegotiation affects design of original contract); Oliver Hart & John Moore, *Incomplete Contracts and Renegotiation*, 56 ECONOMETRICA 755 (1988) (suggesting that communication and renegotiation between parties can result in optimal contract); Georg Noldeke & Klaus M. Schmidt, *Option Contracts and Renegotiation: A Solution to the Hold-Up Problem*, 26 RAND J. ECON. 163 (1995) (exploring use of option contracts to overcome underinvestment problem).

tive contingencies (such as factory fires or rising interest rates) and to focus on designing bargaining procedures that will govern ex post negotiation over the terms of trade. For example, the parties may set up a process ex ante whereby the buyer will make a price offer at the time of performance, which the seller can accept or reject.[151] Under this regime, and assuming (perhaps strongly) that the buyer can observe the seller's cost, the buyer will set a low price if the cost exceeds her valuation (recognizing that the seller will not perform below cost and thus avoiding the trade) and will set a price equal to the cost if her valuation is higher (in order to induce trade and capture all surplus above seller cost).[152] This procedural framework should also encourage efficient investment because the buyer knows, again ex ante, that she will have to perform the contract only if her valuation exceeds the seller's cost.[153]

Incomplete-contracting theory can quickly become complicated in a world of asymmetrical information, two-sided investment, or third-party effects. It is a thriving literature, however, and has significant normative implications for contract law.[154] Most importantly, if parties can install procedural bargaining mechanisms to avoid postexecution opportunism, then the role of contract law becomes much more limited. Rather than applying an extensive array of default rules, a court would simply enforce contractual terms as they are written.[155]

Unfortunately, incomplete-contracting theory faces a potential problem: Scholars have suggested that ex ante procedural frameworks do not commonly exist in real-world contracts.[156] This is a somewhat puzzling observation, given the theoretical promise of incomplete-contracting scholarship. Critics have pointed out, however, that procedural models are too complex for ordinary contracting

151 Posner, *supra* note 16, at 857.

152 *Id.*

153 *Id.* at 857–58.

154 For a recent collection of work in this area, see BOLTON & DEWATRIPONT, *supra* note 150, at 489–641.

155 *See, e.g.*, Robert E. Scott & George G. Triantis, *Incomplete Contracts and the Theory of Contract Design*, 56 CASE W. RES. L. REV. 187, 188–95 (2005) (relating incomplete-contracting literature to contract law and judicial enforcement of terms). Some legal scholars have argued as much for certain groups of contracting parties. *See* Schwartz & Scott, *supra* note 27, at 549–50 (arguing that courts should usually enforce contracts between sophisticated economic actors as written).

156 *See* Posner, *supra* note 16, at 859 ("The contracts that the models predict do not exist in the world.").

parties, and this scholarship may be starting to drift into the realm of bounded rationality.[157]

I wonder, however, whether the contracts that economists envision are completely fictional. Some agreements do employ a variety of procedural contingencies or structures that roughly approximate some of incomplete-contracting theory's processes. Consider, for example, venture capital contracts, which investors use to fund entrepreneurial endeavors. These contracts often provide structural self-help protection in the event of entrepreneurial opportunism, meaning that venture capitalists are unlikely to care about underlying legal default rules.[158] Other agreements also provide procedural mechanisms for terminating contractual relationships, often at a price and without substantive cause.[159]

If there are circumstances in which parties actually erect bargaining procedures to channel efficient investment and trade, then we know the normative implication: Courts should enforce these contracts as written. We cannot endorse this implication, however, unless we know whether such circumstances exist. It is here that meaning-based computing can play an important role. Using meaning-based algorithms, scholars could directly analyze thousands of contracts to determine when parties use procedural mechanisms to deal with future events. How, for example, do the contracts cluster in their treatment of exit rights? Are there similar patterns involving the use of take-or-pay terms? Do some agreements provide mechanisms that allow the buyer to benchmark the seller's cost and the seller to take or refuse the buyer's offer? By improving our ability to process unstruc-

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157 *See, e.g.*, Oliver Hart, *Is "Bounded Rationality" an Important Element of a Theory of Institutions?*, 146 J. INSTITUTIONAL & THEORETICAL ECON. 696, 700–01 (1990) (suggesting that bounded rationality is only way to explain why parties leave courts with discretion to fill contractual gaps); Eric Maskin & Jean Tirole, *Unforeseen Contingencies and Incomplete Contracts*, 66 REV. ECON. STUD. 83, 107–08 (1999) (questioning full rationality assumption). I will pick up on some concerns presented by bounded rationality and on some possible solutions through imperfect answers and predictive modeling *infra* Part III.C.

