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The failed institutionalization of “complexity science:” A focus on the Santa Fe Institute’s legitimization strategy

Fabrizio Li Vigni

Postdoctoral researcher at Laboratoire Interdisciplinaire Sciences Innovations Sociétés, France; Associated researcher at Groupe de Sociologie Pragmatique et Réflexive, EHESS, France

Abstract

“Complexity sciences” are an interdisciplinary and transnational domain of study that aims at modeling natural and social “complex systems.” They appeared in the 1970s in Europe and the United States, but were boosted in the mid-1980s by the Santa Fe Institute (SFI) under the formula of “science of complexity.” This small but famous institution is the object of the present article. According to their promissory ambitions and to the enthusiastic claims of some scientific journalists, complexity sciences were going to revolutionize all of knowledge and even private and public actors who had learnt to master them. In the light of this, one would expect to observe a well-established and autonomous research and educational field, capable of reproducing itself through professional institutions. Yet this is not the case. To explain the paradox, I propose to combine different models of history and sociology of emergent and declining domains, in order to give account of the rise and failure of complexity sciences.

Keywords

Complexity science, Santa Fe Institute, failed institutionalization, legitimization strategies, emergent domains

“Complexity science” is an interdisciplinary and transnational field of study that aims at modeling natural and social “complex systems.” These are defined as big ensembles of heterogeneous elements which, by interaction, produce emergent properties that are not deductible from their microscopic level.¹ Some examples of complex systems are genetic networks, ecosystems, cities, the Internet, financial markets, epidemics, and so on. “Complex systems sciences,” as the field is also called (especially in European countries), gather a group of natural, engineering, and social scientists that approach their typical study objects through mathematical, physical, and computational tools. The most common inquiry methods used by complexity specialists are statistical physics, dynamical systems mathematics, agent-based modeling, network theory, genetic algorithms, spin glasses, and cellular automata. The groups of research displaying complex systems among their operational keywords are several hundred in

¹ Melanie Mitchell, *Complexity. A Guided Tour* (Oxford, New York: Oxford University Press, 2009).

the world, sometimes reunited in complex systems institutes.² Scientists often loosely know each other, meet at international conferences, and sometimes collaborate at distance.

This domain of study appeared in the 1970s in Europe and the United States, but it was boosted in the midst 1980s by the Santa Fe Institute (SFI), a private research center based in New Mexico which does not host permanent faculty neither grants degrees. This small but famous institution is the object of the present article, for it has largely contributed to disseminate the term of “complexity science(s)” to several fields of knowledge and to popular culture through general audience books. According to some human and social scientists, complexity sciences have exerted a revolutionary power over all of natural and social sciences, as well as over general culture (painting, architecture, literature, cinema, etc.), providing either a new theory capable of explaining disparate phenomena or a new philosophical paradigm.³ Such claims, however sincere, closely resemble the promissory discourses held by complexity scientists themselves, who announced their nascent domain as the “science of the XXI century.”⁴ In its official reports or “bulletins,” the SFI used to present itself as a “multidisciplinary collaboration in pursuit of understanding the common themes that arise in natural, artificial, and social systems.” Stretching the idea further, SFI’s enthusiast biographers – sometimes its own members, sometimes independent writers – wrote that the objective of this research center was “to catalyze the complexity revolution in science as a whole;”⁵ that SFI is “the leading center for the study of complexity in all its manifestations”⁶ and that its theoretical aspiration is to build a “theory of everything.”⁷ After that chaos theory had benefitted of much attention both in media and in academia during the 1970s and the 1980s,⁸ complexity science *à la* Santa Fe picked up the slack, partially inheriting some of the excitement that chaos theory had arisen in public and scientific reception until then. Scientific journalist and writer James Gleick had already qualified “chaos theory” as the “third great revolution

² As Wolfram shows, complexity institutes exist only in the Americas, in Europe, in China, in Japan and in Australia: Stephen Wolfram, “It’s Been 10 Years: What’s Happened with *A New Kind of Science*?”, 7 May 2012, <http://blog.stephenwolfram.com/2012/05/its-been-10-years-whats-happened-with-a-new-kind-of-science/>.

