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Hayek at the Santa Fe Institute: Origins, Models, and Organization of the Cradle of Complexity Sciences

▼ ARTICLE

▼ **ABSTRACT** Complexity sciences are one of the most mediatized scientific fields of the last 40 years. While this domain has attracted the attention of many philosophers of science, its normative views have not yet been the object of any systematic study. This article is a contribution to the thin social science literature about complexity sciences and proposes a contribution focused on an analysis of the origins, models, and organization of the Santa Fe Institute (SFI), cradle of the field. The paper defends the thesis that the notion of “complex adaptive systems” bears a project of naturalization of society through numerical and evolutionary lenses by promoting a Darwinian and capitalist view of the economy. At the same time, such a view has been embodied in the very way of functioning of the institute, which was conceived as an agile organization in a competitive environment and which relies on a fundraising philosophy that tends to commodify science. From a theoretical viewpoint, this text is anchored in the field of Science and Technology Studies and particularly in the coproductionist paradigm, which theorizes the dynamic entanglement of science and society. In terms of empirical sources, the article is based on interviews conducted by the author, and on the SFI's scientific publications as well as institutional archives.

▼ **KEYWORDS** Complex systems, Hayek, Darwin, Schumpeter, Science and Technology Studies, Coproduction

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Along with chaos and superstring theories, complexity sciences are one of the most mediatized scientific fields of the last 40 years.¹ Although several researchers had already been talking about complexity and complex systems in both Europe and the US since the 1970s, an American private research center founded in 1984 in New Mexico, the Santa Fe Institute (SFI), has played a fundamental role in the institutionalization and dissemination of the “complexity science” label—which is more than an umbrella name and less than a discipline or specialty.² This label designates an interdisciplinary and transnational association of specialties, whose aim is to model natural and social “complex systems,” namely sets of heterogeneous elements whose interactions produce emergent properties.³ This field has attracted the attention of numerous philosophers of science, but its origins, normative views, and institutions have rarely been treated by social scientists.⁴ Although the history and sociology of complexity sciences is of interest to scholars from various disciplines, the question of whether complexity sciences have politics is rarely asked. A central motivation for such a normative analysis is given by Australian sociologist Melinda Cooper, who suggests that complexity theory approaches to economics “have exercised the greatest influence on the political and social forms of neoliberalism.”⁵

The SFI has always defined itself as “apolitical” and refused the qualification of “think tank,” while having strong contacts with politics, industry, finance, and media. At the same time, suggestions about the ideological tendency of this unusual institute circulate in some social science publications, both in primary and secondary sources. As for primary sources, several representatives of complexity sciences and economics have either fostered or underlined an intellectual proximity between SFI's approach to economic theory and Friedrich von Hayek's texts.⁶ Among secondary sources, the recurrent opinion is that there exists a liaison between complexity science and the theories and practices of “liberalism.” Among the authors who have proposed such a parallel, Spanish sociologist Manuel Castells claims that information society and globalization are based on the paradigm of networks and complex systems—and the SFI is acknowledged as one of the initiators of such paradigms, along with chaos theory.⁷ As a second example, German philosopher of science Claus Pias has analyzed an agent-based model produced by some complexity specialists from the Los

1 Gleick (1988); Greene (2003). Waldrop (1992) has sold more than 100,000 copies as of today.

2 For some European pioneers, see Anderson (1972); Nicolis & Prigogine (1989). For a sociological characterization of complexity sciences as a field, see Li Vigni (2021).

3 Mitchell (2009).

4 For the former, see Wimsatt (1994); Rescher (1998); Cilliers & Spurrett (1999); Schweber & Wächter (2000); Knyazeva (2005); Bedau & Humphreys (2008); Aziz-Alaoui & Bertelle (2009); Fox-Keller (2009); Hooker (2011); Fraiso (2012); Ladyman, Lambert, & Wiesner (2013); Taborsky (2014); Zuchowski (2018). For the latter, Helmreich (1998); Williams (2012); Li Vigni (2018).

5 Cooper (2008, p. 9).

6 Kelly (1994); Kauffman (1995); Page (2011); Axtell (2016); Pearce (1994); Tucker (1996); Vaughn (1999); Kilpatrick (2001); Vriend (2002); Markose (2005); Foster (2005); Koppl (2009); Barkley Rosser (2010); Fisher (2012); Barbieri (2013).

7 Castells (1996, pp. 74–76).

Alamos National Laboratory.⁸ He claims that “these simulations are not only a kind of signature of the age of liberalism but at one and the same time a media instrument for obtaining insights into society as well as a scientific field of experimentation for this new style of governance.”⁹ Thirdly, political scientists Michael Dillon and Julian Reid have argued that “contemporary biopolitics, both national and global, has become informed by a new biophilosophical discourse that often refers to itself as a new form of science, ‘the complexity sciences.’”¹⁰ According to Dillon and Reid, in war strategy discourses the world is often described as a network that has to adapt to changing circumstances.¹¹ Fourthly, American cultural anthropologist Stefan Helmreich has intrigued his readers in his study about artificial life by briefly reporting on the SFI “business network,” composed of companies like Coca-Cola, Citibank, Intel, Xerox, John Deere, and others.¹² Yet, he did not explain what the relation between the institute and these companies consists of. In brief, such claims and descriptions often remain at the stage of insights or allusions, and are not further substantiated. Our starting point here is the following exert from a book about digital cultures written by British media specialist Charlie Gere:

The recognition of complexity as an area of research worth funding was explicitly bound up with the emergence of post-Fordist capitalism. The Santa Fe Institute itself was funded by Citibank with the expectation that its research might contribute to the bank's capacity to understand and manage the complexities of globalized capital. Much of the work done in the Institute has been and continues to be concerned with the application of complexity to economics. To some extent complexity theory represents a kind of scientific legitimation of the ideology of neo-liberalism. It enables a conflation of capitalism, nature and technology, and introduces a new version of Smith's invisible hand, one in which order emerges out of complex and apparently chaotic situations.¹³

Drawing on fieldwork conducted between 2014 and 2018 in Europe and the US, this paper proposes to explore the normativity of complex systems sciences as expressed by the SFI—ancestor of and model for other complexity institutes in the world.¹⁴ The first objective of the article is to substantiate the quote above with empirical evidence, before pushing Gere's analysis further with a focus on the intellectual and practical exchanges that have taken place at the SFI between complexity and “liberalism.” The latter is a general term I use to refer to different intellectual strains of capitalistic theories as they are mobilized by the institute, from classical “liberals” (like Smith, Ricardo, and Mill) to “libertarians” (such as certain hedge funders associated to the

⁸ Agent-based modeling is a digital tool for simulating the interactions of individual or collective agents in order to understand and predict the behavior of a system, be it natural, social, artificial, or hybrid.

⁹ Pias (2011, p. 52).

¹⁰ Dillon & Reid (2001, p. 42).

¹¹ Dillon & Reid (2001, p. 62).

¹² Helmreich (1998, p. 47).

¹³ Gere (2002, p. 147).

¹⁴ For a panorama of complexity sciences, see Wolfram (2012); for an ideal-typology of complexity institutes, see Li Vigni (2021).

institute), passing through “neoliberals” (essentially represented here by Friedrich von Hayek, who moved toward libertarianism at the end of his career in what concerns his theory of money).¹⁵ In particular, the article defends the thesis that the complexity project of naturalization of society, through numerical and evolutionary lenses, has played a role in legitimizing a Darwinian and capitalistic view of the economy. At the same time, such a view has been embodied by the SFI administration in the very mode of functioning of the institute. Put differently, on the one hand I show that complexity and liberalism have reciprocally influenced and reinforced each other on the theoretical level by inscribing into digital tools a form of “social Darwinism” (the 19th-century idea according to which natural selection and the survival of the fittest operate also in society, economy, and politics). On the other hand, the paper holds that liberalism has been materially inscribed in the organization of the SFI, in a historical moment where this political economy began to be hegemonic internationally. Other works have precedingly emphasized (and philosophically criticized) the reductionism of complexity sciences, whereby physics, mathematics, computer science, and a unilateral interpretation of natural selection are valued above the other disciplines involved under their label.¹⁶ Yet, a sociological and political analysis of this field was still lacking. While preparing the final version of this article for publication, historian of science Erik Baker has published a paper entitled “The Ultimate Think Tank: The Rise of the Santa Fe Institute Libertarian.”¹⁷ Equally identifying Hayek as the pivotal intellectual reference of the institute, Baker argues that this private research institute has not created a new ideology, but has rather socialized different groups of actors (scientists, entrepreneurs, media professionals, philanthropists, and politicians) to a common worldview based on innovative adaptation. Baker's claims are complementary to mine and will be mentioned throughout the article when useful to clarify some points.

The first section of the paper tells the history of SFI's foundation as well as of the close relationship that the institute has had with the discipline of economics, which attracted some of the early research funding and fellows. While giving some hints about the possible impact of SFI's economics on academia and beyond, the

15 The concept of liberalism is multiple, stratified, and controversial, so it deserves some further comment. At least since Michel Foucault's works on biopolitics, many authors have used the concept of “neoliberalism” to distinguish the first liberals like Smith, Ricardo, and Stuart Mill—who saw the State as necessary to limit the excesses of markets—from the new liberals who gathered at the Lipmann Colloquium in Paris in 1938, where the term was coined by German sociologist and economist Alexander Rüstow: Foucault (2008); Reinhoudt & Audier (2018). Many authors use this term to refer to a political project—with its theoreticians, supporters, and executors—and to the historical period in which such a project has started to become dominant on a planetary level, starting from the 1970s–1980s. As an ideology, “neoliberalism” describes society as an aggregate of individuals selfishly competing for their own good, the sum of whose interactions brings wellbeing to the collective, which cannot be efficiently planned by a central authority such as the State: Harvey (2005); Mirowski & Plehwe (2009); Audier (2012); Slobodian (2018). Contrary to liberalism and neoliberalism, which both attribute (albeit in different ways) a regulatory role to the State, “libertarianism” aims at minimizing the State by privatizing justice, police, and defense and by leaving to the actors the function of self-regulating through unfettered competition.

16 Helmreich (1998; 2000); Hayles (1999); Israel (2005); Li Vigni (2020a).

17 Baker (2022).

first section also explores the mutual influences between complexity and Friedrich von Hayek's strain of liberalism. The second section considers some examples of SFI's knowledge production, in order to illustrate the way certain liberal tenets are implicitly embedded in the premises and results of complex systems models. It also argues that various receptions of (social) Darwinism have played the role of connector between complexity theory and some of the pillars of capitalistic views. The third and last section shows the way in which the SFI has come to be an embodiment of the commodification of science. It will particularly focus on a funding device that brings the institute closer to a think tank—something that the conclusion comments on in more detail.

From a theoretical viewpoint, the present text is anchored in the field of Science and Technology Studies (STS), for its interdisciplinary methods based in history and sociology, and for its “coproductionist” approach that theorizes the dynamic entanglement of science and society.¹⁸ Within this framework, the epistemic, ontological, normative, and social dimensions of technosciences are tied together, making the researcher's quest for “original causes” arduous. For STS scholars, technoscience is a social activity like any other:

Briefly stated, co-production is shorthand for the proposition that the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we choose to live in it. Knowledge and its material embodiments are at once products of social work and constitutive of forms of social life; society cannot function without knowledge any more than knowledge can exist without appropriate social supports.¹⁹

As for the empirical data, this paper relies upon different materials. Several dozen semi-directive interviews (averaging 2.5 hours in duration) have been conducted with complexity scientists.²⁰ A bibliographic analysis and an examination of SFI's institutional archives complete the list of sources.²¹

18 Knorr-Cetina (1999); Jasanoff (2004); Felt, Fouché, Miller, & Smith-Doerr (2017).

19 Jasanoff (2004, pp. 2–3).

20 The present article relies upon 50 interviews with SFI's complexity scientists (associated and resident) and staff members, journalists, and one NGO leader. Interviews with researchers were semi-structured: partly open and individualized, and partly following a general framework that contained questions about personal pathway, epistemological practices and methods, as well as consulting activities with policy-makers and private actors. Interviewed researchers were mostly confirmed ones, but six of them were PhD or postdoctoral. Among the scientists, 29 were men and 7 women. Interviews with SFI staff members—seven women and four men—were all personalized and revolved around their tasks. Two interviews with journalists who had written about the institute and one with an NGO that funded it complete the set (these three are men). The interviews lasted 1 hour on average; they were always recorded and were mostly conducted in face-to-face settings at the SFI, or in six cases by telephone or video conference.

21 Archives were collected at the SFI in September–October 2016 during a short ethnographic visit, as well as from the internet. A particularly important source is the *Bulletin*, the SFI's main outreach document. From 1986 to 2014, the SFI published 40 issues of it. The *Bulletin's* articles were written by the institute's staff members, resident scientists, and freelance journalists. It was addressed to the members of the Board of Trustees, the research officers, the SFI advisors, the scientists, the donors (past and potential), as well as to universities, and industrial and governmental directors. The *Bulletin* was published once to twice per year. Printed in 5,000 copies, it was available for free upon request. Later, its publication became exclusively electronic and old issues were

1. Economics, Management, and Business at the SFI

The SFI was founded by a group of senior physicists from the Los Alamos National Laboratory (LANL), the University of Illinois, Princeton, and Caltech.²² Between 1982 and 1984, they gathered regularly to discuss the foundation of an interdisciplinary research institution (see Table 1 for an overall view). In 1984, they established it in Santa Fe (1 hour by car from the LANL) with the idea of employing interdisciplinarity and computers to provide useful science both to the government and to the private sector.²³ To this purpose, they launched the “science of complexity,” conceived of as an overarching theory of all “complex adaptive systems,” be they natural, social, or artificial. These are characterized by the presence of “networks of components with no central control and simple rules of operation [that] give rise to complex collective behavior, sophisticated information processing, and adaptation via learning or evolution.”²⁴ This definition condenses the epistemic and political identity of the SFI, as it is strongly influenced by economists. If absent in the founding moments of the institute, economics indeed entered the scene quite soon in its history.