158 This self-help is typically executed via preferred-stock contracts and involves techniques like increasing board representation, manager stock vesting, liquidation preferences, and other procedural events that are often tied to manager performance. For further discussion of venture capital contracts, see Robert P. Bartlett III, *Venture Capital, Agency Costs, and the False Dichotomy of the Corporation*, 54 UCLA L. REV. 37 (2006), Kaplan & Stromberg, *supra* note 47, at 2177–81, and D. Gordon Smith, *The Exit Structure of Venture Capital*, 53 UCLA L. REV. 315 (2005).

159 For example, business-outsourcing contracts sometimes grant parties the procedural right to exit a long-term relationship by demonstrating inadequate service ("for cause" termination). Alternatively, a party may negotiate to end the deal "for convenience" by paying an exit fee. *See* George S. Geis, *Business Outsourcing and the Agency Cost Problem*, 82 NOTRE DAME L. REV. 955, 994–97 (2007) (discussing these procedural clauses in outsourcing context).

tured information, meaning-based algorithms enable us to compare and evaluate terms on a massive scale. I suspect that this work, while complicated, would reveal some areas where parties have restructured their contracts in procedural terms.

To be sure, there is a granularity problem with this sort of meaning-based analysis. If, for example, eighty percent of venture capital contracts have procedural bargaining mechanisms—but a specific contract under dispute does not—then what approach should courts take? Should they enforce the agreement as it stands or look to default rules to plug gaps? Put differently, at what level of precision should contract law operate? One approach for everyone? One approach for all venture capital contracts? One approach for each contract? These are thorny questions, and I will discuss them further when considering default-rule theory.[160] Assuming, however, that we can establish a workable approach to granularity (as we really have had to do all along[161]), then meaning-based computing might help provide a principled basis for hiving off a subset of agreements that courts should specifically enforce as drafted.[162]

Yet even a quick glance through CORI or other contract databases suggests that many agreements do indeed lack the sort of procedural bargaining mechanisms prescribed in the incomplete-contracting literature. They are simple fixed-price deals, or they focus more on substantive contingencies. What about these contracts? This question brings us into the realm of default-rule theory.

2. *Default-Rule Theory*

According to default-rule theorists, contract law's primary task is to provide background rules to govern situations in which parties have not explicitly defined some aspect of their agreement in advance.[163] An effective default-rule regime might provide a number of benefits, such as lowering transaction costs by freeing parties from specifying the minute details of their agreement. How, then, might we use

160 *See infra* notes 171–73 and accompanying text.

161 *See* Richard Craswell, *Contract Law: General Theories*, *in* 3 ENCYCLOPEDIA OF LAW AND ECONOMICS, *supra* note 26, § 4000, at 4–5 (describing general approach to precision in contract law default rules); Ian Ayres, *Preliminary Thoughts on Optimal Tailoring of Contractual Default Rules*, 3 S. CAL. INTERDISC. L.J. 1, 1, 9–15 (1993) (explicitly analyzing default-rule precision problem in contract law).

162 It is an open question whether this subset should comprise a large or small portion of agreements made in our economy. Schwartz and Scott have argued, for example, that courts should take this exact approach for all agreements between commercially sophisticated entities. Schwartz & Scott, *supra* note 27, at 594–609.

163 *See* Ayres & Gertner, *supra* note 147, at 87–91 (introducing theory of default rules).

meaning-based computing to inform the rules that should operate when parties' contractual intentions go unexpressed?

Here, unfortunately, the path is much steeper. Twenty years ago, I might have argued that we could simply examine a million contracts to glean the popular preferences of contracting parties across a wide variety of terms. For example, do most contracts require that the delivery of bulk goods occurs all at once, or will they permit a seller to deliver small lots of the product over time?[164] Do most agreements limit damages for breach, and if so, how?[165] In essence, each contract could serve as a ballot, and we could import the most-voted-for term as a majoritarian default rule. Meaning-based computing would simply be a way to tally the votes faster.