³ John Urry, “Complexity,” *Theory, Culture & Society* 23, 2-3, 2006, 111-117; Brian Castellani, “Brian Castellani on the Complexity Science,” *Theory Culture & Society blog*, 2014: <https://www.theoryculturesociety.org/brian-castellani-on-the-complexity-sciences/>; Mark Taylor, *The Moment of Complexity. Emerging Network Culture*, (Chicago: University of Chicago Press, 2003); Cliff Hooker (ed.), *Philosophy of Complex Systems*, Volume 10 (Amsterdam: Elsevier/North Holland, 2011).

⁴ SFI, “The Bulletin of the Santa Fe Institute,” 24 (2009); the European community had similar statements, see for example: IXXI, “Communiqué de presse. L’Institut rhonalpin des systèmes complexes au cœur de la recherche du 21^{ème} siècle !” (Lyon: IXXI, 2005).

⁵ Mitchell M. Waldrop, *Complexity. The Emerging Science at the Edge of Order and Chaos* (New York: Simon & Schuster Paperbacks, 1992), p. 327.

⁶ Robert Axelrod and Michael D. Cohen, *Harnessing Complexity. Organizational Implications of a Scientific Frontier* (New York: The Free Press, 1999), p. 16.

⁷ Jeffrey Kluger, *Simplexity* (New York: Hiperion, 2008), cover back.

⁸ James Gleick, *Chaos. Making a new science* (London: Sphere Books, 1988).

in the physical sciences,” after relativity and quantum mechanics.⁹ Similarly, complexity science storytellers compared SFI scientific production to something revolutionary for knowledge in general and for society at large. According to physicist Heinz Pagel – active in chaos theory and sympathetic with the New Mexican institute –, complexity science was going to transform the nations who will be able to master it into “the economic, cultural, and political superpowers of the next century.”¹⁰

Yet, not all the books dedicated to the SFI were so laudatory toward it. For example, British-American writer Roger Lewin commented the just quoted declarations of Pagels’ in the following way: “That’s quite a claim for a science that as yet has perhaps a few dozen active practitioners, a science that most people have never heard of, and if they have, ask: Is that the same as chaos?”¹¹

SFI founders’ ambitions were truly vast: “Either the (...) Institute will be a new scientific institution of historic importance and dimensions, or it will not be,” one can read in a 1984 discussion paper.¹² Back then, the founders wished to raise up to 230 million dollars – 80 for the establishment of 40 chairs, 60 for hiring a hundred scientists, 20 for laboratory facilities, offices, and seminar classes, and the rest for other functioning needs.¹³ (The institute will never reach those sums).¹⁴ Intellectually, they aimed at creating a new paradigm for all sciences, to make them more rigorous through mathematical and computational tools – the institute was among the first research institutions to be connected to the ancestors of the Internet (New Mexico Technet and ARPANET).¹⁵ Politically, they wanted to solve “real world”¹⁶ problems. In 1988, George Cowan, a physical chemist from the LANL and first president of the SFI (Table 1), launched with a few others an interdisciplinary program of research and simulation, in order to predict the geopolitical future of the planet in the Cold War context.¹⁷

In the light of such promissory ambitions and claims, and before the banalization of complexity idiom beyond the strict circle of the domain representatives, one would expect to see an established field of inquiry, with its institutions, its autonomy, and its capacity to reproduce and self-sustain. But it is not the case. How to explain the

⁹ Gleick, *Chaos*, p. 6.

¹⁰ Heinz R. Pagels, *The Dreams of Reason. The Computer and the Rise of the Sciences of Complexity* (New York: Bantam Books, 1989).

¹¹ Lewin, *Complexity*, p. 10.

¹² SFI, “Discussion Paper Concerning the Conception, Creation and Operation of the Rio Grande Institute. May 15, 1984,” box “SFI Early Docs Development Archives.”

¹³ SFI, “The Aims of the Rio Grande Institute. Draft 5/30/84,” box “SFI Early Docs Development Archives.”

¹⁴ The budget was of 571.000 dollars in 1987, it overcame the million in 1988; another important threshold was exceeded in 1994, when the funds approached four million dollars; since the 2000s, SFI budget has stabilized around the dozen million dollars.

¹⁵ SFI, “Report of the Computational Resources Committee to the Annual Meeting of the Science Board of the Santa Fe Institute. March 11, 1988,” box “SFI Board Meetings 1988.”

¹⁶ An expression often used to mark the distinction with digital simulations.

