Competition or Monopoly? The Implications of Complexity Science, Chaos Theory, and Evolutionary Biology for Antitrust Competition Policy

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Competition or monopoly?
The implications of complexity science, chaos theory, and evolutionary biology for antitrust and competition policy

BY THOMAS J. HORTON*

I. INTRODUCTION

Predicting the competitive and economic impacts of business conduct and relationships ranging from horizontal marketing joint ventures to vertical restraints demands an assessment and understanding of "immeasurable dynamic relationships."2 Despite the assiduous efforts of economists and lawyers to bring order and predictability to the competitive effects evaluation process, antitrust regulation and

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1 See N. Pac. Ry. Co. v. U. S., 356 U.S. 1, 4 (1958) ("The Sherman Act was designed to be a comprehensive charter of economic liberty aimed at preserving free and unfettered competition as a rule of trade. It rests on the premise that unrestrained interaction of competitive forces will yield the best allocation of our economic resources, the lowest prices, the highest quality, and the greatest national progress, while at the same time providing an environment conducive to the preservation of our democratic political and social institutions.")


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decisionmaking are guided as much by assumptions and values they are by neutral economic or scientific principles.

Can antitrust and competition lawyers and economists look to modern science for guidance? As shown by the surrounding Antitrust Bulletin articles, several commentators have recommended looking to the emergent scientific field of complexity theory, as well as evolutionary biology. Their noble and creative efforts have been useful in emphasizing the importance of competition and diversity, creating and maintaining productive and stable economic systems, and in identifying potential emergent forms of economic order. Continuing efforts to employ rigorous multidisciplinary thinking in addressing antitrust and competition issues should be encouraged.

We must be careful, however, not to misapply scientific and biological metaphors in seeking to support values-driven economic conclusions. In *The Keystone Advantage*, Marco Iansiti and Roy Leven seek to bolster Milton Friedman's and the Chicago school's efficiency and concentration values-driven defense of monopoly through a biological metaphor. They argue that dominant business firms and monopolies should be shielded from antitrust regulations because they are analogous to keystone species in biological ecosystems.

*The Keystone Advantage*’s biological metaphor is facially compelling, but ultimately unsupported by sound biological principles or evidence. Indeed, biological studies show that ongoing aggressive horizontal competition at all levels, including the keystone level, is critical to building and maintaining healthy, stable, and productive ecosystems.

Unlike biological ecosystems, our economic system is based upon voluntary contractual relationships. Fairness and ethical behavior are crucial to maintaining the long-term health and stability of our economic system. Antitrust regulation of monopolies protects the integrity of our economic system by promoting fair and ethical competition and contractual dealings.

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We should continue to look to the teachings of complexity science, chaos theory, and evolutionary biology to better understand our complex competitive economic system and to identify potential emergent forms of order. In so doing, we will gain a greater appreciation for the importance of diversity and ongoing competition at all levels of our economic system. We also must keep foremost in mind that effective antitrust regulation requires a continuing effort to delicately balance conflicting implied values such as freedom and fairness, competition and collaboration, and diversity and efficiency.

II. COMPLEXITY SCIENCE, CHAOS THEORY, AND COMPETITION

Biologist Edward O. Wilson of Harvard University, the author of two Pulitzer Prize-winning books, On Human Nature (1978) and The Ants (1990, with Bert Hölldobler), believes that “[t]he greatest challenge today, not just in cell biology and ecology, but in all of science, is the accurate and complete description of complex systems.”

Complexity theory seeks to go beyond breaking down complex systems and describing their underlying elements and forces, to creating mathematical models that describe the emergent forces in a system. Born in the 1970s, complexity science aims to discover deep mathematical algorithms that will help “achieve a comprehensive understanding of the higher productions of the material world.”

Complexity theory seeks to understand such complex processes as ecosystems and patterns of human culture “in terms of complex dynamics from which emerge characteristic patterns of order.”