But work over the past two decades suggests that the selection of contract default rules is much more difficult than simply picking the most popular terms. There are at least three major complications: how to count silence, when to adopt penalty defaults that provide information by inducing parties to contract around disliked rules, and how to deal with the above-mentioned granularity problem. Let me touch briefly on each of these concerns.

The first problem is that we cannot always infer that failure to change a default rule constitutes approval.[166] It is, after all, not costless to strike a disliked rule—the parties must negotiate and draft a replacement. If the transaction costs of these efforts exceed the likely benefit from the new legal term, then they may not bother to make the change, even when both would be better off with a different term. Moreover, some commentators have argued that default rules are "sticky," meaning that parties are loath to change a term even when the benefits of doing so may exceed the costs.[167] Even when parties love a default rule, they may not bother to write it into the

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164 *See* U.C.C. § 2-307 (2005) (stating that, by default, goods must be delivered in single lots).

165 Some commentators have argued, for example, that the *Hadley* default rule limiting unforeseeable consequential damages is often replaced by a rule prohibiting all consequential damages for breach, whether foreseeable or not. DOUGLAS G. BAIRD ET AL., GAME THEORY AND THE LAW 147 n.16 (1994); *see also* Richard A. Epstein, *Beyond Foreseeability: Consequential Damages in the Law of Contract*, 18 J. LEGAL STUD. 105, 114–18 (1989) (discussing reasons why parties may want to avoid contracts altogether where breach triggers liability for consequential damages).

166 *See* Ayres, *supra* note 161, at 15–17 (discussing lack of clear rules specifying how parties can contract around defaults).

167 This "stickiness" is generally explained with reference to behavioral economics. *See* Russell Korobkin, *The Status Quo Bias and Contract Default Rules*, 83 CORNELL L. REV. 608, 630–33 (1998) (relating preference toward status quo to general reluctance to alter contract-law default rules).

contract—that's the point, after all, of having popular defaults.[168] For these reasons, it can be hard to know how to "count the votes."

The theory of penalty default rules creates a second complication by offering an economic reason why lawmakers may wish sometimes to impose an unpopular default rule. In a nutshell, penalty defaults may provide a way to reduce information asymmetries by forcing parties to reveal data that is personally disadvantageous but socially desirable.[169] The classic example is the *Hadley* rule, which requires high-value buyers to reveal unforeseeable consequential damages so that the seller can take efficient precautions against breach.[170] Encouraging the flow of necessary information may make it economically efficient to choose a default rule that a majority of contracting parties actually dislike.

Finally, default-rule theory presents a granularity problem because lawmakers are free to set different default rules for different groups of contracting parties.[171] The notion of writing unequal laws may seem offensive at first, but it should not be that troubling—the parties can presumably just change disliked terms. Further, while writing and administering granular defaults may incur additional costs, they may be worth the price in some circumstances.[172] Selecting a level of precision for contract default rules is a tortuous task, however.

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168 Some parties preferring the default rule may still incur the costs of explicitly inserting it into their agreements simply to avoid taking the time and expense to determine how the law will handle contractual silence or because they are worried that courts might make mistakes. *See* Ayres, *supra* note 161, at 9–10 (discussing these concerns); Louis Kaplow, *Rules Versus Standards: An Economic Analysis*, 42 DUKE L.J. 557, 618–20 (1992) (asserting that default, or "background," rules raise unique jurisprudential problems).

169 *See* Ayres & Gertner, *supra* note 147, at 95–100 (introducing theory of penalty default rules in contract law); Lucian Ayre Bebchuk & Steven Shavell, *Information and the Scope of Liability for Breach of Contract: The Rule of* Hadley v. Baxendale, 7 J.L. ECON. & ORG. 284, 289–93 (1991) (comparing informational properties of *Hadley* default with unlimited-liability rule). Most scholars consider the theory behind penalty defaults generally sound, but a recent debate has emerged over their actual use in the law. *Compare* Eric A. Posner, *There Are No Penalty Default Rules in Contract Law*, 33 FLA. ST. U. L. REV. 563, 565 (2006) (claiming that penalty defaults do not appear in practice), *with* Ian Ayres, *Ya-Huh: There Are and Should Be Penalty Defaults*, 33 FLA. ST. U. L. REV. 589, 590–613 (2006) (disagreeing with Posner).