¹⁷ SFI, “The Bulletin of the Santa Fe Institute,” 3, 1 (1988).

paradox? By mobilizing different approaches to the study of emergent domains, in the following pages I will show that, from a sociological viewpoint, complexity sciences failed to institutionalize. Their cultural influence is undeniable – it suffices to see how spread in science and in common language are some of its core terms and concepts, such as “complexity,” “complex (adaptive) systems,” “networks,” “edge of chaos,” “tipping point,” etc., all terms that were spread by general audience publications. Yet, the generalization of an idiom or a set of metaphors does not imply that we face a scientific field in the Bourdieusian sense. As we will see, complex systems specialists form a loose, international community, which has its paradigmatic models, tools, and practices, as well as its institutions and venues. But such a community cannot be apprehended through one of the classical concepts that sociology and history of science offer, such as “discipline,” “specialty,” “interdiscipline,” etc. For this reason, at a moment in which social studies about the collaboration between different disciplines increase incessantly, the present article is a contribution both to the thin literature about the decline of research domains, and to the much more abundant one about interdisciplinarity.¹⁸

Two histories of the SFI exist.¹⁹ One is the above mentioned Mitchell Waldrop’s 1992 best seller *Complexity*. The other account of the institute is contained in historian of science Lambert Williams’ PhD thesis, entitled *Modeling, Building, Writing: A History of Nonlinear Dynamics and Complex Systems*.²⁰ By telling together the history of chaos theory and of complexity sciences, Williams has claimed that “the popular science genre [is] something *constitutive* of fields, and not just post-facto vehicles for reporting on them.”²¹ In this sense “literary strategies (...) helped to *manufacture* chaos and complexity science.”²² According to him, complexity science is a *quasi-discipline*, not a full one.

While Waldrop’s text is mainly based on interviews and William’s on the critical analysis of the above-listed popular books, the present research lays on these materials but integrates them with SFI’s institutional archives.²³ While I confirm and extend

¹⁸ Julie Thompson Klein, “A Taxonomy of Interdisciplinarity,” in Robert Frodeman, Julie Thompson Klein, and Carl Mitcham (eds.), *Oxford Handbook of Interdisciplinarity* (Oxford: Oxford University Press, 2010), 16-30; Frank Siedlok and Paul Hibbert, “The organization of interdisciplinary research: modes, drivers and barriers,” *International Journal of Management Reviews*, 16, 2, 2014, 194-210.

¹⁹ Another account of the SFI is: Stefan Helmreich, *Silicon Second Nature. Constructing Artificial Life in a Digital World* (Berkeley, Los Angeles: University of California Press, 1998). But it focuses on a subgroup of SFI members, Artificial Life.

²⁰ Lambert Williams, *Modeling, Building, Writing: A History of Nonlinear Dynamics and Complex Systems*, PhD Thesis (Cambridge: Harvard University, 2012).

²¹ *Ibid.*, p. 52.

²² *Ibid.*, p. 188.

²³ I have taken pictures of roughly 90% of the 48 boxes present at the SFI, the complete list of which is contained in my PhD thesis: *Fabrizio Li Vigni, Les systèmes complexes et la digitalisation des sciences. Histoire et sociologie des instituts de la complexité aux États-Unis et en France* (Doctoral dissertation, Paris: Ecole des Hautes Etudes en Sciences Sociales, 2018). For space reasons, only a few documents will be mentioned in this article.

Williams' thesis, I will additionally offer a thorough approach to give account of complexity sciences rise and institutional failure. To do this, I get inspiration from an approach which describes fledgling domains by taking into account the various intellectual and institutional strategies their founders and supporters deployed to gain legitimacy.

The first section of the present article discusses about the different models available in sociology and history to give account of emergent domains, and of their institutional failure. The second section is divided in ten subsections, each one of which is dedicated to one of the strategies the SFI put in place to install its credibility as a research center, and that of complexity science as a respectable domain of research in general. The conclusion/discussion will comment on complexity science institutional failure in becoming an autonomous field of research.