As a starting point, complexity theorists have focused primarily on biological systems. Edward O. Wilson notes:

Organisms and their assemblages are the most complex systems known. They are also self-assembling and adaptive. Living systems in general, by constructing themselves from molecule to cell to organism to ecosys-

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4 WILSON, CONSENSILE, supra note 2, at 93.
5 Id. at 96.
6 RICHARD SOLÈ & BRIAN GOODWIN, SIGNS OF LIFE: HOW COMPLEXITY PERVERDES BIOLOGY at xi (2000).
tem, surely display whatever laws of complexity and emergenc
within our reach.7

In The Origins of Order,8 an ambitious and seminal work on complexity theory, biologist Stuart Kauffman describes how he created massive computer-aided simulations exploring a variety of possible worlds in the hopes of revealing the methods to achieve a comprehensive understanding of complex systems in today's world. Kauffman theorizes that both simple and complex systems reach ordered states spontaneously. Consequently, to understand complex systems, Kauffman argues that we must integrate scientific theories of self-organization and natural selection to “understand how selection interacts with systems which have their own spontaneously ordered properties.”9 Kauffman ultimately posits that “the evolution of the marriage of self-organization and selection is itself governed by that selection achieves and maintains complex systems poised on the boundary, or edge, between order and chaos.”10 Within such systems, system members co-evolve successfully and “optimize their capabilities to co-evolve by mutually attaining the edge of chaos.”11

A. The need for caution in applying complexity science and complexity theory to antitrust analyses

1. THE NEED FOR GREATER EMPIRICAL INFORMATION

Our knowledge is a little island in a great ocean of non-knowledge.12

7 WILSON, CONSILIENCE supra note 2, at 96.
9 Id. at xv.
10 Id. at xv, 261. In describing the “edge of chaos,” Edward O. Wilson observes “that in a system containing perfect internal order, such as a crystal, there can be no further change. At the extreme opposite, in a chaotic system such as a boiling liquid, there is very little order to change. The system that evolve the most rapidly must fall between, and more precisely on the edge of chaos, possessing order but with the parts connected loosely enough to be easily altered either singly or in small groups.” WILSON, CONSILIENCE, supra note 2, at xvi.
11 KAUFFMANN, supra note 8, at xvi.
Complexity theory needs vastly more empirical information and objective scientific testing before we can apply it to fields such as economics with a high degree of confidence or certainty. We must humbly recognize that we are a long way from comprehending the full mystery of even the simplest living systems. As observed by the Nobel Prize-winning molecular biologist François Jacob:

The only logic that biologists really master is one-dimensional. As soon as a second dimension is added, not to mention a third one, biologists are no longer at ease. However, during the development of the embryo, the world is no longer merely linear. The one-dimensional sequence of bases in the genes determines in some way the production of two-dimensional tissues and organs that give the organism its shape, its properties, and . . . its four-dimensional behavior. How this occurs is a mystery.\(^{13}\)

If we look at our genetic information in terms of computer storage capacity, our current inability to fully understand our biological processes is put into simple perspective. We find that a single-spaced typed page contains 10\(^4\) bytes of information, while all of the currently published scientific articles contain 10\(^{12}\) bytes, and the sum total of human knowledge of books contains 10\(^{18}\) bytes. In comparison, storing the daily information flow within a single human’s body would require 10\(^{24}\) bytes of capacity. As observed by Harvard evolutionary biologist Richard Lewontin:

Our problem is that, in contrast to other domains of the physical world where a few strong forces dominate phenomena, the organism is the nexus of a very large number of weakly determining causal pathways, making it extremely difficult to provide complete explanations.\(^{14}\)

Since modern biologists are still a long way from understanding the true complexity of even a single cell, much less the workings of complex non-linear biological systems, we must exercise caution in applying the nascent science of complexity theory to complex economic systems.

\(^{13}\) See \textit{Suzuki \& Knudtson}, supra note 12, at 329.

\(^{14}\) \textit{Richard Lewontin: It Ain’t Necessarily So: The Dream of the Human Genome and Other Illusions} xxii (2000).
2. THE INHERENT UNPREDICTABILITY OF CHAOTIC SYSTEMS

The classification of the constituents of a chaos, nothing less here is essayed.\(^\text{15}\)

Chaos theory describes inherent unpredictability and observes that extremely complicated, outwardly indecipherable patterns result from small measurable changes within a system. In other words, in non-linear systems such as biological ecosystems or our economic system, “many components interact [. . .] in complex ways, leading to notorious unpredictability. . . . [Moreover,] very slight differences in initial conditions produce very different outcomes.”\(^\text{16}\) As aptly described in folklore:

For want of a nail, the shoe was lost;  
For want of a shoe, the horse was lost;  
For want of a horse; the rider was lost;  
For want of a rider, the battle was lost;  
For want of a battle, the kingdom was lost.