170 *See infra* notes 196–97 and accompanying text.

171 *See, e.g.*, Craswell, *supra* note 161, § 4000, at 5 ("If different rules would be efficient for different contracting pairs, the law must also to [sic] decide the extent to which its default rules should be 'tailored', or customized to match the rule that would be most efficient for each individual contracting pair.").

172 This is true because more precise default rules offer some potential benefits, such as reduced transaction costs and reduced error costs. I have explored the tradeoffs elsewhere. *See* Geis, *Optimal Precision*, *supra* note 55, at 1129–38 (modeling these tradeoffs through simple empirical experiment).

Into how many groups should we parse our society?[173] What are the right parameters for ex ante segmentation of the contracting population?

Silence, penalty defaults, and the granularity problem all make me skeptical of any project that aims to select an optimal default rule. Yet precisely because this task is so hard, it is worth asking whether powerful computing technology might assist with the process. After all, lawmakers cannot abandon the job; there must be some legal rule or standard that takes effect in the absence of stated contractual intentions. Even a decision to eschew default rules or, analogously, to strike contracts void for indefiniteness whenever undocumented contingencies arise is itself a default rule.[174] So, let me offer a few tentative thoughts on how meaning-based computing might help with the selection of rules.

One possibility is to use knowledge-management algorithms to conduct natural experiments on change and effect in contract law. The basic idea here is to find a situation where there has been a doctrinal change—perhaps due to a landmark court decision or statutory enactment—and measure the impact of the change on subsequent contract terms in that jurisdiction. Parallel jurisdictions might also be included as a form of control. This would be analogous to an event study in finance or economics[175] and might help to shed light on the incentives and effects of differing legal default rules.

For example, Ian Ayres has recently suggested that a state law imposing a low interest rate on loans lacking a specified rate acts as a sort of penalty default: It forces a lender to disclose the governing interest rate clearly in order to avoid punishment by a low rate.[176] It would be interesting to ask how long this law has been in effect and whether it is achieving these predicted aims. To do this, we might gather a collection of loan contracts formed both before and after the rule's adoption. We could then use computer algorithms to assess the frequency and manner with which the interest rate is reported and compare the results across times and jurisdictions. This may not pro-

[173] The Uniform Commercial Code, for example, uses different rules for consumers and merchants. U.C.C. § 2-104(1) (2005) defines "merchant," and several other sections of the Code offer customized default rules for merchants. *See, e.g.*, *id.* § 2-205 (allowing merchants to create binding firm offers); *id.* § 2-314 (implying warranty of merchantability only if seller is merchant). But it is not obvious that this presents an optimal (or even sensible) segmentation.

[174] Craswell, *supra* note 161, § 4000, at 2.

[175] *See* Sanjai Bhagat & Roberta Romano, *Event Studies and the Law: Part I: Technique and Corporate Litigation*, 4 AM. L. & ECON. REV. 141, 141–43 (2002) (describing event studies and their use in law).

[176] Ayres, *supra* note 169, at 590.

vide a complete basis for preferring one rule over another, but it could help us to understand the impact of changes on contractual behavior while also yielding data on whether default rules are working as expected.

A second, related project would involve studying hundreds of thousands of contracts to identify and cluster standard boilerplate provisions.[177] This would allow us to assess how and when these provisions change and to try to link this evolution to default-rule changes in contract law. Again, this would not give us a complete normative basis for choosing a particular default over another, but it would speed the partial analysis of incentives and effects.

Third, if we decide that it is appropriate to enact different default rules for different contracting segments, then it might be possible to use computer-aided clustering to help determine a meaningful segmentation. As mentioned above, one of the most difficult problems here is identifying appropriate ways to classify parties into different treatment groups—who gets Default A, who gets Default B, and so on. It might be powerful, therefore, to run knowledge-management clustering analysis on many different types of contracts in order to gather evidence on where salient characteristics diverge. These clues could then suggest whether to segment groups—and if so, whether industry, the size of the agreement, the nature of the transaction, or some other dimension should define the segments.[178] Related to this, we might study term outliers or build a taxonomy of features that best define a contract type.