1.1. *The Role of Economics in Kicking Off the SFI*

Along with Artificial Life, condensed matter physics, theoretical biology, and computational social sciences, the study of economy and finance was one of the first research themes pursued by the SFI.²⁵ As a matter of fact, the first important workshop organized in 1987 by the institute featured physicists and economists, and dealt with the modeling of chaotic market patterns.²⁶ Citigroup bank CEO John Reed famously supported the workshop. As a later bulletin recalled, “It’s ironic that with all the physicists in the founding group, the first big money that came in was for economics. The funding came from Citibank: \$250,000 to study the global economy.”²⁷ Reed was particularly keen for new mathematical models with the hope that they could

digitized. In the mid-2010s, the *Bulletin* was discontinued because it was considered too expensive and less efficient than other paper and digital supports. The *Bulletin* provides excellent material for exploring some of the main research projects, frameworks, funders, and values of the SFI.

²² These were: Herbert Anderson, David Campbell, Peter Carruthers, George Cowan, Stirling Colgate, Nobel laureate Murray Gell-Mann, Edward Knapp, Nicholas Metropolis, Darragh Nagle, David Pines, Louis Rosen, Gian-Carlo Rota, Mike Simmons, Richard Slansky, and Anthony Turkevich. For a historical account, see Waldrop (1992); Cowan (2010); Williams (2012); Li Vigni (2020b).

²³ Letters of Arthur Spiegel (1984), Box: “SFI Early Docs Development Archives,” SFI Archive, Santa Fe, NM; Li Vigni (2020b). Some of the LANL fellows participated in the Manhattan Project, and thus attributed to their elderly endeavor in Santa Fe a sort of redemption for their lethal but “necessary” original sin: Waldrop (1992, p. 55).

²⁴ Mitchell (2009, p. 13). See also Cowan, Pines, & Meltzer (1994); Holland (1996).

²⁵ Respectively, Langton (1988; 1997); Stein (1989); Kauffman (1993) and Holland (1996); Epstein & Axtell (1996) and Dean et al. (1999); Palmer, Arthur, Holland, LeBaron, & Tayler (1994). For an overall view of the different streams of research in economics at the institute, see Fontana (2010).

²⁶ Anderson, Arrow, & Pines (1988).

²⁷ King (2004b, pp. 9–10).

predict global financial dynamics and thus avoid loss from economic crises and stock exchange crashes.²⁸ The 1987 workshop had some related projects and led to two follow-ups, but the interest of the SFI in economics went far beyond that.²⁹

In its promotional material, the institute has strongly advertised its intention to tackle “the very ‘real world’ nature of the problems” that humanity has to face today, such as climate change, biodiversity loss, deforestation, terrorism, epidemics, and social inequalities.³⁰ The *Bulletin* has indeed featured research projects about the interaction of HIV with the immune system, the problem of economic disparities, models of species’ responses to climate change in different ecosystems, anticipation of terrorist attacks, as well as the development of a vaccine against HIV.³¹ Yet, economics—and especially the study of stock markets—is one of the topics that reappears most often in the *Bulletin*.³² Presented as a topic of general interest, such inquiries are generally funded or commissioned by private actors (foundations, banks, and hedge funds). The link between these actors and the SFI has always been strong. For example, one of its first postdocs, Bill Miller, became an investor, fund manager, and strenuous supporter of the institute, later also serving as its chairman.³³ Even more importantly, SFI cofounder George Cowan—who also founded the Los Alamos National Bank in 1963—was able, in 1992, to donate to the SFI part of the funding necessary to buy the institute’s current building, which is named after him.³⁴ In this context, it is not surprising to see that some of the most recurrent research questions found in the bulletins are: “Why do [stock market] crashes happen? And how can we design and regulate markets to reduce the risk of them happening in the future?”³⁵

In light of these elements, one may ask what kind of economic knowledge the institute produced. While “complexity economics” was presented by its supporters as a revolutionary approach, it was in fact thought of as a reappraisal of the hegemonic paradigm of neoclassical economics, whose theoretical core is described by the SFI as resting upon “four commandments”:

- 1) the assumption that the economy is based on diminishing returns, 2) the assumption that all the action that is interesting happens at equilibrium, 3) the assumption that there is a fixed number of goods and services, 4) the assumption that we can regard people as infinitely rational.³⁶

²⁸ Rockmore (2009, p. 29).

²⁹ Friedman & Rust (1993); Arthur, Durlauf, & Lane (1997); Blume & Durlauf (2005).

³⁰ Knapp (1991, p. 3); Cowan (1989, p. 3); West (2007, p. 1).

³¹ Respectively, Simmons (1989, p. 16); Gintis (2002); Beck (2008b, p. 9); Beck (2008c, p. 18); Rehmeier (2012, p. 28).

³² Moreover, an exhaustive review of the bulletins has shown that, while economics has always been present in the history of the SFI in terms of associates and research programs, other social sciences such as archeology, anthropology, linguistics, history, or psychology have also appeared anecdotally.

³³ From Bill Miller’s page on the SFI website: “Bill Miller” (n.d.).

³⁴ Cowan (2010, pp. 80–81).

³⁵ Whitfield (2008, p. 33).

³⁶ Stites (1994, p. 6).

In opposition to these points, SFI's economists present another view. In a recent text, which collects his precedent works alone or in collaboration, Irish-American economist Brian Arthur—who coined “complexity economics” and who is one of the “stars” of the general audience books about the SFI—characterizes such an alternative perspective by opposing each one of the neoclassical tenets as follows:

Looking back now, the features of complexity economics are clear. The economy ... is usually in nonequilibrium. Agents are not all knowing and perfectly rational; they must make sense of the situations they are in and explore strategies as they do this. The economy is not given, not a simple container of its technologies; it forms from them and changes in structure as this happens. In this way the economy is organic, one layer forms on top of the previous ones; it is ever changing, it shows perpetual novelty; and structures within it appear, persist for a while, and melt back into it again.³⁷

Some authors qualify and welcome such a project as “heterodox” but the situation is more complex than that.³⁸ It is thus useful to contextualize complexity economics within the larger intellectual panorama of the discipline. Criticizing neoclassical economics does not automatically make of SFI's school a Keynesian or progressive stream of thought—the “heterodoxy” *par excellence* today. French philosopher Jean-Pierre Dupuy was one of the first to distinguish liberalism as an intellectual movement in “political economics” from “scientific economics,” where the hegemonic stream of research fits into the neoclassical approach.³⁹ In light of such a distinction, complexity economics can be considered as heterodox only in regard to the neoclassical mainstream approach; however, the remainder of the article is dedicated to showing the way in which the SFI approach fits into mainstream political economics—neoliberalism—by refurnishing it with new theoretical discourse. Indeed, as Arthur has recently written, complexity economics is in his view “economics done in a more general way. This broadening of principles is not due to a shift in ideology. It is due, I believe, to new tools becoming available to economics.”⁴⁰ That being said, what impact did SFI's approach have on academia and outside of it?

1.2. *The Influence of SFI's Economics*

While the intellectual impact of complexity economics has yet to be assessed through quantitative studies, and while its practical impact needs to be investigated through ethnographic work in the business world, it is however possible to mention some clues and advance a hypothesis about these issues.⁴¹ Let us begin by looking at some

37 Arthur (2015, pp. xix–xx). For his coinage of the term, see Arthur (1999).

38 See, for example, Elsner (2017) and the references therein.

39 Dupuy (1992).

40 Arthur (2021, p. 143).

41 For qualitative and engaged accounts, see Elsner, Heinrich, & Schwardt (2015); Schasfoort (2017); Colander (2000).

of the explicit intersections being made by researchers between complexity science and economics.

To start with, Brian Arthur's article for *Science*—published in 1999 and entitled “Complexity and the Economy”—has today more than 1300 citations on Google Scholar. Even if Google Books Ngram Viewer shows that the occurrences of “complexity economics” are four times rarer than “econophysics,” this remains a respectable amount of citations among similar fields. Moreover, the movement has been revived by Arthur's recent publication for *Nature* about the “Foundations of Complexity Economics,” as well as by the proceedings of a symposium on complexity economics held at the SFI in 2019.⁴² In addition to the self-promotion of SFI members, Paul Krugman—laureate of the Bank of Sweden Nobel prize for economics—has contributed to the visibility of SFI's approach through one of his books, entitled *The Self-Organizing Economy*, where the SFI is acknowledged as “one of the hotbeds” of the interdisciplinary study of markets as complex systems.⁴³ Also, a few university departments are involved in economic complexity. Besides the SFI, one can mention the Institute for New Economic Thinking at the Oxford Martin School and the London School of Economics Complexity Group. All in all, if some have seen in complexity a revolution for economics, what precedes shows that, while SFI's approach has certainly had some influence, it has as yet remained marginal within the discipline.⁴⁴

A second factor to assess SFI's impact is the interest policy-makers and think tanks—like the OECD and the McKinsey Global Institute—have manifested in SFI-style economics in publications and workshops.⁴⁵ Back in the 1990s, businesswoman Esther Dyson and physicist George Keyworth II, both SFI trustees, wrote an important document with libertarian writer George Gilder and futurologist Alvin Toffler.⁴⁶ This document was entitled “Cyberspace and the American Dream: A Magna Carta for the Knowledge Age” and advocated for telecom deregulation, alleging the unplannable nature of economic markets. Highly influential, this document was the result of a conference organized by the Progress & Freedom Foundation, a libertarian think tank funded by large corporations in the computer and media sectors, such as Microsoft, AT&T, and Walt Disney. By leaning on Hayekian spontaneous order, the “Magna Carta” established the guidelines for fostering the new digital economy, which Bill Clinton operationalized through targeted tax cuts, subsidies for specific technology programs, and public investment in infrastructure.⁴⁷ In addition, Erik Baker's article further illustrates the close relationships between the SFI and some important conservative institutions, such as the John Templeton Foundation, the Institute for Humane

42 Arthur (2021); Arthur, Beinhocker, & Stanger (2020).

43 Krugman (1996, p. 2).

44 Mirowski (1996); Holt, Rosser, & Colander (2011); Thornton (2016).

45 See the workshop that the OECD dedicated to the “Complexity of the Economy” in October 2015: “New Approaches to Economic Challenges” (2015). See also Hidalgo & Hartmann (2017); and “Redefining Capitalism” by SFI external professor Eric Beinhocker: Beinhocker & Hanauer (2014).

46 Baker (2022).

47 Durand (2020).

Studies, and the web magazine *Reason*.⁴⁸ Moreover, Australian political scientist Jeremy Walker has shown how resilience—one of the key complexity concepts—“was singled out as the watchword for new models of adaptive risk management sensitive enough to cope with the systemic risks of deregulated finance.” In support of this point, Walker argues that in 2008 “a group of leading ecologists including Robert May (at the time an advisor to the Bank of England) published a paper in *Nature* which offered the insights of complex ecological systems as a model for bankers during the gathering financial crisis.”⁴⁹ Walker also mentions the speech delivered at the Financial Students Associations in Amsterdam by Andrew Haldane, the executive director of the Financial Stability section of the Bank of England. Haldane considered “the financial system as a complex adaptive system” and proposed to apply “some of the lessons from other network disciplines—such as ecology, epidemiology, biology and engineering—to the financial sphere” in order to suggest “ways of improving [financial system] robustness in the period ahead.”⁵⁰ Walker also argues that “the science of complex adaptive systems has become a discursive reference point for the full spectrum of contemporary risk interventions” through its discourses on resilience and limited knowledge epistemology.⁵¹ In the same vein, political philosophers Michael Dillon and Julien Reid claim that complexity discourse has also impacted “distinguished scholars of international relations, as well as influential strategists,” and more generally “the US strategic doctrine.”⁵²

Last but not least, management, business, and organizations literature offers dozens of books and articles that mention “complexity” in their title, and that mobilize concepts and tools from complex systems sciences in order to “lead on the edge of chaos” or “to understand organizational stability and change by focusing on the emergence of novelty and creativity in the course of everyday processes.”⁵³ As Erik Baker recently wrote:

The most popular expositions of SFI ideas and their implications for public policy and business in the 1990s did not come from permanent SFI faculty members but from members of the constellation of donors, visitors, advisors, and admirers who came to orbit the Institute with increasing density.⁵⁴

⁴⁸ Baker (2022).

⁴⁹ Walker (2020, pp. 325, 326). See May, Levin, & Sugihara (2008) for the paper cited by Walker.

⁵⁰ Haldane (2009).

⁵¹ Walker (2020, p. 312).

⁵² Dillon & Reid (2001, pp. 51–52), especially the books and working papers cited as evidence at p. 52 n. 49.

⁵³ Murphy & Murphy (2002); Stacey, Griffin, & Shaw (2000). See also Kelly (1994); Axelrod & Cohen (1999); Frame (2002); Shaw (2002); McMillan (2003); Mauboussin (2006); Paraskevas (2006); North & Macal (2007); Blandin (2007); Curlee & Gordon (2011); Khalil (2014); Lichtenstein (2016); Miller (2016); Woodside (2017); Nason (2017). A special issue of the journal *Organization Science* was dedicated to the introduction of complexity in organization studies: Anderson, Meyer, Eisenhardt, Carley, & Pettigrew (1999). A whole academic journal has furthermore been dedicated to the application of complexity theory to business: *Emergence: Complexity and Organization* (<http://journal.emergentpublications.com/>).

⁵⁴ Baker (2022).