Nobel Prize-winning brain researcher Roger Sperry and others have conjectured “that at each layer of complexity in living creatures the physical interaction of what we label constituent parts results in ‘emergent properties’—qualities that paradoxically seem to exceed the sum of those parts.”\(^\text{17}\) Just as nuclear physicists, including Einstein, have been forced to accept inherent vagaries in defining subatomic particles, biologists are coming to learn that living systems contain inherent levels of unpredictability and chaos. And the unpredictability appears to become even greater when we look at systems involving human behavior and choice.

Complexity, chaos, and unpredictability are to be embraced and cherished.\(^\text{18}\) Our recognition of the complexity of our world need not condemn us to “some mystical, antiscientific world

\(^\text{15}\) Herman Melville, describing Moby Dick.
\(^\text{17}\) Suzuki & Knudtson, supra note 12, at 327–28.
\(^\text{18}\) See, e.g., Stephen Jay Gould, Wonderful Life: The Burgess Shale and the Nature of History 320 (1989) (“[B]iology’s most profound insight into human nature, status, and potential lies in the simple phrase, the embodiment of contingency: Homo sapiens is an entity, not a tendency.”).
view." In the words of one of the self-proclaimed evangelists of chaos theory, Joseph Ford of the Georgia Institute of Technology:

Dynamics at last freed from the shackles of order and predictability. . . .
Systems liberated to randomly explore their every dynamical possibility. . . .
Exciting variety, richness of choice, a cornucopia of opportunity.

At the same time, however, we must temper our enthusiasm and excitement about complexity and chaos theory with humility in applying this nascent science to draw broad conclusions about complex economic systems ultimately steered by unpredictable humans.

3. THE DANGERS OF CONFUSING SCIENCE WITH VALUES AND ASSUMPTIONS Science is ever subject to being seized upon and misused to support underlying premises and assumptions and implied values. As noted by Richard Lewontin:

Darwinism, born in ideological struggle, has never escaped from an intimate reciprocal relationship with worldviews exported from and imported into the science. No one challenges the claim that evolutionary theory has had a wide effect on social theory. It is a cliché of cultural history that the explanation of evolution by natural selection served as an ideological justification for laissez-faire capitalism and the colonial domination of the lesser breeds without the law.

III. THE IMPORTANCE OF ASSUMPTIONS AND VALUES IN ANTITRUST ANALYSIS AND REGULATION

The history of the continuing debates as to antitrust legislation and regulation reveals that how people think about antitrust issues is generally tied to their underlying assumptions and premises, as well as their implied values. For example, in the legislative history of the

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19 Suzuki & Knudtson, supra note 12, at 327.
20 See James Gleick, Chaos: Making a New Science 306 (1987). Joseph Ford further believes that “evolution is chaos with feedback.” Id. at 314. He argues that “God plays dice with the universe. But they’re loaded dice.” Id.
21 Lewontin, supra note 14, at 306.
Hart-Scott-Rodino (HSR) Act of 1976,\(^2\) one of the key underlying assumptions of the proponents, who generally were Democrats, such as Senator Edward Kennedy (D-Mass.), was that there was “a frightening amount of concentration of power in a few corporate hands, [and] that this had dangerous implications for our social and political, as well as our economic welfare.”\(^3\) A second underlying assumption was that corporate economic power increasingly was undeserved, and came, in the words of Senator Philip Hart (D-Mich.), “not from hard-nose competition, but from gobbling up a competitor rather than going out and establishing new competition.”\(^4\) In general, the HSR proponents shared such implied values as a belief in fair competition (equality of opportunity), diversity (smaller is better), and fairness (through government oversight).

On the other hand, the opponents of the HSR legislation, who generally were Republicans, assumed that the burdens of the proposed regulation “would inhibit the competitive, efficient

\(^2\) Decades of efforts to reform, modernize, and improve the Progressive Era antitrust laws culminated in 1976, when Congress passed, after furious debating, maneuvering, and infighting, the Hart-Scott-Rodino Antitrust Improvements Act (HSR Act). Title II of the three-part Act reformed the 1914 Progressive Era Clayton Act, which forbids anticompetitive mergers and acquisitions, by establishing “premerger notification and waiting period” requirements for many mergers and acquisitions. President Ford reluctantly signed the HSR Act on September 30, 1976. Under Title II of the HSR Act, companies with the requisite respective net assets or annual sales are required to notify the Federal Trade Commission (FTC) and the Antitrust Division of the United States Department of Justice (DOJ) before merging. See Pub. L. No. 94-435, Title II, § 201, 90 Stat. 1390. Title II became known as Section 7A of the Clayton Act, 15 U.S.C. § 18a.