Regrettably, these problems are difficult, and I am not sure how far meaning-based computing can take us toward normative reform. Nonetheless, there is one other possibility that I want to discuss in greater detail: predictive modeling. This approach presents another strategy for using meaning-based computing to finesse some of the problems just discussed.

C. Predictive Modeling

Let me try a completely different angle on the default-rule problem. A likely criticism of the discussion thus far is that this sort of computer-aided normative analysis will prove too difficult to conduct.

177 The topic of contractual boilerplate has received some attention lately. *See* Omri Ben-Shahar, *Foreword* to *"Boilerplate": Foundations of Market Contracts Symposium*, 104 MICH. L. REV. 821, 821–25 (2006) (introducing papers from recent symposium on contractual boilerplate).

178 In order for this to work, there would need to be relative homogeneity within the subclasses. Otherwise, the results would tell us little about individual members in each class, and we might conclude that we are better served by simple, one-size-fits-all rules.

Even if we cut through the noise and pull out information relevant to our choice of contract default rules, it may be impossible to sum up the analysis into an optimal array of legal prescriptions.[179] After all, what are the full costs and benefits of a given default rule? And how granular should those rules be? We may never be able to answer these questions with absolute certainty.

But there is a response: We may not have to get it perfect. There might be benefits from using knowledge-management technology to conduct predictive modeling to determine which legal rules will "do a good job" most of the time—even if they're not flawless. I think the easiest way to introduce this idea is through an analogy.

In 1997, IBM stunned the world by beating the current chess champion, Garry Kasparov, with its Deep Blue supercomputer.[180] The victory was seen as a signpost in the gradual march toward artificial intelligence because chess provides the perfect setting to test concepts like pattern recognition, learning, and planning. More recently, computers have become the undisputed champions in other arenas of the parlor—including Othello, Scrabble, backgammon, and bridge.[181]

The success of computers in these games is largely due to sophisticated processors that enable programmers to design "brute force" strategies similar to the one that Deep Blue used to defeat Kasparov.[182] Essentially, the computer trees out all possible moves, countermoves, counter-countermoves, and so on until it has enough information to pick the move with the highest probability of success.[183] Brute force often amounts to complex decision trees with millions and millions of branches.

But there is one game where computers have never been able to give humans a good fight: the East Asian game of Go.[184] Go requires players to take territory by placing black and white stones on the intersections of a grid to surround their opponent. It is a complex game, with some stones appearing "dead" until the very end, when they spring back into life at a critical moment. A computerized brute-force strategy has not succeeded because Go has many more potential

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[179] *See supra* notes 49–55 and accompanying text.

[180] *See* FENG-HSIUNG HSU, BEHIND DEEP BLUE: BUILDING THE COMPUTER THAT DEFEATED THE WORLD CHESS CHAMPION 3–5 (2004) (narrating story behind famous tournament).

[181] *Artificial Intelligence: Winning Ways*, ECONOMIST, Jan. 25, 2007, at 80, 80 [hereinafter *Artificial Intelligence*].

[182] *Id.*

[183] *Id.*

[184] *Id.*

moves than chess, and it is very tricky to evaluate any given position.[185]

Recently, however, programmers have started using a different sort of algorithm to give human Go players a tougher match. Instead of drawing comprehensive decision trees, the computer uses Monte Carlo simulation, a method of statistical sampling using random-number generation.[186] In a nutshell, the computer will pick one move and randomly play out thousands or millions of games to the finish. If the computer wins often with this move, say seventy-five or eighty percent of the time, then it will stop analyzing the position and take its chances with this move. Otherwise, it goes on, selecting a second move, rerunning the Monte Carlo simulation, and recording the probability of success. The process is repeated only until an acceptable move is found; there is no attempt at perfection. This strategy is intriguing (and apparently successful) because it mitigates complexity by replacing a search for the optimal move with a search for one that is just good enough most of the time.[187]

In the same way, we may not need to search, via brute force, for the perfect contract-law default rule. Instead, we might approach the problem like the computer programmer seeking a win at Go. In some cases, we may be able to use unstructured information to form probability distributions for the parameters that are critical to economic models of contract law. We could then use Monte Carlo simulation to run millions of different iterations on our predictive model to find a default-rule structure that seems to produce high-Pareto outcomes.[188] In other words, we could populate economic theories of contract law with empirically derived assumption bands for the most critical variables and then run arrays of simulated transactions until we find a good, though not perfect, rule.[189]

In order to run predictive models, we would first need to set an objective function—similar to defining a "win" in chess or back-

[185] *The Economist* reports that the fastest computers can assess only fifty Go positions in a second, compared with a half-million positions per second in chess. *Id*.