Table 1. 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

Three theoretical models for emergent domains

The few existing histories of the SFI are the product of scientists and enthusiast journalists who gravitated around it. Most of these reports are fractional and partial, sometimes neatly hagiographic. They always focus on a few people involved into the institute, and miss to address SFI's archive materials – never fully exploited before now. The originality of this article lays in two aspects. First, its empirical material, composed by SFI bulletins,²⁴ annual reports, internal reports, research projects, flyers,

²⁴ SFI published 40 issues of its Bulletin from 1986 to 2014. The articles were written by SFI staff members, resident scientists, and mostly by 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 university, industrial and governmental directors. Its aim was to inform such a public about the scientific and administrative programs of the institute. The Bulletin was published once to twice per year. Printed in 5000 copies, it was available for free upon request. Later, its publication became uniquely electronical and old issues were digitalized. In the mid-2010s, the bulletin was suppressed because it was considered too expensive and less efficient than the SFI newsletter "Parallax," the SFI "Annual Report," and the many general audience venues. Such fund raising tool is an important document for it contains promotional, financial, and institutional elements

and correspondence; by 50 interviews with SFI scientists and staff;²⁵ and by an ethnography conducted at the institute from September 19th to October 7th, 2016. The second specificity of this text is its theoretical approach based on the mixing up of different models to analyze the way scientific entrepreneurs fabricate a new domain of scientific activity.

In history and sociology of sciences, the researcher has at his/her disposal several theoretical models. Among them, four seem to be the most common. The first one is what we can call the *teleonomic-gradualist model*. The epitome of it is Nicholas Mullins' history of the Phage Group, which was at the origins of molecular biology.²⁶ In his model, the American sociologist identifies four stages to retrack the emergence of a new research domain: a) the paradigmatic group formation, where some scientists start working on a common subject; b) the formation of a weak social network and a first terminological common ground; c) the stage of clustering, where scientists start drawing boundaries and founding the first institutions; and d) the institutionalization of the domain, through the establishment of education devices and the hiring of new researchers to perpetuate it. Another classic that pertains to this first category is the collective book entitled *Perspectives on the Emergence of Scientific Disciplines*, published in 1976 by Gérard Lemaine, Roy MacLeod, Michael Mulkey, and Peter Weingart.²⁷

A series of problems affect this model type. In the first place, despite their attention for social networks dynamics, Mullins and the others are mainly cognitive-centered. The political sphere (writ large) is neglected – scientists are only seen as researchers, never as scientific entrepreneurs, or as strategists. Secondly, the accounts of this type somehow presuppose a teleonomy in the evolution of new fields, following the Kuhnian tempos of science stages – “normal science – crisis and revolution – new normal science” – as if every emergent domain followed the same evolutionary pathway and the same gradual steps. One of the things that characterize complexity science is that some forms of institutionalization preceded the epistemic content – the former setting up the conditions to produce the latter.

Secondly, a category which can be called the *professional autonomy model* includes several specialists who emphasize one or another of the following elements, which are

that have to be taken as such, in order to illustrate the institute's strategies. Moreover, because of their easier accessibility through the Internet, I will mention the bulletins for factual elements (dates, facilities and staff modifications, etc.), every time that the information they give is cross-checked with institutional archives.

²⁵ Only the ones with the staff and with scientists holding management jobs will be mentioned here, the other ones mostly concerning theoretical, practical, ontological, and political issues other than the SFI legitimation strategies. The knowledge they provide about the intellectual, material, and normative dimensions of the American institute and of complexity sciences at large remains in the background of this piece, but is and will be exploited in other works of mine.

²⁶ Nicholas C. Mullins, “The development of a scientific specialty: The phage group and the origins of molecular biology,” *Minerva* 10, 1 (1972): 51-82, 51-52.

²⁷ Gérard Lemaine, Roy Macleod, Michael Mulkey and Peter Weingart, *Perspectives on the Emergence of Scientific Disciplines* (The Hague: Mouton & Co. and Paris: Maison des Sciences de l'Homme, 1976).

often all present in their works: The role of education and university degrees, courses, and PhD curricula in order to perpetuate the fields by the training of neophytes;²⁸ the institutionalization of fields through the classical venues of science (societies, conferences, journals, departments, committees, facilities, etc.);²⁹ and the role of social support, which can come either by the State, the industry, the general public or all of them.³⁰ In many of these cases, the approach has a flavor of sociology of work, since the role of scientists is analyzed under the professional dimension – acknowledged competences are requested for specific tasks (education, research, industry, governmental needs, etc.) and are rewarded through ad hoc occupational categories, social functions, salaries, and budgets.³¹ Despite its interest, this approach fails to take into account other aspects of the fabrication of scientific fields, among which the role of promotional discourses and strategies.