\(^3\) 122 Cong. Rec. 8975 (1976). Senator Kennedy pointed to “the almost daily newspaper stories on how these giant corporations have taken this power and used it to corrupt and illegally influence governments and to destroy many of our traditional values.” Senator James Abourezk (D-S. Dak.) added: “I believe that this concentration of economic power is one of the root causes of the country’s present economic difficulties. This concentration of power is the simultaneous cause of inflation and depression.” 122 Cong. Rec. 15313–14 (1976).

formation and allocation of capital resources."26 Senator Strom Thurmond (R-SC) argued that it would "put [.. .] more big brotherism in Government,"27 and that "the assertion that the alleged 'concentrated structure of American industry . . . in part stems from mergers and acquisitions' is not only unsupported by the record, but is contrary to fact."28 The HSR legislation's opponents shared such implied values as concentration (bigger is better), free market places (no government interference), and "the survival of the fittest."

Not surprisingly, in the later legislative battles over the National Cooperative Production Amendments of 1993 to the National Cooperative Research Act (NCRA) of 1984,29 the same assumptions and implied values were cited, but on the opposite sides of the legislation.30 For example, a key driving assumption of the proponents was that the Japanese and the Europeans were winning the long-term economic battle for control of the

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26 See Minority Views of the Report of the Committee on the Judiciary, S. 1284 at 210 (May 20, 1976) [hereinafter "Senate Minority Subcommittee Report."]


28 Senate Minority Subcommittee Report, supra note 26, at 215.

29 In 1993, after four years of spirited hearings and debate, Congress passed and President Clinton enthusiastically signed the National Cooperative Production Amendments of 1993, Pub. L. No. 103-42, to the National Cooperative Research Act of 1984, Pub. L. No. 98-462. The 1993 National Cooperative Production Amendments received strong bipartisan support in extending protection from the full reach of the antitrust laws to production joint ventures between competitors. President Clinton, moderate Democrats and Republicans, and domestic business interests believed that they had formed a "real bipartisan coalition to make our economy work again, to help our business and our working people to move forward in the global economy." See Remarks of President Clinton on signing the National Cooperative Production Amendments of 1993, Weekly Compilation of Presidential Documents, Vol. 29, No. 23, at 1058-59 (June 10, 1993).

globalized marketplace due to their government-sanctioned cooperative efforts. Favoring cooperation over competition and concentration over diversity, proponents such as Representative Tom Campbell (R-Cal.) presented the specter of per se treatment in arguing that far more joint ventures would exist in a more hospitable legal environment.

NCRA opponents such as Senator Howard Metzenbaum (D-Ohio) countered that the durability of the antitrust laws had helped protect America's long-term economic and competitive

31 By 1993, Japan was being referred to as "Japan, Inc." and authors like Michael Crichton were writing sinister novels about Japan's economic conquest of the Western world. In the 1993 words of Pat Choate, an economist and former vice-president for policy analysis at TRW, and director of the Manufacturing Policy Project, "global competition for American entrepreneurs and firms is a bet your company gamble. And we are losing." Production Joint Ventures Legislation: Hearings on H.R. 423, H.R. 1024, H.R. 1025, and H.R. 2264 Before the Subcomm. on Econ. & Com. L. of the H. Comm. on the Judiciary, 103rd Cong. 39-41 (March 18, 1993) [hereinafter House Subcommittee Hearings]. Choate favored cooperation and concentration over competition and diversity.

32 House Subcommittee Hearings, supra note 31, at 53. Representative Campbell added that:

Many of the cutting-edge industries for international competition require massive amounts of capital. . . . This high specific capital cost takes many of these investments beyond the scope of single American firms. The joint venture, or consortium, provides an appealing alternative. Capital costs are shared; market risks are diversified.

Id. at 57.

Judge Frank Easterbrook provided moral support for Campbell and the other proponents of cooperation:

Cooperation is the basis of productivity. It is necessary for people to cooperate in some respects before they may compete in others, and cooperation facilitates efficient production. The war of all against all is not a good model for any economy. Antitrust law is designed to ensure an appropriate blend of cooperation and competition, not to require all economic actors to compete full tilt at every moment.