I can mention, for example, two books that have fostered the institute's approach within the business world: on one side, the bestseller entitled *Bionomics: The Inevitability of Capitalism*, in which consultant Michael Rothschild claims capitalism is part of nature and that as such it is unstoppable; on the other side, the volume entitled *The Biology of Business: Decoding the Natural Laws of Enterprise*, edited by entrepreneur and SFI Business Network member John Clippinger, who therein explains the strategies for restructuring a firm as a complex adaptive system.⁵⁵ Both promote a self-organizing approach to the economy.

1.3. *The SFI and Business*

Besides economics, the SFI has also played a role in the economy and in finance. In this regard, this subsection looks at the intersections between complexity science and entrepreneurship. Thanks to archival material, I can clearly state that the economic modeling tools developed at the SFI did not remain confined to academia. For instance, at the time of a meeting in 1991, a group of bankers and financiers from Salomon Brothers, Goldman Sachs, and other hedge funds claimed to use some of SFI's tools in their speculative activities.⁵⁶ Bill Miller, who in 1998 was director of Legg Mason Value Trust (a \$6 billion fund), explained straightforwardly that "We are only interested in what works to help us make money."⁵⁷ Similarly, Deere & Company—an American corporation that produces agricultural engines and other machinery for several sectors—has employed Christopher Langton's agent-based models and John Holland's genetic algorithms in order to make their management more efficient and increase the productivity of their supply chain:

With the introduction of the new scheduling system, the atmosphere of the factory improved along with productivity. Shop floor schedulers and supervisors were free to focus on strategic issues. Now, the [Genetic Algorithm] has the final word; it produces daily and weekly schedules. Employees even began checking the GA-generated production schedules to plan their weekly activities—even vacation time.⁵⁸

Furthermore, some SFI members have founded a few entrepreneurial ventures of their own. In 1991, chaos physicists Doyne Farmer and Norman Packard left academia for some years in order to launch a start-up to "beat the market."⁵⁹ They founded the Prediction Company in Santa Fe to apply machine learning techniques to stock options trading. In another sector, biologist Stuart Kauffman and consulting company Ernst & Young founded Bios Group in 1997, a company providing application soft-

⁵⁵ Rothschild (1990); Clippinger (1999).

⁵⁶ Richardson (1991, p. 31).

⁵⁷ Banegas (1998, p. 13).

⁵⁸ Graham (1998, p. 9). Genetic algorithms are used in computer science and operations research to generate solutions to optimization and search problems by relying on mutation, crossover, and selection. They are further defined below.

⁵⁹ Bass (2000).

were based on complexity science tools for project management and supply chains. Among its contractors were private companies such as Ford and Boeing, but also government agencies such as the Office of Naval Research.

How to interpret such clues? A hypothesis for future inquiries is that complexity economics may have played, for American capitalism, a similar transforming role to that which, according to French sociologists Luc Boltanski and Ève Chiapello, French network and complexity theories have had on French capitalism. Such theories have, according to them, provided a language that led to a redevelopment of management and business theory and practice, by encapsulating May 68's anticapitalistic critiques and self-management revendications.⁶⁰ One of the reasons for this is the above-mentioned influence of complexity theory on business publications. Another reason is the fact that SFI's economists have never expressed any criticism of the theoretical and political tenets of capitalism, but only of what they considered as neoclassical modeling flaws. In complexity economics, markets are indeed inefficient and agents have a bounded rationality, but their driving forces remain self-interest, accumulation, and competition, while little or nothing is said about inequalities. Another reason behind this hypothesis is the mutual intellectual influence between complexity and some liberal theories. To support this claim, I shall now consider now some SFI economists' and commentators' retrospective and programmatic discourses.

1.4. Hayek as a Precursor of and an Inspiration for Complexity Science

To begin with, a point can be made on the explicit declarations of interest that complexity scientists have repeatedly made vis-à-vis Friedrich von Hayek's and Joseph Schumpeter's theories. For example, former SFI postdoctoral fellow Cosma Shalizi, who worked on adaptive computation, claims that "Today we have a much better body of abstract theory about emergence, and a wonderful assortment of models, and they make very nice analogies to what Hayek and Schumpeter talked about; Hayek even lived long enough to appreciate some of them."⁶¹ While some members of the SFI ignored the works of Hayek before contributing to launch complexity economics, other fellows did not, arguing that he should be acknowledged for his older, deep reflections about "spontaneous order." Brian Arthur belongs to the first category. His declarations have bolstered the views of certain observers who believe that the SFI's approach is nothing but a "rediscovery" of Hayek's theories and that Hayek can be seen as a "precursor" of complexity sciences.⁶² In this regard, consider the following extract from an article by William Tucker, a libertarian think-tank fellow:

Brian Arthur, head of economics research at Santa Fe, readily acknowledges this precedence. "Right after we published our first findings, we started getting letters

⁶⁰ Through text analysis tools, Boltanski & Chiapello (2007) have studied the impact of the concepts of "rhizome" (by Gilles Deleuze), "network" (by Bruno Latour), and "complexity" (by Edgar Morin) on management and business literature, by comparing texts from the 1960s and 1990s.

⁶¹ Shalizi (1999, p. 10).

⁶² Pearce (1994); Vaughn (1999).

from all over the country saying, 'You know, all you guys have done is rediscover Austrian economics,'" says Arthur ... "I admit I wasn't familiar with Hayek and von Mises at the time. But now that I've read them, I can see that this is essentially true."⁶³

Within the second category of SFI fellows is American computational social scientist Robert Axtell, who sees in Hayek's writings a possibility to advance further the complexity approach to economics:

Not only does Hayek deserve credit for beating the physicists and other complexity scientists to the punch in articulating a coherent view of complex systems, his radically distributed and decentralized view of the world is a wellspring for renewal of the complexity program as the methodology continues its colonization of new scientific fields.⁶⁴

In his writings (especially the final ones), Hayek did indeed refresh the Smithian metaphor of the invisible hand using inspiration from cybernetics' and systems theory's concepts of self-organization—a phenomenon he came to call "catallaxy."⁶⁵ According to this concept, decentralized economies appear to have an order, despite the lack of a central planner, thanks to the myriads of local interactions occurring in the markets. Three simple laws—property, tort, and contract—rule the ensemble, whose coordination "comes about through competition of agents for profits aided by the price system."⁶⁶ In his article, Axtell equates Hayek's "spontaneous order" to complexity's "emergence," by pointing out two differences.⁶⁷

On the one hand, Hayek did not use mathematics nor computational models, not only for historical reasons but above all because of his epistemology. Indeed, as Melinda Cooper observes, while the neoliberal and neoclassical school of Chicago defended a radical positivism, Hayek "espoused an epistemology of limited knowledge as the only legitimate framework for understanding market processes."⁶⁸ Even if Hayek and his mentor Ludwig von Mises did not eschew predictive claims about economic cycle modeling, they thought that prediction is not possible in view of the central planning of economy. Concerning modeling, SFI's scholars, who agree that the central planning of markets is impossible, are epistemologically closer to the Chicago school than to Hayek, because for them the modeler is capable of modeling the markets with a godlike eye. Both Arthur's and Axtell's SFI research groups have performed bottom-up simulations in which economic and financial markets are "grown up" to form structures and regularities through local interactions of agents following simple rules.⁶⁹ Now, as the next section shows, the principle of a distributed

63 Tucker (1996, p. 38).

64 Axtell (2016, p. 104).

65 Hayek (1978).

66 Vaughn (1999, p. 250).

67 Axtell (2016).

68 Cooper (2011, p. 375).

69 Epstein & Axtell (1996).

organization can become a way to legitimate a capitalistic interpretation of society at large.

On the other hand, Hayek tended to associate decentralization with positive outcomes, while Axtell pretends that the complexity notion of emergence is axiologically neutral. Yet, as more than one commentator has noted, the SFI school has made explicit normative statements too (besides the implicit ones that are the subject of the next section). It is well known that Hayek's notion of spontaneous order brought him to anti-planning prescriptions. The alliance between neoclassical economics and socialist planning embodied by "*Trente Glorieuses*" Keynesian politics was indeed opposed by Hayek throughout his whole life, for he believed that no central authority could ever possess an overall view of the market, as it is too complex and dynamic. However, for some SFI researchers, the State's intervention in the economy is not to be absolutely proscribed. As William Tucker writes from his libertarian point of view, the fact of getting inspiration from Hayek "has not prevented Arthur and the other economists at Santa Fe from turning complexity into a rationale for government intervention," for example to overcome the inertia of technological lock-in (or path dependence) phenomena, which according to them may reveal inefficiencies in the economy.⁷⁰

2. Darwin as a Proxy of Hayek

While the SFI's associates and trustees may give political advice in articles, books, and consulting activities, the image the institute wants to promulgate is that of a neutral, bipartisan institution that can attract anybody from academia, business, or government. This is evident in the official statements of the institute's presidents, but also in the answers given to my questions by the institute's researchers, among whom are supporters of the Democratic, Republican, and Green parties. Nonetheless, whatever their political color, the tenets of capitalism are not questioned by SFI members. For example, faced with a query about the ideological normativity of his models, a quantitative geographer from the SFI defended the classical view separating "pure science" from "policy." Yet, in the course of the interview he fell into an involuntary contradiction when he claimed to be doing "fundamental science" while at the same time following a "great framework of choice" that he characterized as follows:

It's a bit like liberalism with a capital L, not political liberalism, but the idea that we should create societies where we have a lot of choice and capacity for action, where most of our basic needs are met and ... the pursuit of happiness is a fundamental right for everyone. You can say that this is political, but I think it's also quite consensual.⁷¹

⁷⁰ Tucker (1996); Kilpatrick (2001).

⁷¹ Interview with a quantitative geographer from the SFI (2016, Sept. 28).

Explicit evidence of the political views of the institute is thus quite rare, but, as the next section shows, implicit evidence abounds within the SFI's intellectual production.

2.1. *How Liberalism Informs Complex Systems Modeling*

The SFI's scientific works allow the exploration of the mutual influence between complexity and some of the tenets of "liberalism." In particular, models show the way in which SFI's researchers get inspiration from Hayek to reinterpret natural, social, and artificial "complex adaptive systems" (CAS) in liberal terms. By way of illustration, consider the following extract from one of the general-audience books written by theoretical biologist Stuart Kauffman:

the emerging sciences of complexity begin to suggest that the order is not all accidental, that vast veins of spontaneous order lie at hand. Laws of complexity spontaneously generate much of the order of the natural world. ... We have all known that simple physical systems exhibit spontaneous order: an oil droplet in water forms a sphere; snowflakes exhibit their evanescent sixfold symmetry. What is new is that the range of spontaneous order is enormously greater than we have supposed. ... I believe that this emergent order underlies not only the origin of life itself, but much of the order seen in organisms today. So, too, do many of my colleagues, who are starting to find overlapping evidence of such emergent order in all different kinds of complex systems.⁷²

According to the SFI's perspective—well interpreted here by Kauffman—the natural, social, and artificial complex systems respond to similar principles and ways of functioning, such as evolution. This tendency to unify different phenomena under the umbrella of a general theory comes from physics, the sovereign discipline within complexity, and leads to the naturalization of sociotechnical systems.⁷³ Indeed, one of the institute's first leitmotifs was a phrase by Nobel-winning physicist Murray Gell-Mann, contained in the proceedings of one of the institute's founding conferences: "Surface complexity arising out of deep simplicity."⁷⁴ That is why the initial scientific goal of the SFI and of other complexity institutes was, at least until the mid-1990s, to achieve a general theory of complex systems.⁷⁵ The argument goes as follows: If things at the bottom are simple, then the macroscopic heterogeneity of the world can be ignored in order to find the underlying commonality between systems. In

⁷² Kauffman (1995, pp. 7–8).

⁷³ Li Vigni (2020a).

⁷⁴ Pines (1988, p. 3).

⁷⁵ Several integrative workshops were organized to achieve such a goal: see, for example, Cowan et al. (1994). But the project was abandoned in the second half of the 1990s, following the publication of a critical article published in the *Scientific American* by journalist John Horgan (1995). In it, the writer bitterly criticized the research being conducted at the SFI as "flaky" and "fact-free." See also Smith (1995). However, the search for unification remained intact among complexity scholars; it has simply been reinvested into research on local disciplinary theories (for example, in ecology and geography) or on partial conceptual generalizations (through transversal concepts like adaptation, contagion, ageing, robustness, and so forth).

this context, the CAS perspective has become a means for complexity scientists to legitimate capitalism through the naturalization of socioeconomic dynamics. This is done in at least two ways: by generalizing competition to every system, and by considering economic growth as inevitable.

Firstly, the idea of competition. According to computer scientist John Holland, the emergence of a CAS collective organization does not depend on a “central authority” (note that the term is intrinsically political).⁷⁶ Instead it entails the capacity of individuals to innovate (genetically, economically, and strategically), if they are to survive. Besides genetic algorithms, other complexity tools—such as Christopher Langton's agent-based models, Stuart Kauffman's Boolean networks, and Doyne Farmer's neuronal networks—embody some form of encoded rivalry. These tools display a series of agents that constantly compete, learn, and adapt. Their philosophy leans on a certain reading of Darwin that seeks to enlist him as a precursor of complexity science, disregarding the role that different forms of cooperation play in his work.⁷⁷ In fact, as is well known, neither Darwin nor biologists in general have ignored the different forms of collaboration that are observable in nature.⁷⁸ More recently, some SFI affiliates have presented cooperation as a structuring principle of human and social-insect societies, but prior to the early 2000s they were an exception.⁷⁹ In most SFI publications, models, and conferences from the 1980s and 1990s, cooperation does not predominate in systems dynamics, nor even a complementarity between it and competition, but only the latter. Other examples of the convergence of physicalist unification and a certain reading of Darwin can also be found in Artificial Life, network theory, and other complexity subfields.⁸⁰

From a coproductionist perspective, it is equally interesting to show how the SFI's interest in competitive evolution is illustrated by funding from foundations and other private donors for several research projects on the interdisciplinary study of innovation, involving biology, economics, and computer science. The question behind these projects—which are scattered throughout the entire history of the institute—is: “To what extent are social organizations an extension of biology?”⁸¹ For instance, the presentation of a program about evolutionary dynamics funded by the Keck Foundation (established by the founder of the Superior Oil Company) “reflects the fact that the concept of evolution has become central to our view of a wide range of natural and social phenomena.”⁸² The objective of this kind of research was to synthesize in a coherent framework several dispersed insights about evolution, so as to understand what processes can better foster innovation in real life: “With

⁷⁶ Hightower (1991, p. 25).