[186] *See, e.g.*, Dennis W. Carlton, *Using Economics To Improve Antitrust Policy*, 2004 COLUM. BUS. L. REV. 283, 304–05 (describing sampling feature of Monte Carlo simulation and how it might be used to guide antitrust law); Savvakis Savvides, *Risk Analysis in Investment Appraisal*, 9 PROJECT APPRAISAL 3, 4–11 (1994).

[187] Perhaps surprisingly, it is also much faster for computers to play many repeated random games than to tree out and evaluate all possible moves. *See Artificial Intelligence*, *supra* note 181, at 80 ("Monte Carlo techniques are much faster than brute force.").

[188] For some simple examples of this, see Geis, *Empirically Assessing* Hadley, *supra* note 55, at 936–42, and Geis, *Optimal Precision*, *supra* note 55, at 1129–58.

[189] The correctness of a decision should be based on both (1) the adequacy of the results that are obtained and (2) the efficiency with which the decision is made. It might be worth sacrificing some of the first element in order to make gains in the second.

gammon. This is a little tricky in contract law, since there is no natural end game, but we might characterize the objective in terms of a high-Pareto outcome (primarily trade and investment gains net of transaction costs). After that, we could build a model economy that includes all key variables related to the rule under examination, such as buyer valuations, cost functions, investment opportunities, breach precautions and probabilities, and other contingencies. Finally, we would use Monte Carlo analysis to vary these parameters (within empirically derived assumption bands) and to analyze the results under alternative contract default rules. In short, we would split our model economy into two or more parallel universes, give each universe a different default rule, and run millions of random iterations to see which rule typically leads to higher-Pareto outcomes.

To be sure, predictive modeling will not let us empirically solve for the optimal, or most efficient, answer. It may not be very satisfying to concede that we can't know which rule of law is best. But if the East Asian game of Go is complicated, the collective choices of billions of people across a diverse range of economic settings are even more so. Adding to this complexity, contract law permits parties to change many disliked rules, and there are theoretical benefits, in some cases, from forcing them to make these changes.[190] Optimal precision in contract law is probably beyond our grasp right now, but we can still use partial economic analysis to inform—and perhaps reform—our legal rules.[191] While it may not be easy, we are closer than many might think to securing helpful information through predictive modeling.

IV
Practical Obstacles and a Potential Path Forward

These ideas are exciting (at least to me), but now it is time to let some air out of the balloon by addressing an obvious question: If there is so much potential here, then why haven't we already seen an automated revolution? I will finish the Essay by mentioning a few practical obstacles to the ideas I have laid out and speculating on when (and how) automation could play a greater role in empirical contracts analysis.

The first obstacle, a common one in academic research, relates to funding. The price tag for this technology—and for the hardware and

[190] *See supra* notes 169–70 and accompanying text.

[191] *See* Craswell, *supra* note 10, at 910–15 (describing benefits of partial economic analysis in contract law).

skills needed to support the analysis—can be steep. It is one thing to open the wallet for corporate knowledge-management investments that will translate into bottom-line income gains. The budget may be harder to swallow, however, for legal research seeking to fine-tune our contract laws.

For example, I recently entered negotiations to license software from one of the leading vendors in this area. Despite my pleas for an "academic license," the firm wanted to charge $100,000 for the license and an additional $20,000 or $30,000 to install the system. Needless to say, this was slightly beyond my annual research stipend. Nonetheless, this problem will undoubtedly be solved before too long, especially as vendors realize that legal research is a lucrative potential market and thus seek to prove the viability of their technology.