Polk Brothers v. Forest City Enterprises, 776 F.2d 185 (7th Cir. 1985).
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prospects. For them, wide open competition was the solution—not the problem. They argued that diversity was critical because small companies produce the bulk of new innovations and products and benefit from markets that are “free, open and unfettered.”

The HSR and NCRA debates highlight how personal implied values and assumptions drive the thinking about competition and antitrust regulation. As described below, The Keystone Advantage misapplies complexity theory and evolutionary biology in support of the cooperation/concentration/efficiencies values paradigm.

IV. REBUTTING THE KEYSTONE ADVANTAGE:
COMPLEXITY SCIENCE, CHAOS THEORY, AND EVOLUTIONARY BIOLOGY SUPPORT AGGRESSIVE ONGOING COMPETITION—NOT MONOPOLY

The only argument that has been seriously advanced in favor of private monopoly is that competition involves waste, while the monopoly pre-

33 For example, George R. Heaton, an MIT industrial economist, stated in 1989: “To me, the fact of 100 years [of American antitrust laws] suggest a differing starting assumption, and that is, conservatism. The durability of antitrust law coupled with its relative resistance to change reflect, in my view, a well-considered wisdom of the American people.” House Subcommittee Hearings, supra note 31, at 88.

34 Dr. T.J. Rodgers of Cypress Semiconductor Corp. argued that “if the antitrust laws had been relaxed a few years ago at the expense of these start-ups who held their ground in the memory market, the Japanese would have been virtually 100% successful in wiping out our semiconductor industry.” House Subcommittee Hearings, supra note 31, at 198.

35 Plaintiffs’ antitrust attorney (and former San Francisco mayor) Joe Alioto testified that “there’s absolutely no question that something like 8 to 9 out of 10 of the new products are developed by smaller companies and that 8 out of 10 of the new jobs are created by smaller companies.” House Subcommittee Hearings, supra note 31, at 260. Alioto opined that “[e]veryone should have the right to compete and all of our markets should be free, open and unfettered. There should be no fixes.” Id. at 250. Mr. Alioto added that “the antitrust laws are our Magna Carta of free enterprises. They are as important to our economic freedom as the Bill of Rights is to our personal freedom.” Id. at 256.
vents waste and leads to efficiency. This argument is essentially unsound. The wastes of competition are negligible. The economies of monopoly are superficial and delusive. The efficiency of monopoly is at the best temporary.\(^{36}\)

Justice Louis Brandeis warned that "[e]very business requires for its business health the memento mori of competition from without [... as well as] a certain competition from within. [...]."\(^{37}\) Disagreeing with Brandeis, and advancing their implied values of collaboration, concentration, and efficiency, conservative economists and jurists have sought to rewrite and ultimately deconstruct America’s antitrust laws by attacking the countervales of fair competition and diversity. They began succeeding in the 1980s, by trumpeting their values and assumptions as objective economic science.

*The Keystone Advantage* represents a new assault by the Chicago school adherents. Using biological ecosystem metaphors, the authors argue that dominant firms and monopolies frequently "have promoted the health of their ecosystems, and have benefited as a result."\(^{38}\) They conclude that "[s]ociety would suffer deeply if these organizations stopped playing their respective roles (or if competition or regulation somehow prevented them from doing so)."\(^{39}\) Ultimately, they "hope that the ideas in [their] book will spur a new look at antitrust economics, balancing the potential threat of monopolistic behavior with the value that can be created by an effective keystone strategy."\(^{40}\)

Although the authors seek to disguise their thesis through misapplied evolutionary biology and complexity theory metaphors, their conclusions ultimately rehash the values and assumptions of the conservative economic disciples of Milton Friedman and the Chicago school of economics and reaffirm their faith that "collusion agreements


\(^{37}\) Id. at 107.


\(^{39}\) Id.

\(^{40}\) Id. at 223–24.
[and monopolies] generally will be destroyed by competition." The Keystone Advantage highlights the dangers of misapplying scientific theories and erroneous assumptions to support conservative implied values.