A third approach for describing emergent domains is the *promise-based model* which comes from STS works on “expectation communities.”³² Within this framework, nascent technoscientific fields are described by analyzing their discursive regime based on future promises. Here, expectations serve to create a R&D agenda, to gain legitimacy and power, and to obtain symbolic and financial credit. The expectations framework analyzes the normativity of promises, which are in its view operational ways to self-fulfil the promises themselves.³³ Though, the power of this framework appears to be its very limit – the role of promises is certainly fundamental in emergent processes, but it is not the only pertinent dimension to take into account. Scientific entrepreneurs always address several fronts at the same time.

Thereby the fourth approach, which can be called the *legitimacy-based model*. If nourished by the precedent one, this framework reveals very powerful and extremely pertinent to describe our study object here. Following a science studies approach,

²⁸ Jean-Louis Fabiani, “À quoi sert la notion de discipline?,” in Jean Boutier, Jean-Claude Passeron, and Jacques Revel (eds.) *Qu'est-ce qu'une discipline?* (Paris: EHESS, 2006), 11-34; Kate Bulpin and Susan Molyneux-Hodgson, “The disciplining of scientific communities,” *Interdisciplinary Science Reviews*, 38, 2, 2013.

²⁹ Martin Guntau and Hubert Latkau, “On the origins and Nature of Scientific Disciplines,” in William R. Woodward and Robert S. Cohen, *World Views and Scientific Discipline Formation*, (Dordrecht: Springer, 1991), 17-28; Timothy Lenoir, *Instituting Science. The Cultural Production of Scientific Disciplines* (Stanford: Stanford University Press, 1997).

³⁰ Karl Hufbauer, “Social Support for Chemistry in Germany during the 18th Century: How and Why Did It Change?,” *Historical Studies in the Physical Sciences*, 3, 1971, 205-231; Sara Angeli Aguiton, *La Démocratie des chimères* (Lormont, Editions Le Bord de l'eau, 2018).

³¹ Doris S. Goldstein, “[The Professionalization of History in Britain in the Late Nineteenth and Early Twentieth Centuries](#),” *Storia della Storiografia*, 3, 1982, 3-26; Yves Gingras, “L'institutionnalisation de la recherche en milieu universitaire et ses effets,” *Sociologie et sociétés*, XXIII, 1, 1991, 41-54; Richard Whitley, *The Intellectual and Social Organization of the Sciences* (Oxford: Clarendon Press, 1984).

³² Nik Brown, “Hope against hype. Accountability in biopasts, presents and futures,” *Science Studies*, 16, 2 (2003): 3-21; Mads Borup, Nik Brown, Kornelia Konrad and Harro Van Lente, “The sociology of expectations in science and technology,” *Technology Analysis & Strategic Management*, 18, 3-4 (2006): 285-298.

³³ Peter Miller and Ted O'Leary, “Mediating instruments and making markets: capital budgeting, science and the economy,” *Accounting, Organization and Society*, 32 (2007): 701-734; Brice Laurent, *Les politiques des nanotechnologies. Pour un traitement démocratique d'une science émergente* (Paris: Éditions Charles Léopold Mayer, 2010).

historians Pierre-Olaf Schut and Matthieu Delalandre have told the rise and decline of speleology in France.³⁴ In order to analyze this discipline in all its epistemic, ontological, professional, instrumental, and institutional depth, they have considered nine foci that contributed to make it exist: scientific texts, societies, journals, conferences, teachings, CNRS commissions, research centers, clubs, and amateur federations. According to them, speleology does not disappear in terms of objects and techniques, which are gradually incorporated into other disciplines like biology, geology, etc.; in turn, it disappears from French institutions, which means that its educational reproduction, as well as its administrative existence and social identity are no longer perpetuated.

Such social-cognitive approach – which will be followed in the present article – is drawn from science studies, is compatible with the Bourdieusian approach of Yves Gingras’ – who has analyzed econophysics, a complexity science related specialty that developed “in the shadow of physics”³⁵ –, but is to contradict the dualistic and cognitive-centered approach of historian Reba Soffer. The latter has written an article titled “Why do disciplines fail?,” in which she analyzes the failure, until the 1950s, of sociology in establishing as a discipline in Britain, whereas in the US, France, and Germany the field had managed to take root much before.³⁶ In her account, Soffer explains the lack of implantation success of British sociology because of the lack of “vitality” of its ideas, compared to those of American, French, and German sociologists – in her view, institutions are neatly separated from, and secondary to ideas. Here the distinction and hierarchy between the social and the cognitive will not be made. Inscribed in science studies for which science is inherently multidimensional at all times, in the present text I adopt the *legitimacy-based model* – which integrates the *professional autonomy* one –, and get inspiration from the *promised-based* one, in order to analyze why the establishment of a domain like complexity sciences failed to establish as an autonomous field, even if it still continues to exist under certain forms.