⁷⁷ Kepler (1992, p. 16).

⁷⁸ Roughgarden (2009).

⁷⁹ Axelrod (1997); Bonabeau, Dorigo, & Theraulaz (1999). Baker (2022) shows that in the last 20 years, the SFI has made “cooperation” one of its main themes, “though this has ... ushered in a different sort of neoliberal perspective”: Erik Baker, personal comment to the author (2022, May 13).

⁸⁰ Simmons (1988, p. 15); Barabási (2003, p. 6).

⁸¹ West (2006, p. 2).

⁸² Jen (1999, p. B).

a synthetic approach ... successions of evolutionary innovations will be understood not as isolated events, but in terms of how each innovation affects the potential ... for future innovation.”⁸³ A flyer advertising SFI's scientific support for businesses parallels Darwin's theory with a “Theory of Innovation” that might “describe the emergence and survival of novelty across the technological, social, and biological domains” with the aim of providing “a quantitative, possibly predictive theory of novelty.”⁸⁴

As for the second way in which capitalism is naturalized by complexity science, consider now the example of quantitative geography, a specialty that has benefited from a certain visibility at the SFI in the first two decades of the 21st century. What emerges from the texts, models, and interviews of SFI's quantitative geographers is not only that competition and innovation are seen as the driving forces of history, but that this is the very reason why the economy is inevitably bound to grow. Consistent with the liberal views of economic life, complexity geographers—who are former physicists—assign to cities the possibility of infinite development. The unlimited growth of cities is put into a mathematical formula which takes into account a city's population (N), its material resources (energy, infrastructure) or social activities (wealth, pollution) (Y), three possible dynamics of urban centers (growth, decline, stagnation) (β), the amount of resources needed to maintain a single citizen (R), as well as the amount of resources needed to add a citizen (E).⁸⁵ The interesting variable in this equation is represented by β , which has the following implications. If growth takes the so-called “biological” (rather than economic) logic of economies of scale, and therefore of optimization and efficiency (where β is less than one), then the demographic rate of the city tends toward a plateau and then declines (for living organisms, see their life rate decreasing as they grow). If, on the other hand, demography follows a so-called “sociological” organization of information, wealth, and resource creation, its growth may continue indefinitely (where β is greater than one), provided that innovation takes place in increasingly shorter cycles. The following extract from an SFI *Bulletin* interviewing one of these authors clearly demonstrates the normative conclusions they draw from their research:

To grow indefinitely, a city has to periodically reset its growth rate. Such “resetting” can come from innovations that revitalize the economy, or from outside factors, such as shifts in immigration. The pattern that an ever-growing city falls into is one of successive growth cycles—each one shorter than the last as the size of the city increases. “You're on this treadmill and you've got to go on making these changes, these innovative changes, faster and faster because if you don't you'll stagnate and collapse,” [Geoffrey] West says.⁸⁶

83 Jen (1999, p. B).

84 “ACTioN. Applied Complexity Network @ the Santa Fe Institute” (2015–2016), Box: “2015–2016 SFI Promotional Material,” SFI Archive.

85 Bettencourt, Lobo, Helbing, Kühnert, & West (2007).

86 Beck (2008a, p. 8).

In a seminal edited volume on computational modeling and predicting the future, French economist and geophysicist Pierre Matarasso shows how John von Neumann's introduction of a mathematical formula into economics eventually endorsed the normative ideal of endless growth; the "infinite horizon" thus became paradigmatic in this field of knowledge.⁸⁷ In the same book, French sociologist Élodie Vieille-Blanchard notes, with regard to the model that the neoclassical economist William Nordhaus constructed to counter the Club of Rome model published in *Limits to Growth*, that "it was a priori unlikely that the conclusions of his simulations would be opposed to growth," precisely because his model was based on Frank Ramsey's "optimal growth" model, which itself incorporated von Neumann's formula.⁸⁸ In a similar way, the mathematical and computational modeling used by complexity geographers favors some scenarios over others, because of the theoretical and axiological assumptions that are implicitly inscribed in them.

2.2. Coproducing Complexity Science and Liberal Ideology

As a consequence of what precedes, the thesis I defend in this section is that the SFI was one of the arenas in which certain theories of natural and social systems have been coproduced with liberal ideologies. Indeed, the naturalization of society through the lens of evolution is a way to legitimize a form of social Darwinism by using Darwin as a proxy for liberalism. Evolutionism is what links natural and social CAS by reducing the latter to the former. After all, the SFI explicitly associates the name of Darwin with those of Hayek and Smith. For instance, economist and businessman Bill Miller declares that "one aim of his modeling work [was] to expose the 'invisible hand'" for which complexity science could provide "a coherent explanation." For him, "the invisible hand [is] at work in many kinds of social phenomena, even in one of the most baffling human behaviors: politics."⁸⁹ Anthropologist Stefan Helmreich makes a similar point about SFI's discourse. He claims that "The neoliberal biological language in which the market is understood further serves to naturalize the value systems and institutions of advanced capitalism, posing their human authors as mere instruments of processes beyond their control."⁹⁰ Consequently, in the eyes of the SFI's fellows, combating capitalism is literally a waste of time.

Such empirical elements pinpoint a depoliticized anthropology in which decision-making can at best play the role of a flow regulator. For instance, in the view of the quantitative geographers cited above, the size of a city is a stronger determining factor than its political or social history and design. They also reject cultural geography's emphasis on the relativity of customs and traditions, arguing that human beings are fundamentally predictable even when they feel free. Within this framework, policy "cannot break those rules or build them anew but [it] can drive them in the right or

87 Matarasso (2007, p. 54).

88 Vieille-Blanchard (2007, p. 38). See Meadows, Meadows, Randers, & Behrens (1972).

89 Graham (1999, p. 16).

90 Helmreich (2000, p. 501).

wrong direction.”⁹¹ Coherently, one of the two researchers in question declared to the *SFI Bulletin* that the room for political initiative in the government of a city is limited, which perfectly illustrates their physical determinism: “[T]he general trend and the coarse-grained scale of it is probably determined for you.”⁹²

For the sake of completeness, it should be noted that slightly discordant voices regarding such a view exist within the SFI, even if they remain rare and discrete. For instance, computer scientist Cristopher Moore, a resident member of the SFI since 2007 and former city counselor for the Green Party in Santa Fe, maintains a distance from the application of biological metaphors to economics and social sciences. He declares, for example, that “The economy is not a jungle” because “Economic systems are governed by governments, which are not present in a rainforest.”⁹³ Another example may be economist Samuel Bowles, an SFI associate since 2000, who has written about social inequalities and argued that “wealth, race, and schooling are important to the inheritance of economic status, but [that] IQ is a less important contributor and ... [that] the genetic transmission of IQ is even less important.”⁹⁴ He has also contended that *Homo sapiens* is a “cooperative species” and thus challenged “the conventional economic assumption that people are motivated entirely by self-interest.”⁹⁵ Yet, these examples are exceptions that do not aspire to fundamentally question the SFI’s capitalistic view of nature and society nor to propose an alternative to it.

3. The SFI and the Commodification of Science

The coproduction frame invites to investigate the way in which scientific theories translate into and are influenced by material practices. The present section focuses on the SFI administration’s conception of the institute’s mission and mode of functioning. The following pages describe more particularly the institute’s historical context, organizational philosophy, and fundraising strategies.

3.1. The Historical Context

According to French historian of science Dominique Pestre, in the last 40 years the technoscientific world has entered a new period characterized by: 1) a specific regime of funding through projects; 2) the loss of centrality of the State in the production and management of knowledge; and 3) a shrinking of fundamental research in the name of market imperatives, international concurrence, and the race for patents.⁹⁶

91 Interview with a quantitative geographer from the SFI (2016, Sept. 28).

92 Beck (2008a, p. 8).

93 Baake (1999, p. 29).

94 Bowles, Gintis, & Groves (2009, p. 21).

95 Bowles & Gintis (2011); “Sam Bowles” (n.d.). In addition, as Erik Baker points out, “Bowles vastly overestimates the politically transgressive character of his work on cooperation. Hayek and Mises certainly did not believe that humans were ‘motivated entirely by self-interest’ either”: Erik Baker, personal comment to the author (2022, May 15).

96 Pestre (2003). See also Mirowski (2011); Busch (2017).

Put differently, technoscience has moved closer to business in terms of both organization (being based on generalized competition) and objectives (seeking returns on investment and commercial exploitability). The “new sociology of science” has for its part qualified this phenomenon as an “asymmetrical convergence,” where “industry maintains an economic and (increasingly) cultural advantage [over academia].”⁹⁷ In such a context, the SFI presents two specificities compared to most “academic neoliberalism” that deserve to be addressed. In the first place, more than an asymmetrical convergence, we should talk here of an ideological affinity between SFI’s founders and the world of finance, the fledgling Reagan government, and the Cold War mission of better understanding and predicting the complexity of the world. As philosopher of science Christophe Schinckus sums it up in a recent paper:

In 1982, Cowan accepted an appointment to the White House Science Council (WHSC) under the Reagan administration. In his memoirs, Cowan (2010) explained how the new administration relied on science for the development of their new Manhattan Project, the Strategic Defense Initiative also called the “Star Wars project” by the popular press, which was supposed to protect the US from potential nuclear attack.⁹⁸

In the second place, far from pursuing patents and other commercial applications, the SFI’s archives show that the institute’s founders emphasized the geopolitical dimension of their scientific efforts. To illustrate this point, it is instructive to take into account the letters of the first fundraiser of the institute, Art Spiegel, an art dealer and friend of Cowan’s from Los Alamos. One of the arguments he deployed in his missives to attract potential donors (retired scientists, entrepreneurs, art dealers, and so forth) was that the institute had to contribute, in the context of the Cold War, to ensuring that the United States would continue to “set the pace in the advancement of science and its applications” on the international level.⁹⁹ In this regard, the initial ambitions of SFI’s founders were vast. At the time, the senior fellows sought to raise up to \$230 million: \$80 million for the establishment of 40 chairs; \$60 million for hiring 100 scientists; \$20 million for laboratory facilities, offices, and seminar classes; and the rest for other functioning needs.¹⁰⁰ More tellingly, together with some colleagues from academia, public administration, and liberal think tanks, Cowan organized in the early 1990s a working group at the SFI with the goal of modeling the ecological and geopolitical (in)stability of the planet.¹⁰¹ The program was named “Elements of International Stability,” and later renamed “Multiple Paths Toward a

⁹⁷ Moore, Kleinman, Hess, & Frickel (2011, p. 513).

⁹⁸ Schinckus (2021).

⁹⁹ Letters of Arthur Spiegel (1984), Box: “SFI Early Docs Development Archives,” SFI Archive.

¹⁰⁰ “The Aims of the Rio Grande Institute, Draft 5/30/84” (1984, May 30), Box: “SFI Early Docs Development Archives,” SFI Archive.

¹⁰¹ It is worthwhile to mention that a few senior fellows were *habitués* of famous American private policy groups. For example, from 1956 to 1989 and from 1991 to 1994, Murray Gell-Mann has repeatedly worked as a consultant to the RAND Corporation to solve physics problems for classified issues: “The Nobel Prize and RAND” (n.d.); Erwin, Karklins, Knox, Lifshitz, & Piccio (2007); Hoddson (1982).

Sustainable Human Society.”¹⁰² In the vein of the Club of Rome’s “World” model, the aim of this working group was to help predict future military and environmental scenarios in order to avoid nuclear war and environmental collapse.¹⁰³ In 1993, the program was extended to include the World Resources Institute and the liberal think tank Brookings Institution, and was dubbed “Project 2050: Transition to Sustainability.”¹⁰⁴

3.2. *Organizational Philosophy*

Besides its historical and ideological context, let us consider now the way of functioning of the SFI as a private institution. A sentence from the fourth president of the institute, Robert Eisenstein, condenses the essential points of this section: “SFI’s connection to the business world, and the way it operates primarily with money from private sources rather than governmental funding, make it much like a business.”¹⁰⁵

The first point to mention here is that the institute’s administration and faculty have always had a very negative opinion of public funding, which they describe as too bureaucratic; they see government agencies as too directive, old-fashioned, short-sighted, and rigid. In the institute’s view, these are unfit characteristics to thrive in an ever-moving and competitive world. Indeed, the faculty and the Board of Trustees have generally preferred companies’, foundations’, and donors’ funds to public ones (Figure 1 shows that private funding has constituted about two thirds of the institute’s income since the early 1990s). According to the SFI, philanthropic and business resources have a major advantage: the guarantee of “intellectual independence.” As one of the institute’s treasurers explains in the *Bulletin*, private gifts are generally accompanied by a letter that specifies to the institute how and when the money shall be spent—but according to her, governmental scholarships are much more restrictive. “The tracking of funds is endless,” she declares.¹⁰⁶ Federal agencies demands frequent reports and status updates from the recipients. They also impose a number of regulations and audits. If the SFI, despite such difficulties, has never renounced accepting public money, this has largely been a symbolic gesture: “Competitive peer-reviewed grant funding provides credibility for the Institute’s science, while the availability of unrestricted funds from contributions allows investment in cutting-edge, high-risk ideas.”¹⁰⁷ In the remainder of the paper I show that, in establishing the institute as a private center, its founders have come to blur the line between the scientific and the

102 Metropolis (1988, p. 16); Simmons (1990, pp. 19–20).

103 Founded in 1968 in Rome by the industrialist Aurelio Peccei, the Club of Rome is an extant think tank combining politicians, scientists, economists, and business leaders from around the globe, with the aim of stimulating reflection on and action in the field of sustainable development. The 1972 book *Limits to Growth* was its first and most famous report. It strongly influenced the de-growth movement and the studies about the risk of globalized capitalist society collapse. For the Club of Rome report, see Meadows et al. (1972); for a historical and sociological analysis of “World 3,” see Vieille-Blanchard (2010).