A. Dominant firms and monopolies are not analogous to species and should not be immunized against aggressive competition

In biological terms, a species is the “basic unit of classification consisting of . . . a population or series of populations of closely related and similar organisms. In sexually reproducing organisms, . . . [the organisms can] freely interbreed with one another in natural conditions, but not with members of other species.” A “keystone species” is a “species, such as the sea otter, that affects the survival and abundance of many other species in the community in which it lives. Its removal or addition results in a relatively significant shift in the composition of the community and sometimes even in the physical structure of the environment.” The Keystone Advantage’s central thesis is that dominant firms and monopolies frequently are keystone species in their business ecosystems. The authors argue that “increasing diversity at [the monopoly firm’s] level could actually destabilize the ecosystem by undermining the predictability of its foundations and lead [. . .] to a loss of diversity at all levels.”

The scientific theory underlying The Keystone Advantage is seriously flawed. The dominant firms the authors cite cannot be analogized to biological species. Each has numerous actual or

41 Milton Friedman, Capitalism and Freedom 131 (40th anniv. ed., 2002). Friedman, however, recognized that “[i]n the economic area, a major problem arises in respect of the conflict between freedom to combine and freedom to compete.” Id. at 26. Friedman never solved the key values dilemma he posited, and indeed conceded that “monopoly raises . . . problems for a free society.” Id. at 120.

42 Edward O. Wilson, The Diversity of Life 405 (1992) [hereinafter Wilson, Diversity of Life].

43 Id. at 401.

potential competitors that are closely related and similar in function, just as there are multiple companies that manufacture and sell automobiles, tires, and gasoline. It might be meaningful to view automobiles and jet airplanes as different economic species, but it makes no sense to view Ford and GM as separate species.

Biological competition studies have shown that "where competition occurs at all, it is generally more intense within species than between species." As Auguste Forrel observed, "the greatest enemies of ants are other ants, just as the greatest enemies of men are other men." Even keystone species like the Florida alligator find themselves engaged in potentially deadly competition on a daily basis with other alligators. Moreover, the total alligator gene pool has enabled the species to adapt successfully to many environmental changes. Therefore, The Keystone Advantage's plea that dominant firms and monopolies should be protected against aggressive intraspecies competition finds no biological support in nature.

Iansiti's and Levien's contention that increased intraspecies competition at the keystone species level could ultimately harm economic "diversity at all levels" similarly lacks any biological or other scientific basis. Biological field studies have found competition to be more common "in species belonging to stable ecosystems than those belonging to unstable ecosystems." Indeed, Wilson and other biologists have concluded that "impoverished faunas promote dominant species," and that "the fewer the ant species in a local community, the more likely the community is to be dominated

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45 Edward O. Wilson, Sociobiology 120 (abridged ed. 1980) [hereinafter Wilson, Sociobiology]. Wilson observes that "[c]ompetition, as most ecologists employ the word, means the active demand by two or more individuals of the same species (intraspecific competition) or members of two or more species at the same trophic level (interspecific competition) for a common resource or requirement that is actually or potentially limiting." Id. at 119.


47 Wilson, Sociobiology, supra note 45, at 120.
behaviorally by one or a few species with large, aggressive colonies that maintain absolute territories.”

Furthermore, "interference [competition] between colonies belonging to the same species has the important effect of increasing the numbers of species that can coexist." Direct intraspecies competition also can promote evolutionary specialization, which ultimately "permits the coexistence of species that are ecologically identical in all respects except in the distribution of their food items." Perhaps most importantly, "the more species that live in an ecosystem, the higher its productivity and the greater its ability to withstand drought and other kinds of environmental stress." Therefore, based on biological studies, sound economics should encourage, rather than discourage, intraspecies competition at all economic levels, including the purported keystone species (dominant firms and monopolies) level.

B. Contractually based economic networks are fundamentally different from biological ecosystems

An ecosystem "is an ecological community that includes all organisms that occur naturally within a specific area." Biologists

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48 HÖLDABLER & WILSON, supra note 46, at 423. "When we think about nature we usually think about creatures like us, large vertebrates. But vertebrates are rarities in the world of nature, compared with insects. And ants are king of the insects, or at least king of the jungle. A Smithsonian Institution scientist recently demonstrated that in the tropical forest canopy, ants make up 70 percent of the total insect population." LEWIN, supra note 16, at 173 (quoting Edward O. Wilson).

49 HÖLDABLER & WILSON, supra note 46, at 423.

50 Id. at 427. Wilson further notes that in the case of Darwin’s finches, "where the species has been forced to compete, it evolved away from its opponent to fill a special niche, and where it lacked competition it stayed put—or else evolved in the direction of the opponent to fill both niches." WILSON, DIVERSITY OF LIFE, supra note 42, at 175.