The second obstacle relates back to data availability. Thus far, I have focused primarily on how the unstructured information found in published court opinions and historically executed contracts might inform contract law. This data may prove useful, but these sources will be irrelevant to key parameters of some economic models. For meaning-based computing to be of any use in these situations, we would need to access other sources of empirical data.

Let me give two short examples. First, recall the lost-volume seller problem: Should a breached-against seller maintain a valid claim for lost profits even if she is able to mitigate the breach by reselling the product to someone else?[192] The argument against recovery is that she eluded harm by reselling. The argument for lost-profits damages is that she missed an incremental sale—she might have enjoyed both sales if the initial buyer had not breached.[193]

The problem quickly becomes more nuanced when we consider the relation of sales volume to profit margin. If selling more products leads to cheaper marginal (or average, depending on your point of view) costs, then actual damages should exceed lost profits on the initial sale.[194] Conversely, if the seller faces a rising cost function, then

192 *E.g.*, Neri v. Retail Marine Corp., 285 N.E.2d 311, 314–15 (N.Y. 1972) (famously applying lost-volume profit rule in commercial boat sale).

193 *See* FARNSWORTH, *supra* note 129, at § 12.10 ("Even the . . . seller that has purchased the goods for resale from stock and disposed of them to another buyer may claim to have lost volume as a result of the breach so that damages will not be reduced by what was realized on the second sale.").

194 *See* Charles J. Goetz & Robert E. Scott, *Measuring Sellers' Damages: The Lost-Profits Puzzle*, 31 STAN. L. REV. 323, 329–30 (1979) (discussing lost-volume seller rule and arguing that it is often applied in overcompensatory manner); Victor P. Goldberg, *An Economic Analysis of the Lost-Volume Retail Seller*, 57 S. CAL. L. REV. 283, 292–93 (1984) (insisting that lost-volume profits should be measured with reference to ex ante marginal cost curves).

damages are less than foregone profits because the seller avoids the need to make a higher-cost product. Moreover, lawmakers may want to choose a default rule to expose a seller's cost structure so that buyers will efficiently internalize the cost of breach.[195]

Ultimately, then, the best default rule for the lost-volume seller problem involves empirical evidence about seller cost functions. This empirical data is rarely found in executed sales contracts—sellers often want to keep their profit margins secret. While a few courts may hear evidence on seller cost curves, decisions are unlikely to yield sufficient data to successfully model the problem. Scholars will need to look elsewhere for the information.

For a second example of the external data problem, consider the *Hadley* rule barring unforeseeable consequential damages. Economic models pitting this rule against one allowing full damages for breach are complex and require an extended discussion.[196] But ultimately, the best rule turns on a host of variables, including contracting transaction costs, the probability of successful performance with greater seller precautions, and the overall distribution of buyer valuations in a contracting population.[197] Unfortunately, even if we could collect several thousand contracts for the exact same product, these variables cannot be measured from this data. For example, a contract's price term tells us little about the buyer's valuation.[198] Again, we would need to find data from different sources to investigate what damages rule is more likely to lead to the better economic result.

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195 For example, a penalty default awarding no lost-profit damages might force some retailers to come forward and contract for a nonrefundable deposit or for liquidated damages.

196 *See generally* Barry E. Adler, *The Questionable Ascent of* Hadley v. Baxendale, 51 STAN. L. REV. 1547, 1550–54 (1999) (refining *Hadley* model to reflect uncertainty of incurring consequential damages with breach); Ayres & Gertner, *supra* note 147, at 101–03, 108–18 (describing *Hadley* problem and setting out economic model of default rule); Jason Scott Johnston, *Strategic Bargaining and the Economic Theory of Contract Default Rules*, 100 YALE L.J. 615, 616–19 (1990) (analyzing *Hadley* problem under dynamic situations with seller market power).

197 *See* Adler, *supra* note 196, at 1554–59 (arguing that *Hadley* rule may be more efficient than expansive liability rule even though it may not minimize aggregate transaction costs of contracting); Posner, *supra* note 16, at 836–37 (explaining argument that many factors influence whether expansive liability rule is superior, including distribution of valuations, cost of information, and relative bargaining power of parties).