104 Simmons (1993, pp. 9–10).

105 King (2004a, p. 5).

106 Banegas (1991, p. 20).

107 SFI (2009, p. 60).

entrepreneurial—the ultimate state of asymmetric convergence where science works *with, like, and for* business.

From an institutional point of view, SFI defines itself as a visiting institute and as an intrinsically unstable and precarious endeavor, which could disappear the same way it has emerged. The center is sometimes called an institution “without walls” or defined “as a growing, extended family whose members stay in touch by phone and computer and who return frequently to sit around the table at SFI.”¹⁰⁸ More specifically:

At any one time there are between 20 and 50 researchers in residence. Scientists in residence include faculty, postdoctoral fellows, graduate students, corporate affiliates, and visiting researchers. Resident Professors' appointments are from one to five years, and in some cases longer.¹⁰⁹ Postdoctoral Fellows are at SFI from one to three years. Graduate students hold fellowships at the Institute for up to one year under the guidance of senior scientists. Visiting scientists from other institutions come for periods of a few days to year-long sabbatical visits.¹¹⁰

Translating biological theory into practice, the SFI sees itself as an evolutive and competitive organization that needs to be agile to survive. As then-vice president of the institute Bruce Abell wrote in 1995: “As organizations age, they often become less agile SFI must fight that tendency. ... [W]e should make some efforts to keep it a little unstable to permit intellectual niches to continue to evolve.”¹¹¹ To obtain such an agility, the institute's founders conceived of the SFI as the opposite of a traditional university with its bureaucracy and disciplinary boundaries. In a 2004 *Bulletin*, Cowan explained that the need for flexibility and freedom was more important than the desire to make the SFI a university: “Murray Gell-Mann had been fettered by a system focused on departments, and so insisted there be none. The group discussed becoming a fully accredited graduate school, but realized that without departments it would be hard to give Ph.D. degrees.”¹¹² The first vice president of the institute, physicist Mike Simmons, found in SFI's small size and flexibility a precious asset because it can rapidly adapt to changes in the scientific environment.¹¹³ The institute's initiators sought to create the conditions for a scientific dynamism they could barely find elsewhere: “Unfortunately, universities still fail to encourage the interaction among disciplines.”¹¹⁴ “[At SFI] there are no departments, no positions, no permanent research staff, no day-to-day responsibilities for researchers beyond trying out embryonic interests and following them up.”¹¹⁵ Indeed, the institute sought to constantly and strategically attract new faculty in order to foster scientific renewal:

¹⁰⁸ Simmons (1992a, p. 28).

¹⁰⁹ As physicist and computer scientist Cristopher Moore explained to me in an interview (2016, Sept. 28), “The current culture ... is that there is no upper bound if you are still very active and very productive.”

¹¹⁰ SFI (2007, p. 42).

¹¹¹ Abell (1995, p. o).

¹¹² King (2004b, pp. 11–12).

¹¹³ “An Interview with L. M. Simmons: Creating the Right Environment” (1990, p. 9).

¹¹⁴ Simmons (1987, p. 11).

¹¹⁵ Kelly (1992, p. 6).

"We must continue to expand our horizons to include visitors with different points of view and those who have expertise in disciplines not presently resident at SFI."¹¹⁶ Moreover, SFI's writings, faculty, and staff members have always celebrated the rapid rate of turnover in the institute, highlighting the positive effects that this has on scientific innovation. The following quote from a 2003 *Bulletin* editorial by SFI secretary Ginger Richardson is, in this sense, illustrative of the coproduction between a theoretical discourse about evolution and the material organization of the SFI as a neoliberal organization:

Anyone who dislikes change should not work at SFI. The constant variation in the Institute's scientist roster, permutations in our research agenda, and the almost constant alterations in the campus environment can sometimes make your head spin. ... In SFI's early years folks like George Cowan and David Pines were fond of describing the endeavor as a "floating crap game," a clever metaphor that aptly depicted the fledgling organization's seemingly boundless flux. ... [N]ew approaches, research themes, and collaborators emerge here all the time.¹¹⁷

Joseph Schumpeter is cited less explicitly than Hayek, Smith, and Darwin in SFI circles, but, as this quote suggests, his idea of "creative destruction" still forms an important part of the SFI's cultural backdrop. Hayek, for example, appears 26 times in Brian Arthur's book *Complexity and the Economy*.¹¹⁸ In May 2001, SFI trustee and director of McKinsey & Co. Richard Foster gave an informal talk at the institute about a book he had coauthored with economist Sarah Kaplan. The title of their text was *Creative Destruction: Why Companies That Are Built to Last Underperform the Market—And How to Successfully Transform Them*.¹¹⁹ Today, Schumpeter is notorious for his focus on the disruptive power of innovative entrepreneurs and on the related concept of "creative destruction," described as the "process of industrial mutation ... that incessantly revolutionizes the economic structure *from within*, incessantly destroying the old one, incessantly creating a new one."¹²⁰ In Schumpeter's perspective, innovation is what "dislodges the market from the somnolence of equilibrium," especially when it comes to reorganizing economic development into new combinations.¹²¹ As Melinda Cooper underlines, Schumpeterian influences on the SFI are also visible "in the work of someone like theoretical biologist Stuart Kauffman," according to whom "the catastrophe event becomes the very condition of life's continuing tendency toward complexity: life evolves through periodic moments of crisis; the creation of new life, of biological innovation, requires the perpetual destruction of the old."¹²²

¹¹⁶ Goldberg (1996, p. 1).

¹¹⁷ Richardson (2003, p. o).

¹¹⁸ Arthur (2015).

¹¹⁹ Foster & Kaplan (2001).

¹²⁰ Schumpeter (2003, p. 83).

¹²¹ Kirzner (1973, p. 127); Schumpeter (1983).

¹²² Cooper (2008, p. 39).

3.3. Fundraising Strategies

With regard to fundraising strategies, the SFI explicitly refuses to rush for patents—it defines itself as a theoretical institute—but still pursues a form of commodification of science. The research center is provided with a strategic partnership office, divided into three sections. One is in charge of collecting scholarships from federal agencies by responding to public calls. Another one is responsible seeking out and maintaining contact with individual donors, particularly those whose gifts have exceed \$25,000 per year. The person who covers this role is also tasked with organizing private parties where donors and scientists can meet and chat. In explaining how the SFI's "satellite program" works, this individual explains: "So I need a room full of tens of [donors] and then I usually have a faculty member and then I sort of run a conversation like a seller in order to introduce these people to what is complex adaptive system thinking."¹²³ The "seller" attitude involves customizing the service to the donors' interests: "when I find the sweet spot, when I find the things that excite them the most, then I can say, well this is the kind of program that can benefit from your support."¹²⁴ New programs for individual donors have been introduced since current SFI president David Krakauer took office in 2015. Depending on the value of their gift, donors can obtain certain services, such as "Science Club conversations with SFI researchers, breakfast science talks around the country, and preferred seating at SFI community lectures" or "attending private dinners with scholars."¹²⁵

The third and most important fundraising tool is the Business Network for Complex Systems Research (BusNet), first implemented in 1992 under Edward Knapp's presidency and augmented twice since then. In return for a \$25,000 annual fee, the first five BusNet members used to receive scientific materials about the ongoing SFI research, as well as the chance to chat with the institute's scientists.¹²⁶ In 1995, the institute organized two conferences for the business sector, one in San Francisco and one in London, with the same title: "Complexity and Strategy: The Intelligent Organization."¹²⁷ The BusNet program was enhanced the first time under immunologist Ellen Goldberg's presidency (1996–2002). Goldberg had been appointed for at least two reasons. Firstly, to give the institute a more sober profile after John Horgan's critical article in 1995.¹²⁸ She accordingly evicted some of the most self-glorifying faculty members and redirected the scientific projects "to make sure we're doing the kind of science that solves problems."¹²⁹ Secondly, she was to strengthen SFI's finances by increasing the institute's credibility in the eyes of business. Goldberg multiplied BusNet meeting activities and increased the number *Bulletin* advertisements aimed at

123 Interview with SFI's Director of Advancement Network (2016, Sept. 23).

124 Interview with SFI's Director of Advancement Network (2016, Sept. 23).

125 "SFI at 7200 Feet: A Resource Guide for the Board of Trustees of the Santa Fe Institute" (2015–2016), Box: "2015–2016 SFI Promotional Material," SFI Archive.

126 Simmons (1992b, p. 47).

127 Stites (1995, p. 5).

128 Horgan (1995).

129 Richardson & Reed (1996–1997, p. 8).

business. The benefits of such an intensification of contacts with the business world were not long in coming. The number of BusNet affiliates rose to 53 in 1998, which testifies to a certain appetite in the industry and finance worlds for complexity science at that time.¹³⁰ In 2007, the 55 partners belonged to various sectors: agriculture (John Deere), accounting and consultancy (Deloitte), defense (Lockheed), communications (Cisco), semiconductors (Sun Microsystems), internet (Google), banking (Barclays), finance (Morgan Stanley), transport (FedEx), aeronautics (Boeing), automobiles (Toyota), and so on. Some non-profit organizations like the National Institute of Aerospace, NASA, and the Argonne National Laboratory also appear on the list, as well as certain foreign organizations like Telecom Italia.¹³¹ In this context, the SFI's digital simulations have been generally seen as tools capable of providing managers with "hands-on experiences in experimenting (in the computer) with different business strategies."¹³² But donors also benefited in another way, as the BusNet reunions provided an occasion to network and meet potential investors, partners, and clients.¹³³

The current SFI president, David Krakauer, has brought other important changes to BusNet. Firstly, he renamed it as the Applied Complexity Network (ACTioN) to reflect the fact that the funding program included public organizations as well as private corporations.¹³⁴ Secondly, the service became more expensive, requiring a donation of \$40,000 per year. Thirdly, it extended its services to include: a specific newsletter called *Vertex* to keep donors "up-to-date on the latest ideas and publications from SFI, with a view to how those concepts apply to [their] organization and how [their] peers are tackling their toughest business challenges"; the possibility to receive (at an additional cost) a personalized program with a member of the institute or a customized encounter between the donor's team and the institute's researchers; the ability to request short introductory courses on complexity or a period of stay at the institute for an "immersive experience." As a member of the staff explained to me, the ACTioN program is intended to speed up the spread of complexity ideas and tools, and to help contributors make better decisions.¹³⁵ It is in this process that SFI commodifies science. With the intention of bolstering the funding program, Krakauer has further pushed scientists to become ambassadors and active fundraisers. In particular, ACTioN promotional material advances the idea that enterprises may be interested in hiring young scientists from the institute. Partners are also allowed to solicit researchers for educational support or for advice on specific issues. Since SFI's research is published in scientific journals and is not classified (except for DARPA's contracts), the "companies that want to get involved with [SFI] just want early access

130 Graham (1998, p. 8). The renewed interest in complexity at the end of the 1990s is partly due to the rise of network theory.

131 SFI (2007, p. 37).

132 Stites (1995, p. 5).

133 Banegas (1998, p. 13).

134 "ACTioN. Applied Complexity Network @ the Santa Fe Institute" (2015–2016), Box: "2015–2016 SFI Promotional Material," SFI Archive.

135 Interview with vice president for ACTioN (2016, Oct. 5).

to the kinds of theories [the institute is] working on.”¹³⁶ An ex-postdoctoral resident from the institute moreover explains that “There is no formal obligation ... for us researchers to participate in ACTioN. We are nevertheless encouraged to do it, but always with discretion and never in an insistent fashion.”¹³⁷ In fact, ACTioN members can visit the institute, where they expect scientists to provide them with orientation in a specific scientific literature or to advise them on novel methods and approaches that might help solve their problems. For example, when John Deere or Syngenta come to the SFI to meet its faculty, what they receive is a personalized introduction to a difficult field that may impact their industrial processes:

Unless they are like Amazon, which is provided with an internal group working on machine learning, corporations rarely have such scientific competence inhouse. And by searching on the Internet they won't easily find that specific article that may be useful for them.¹³⁸

The SFI rejects developmental contracts, but it is “totally open to the possibility that the researcher take a greater interest for the specific problem of a given company and go further in developing models that overcome the particular application into that company.”¹³⁹ The collaboration is described as a win-win game where the firm gets what it needs, while the researcher can exploit the data to produce a new model and a new publication. Although ACTioN frames scientists more as “counselors” than as “consultants,” the line between the two seems to be fading. Ultimately, all this leads to a question that more than one observer has asked since the birth of the institute: Is the SFI a think tank or not? And if not, why does it resembles one so much?