The strategies of legitimation

Historically, the SFI was not the first social group reclaiming the study of complex systems in the scientific world. Nevertheless, the New Mexican center was the first institution that has worked, in a strategic manner, to give body to a new research domain that it has named the “science of complexity.” As one can read from a project that the institute had sent to the National Science Foundation in 1990 to obtain funds:

³⁴ Pierre-Olaf Schut and Matthieu Delalandre, “L’échec d’une discipline: montée et déclin de la spéléologie en France (1888-1978),” *Revue d’histoire des sciences*, 1, 68 (2015): 81-107.

³⁵ Yves Gingras and Christophe Schinckus, “Institutionalization of econophysics in the shadow of physics,” *Journal of the History of Economic Thought*, 34, 1, 2012, 109-130.

³⁶ Reba Soffer, “Why Do disciplines fail? The strange case of British Sociology,” *English Historical Review*, 97, 385, 1982, 767-802.

“Our broad program of research on complex systems is a prerequisite for understanding both their common functions, which can help define the principles of a general science of complexity.”³⁷

The explicit, committed, and collectively organized character of SFI endeavor in the creation of such a new “science,” is what motivates my choice of retracking the history of this institute instead of that of other centers, groups or individuals. The latter however ended up going to and associating with the American institute during their career.

The list of elements that Schut and Delalandre take into account for speleology is not exhaustive, and its composition can vary depending on the field under study. For complexity science, the following ways of legitimation can be identified: 1) founders’ social networks, 2) the role of media and popular books, 3) the role of federal agencies, foundations and big enterprises, 4) the role of scientific publications, 5) the role of summer schools, 6) the role of pedagogical projects, 7) the role of integrative workshops, 8) the role of scientific journals, 9) and the role of prizes and rewards.³⁸ If some of these strategies revealed unsuccessful, the first two turned up to be the most effective.

Founders’ social networks

Why did SFI’s founders decide to begin such a project at the end of their career? Prior to answer this question, we have to distinguish between at least two types of SFI’s members. A first category is that of those whose social, symbolic, and economic capital is big enough that their implication in the field of complexity is not done in view of self-affirmation in academia. This is precisely the category of SFI’s founders, who justified their endeavor because of their multiple interests,³⁹ the need of a new scientific paradigm for science, and the will to contribute in solving major issues affecting society. A second category of actors includes scientists that were situated in a position of weakness, due to their young age and/or to their scientific marginality. This is the category of the first SFI members, who – according to their own account – lamented isolation because of their interdisciplinary approach to science. These researchers sought in SFI a home where to stay and, at the same time, a means through which gaining scientific credibility.

³⁷ SFI, “A proposal to the National Science Foundation for a broad research program on the sciences of complexity at the Santa Fe Institute, Santa Fe, New Mexico”, July 1st 1990, box “Ronda’s unsorted archives”, p. 3.

³⁸ Astonishingly, the only classical legitimation instrument that SFI did not plough is the one of scientific societies. A *Complex Systems Society* does exist at the international level and SFI participates into it, but it is an extension of the European society for complex systems, which was founded at the beginning of 2000s by a group of researchers from France, UK and Italy: <https://cssociety.org/about-us>.

³⁹ SFI founders entertained a specific self-mythology, in which they claimed high-level scholarship and an insatiable curiosity.