198 This is true because, in most markets, price is determined by supply and demand and is not equal to buyer willingness to pay. Indeed, the difference between a buyer's valuation and the market price benefits the buyer in the form of consumer surplus. *See, e.g.*, Peter J. Hammer, *Antitrust Beyond Competition: Market Failures, Total Welfare, and the Challenge of Intramarket Second-Best Tradeoffs*, 98 MICH. L. REV. 849, 891–92 (2000) (describing difference between price and consumer surplus).

If these data problems sound somewhat familiar, it is because I am echoing earlier concerns raised by Posner, who doubts that decisionmakers will ever be able to gather data on, say, seller cost functions or buyer valuation curves.[199] I am more sanguine than Posner on the possibility of obtaining information for some of these variables through other means—perhaps via experimental methods or through the mining of organizational information. Further, I have argued elsewhere that data from the field of marketing might prove useful to contract law scholars.[200] Regardless of these possibilities, however, it will be necessary to tap into other data sources. None of the unstructured information discussed earlier in this Essay will go very far toward implementing normative theories of the lost-volume seller problem, the *Hadley* rule, or other economic theories of contract law that rely on more nuanced variables.[201]

How, then, is automation likely to become a reality in contract law scholarship? The easiest place to start is with doctrinal projects that evaluate historical case law. I suspect that the next few years will yield some comparative studies, in which this type of analysis is conducted side by side with human-based coding in order to test the robustness of the automating algorithms and clusters. As we grow more confident that these pilot projects are generating meaningful results, the breadth and depth of scholarship will be able to accelerate.

After that, it may make sense to tackle predictive modeling and other techniques for evaluating normative claims in contract law. Ultimately, the results here will only be as good as the assumption bands used on key variables—and we will probably never know when we have reached an optimally efficient rule (if such a thing is possible). Nonetheless, we could form a valuable basis for revising the assumptions underlying many economic theories of contract law with empirically derived models that are closer to reality. Like the algorithms powering computerized Go, there is no attempt at perfection, but we still might gain greater insight into the practical effects of the rules governing contract law.

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199 *See* Posner, *supra* note 16, at 880 ("Models that have been proposed in the literature either focus on small aspects of contractual behavior or make optimal doctrine a function of variables that cannot realistically be observed, measured, or estimated.").

200 Geis, *Empirically Assessing* Hadley, *supra* note 55, at 951–55. Furthermore, the knowledge-management technology described in this Essay might help scholars gather relevant information on these other parameters.

201 Admittedly, many economic models of contract law may pose problems along these lines. There may still be opportunities, however, to conduct partial analysis with the data that is available. *See* Craswell, *supra* note 10, at 915–17 (arguing value of partial economic analysis in contract law).

CONCLUSION

Perhaps I am too much of an optimist. Certainly it would be easier to say that large-scale empirical work in contract law cannot be done—that we should move on or just accept what we have. But that really isn't much of a choice. Even in the absence of perfect information, lawmakers need to make decisions about the default rules that govern the creation, interpretation, and enforcement of contracts. Economic theory offers a principled way to make these choices, but to be sound it must be combined with empirical facts.

Furthermore, I believe that we are on the edge of innovation in the fields of search and organizational knowledge management. Recent advances in information theory, statistical inference, and other technologies are helping organizations to draw upon unstructured information in order to make better decisions. These algorithms are not perfect. No computer has passed the Turing test,[202] and artificial intelligence is a distant dream (or nightmare). But the technology of organizational knowledge management is getting better at estimating meaning, and it is worth considering how it might be used to assist descriptive and normative projects in contract law.

Finally, just to be clear, I am not advocating the substitution of computer algorithms for human choices. As I have argued, contract law is a social construct, as well as an economic one, and we will never be able to set our rules without subjective judgment. Until a supercomputer can simultaneously mimic the mental activity of seven billion brains, we will probably have to settle for contract laws that are good enough—instead of demanding ones that are perfect. Ultimately, however, we must make granular choices about what rules to adopt, and we must continue to ask how contract law shapes human action. We should, therefore, take up every available tool to conduct the partial empirical analysis that might help with these complex problems.

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[202] In 1950, Alan Turing suggested an enduring test for artificial intelligence: Can a person holding two natural-language conversations—one with a computer and one with a human—distinguish the two correspondents? A. M. Turing, *Computer Machinery and Intelligence*, 59 MIND 433, 433–34 (1950).