51 WILSON, CONSILIENCE, supra note 2, at 322.

52 WILSON, DIVERSITY OF LIFE, supra note 42, at 396. An ecosystem includes the "organisms living in a particular environment, such as a lake or
have long understood that "[s]pecies do not exist independently; they have coevolved in ecosystems on which they depend. This means that each individual species depends on some set of other species for its continued existence." Therefore, to fully understand an ecosystem, one must study the totality of the myriad complex interrelationships among the various organisms and the organisms and their physical environment.

*The Keystone Advantage* correctly recognizes that "[i]nterconnectedness is a rule in biological systems . . . [and that this] interdependence is the foundation of the stability, productivity, and creativity of biological systems." But they overreach in analogizing dominant or monopolistic firms in networks to "keystone species critical to the stability of the ecosystem."

First, "of all the areas of biology and ecology, few are less understood than interspecific dependencies. Ecologists cannot even identify all the interdependencies in the systems they understand best." Indeed, *The Keystone Advantage*’s authors admit in a footnote that "[t]he ecological literature contains many conflicting definitions of the term keystone, and some debate the extent of its relevance."

Even conceding that "the removal of a keystone species causes a substantial part of the community to decline dramatically," the extinction and consequent total loss of a species in nature is fundamentally different from requiring dominant firms to engage in


54 IANSITI & LEVIEN, *supra* note 3, at 19.

55 *Id.* at 68–72.


57 IANSITI & LEVIEN, *supra* note 3, at 231 n.23.

horizontal (intraspecies) competition. Such competition helps prevent economic stagnation. As Wilson notes, "[s]ometimes other species previously excluded from the community by competition and lack of opportunity now invade it, altering its structure more."\textsuperscript{59} As discussed above, keystone species such as the sea otter and the Florida alligator face harsh day to day intraspecies competition that can result in fundamental shifts in key characteristics of the species. As Wilson notes, "[e]lasticity is the hallmark of Darwin's finches of the Galapagos, for the simple reason that their long-term survival depends on it."\textsuperscript{60} Furthermore, biological "[f]ield studies show that as biodiversity is reduced, so is the quality of the services provided by ecosystems."\textsuperscript{61}

In any event, the critical difference between a business network and a biological ecosystem is that a business network theoretically is based on economic freedom and the right to enter into voluntary contracts. The interrelationships of the various firms in an economic system are theoretically subject to constant outside competitive pressures that can constantly introduce variation and expansion into the economic system through new inventions and developments, as well as voluntary changes in contractual relationships.

On the other hand, a biological ecosystem essentially is a deterministic food web, "a connection of species that prey on other

\textsuperscript{59} \textit{Id.} Wilson adds that biologists reject the extremes of ecosystems where "species come and go as free spirits. Their colonization and extinction are not determined by the presence or absence of other species . . . [and ones where] the species are so closely interdependent, the food webs so rigid, the symbioses so tightly bound that the community is one great organism, a superorganism." Wilson explains:

Ecologists dismiss the possibility of either extreme. They envision an intermediate form of community organization, something like this: whether a particular species occurs in a given suitable habitat is largely due to chance, but for most organisms the chance is strongly affected—the dice are loaded—by the identity of the species already present.

\textit{Id.} at 163–64.

\textsuperscript{60} \textit{Id.} at 173.

\textsuperscript{61} \textit{Id.} at 347–48. Wilson adds that records "of stressed ecosystems also demonstrate that the descent can be unpredictably abrupt." \textit{Id.}
species." Known affectionately as "the circle of life," the system is a limited chain of deterministic consumption where the top predators ultimately return back to the soil and water in the form of constituent molecules. In the "circle of life," there is very little trade (or contractual negotiation) between an alligator and a fish.

C. The long-term success of economic networks ultimately requires mutual adherence to moral precepts and law

The fundamental difference between a biological ecosystem and a human business network is that a business network is based on voluntary contracts. As explained by Wilson:

Contratual agreement so thoroughly pervades human social behavior, virtually like the air we breathe, that it attracts no special notice—until it goes bad. For mammals, social life is a contrivance to enhance personal survival and reproductive success. As a consequence, societies of nonhuman mammalian species are far less organized than the insect societies. They depend on a combination of dominance, hierarchies, rapidly shifting alliances, and blood ties. Human beings have loosened this constraint and improved social organization by extending kinship like ties to others through long-term contracts.