4. Concluding Remarks

Having first shown that the “complexity economics” approach was designed by SFI's researchers in opposition to the neoclassical stream, but in harmony with liberal tenets, this paper proceeded to illustrate the proximity between the notion of “self-organization” and Hayek's “spontaneous order.” The second part of the article also illustrated the ways in which complexity models have fostered some tenets of capitalist ideology such as competition, innovation, and economic growth, by using Darwin as a legitimating proxy. The third and last part of the piece described the institute's organization and fundraising strategy, and suggested that the SFI can be seen as the ultimate state of the “asymmetric convergence” described by Moore and colleagues between business and science, where science works *with, like, and for* business. Informed by this analysis, how might the SFI be categorized from an institutional point of view?

136 Interview with vice president for ACTioN (2016, Oct. 5).

137 Interview with a former SFI postdoctoral researcher (2018, Feb. 18).

138 Interview with a former SFI postdoctoral researcher (2018, Feb. 18).

139 Interview with a former SFI postdoctoral researcher (2018, Feb. 18).

Officially the institute is a non-profit, private research center that interacts and collaborates with local public universities and governmental research centers; nevertheless, some observers do not hesitate to define it as a think tank. In their popular books about complexity, American writers Mitchell Waldrop and Jeffrey Kluger used this term to characterize the SFI. As reported by an SFI *Bulletin*, the magazine *Newsweek* has even defined it as a “transdisciplinary think tank that aspires to be a kind of intellectual utopia.”¹⁴⁰ The institute itself is proud of the fact that, “Although [it] does not engage in matters of policy, per the standard definition of a think tank... For the tenth year running [it] has ranked among the world's top science and technology and interdisciplinary think tanks.”¹⁴¹ According to a general definition, think tanks are “independent research organizations which are devoted to public interest questions and to their analysis.”¹⁴² According to sociologist Thomas Medvetz, think tanks occupy an institutional niche and form a specific field in Bourdieu's sense, showcasing dominant and dominated actors. In his analysis, think tanks are hybrid entities at the intersection between policy, academia, business, and media, which exert a strong impact on both decision-making and public discourse.¹⁴³ American sociologist Carol Weiss distinguishes between four kinds of think tanks: the “academic” ones, which are mainly composed of PhD researchers, detached from academia, and funded by the private world and to a lesser extent by government (for example, the Centre for European Policy Studies); the “contract-based research institutes,” which are also composed of researchers, but essentially funded by governmental contracts (for example, RAND Corporation); the “advocacy tanks,” which produce policy recommendations in order to defend a particular set of ideas and values, and which are funded by private actors (for example, Adam Smith Institute); and finally the “political parties think tanks,” which produce ideas for political campaigns and governments (for example, Fondation Jean Jaurès).¹⁴⁴ *Mutatis mutandis*, policy is the common factor explicit in all four categories. In this sense, then, the SFI should not be considered as a think tank, since it does not provide decision-makers with white papers, policy briefs, or other prescriptive reports. Yet, as the coproductionist framework has often underlined, there are other ways in which scientists can have an impact on society; for example, by informing policy think tanks with new theoretical discourses that enrich and legitimize their policy prescriptions and solutions. Indeed, the classical separation between “pure” science and “applied” policy stays strong at the SFI, as we have seen in its members' declarations. Moreover, as the director responsible for the ACTioN program said to me in an interview: “we don't do policy but we share our scientific work [that can] inform policy decision [taken] by others. But it's sort of further up river from policy. ... [I]t must come before good policy can

¹⁴⁰ SFI (2011, p. 6).

¹⁴¹ “SFI Listed in 2019 Global Think Tank Report” (2020).

¹⁴² Boucher & Royo (2012, p. 28).

¹⁴³ Medvetz (2012).

¹⁴⁴ Weiss (1991).

happen.”¹⁴⁵ To interpret the SFI's institutional ambiguity, Baker has an interesting insight that helps clarify the point:

donors have prized SFI above all as the nucleus of a social network—as an institution for training, socializing, and connecting individuals to act in a particular social world with a particular worldview. ... SFI has helped populate this elite world with actors who look to themselves and their own problem-solving capacity, rather than to governments or mass social movements. ... Through the social world of SFI, corporations have hoped to develop executives, employees and investing partners who view businesses as the mechanism through which the complex economic system solves pressing problems. And libertarians have hoped to produce “social entrepreneurs” who embody the libertarian promise that new solutions to social problems will emerge spontaneously on the market without central direction. ... [I]t is above all by forming a node in this network—by producing Santa Fe libertarians—that the Institute repays its funders.¹⁴⁶

In other words, although there have been digital applications of complexity science in industrial production, corporate management, and stock market speculation, it is mostly a discourse and practice of networking that is taking hold via the SFI. The recent increase of science commodification at the SFI and the extension of the ACtioN program to include more governmental actors suggests a radical reformulation of the institute's networking activity. As the first president George Cowan explained in his memoirs, at the founding meetings of the senior fellows, “There was universal agreement that we would not be a think tank that provided legislative options to policy makers. The think tank might come later.”¹⁴⁷ SFI's current president David Krakauer may be in the process of making this idea come true.

¹⁴⁵ Interview with SFI's Director of ACtioN (2016, Sept. 23).

¹⁴⁶ Baker (2022).

¹⁴⁷ Cowan (2010, p. 146).

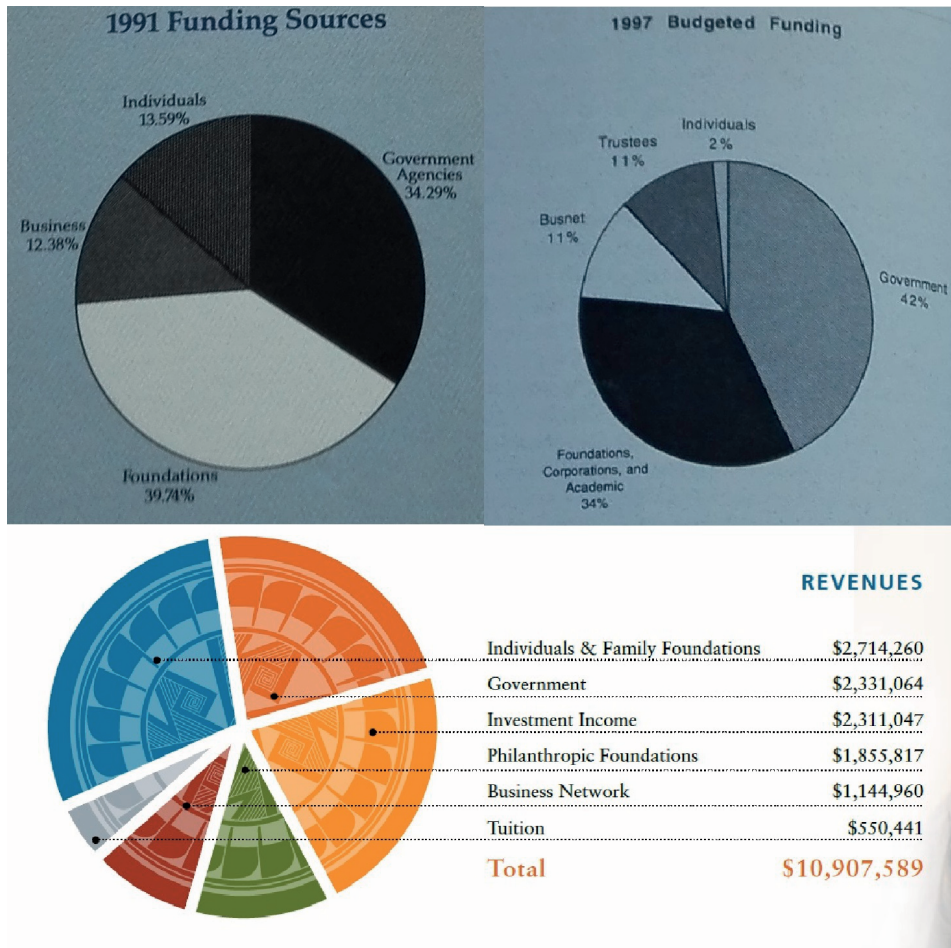


Figure 1. The evolution of SFI's funding sources in three different periods. From *Santa Fe Institute Annual Reports of 1991* (p. 15), *1997* (p. 22), and *2013* (p. 19), by SFI, Santa Fe, NM: SFI.

Table 1. Overall view of the SFI

Foundation date	1984
Headquarters	Cowan Campus, 1399 Hyde Park Road, Santa Fe, NM
Number of resident researchers	Eight until 1986 and around 20 since that date
Number of associate researchers (external faculty)	35 until 1992 and more than 100 from 1993 to today
Funding size	The budget was \$571,000 in 1987; it rose to over \$1 million in 1988. Another important threshold was exceeded in 1994, when the funds approached \$4 million; since the 2000s, SFI's budget has stabilized at around \$10–12 million
Facilities	The SFI is located in a 32-acre (13-hectare) site known locally as the Hurley Estate, after General Patrick Hurley, who built the 12,000-square-foot (1,115 m ²) house on a hill in northeast Santa Fe for his family in the late 1950s. During the year 1996–1997, the institute expanded the house with a 9,260-square-foot (860 m ²) extension.
Website and other outreach supports	Official website: https://www.santafe.edu/ Online education project: https://www.complexityexplorer.org/ Annual education course: <i>Complex Systems Summer Schools</i> Outreach supports: <i>Bulletin</i> (1986–2014), <i>Parallax</i> newsletter, <i>Annual Report</i> , <i>Update</i> , and <i>Complexity</i> , a partnership between <i>The Christian Science Monitor</i> and the SFI, supported by Arizona State University
SFI presidents	1. Physical chemist George Cowan: 1984–1991 2. Physicist Edward Knapp: 1991–1995 3. Immunologist Ellen Goldberg: 1996–2002 4. Physicist Robert Eisenstein: 2003–2004 5. Financier Robert Denison (interim): 2004 6. Ellen Goldberg (interim): 2005 7. Physicist and quantitative geographer Geoffrey West: 2005–2009 8. Anthropologist Jeremy Sabloff: 2009–2015 9. Biologist David Krakauer: 2015–present

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References

- Abell, B. (1995). Message from Bruce Abell, vice president, finance and operation: Hard choices in SFI's second decade. *Bulletin of the Santa Fe Institute*, 10(1), 0.
- An interview with L. M. Simmons: Creating the right environment. (1990). *Bulletin of the Santa Fe Institute*, 5(1), 8–11.
- Anderson, P. (1972). More is different. *Science*, 177, 393–396.
- Anderson, P., Arrow, K., & Pines, D. (1988). *The global economy as an evolving complex system*. Redwood City, CA: Addison-Wesley.
- Anderson, P., Meyer, A., Eisenhardt, K., Carley, K., & Pettigrew, A. (1999). Introduction to the special issue: Applications of complexity theory to organization science. *Organization Science*, 10(3), 233–236.
- Arthur, W. B. (1999). Complexity and the economy. *Science*, 284, 107–109.
- Arthur, W. B. (2015). *Complexity and the economy*. Oxford, UK: Oxford University Press.
- Arthur, W. B. (2021). Foundations of complexity economics. *Nature Reviews Physics*, 3, 136–145. <https://doi.org/10.1038/s42254-020-00273-3>
- Arthur, W. B., Beinhocker, E. D., & Stanger, A. (2020). *Complexity economics: Dialogues of the applied complexity network I: Proceedings of the Santa Fe Institute's 2019 fall symposium*. Santa Fe, NM: SFI Press.
- Arthur, W. B., Durlauf, S., & Lane, D. (1997). *The economy as an evolving complex system II*. New York, NY: Westview.
- Audier, S. (2012). *Néo-libéralisme(s): Une archéologie intellectuelle*. Paris, France: Grasset.
- Axelrod, R. (1997). *The complexity of cooperation: Agent-based models of competition and collaboration*. Princeton, NJ: Princeton University Press.
- Axelrod, R., & Cohen, M. D. (1999). *Harnessing complexity: Organizational implications of a scientific frontier*. New York, NY: The Free Press.
- Axtell, R. L. (2016). Hayek enriched by complexity enriched by Hayek. In P. Boettke & V. Storr (Eds.), *Revisiting Hayek's political economy* (pp. 63–121). Bingley, UK: Emerald Group Publishing Limited.
- Aziz-Alaoui, M. A., & Bertelle, C. (Eds.). (2009). *From system complexity to emergent properties: Understanding complex systems*. Berlin, Germany: Springer.
- Baake, K. (1999). Language issues. *Bulletin of the Santa Fe Institute*, 14(2), 28–29.
- Baker, E. (2022). The ultimate think tank: The rise of the Santa Fe Institute libertarian. *History of the Human Sciences*. <https://doi.org/10.1177/09526951211068995>
- Banegas, D. (1991). Order out of chaos. *Bulletin of the Santa Fe Institute*, 6(1), 20.
- Banegas, D. (1998). Mutual fund manager Bill Miller sees value in the business network: His practical approach to picking stocks looks to SFI for useful insights. *Bulletin of the Santa Fe Institute*, 13(1), 13–14.
- Barabási, A.-L. (2003). *Linked: How everything is connected to everything else and what it means for business, science, and everyday life*. London, UK: Plume.
- Barbieri, F. (2013). Complexity and the Austrians. *Filosofia de la economia*, 1, 47–69.
- Barkley Rosser, J. (2010). How complex are the Austrians. In R. Koppl, S. Horwitz, & P. Desrochers (Eds.), *What is so Austrian about Austrian economics?* (pp. 165–179). Bingley, UK: Emerald Group Publishing Limited.

- Bass, T. (2000). *The predictors: How a band of maverick physicists used chaos theory to trade their way to a fortune on Wall Street*. New York, NY: Holt.
- Beck, J. (2008a). Cities: Large is smart. *Bulletin of the Santa Fe Institute*, 23(1), 4–8.
- Beck, J. (2008b). The revolutionary lizard. *Bulletin of the Santa Fe Institute*, 23(1), 9–11.
- Beck, J. (2008c). Patterns of terror. *Bulletin of the Santa Fe Institute*, 23(1), 18–21.
- Bedau, M., & Humphreys, P. (2008). *Emergence: Contemporary readings in philosophy and science*. Cambridge, MA: MIT Press.
- Beinhocker, E., & Hanauer, N. (2014, September 1). Redefining capitalism. *McKinsey Quarterly*. Retrieved from <https://www.mckinsey.com/featured-insights/long-term-capitalism/redefining-capitalism>
- Bettencourt, L. M. A., Lobo, J., Helbing, D., Kühnert, C., & West, G. B. (2007). Growth, innovation, scaling, and the pace of life in cities. *PNAS*, 104(17), 7301–7306.
- Bill Miller: Life trustee and chairman emeritus. (n.d.). *Santa Fe Institute*. Retrieved from <https://www.santafe.edu/people/profile/bill-miller>
- Blandin, N. M. (2007). Leading at the edge of chaos. In R. S. Morse, T. F. Buss, & C. M. Kinghorn (Eds.), *Transforming public leadership for the 21st century* (pp. 138–153). New York, NY: M. E. Sharpe.
- Blume, L., & Durlauf, S. (2005). *The economy as an evolving complex system III: Current perspectives and future directions*. Oxford, UK: Oxford University Press.
- Boltanski, L., & Chiapello, E. (2007). *The new spirit of capitalism*. New York, NY: Verso.
- Bonabeau, E., Dorigo, M., & Theraulaz, G. (1999). *Swarm intelligence: From natural to artificial systems*. New York, NY: Oxford University Press.
- Boucher, S., & Royo, M. (2012). *Les think tanks: Cerveaux de la guerre des idées*. Paris, France: Edition du Félin.
- Bourgine, P., & Johnson, J. (2006). *Living roadmap for complex systems science: Version 1.2.2*. Project FP6-IST 29814, Open Network of Centres of Excellence in Complex Systems (ONCE-CS).
- Bowles, S., & Gintis, H. (2011). *A cooperative species: Human reciprocity and its evolution*. Princeton, NJ: Princeton University Press.
- Bowles, S., Gintis, H., & Groves, M. O. (Eds.). (2009). *Unequal chances: Family background and economic success*. Princeton, NJ: Princeton University Press.
- Busch, L. (2017). *Knowledge for sale: The neoliberal takeover of higher education*. Cambridge, MA: MIT Press.
- Castells, M. (1996). *The rise of the network society: The information age: Economy, society and culture* (Vol. 1). Malden, MA: Blackwell.
- Cilliers, P., & Spurrett, D. (1999). Complexity and post-modernism: Understanding complex systems. *South African Journal of Philosophy*, 18, 258–274.
- Clippinger, J. H. (1999). *The biology of business: Decoding the natural laws of enterprise*. San Francisco, CA: Jossey-Bass.
- Colander, D. (Ed.). (2000). *Complexity and the history of economic thought*. London, UK: Routledge.
- Cooper, M. (2008). *Life as surplus: Biotechnology and capitalism in the neoliberal era*. Seattle, WA: University of Washington Press.

- Cooper, M. (2011). Complexity theory after the financial crisis: The death of neoliberalism or the triumph of Hayek? *Journal of Cultural Economy*, 4, 371–385.
- Cowan, G. (1989). Read on [Book review]. *Bulletin of the Santa Fe Institute*, 4(2), 3–4.
- Cowan, G. (2010). *Manhattan project to the Santa Fe Institute: The memoirs of George A. Cowan*. Albuquerque, NM: University of New Mexico Press.
- Cowan, G., Pines, D., & Meltzer, D. (Eds.). (1994). *Complexity: Metaphors, models, and reality*. Boston, MA: Addison Wesley.
- Curlee, W., & Gordon, R. L. (2011). *Complexity theory and project management*. Hoboken, NJ: John Wiley.
- Dean, J. S., Gumerman, G. J., Epstein, J. M., Axtell, R. L., Swedlund, A. C., Parker, M. T., & McCarroll, S. (2000). Understanding Anasazi culture change through agent-based modeling. In T. A. Kohler & G. J. Gumerman (Eds.), *Dynamics in human and primate societies: Agent-based modeling of social and spatial processes* (pp. 179–206). New York, NY: Oxford University Press.
- Dent, M., Chandler, J., & Barry, J. (2017). *Questioning the new public management*. London, UK: Routledge.
- Dillon, M., & Reid, J. (2001). Global liberal governance: Biopolitics, security and war. *Millennium*, 30(1), 41–66.
- Dupuy, J.-P. (1992). *Le sacrifice et l'envie: Le libéralisme aux prises avec la justice sociale*. Paris, France: Calmann-Lévy.
- Durand, C. (2020). *Technoféodalisme: Critique de l'économie numérique*. Paris, France: Zones.
- Elsner, W. (2017). Complexity economics as heterodoxy: Theory and policy. *Journal of Economic Issues*, 51(4), 939–978.
- Elsner, W., Heinrich, T., & Schwardt, H. (2015). *The microeconomics of complex economies: Evolutionary, institutional, neoclassical, and complexity perspectives*. San Diego, CA: Academic Press.
- Epstein, J. M., & Axtell, R. (1996). *Growing artificial societies: Social science from the bottom up*. Washington, DC: Brookings Institution Press.
- Erwin, C. E., Karklins, L., Knox, K., Lifshitz, N., & Piccio, E. (2007). Finding aid for the Murray Gell-Mann papers 1931–2001, bulk 1955–1993. *Online Archive of California*. Retrieved from https://oac.cdlib.org/findaid/ark:/13030/kt687026tv/entire_text/
- Felt, U., Fouché, R., Miller, C. A., & Smith-Doerr, L. (Eds.). (2017). *The handbook of science and technology studies*. Cambridge, MA: MIT Press.
- Fisher, G. (2012, February 10). The complexity of Hayek. *Synthesis*. Retrieved from <http://www.synthesisips.net/blog/the-complexity-of-hayek/>
- Fontana, M. (2010). The Santa Fe perspective on economics: Emerging patterns in the science of complexity. *History of Economic Ideas*, 18, 167–196.
- Foster, J. (2005). From simplistic to complex systems in economics. *Cambridge Journal of Economics*, 29, 873–892.
- Foster, R. N., & Kaplan, S. (2001). *Creative destruction: Why companies that are built to last underperform the market, and how to successfully transform them*. New York, NY: Currency/Doubleday.
- Foucault, M. (2008). *The birth of biopolitics: Lectures at the Collège de France, 1978–1979*. New York, NY: Palgrave MacMillan.

- Fox-Keller, E. (2009). Organisms, machines, and thunderstorms: A history of self-organization, part two: Complexity, emergence, and stable attractors. *Historical Studies in the Natural Sciences*, 39(1), 1–31.
- Frame, J. D. (2002). *The new project management: Tools for an age of rapid change, complexity, and other business realities* (2nd ed.). San Francisco, CA: Jossey-Bass.
- Fraisopi, F. (2012). *La complexité et les phénomènes: Nouvelles ouvertures entre science et philosophie*. Paris, France: Hermann.
- Freeman, L. C. (2004). *The development of social network analysis: A study in the sociology of science*. Vancouver, Canada: Empirical Press.
- Friedman, D., & Rust, J. (1993). *The double auction market: Institutions, theories, and evidence*. New York, NY: Westview.
- Gell-Mann, M. (1994). *The quark and the jaguar: Adventures in the simple and the complex*. London, UK: Abacus.
- Gere, C. (2002). *Digital culture*. London, UK: Reaktion Books.
- Gingras, Y., & Schinckus, C. (2012). Institutionalization of econophysics in the shadow of physics. *Journal of the History of Economic Thought*, 34, 109–130.
- Gintis, H. (2002). Keeping it in the family: Does inheritance play a role in inequality? *Bulletin of the Santa Fe Institute*, 17(1), center section.
- Gleick, J. (1988). *Chaos: Making a new science*. London, UK: Sphere Books.
- Goldberg, E. (1996). President's message. *Bulletin of the Santa Fe Institute*, 11(2), 1.
- Graham, R. (1998). Evolving businesses, with a Santa Fe Institute twist: SFI's business network meeting offers participants a competitive edge. *Bulletin of the Santa Fe Institute*, 13(1), 8–10.
- Graham, R. (1999). John Miller: A modeler of messy theories. *Bulletin of the Santa Fe Institute*, 14(1), 15–18.
- Greene, B. (2003). *The elegant universe: Superstrings, hidden dimensions, and the quest for the ultimate theory*. New York, NY: W. W. Norton & Company.
- Haldane, A. (2009). Rethinking the financial network. Speech delivered at the Financial Students Association, Amsterdam, Bank of England. *Bank of England*. Retrieved from <https://www.bankofengland.co.uk/speech/2009/rethinking-the-financial-network>
- Harvey, D. (2005). *A brief history of neoliberalism*. Oxford, UK: Oxford University Press.
- Hayek, F. A. (1978). *Law, legislation, and liberty, Vol. 2: The mirage of social justice*. Chicago, IL: University of Chicago Press.
- Hayles, K. (1999). *How we became posthuman: Virtual bodies in cybernetics, literature, and informatics*. Chicago, IL: University of Chicago Press.
- Heller, C. (2002). From scientific risk to paysan savoir-faire: Peasant expertise in the French and global debate over GM crops. *Science as Culture*, 11, 5–37.
- Helmreich, S. (1998). *Silicon second nature: Constructing artificial life in a digital world*. Berkeley, CA: University of California Press.
- Helmreich, S. (2000). Flexible infections: Computer viruses, human bodies, nation-states, evolutionary capitalism. *Science, Technology, & Human Values*, 25(4), 472–491.
- Hidalgo, C., & Hartmann, D. (2017). Economic complexity, institutions and income inequality. In P. Love & J. Stockdale-Otárola (Eds.), *Debate the issues: Complexity and policy making* (pp. 55–57). Paris, France: OECD Publishing. <https://doi.org/10.1787/9789264271531-en>

- Hightower, R. (1991). Emergent computation and learning from nature. *Bulletin of the Santa Fe Institute*, 6(2), 25–26.
- Hoddeson, L. (1982, July 27). Interview of Murray Gell-Mann. *American Institute of Physics*. Retrieved from <https://www.aip.org/history-programs/niels-bohr-library/oral-histories/32880>
- Holland, J. H. (1975). *Adaptation in natural and artificial systems*. Ann Arbor, MI: University of Michigan Press.
- Holland, J. H. (1992). Genetic algorithms. *Scientific American*, 267(1), 66–73.
- Holland, J. H. (1996). *Hidden order: How adaptation builds complexity*. Cambridge, MA: Perseus Books.
- Holland, J. H. (2014). *Complexity. A very short introduction*. Oxford, UK: Oxford University Press.
- Holt, R. P., Rosser Jr, J. B., & Colander, D. (2011). The complexity era in economics. *Review of Political Economy*, 23(3), 357–369.
- Hooker, C. A. (Ed.). (2011). *Philosophy of complex systems*. Amsterdam, The Netherlands: Elsevier.
- Horgan, J. (1995). From complexity to perplexity. *Scientific American*, 272, 74–79.
- Jasanoff, S. (Ed.). (2004). *States of knowledge: The co-production of science and social order*. London, UK: Routledge.
- Jen, E. (1999). Evolutionary dynamics. *Bulletin of the Santa Fe Institute*, 14(1), A–F.
- Kauffman, S. (1993). *The origins of order: Self-organization and selection in evolution*. Oxford, UK: Oxford University Press.
- Kauffman, S. (1995). *At home in the universe: The search for laws of self-organization and complexity*. New York, NY: Oxford University Press.
- Kelly, K. (1992). A distributed Santa Fe system. *Bulletin of the Santa Fe Institute*, 7(1), 4–6.
- Kelly, K. (1994). *Out of control: The new biology of machines, social systems, and the economic world*. New York, NY: Addison-Wesley.
- Kepler, T. (1992). One long argument [Book review]. *Bulletin of the Santa Fe Institute*, 7(1), 16–17.
- Khalil, W. R. (2014). *Complexity management: Managing organizations in complex environments*. North Charleston, SC: CreateSpace Independent Publishing.
- Kilpatrick, H. E. (2001). Complexity, spontaneous order, and Friedrich Hayek: Are spontaneous order and complexity essentially the same thing? *Complexity*, 6, 16–20.
- King, L. S. (2004a). Good taste in science: Robert Eisenstein. *Bulletin of the Santa Fe Institute*, 19(1), 2–6.
- King, L. S. (2004b). The origins of the Santa Fe Institute. *Bulletin of the Santa Fe Institute*, 19(2), 3–13.
- Kirzner, I. M. (1973). *Competition and entrepreneurship*. Chicago, IL: University of Chicago Press.
- Knapp, E. (1991). The first six months. President's message. *Bulletin of the Santa Fe Institute*, 6(2), 3.
- Knorr-Cetina, K. (1999). *Epistemic cultures: How the sciences make knowledge*. Cambridge, MA: Harvard University Press.