As further noted by Wilson, humans' ability to detect cheating helps ensure fair dealing and ethical behavior in contractual relationships.

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62 Id. at 180.

63 As explained by Wilson:

If you track who eats whom in different parts of the web, you will usually find the number of links in the chain to be five or fewer. For example, in a marshy glade of the north central states, reedgrass is eaten by short-horned grasshoppers, the grasshoppers are eaten by orb-weaver spiders, the spiders are eaten by palm warblers, and the warblers are eaten by marsh hawks. Because the grass eats no one and the hawks are eaten by no one (except by bacteria and other decomposers when they die), these two species form the ends of the chain.

Id. at 180.

64 Wilson, Consilience, supra note 2, at 186.

65 Id. As further explained by Wilson:
The Keystone Advantage's biggest error lies in treating dominant or monopolistic companies as abstract theoretical entities ("species"), rather than as groups of human beings. In so doing, the authors completely overlook the fundamental importance of ethics and the shared values of fairness and trust that drive successful business relationships. By promoting ethical behavior and fair dealing, the antitrust laws enable business networks to thrive and prosper unencumbered by the menaces of predatory and anticompetitive behavior.

V. CONCLUSION

Complexity science, chaos theory, and evolutionary biology help us understand that competition and the diversity it spawns through increased adaptability are fundamental to increasing the overall productivity and stability of both biological ecosystems and complex business networks. Ongoing competition at all levels, including the keystone levels, is critical to maintaining the long-term health of both biological ecosystems and, by analogy, business networks. The creation of efficiencies through sheer size or dominance is vastly overrated, especially when we recognize that in science, dominant species often are found in impoverished ecosystems.

Contract formation is more than a cultural universal. It is a human trait as characteristic of our species as language and abstract thought, having been constructed from both instinct and high intelligence. One capacity, the detection of cheating, is developed to exceptional levels of sharpness and rapid calculation. . . . More than error, more than good deeds, and more even than the margin of profit, the possibility of cheating by others attracts attention. It excites emotion and serves as the principal source of hostile gossip and moralistic aggression by which the integrity of the political economy is maintained.

Id. at 186–87.

As Wilson observes, "[economic] models, while elegant cabinet specimens of applied mathematics, largely ignore human behavior, as understood by contemporary psychology and biology. Lacking such a foundation, they often describe abstract worlds that do not exist." Id. at 318.

Ironically, Gould observes that small animals "seem to have an edge in most mass extinctions, particularly in the Cretaceous event that wiped out remaining dinosaurs." Gould, supra note 18, at 307.
Complexity science, chaos theory and evolutionary biology do not support the Chicago school adherents' attempts to justify monopolies and ongoing predatory behavior. Rather, they point to the need for ongoing competition at all levels of our economic system. The simplistic conservative economic antitrust models in vogue today are "sealed off from the complexities of human behavior and the constraints imposed by the environment." Divorced from the real world, they are insufficient in checking dangerous anticompetitive acts and practices.

We must recognize that the antitrust laws are inherently values-based, and require a continuing effort to balance competitive values such as competition and collaboration and freedom and fairness. Most importantly, we must keep in mind that the antitrust laws at bottom are designed to regulate human ethics and behavior. Our complex network of interrelated contractual arrangements can only thrive and adapt if we are willing to behave ethically and fairly, and demand the same from others.

Nothing less than a consilience between psychology, ethics, economics, and the social and hard sciences ultimately is needed to make the best societal choices. History has taught us that monopolists can and do sometimes act greedily and unethically, especially if they think they can. We must not try to rationalize dangerous and unethical predatory acts as hard-nosed competition and visionary keystone business practices. Instead, we need to recognize that maximum economic diversity and welfare creation will be realized through fair competition and voluntary contractual relationships based on trust, reciprocity, and fairness. As John Donne wrote:

No man is an island, intire of it self; every man is a piece of the continent, a part of the maine; if Clod bee washed away by the Sea, Europe is the lesse, as well as if a Promontorie were, as well as if a Mannor of thy friends or of thine owne were; any mans death diminishes me, because I am involved in Mankinde; And therefore never send to know for whom the bell tolls; It tolls for thee.

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68 Wilson, Consilience, supra note 2, at 214.