- Knyazeva, H. (2005). Figures of time in evolution of complex systems. *Journal for General Philosophy of Science*, 36, 289–304.
- Koppl, R. (2009). Complexity and Austrian economics. In J. Rosser & J. Barkley (Eds.), *Handbook of complexity research* (pp. 393–408). Cheltenham, UK: Edward Elgar.
- Krugman, P. (1996). *The self-organizing economy*. Cambridge, MA: Blackwell Publishers.
- Ladyman, J., Lambert, J., & Wiesner, K. (2013). What is a complex system? *European Journal for Philosophy of Science*, 3(1), 33–67.
- Langton, C. (1988). Toward artificial life. *Whole Earth Review*, 58, 74–79.
- Langton, C. (Ed.). (1997). *Artificial life: An overview*. Cambridge, MA: MIT Press.
- Levin, S. (1999). *Fragile dominion: Complexity and the commons*. New York, NY: Perseus Books.
- Lewin, R. (1992). *Complexity: Life at the edge of chaos*. New York, NY: Macmillan Publishing Company.
- Lichtenstein, B. (2016). Emergence and emergents in entrepreneurship: Complexity science insights into new venture creation. *Entrepreneurship Research Journal*, 6(1), 43–52.
- Li Vigni, F. (2018). *Les systèmes complexes et la digitalisation des sciences: Histoire et sociologie des instituts de la complexité aux États-Unis et en France* (Doctoral dissertation). Ecole des Hautes Etudes en Sciences Sociales, Paris, France.
- Li Vigni, F. (2020a). Le projet épistémique des sciences des systèmes complexes. *Philosophia scientiæ*, 24(1), 181–200.
- Li Vigni, F. (2020b). The failed institutionalization of “complexity science”: A focus on the Santa Fe Institute's legitimization strategy. *History of Science*, 59(3), 344–369.
- Li Vigni, F. (2021). Complexity sciences: A scientific platform. *Science & Technology Studies*, 34(4), 30–55.
- Lorenz, C. (2012). If you're so smart, why are you under surveillance? Universities, neoliberalism, and new public management. *Critical Inquiry*, 38, 599–629.
- Markose, S. M. (2005). Computability and evolutionary complexity: Markets as complex adaptive systems. *The Economic Journal*, 115, 159–192.
- Matarasso, P. (2007). La construction historique des paradigmes de modélisation intégrée: William Nordhaus, Alan Manne et l'apport de la Cowles Commission. In A. Dahan (Ed.), *Les modèles du futur* (pp. 44–62). Paris, France: La Découverte.
- Mauboussin, M. (2006). *More than you know: Finding financial wisdom in unconventional places*. New York, NY: Columbia University Press.
- May, R., Levin, S. & Sugihara, G. (2008). Complex systems: Ecology for bankers. *Nature*, 451, 893–895.
- McMillan, E. (2003). *Complexity, organizations and change*. London, UK: Routledge.
- Meadows, D. H., Meadows, D. L., Randers, J., & Behrens III, W. W. (1972). *The limits to growth: A report for the Club of Rome's project on the predicament of mankind*. New York, NY: Universe Books.
- Medvetz, T. (2012). *Think tanks in America*. Chicago, IL: University of Chicago Press.
- Metropolis, N. (1988). 1988 SFI activities include summer school, study of world problems. *Bulletin of the Santa Fe Institute*, 3(1), 16–17.
- Miller, J. (2016). *A crude look at the whole: The science of complex systems in business, life, and society*. New York, NY: Basic Books.

- Mirowski, P. (1996). Do you know the way to Santa Fe? In S. Pressman (Ed.), *Interaction in political economy: Malvern after ten years* (pp. 13–40). London, UK: Routledge.
- Mirowski, P. (2011). *Science-mart: Privatizing American science*. Cambridge, MA: Harvard University Press.
- Mirowski, P., & Plehwe, D. (Eds.). (2009). *The road to Mont Pèlerin: The making of the neoliberal thought collective*. Cambridge, MA: Harvard University Press.
- Mitchell, M. (2009). *Complexity. A guided tour*. Oxford, UK: Oxford University Press.
- Moore, K., Kleinman, D. L., Hess, D., & Frickel, S. (2011). Science and neoliberal globalization: A political sociological approach. *Theory and Society*, 40, 505–532.
- Murphy, E. C., & Murphy, M. A. (2002). *Leading on the edge of chaos: The 10 critical elements for success in volatile times*. Upper Saddle River, NJ: Prentice Hall.
- Nason, R. (2017). *It's not complicated: The art and science of complexity in business*. Toronto, Canada: University of Toronto Press.
- New approaches to economic challenges—Complexity of the economy. (2015). OECD. Retrieved from <http://www.oecd.org/naec/newapproachestoeconomicchallenges-complexityoftheeconomy.htm>
- Newman, M. (2011). Complex systems: A survey. *American Journal of Physics*, 79, 800–801.
- Newman, M. (2018). *Networks*. Oxford, UK: Oxford University Press.
- Nicolis, G., & Prigogine, I. (1989). *Exploring complexity: An introduction*. New York, NY: Freeman.
- North, M. J., & Macal, C. M. (2007). *Managing business complexity: Discovering strategic solutions with agent-based modeling and simulation*. Oxford, UK: Oxford University Press.
- Page, S. E. (2011). *Diversity and complexity*. Princeton, NJ: Princeton University Press.
- Palmer, R. G., Arthur, W. B., Holland, J. H., LeBaron, B., & Tayler, P. (1994). Artificial economic life: A simple model of a stockmarket. *Physica D: Nonlinear Phenomena*, 75, 264–274.
- Paraskevas, A. (2006). Crisis management or crisis response system? A complexity science approach to organizational crises. *Management Decision*, 44(7), 892–907.
- Pearce, D. (1994). Complexity theory and economics. *Agenda*, 1, 101–110.
- Pestre, D. (2003). *Science, argent et politique*. Versailles, France: Quæ.
- Pias, C. (2011). On the epistemology of computer simulation. *Zeitschrift für Medien- und Kulturforschung*, 1, 29–54.
- Pines, D. (Ed.). (1988). *Emerging syntheses in science: Proceedings of the founding workshops of the Santa Fe Institute, Santa Fe, New Mexico* (Vol. 1). New York, NY: Perseus Books.
- Rassekh, F. (2009). In the shadow of the invisible hand. *History of Economic Ideas*, 17(3), 147–165.
- Reinhoudt, J., & Audier, S. (2018). *The Walter Lippmann colloquium: The birth of neo-liberalism*. Cham, Switzerland: Palgrave Macmillan.
- Rehmeyer, J. (2012). Fighting HIV: The evolution solution. *Bulletin of the Santa Fe Institute*, 26, 28–31.
- Rescher, N. (1998). *Complexity: A philosophical overview*. New Brunswick, Canada: Transaction Publishers.
- Rhoades, G., & Slaughter, S. (2004). Academic capitalism in the new economy: Challenges and choices. *American Academic*, 1, 37–60.
- Richardson, G. (1991). Activity update: Research. *Bulletin of the Santa Fe Institute*, 6(2), 29–32.

- Richardson, G. (2003). Editor's note. *Bulletin of the Santa Fe Institute*, 18(1), 0.
- Richardson, G., & Reed, P. (1996–1997). With Erica Jen. *Bulletin of the Santa Fe Institute*, 12(1), 7–11.
- Rockmore, D. (2009). World of finance. *Bulletin of the Santa Fe Institute*, 24, 29–31.
- Rothschild, M. (1990). *Bionomics: The inevitability of capitalism*. New York, NY: Henry Holt.
- Roughgarden, J. (2009). *The genial gene: Deconstructing Darwinian selfishness*. Berkeley, CA: University of California Press.
- Sam Bowles: Professor. (n.d.). *Santa Fe Institute*. Retrieved from <https://www.santafe.edu/people/profile/sam-bowles>
- Schasfoort, J. (2017, September 18). Complexity economics. *Exploring Economics*. Retrieved from <https://www.exploring-economics.org/en/orientation/complexity-economics/>
- Schinckus, C. (2021). The Santa Fe Institute and econophysics: A possible genealogy? *Foundations of Science*, 26, 925–945. <https://doi.org/10.1007/s10699-020-09714-9>
- Schumpeter, J. (1983). *The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle*. New Brunswick, Canada: Transaction Publishers.
- Schumpeter, J. (2003). *Capitalism, socialism and democracy*. London, UK: Routledge.
- Schweber, S., & Wächter, M. (2000). Complex systems, modelling and simulation. *Studies in History and Philosophy of Modern Physics*, 31, 583–609.
- SFI. (1991). *Santa Fe Institute 1991 annual report*. Santa Fe, NM: SFI.
- SFI. (1997). *Santa Fe Institute 1997 annual report*. Santa Fe, NM: SFI.
- SFI. (2007). *Santa Fe Institute 2007 annual report*. Santa Fe, NM: SFI.
- SFI. (2009). *Santa Fe Institute 2009 annual report*. Santa Fe, NM: SFI.
- SFI. (2011). *Santa Fe Institute 2011 annual report*. Santa Fe, NM: SFI.
- SFI. (2013). *Santa Fe Institute 2013 annual report*. Santa Fe, NM: SFI.
- SFI listed in global think tank report. (2020, February 7). *Santa Fe Institute*. <https://www.santafe.edu/news-center/news/2019-global-think-tank-rankings>
- Shalizi, C. (1999). What can emergence tell us about today's eastern Europe? *Bulletin of the Santa Fe Institute*, 14(1), 8–10.
- Shaw, P. (2002). *Changing conversations in organizations: A complexity approach to change*. London, UK: Routledge.
- Simmons, L. M. (1987). SFI profile: John Holland. *Bulletin of the Santa Fe Institute*, 2(1), 8–11.
- Simmons, L. M. (1988). Artificial life: Computation and biology mixed. *Bulletin of the Santa Fe Institute*, 3(1), 15.
- Simmons, L. M. (1989). The human immune system: AIDS, abzymes, and evolution. *Bulletin of the Santa Fe Institute*, 4(1), 16–17.
- Simmons, L. M. (1990). 1990 research. *Bulletin of the Santa Fe Institute*, 5(2), 17–20.
- Simmons, L. M. (1992a). Selected updates on research visitors: Spring 1992. *Bulletin of the Santa Fe Institute*, 7(1), 28–31.
- Simmons, L. M. (1992b). SFI business network. *Bulletin of the Santa Fe Institute*, 7(2), 47.
- Simmons, L. M. (1993). Project 2050: Transition to sustainability. *Bulletin of the Santa Fe Institute*, 8(2), 9–10.
- Slobodian, Q. (2018). *Globalists: The end of empire and the birth of neoliberalism*. Cambridge, MA: Harvard University Press.
- Smith, J. M. (1995). Life at the edge of chaos? *New York Review of Books*, 42(2), 28–30.

- Stacey, R., Griffin, D., & Shaw, P. (2000). *Complexity and management: Fad or radical challenge to systems thinking?* London, UK: Routledge.
- Stein, D. L. (1989). Spin glasses. *Scientific American*, 261, 52–61.
- Stites, J. (1994). W. Brian Arthur. *Bulletin of the Santa Fe Institute*, 9(2), 5–8.
- Stites, J. (1995). Beyond business as usual. *Bulletin of the Santa Fe Institute*, 10(1), 5.
- Taborsky, P. (2014). Is complexity a scientific concept? *Studies in History and Philosophy of Science Part A*, 47, 51–59.
- The Nobel prize and RAND. (n.d.). *RAND Corporation*. Retrieved from <https://www.rand.org/about/history/nobel.html>
- Thornton, T. (2016). The “complexity revolution” seen from a historical and heterodox perspective. In J. Courvisanos, J. Doughney, & A. Millmow (Eds.), *Reclaiming pluralism in economics* (pp. 238–250). London, UK: Routledge.
- Tucker, W. (1996). Complex questions: The new science of spontaneous order. *Reason*, 1. Retrieved from <https://reason.com/1996/01/01/complex-questions/>
- Vaughn, K. I. (1999). Hayek's theory of the market order as an instance of the theory of complex, adaptive systems. *Journal des économistes et des études humaines*, 9, 241–256.
- Vieille-Blanchard, E. (2007). Croissance ou stabilité? L'entreprise du Club de Rome et le débat autour des modèles. In A. Dahan (Ed.), *Les modèles du futur* (pp. 21–43). Paris, France: La Découverte.
- Vieille-Blanchard, E. (2010). Modelling the future: An overview of the “limits to growth” debate. *Centaurus*, 52(2), 91–116.
- Vriend, N. J. (2002). Was Hayek an ACE? *Southern Economic Journal*, 68, 811–840.
- Waldrop, M. M. (1992). *Complexity: The emerging science at the edge of order and chaos*. New York, NY: Simon & Schuster Paperbacks.
- Walker, J. (2020). *More heat than life: The tangled roots of ecology, energy, and economics*. Singapore: Palgrave Macmillan.
- Weiss, C. (1991). *Organizations for policy analysis: Helping government think*. Washington, DC: World Resources Institute.
- West, G. (2006). A deceptively simple formula. *Bulletin of the Santa Fe Institute*, 21(1), 2.
- West, G. (2007). Bold irreverence meets humble respect. *Bulletin of the Santa Fe Institute*, 22(1), 0–1.
- Whitfield, J. (2008). Markets: Learning from nature. *Bulletin of the Santa Fe Institute*, 23(1), 33–37.
- Williams, L. (2012). *Modeling, building, writing: A history of nonlinear dynamics and complex systems* (Doctoral dissertation). Harvard University, Cambridge, MA.
- Wimsatt, W. C. (1994). The ontology of complex systems: Levels of organization, perspectives, and causal thickets. *Canadian Journal of Philosophy*, 24(supp. 1), 207–274.
- Wolfram, S. (2012, May 7). It's been 10 years: What's happened with *A New Kind of Science*? *Stephen Wolfram Writings*. Retrieved from <https://writings.stephenwolfram.com/2012/05/its-been-10-years-whats-happened-with-a-new-kind-of-science/>
- Woodside, A. G. (2017). *The complexity turn: Cultural, management, and marketing applications*. Cham, Switzerland: Springer.
- Zuchowski, L. (2018). Complexity as a contrast between dynamics and phenomenology. *Studies in History and Philosophy of Science Part B*, 63, 86–99.