Among the founders, one of them – physicist Edward Knapp – enumerates Herbert Anderson, Peter Carruthers, George Cowan, Stirling Colgate, Darragh Nagle, Nicholas Metropolis, Louis Rosen, Richard Slansky, Alwyn C. Scott, David Campbell, and himself from the Los Alamos National Laboratory; Gian-Carlo Rota from the MIT, David Pines from the University of Illinois, chemist Anthony Turkevich from the University of Chicago, Murray Gell-Mann from Caltech, and John Rubel from the Department of Defense.⁴⁰

The group of “Senior Fellows” from LANL and their friends from other institutions gathered regularly between 1982 and 1984, before sealing the birth of their institute. During such meetings, participants debated about a series of fundamental aspects for the creation of the center – Knapp exemplifies: “what would be the best scientific focus for the institute, what should be the scale, what was the right mix of students and faculty, how best to broaden the initial group of founders, and the like.”⁴¹ As Gell-Mann explained in 1994, “[i]n the beginning, we couldn’t see clearly what sorts of emerging scientific syntheses we should seek.”⁴² Cowan related that everyone had his own idea of what he wanted.⁴³ For instance Metropolis initially proposed cognitive science as the central theme of the SFI.⁴⁴ Only after several discussions, complex systems were established as the general object upon which to apply interdisciplinarity.⁴⁵ Also, initially the founder group wished to install natural sciences laboratories in the future campus,⁴⁶ but the neighborhood⁴⁷ and the administration of Santa Fe impeded them to do it.⁴⁸

In May 1984, the founding group officially founded the legal entity. Since the name “Santa Fe Institute” was already utilized by a therapeutic service in the area, they temporarily called it the “Rio Grande Institute.”⁴⁹ In October of the same year, the center received the “non-profit” label from the Internal Revenue Service. In 1985, as soon as the therapeutic center closed, the founders modified the institute bylaws to give it the name it has conserved until today.⁵⁰ At that time the SFI did not possess

⁴⁰ SFI, “The Bulletin of the Santa Fe Institute,” 9, 2 (1994), p. 0.

⁴¹ SFI, “The Bulletin of the Santa Fe Institute,” 4, 1 (1989), p. 21.

⁴² SFI, “The Bulletin of the Santa Fe Institute,” 9, 2 (1994), p. 25.

⁴³ SFI, “The Bulletin of the Santa Fe Institute,” 19, 2 (2004), pp. 4-5.

⁴⁴ SFI, “The Bulletin of the Santa Fe Institute,” 15, 1 (2000), p. 26.

⁴⁵ SFI, “Concluding Comments, October Workshop,” box “SFI Board Meetings September 9, 1984-March 9, 1986.”

⁴⁶ SFI, “Articles of Incorporation of Rio Grande Institute. May 22, 1984,” box “Santa Fe Institute Archival Materials Relating to Acquisition of The Hyde Park Road Campus.”

⁴⁷ SFI, “S.F. Institute’s plan worries neighbors, Bob Quick, The New Mexican,” box “Santa Fe Institute Archival Materials Relating to Acquisition of The Hyde Park Road Campus.”

⁴⁸ SFI, “Santa Fe City Code. Land Development,” box “Santa Fe Institute Archival Materials Relating to Acquisition of The Hyde Park Road Campus;” SFI, “Informational Report. Santa Fe Institute Request for Special Exception. March 22, 1993,” box “Santa Fe Institute Archival Materials Relating to Acquisition of The Hyde Park Road Campus.”

⁴⁹ SFI, “The Bulletin of the Santa Fe Institute,” 9, 2 (1994), p. 16.

⁵⁰ SFI, “Bylaws of the Santa Fe Institute. Santa Fe, New Mexico. As amended on November 3, 2013,” box “2015-2016 SFI Promotional material.”

neither a staff nor a physical headquarter. As Knapp will later relate: “We joke that our early home was a desk drawer in Trustee Art Spiegel’s office in Albuquerque, and we progressed to a Santa Fe post office box before we had a place of substance.”⁵¹ In 1985, SFI rented an office in a building in Santa Fe for its two employees, the polyvalent Ginger Richardson and the development director Ron Zee.⁵² In 1987, the institute was installed at 1120 Canyon Road, in the Cristo Rey Convent.⁵³ This move marked the period in which the institute became widely known, first in the US, then in Europe and the rest of the world. In July 1991 it will be temporarily situated at the 1660 Old Pecos Trail while waiting for the fund raising, the acquisition, and the renovation for/of the final home.⁵⁴ Partially thanks to a donation by Cowan to purchase a mansion on Santa Fe hills, the institute found its final headquarter at 1399 Hyde Park Road in July 1994.

Art Spiegel was an entrepreneur who had been introduced to the group by Cowan.⁵⁵ As the bulletins have reiterated several times, “Cowan is often credited by his colleagues as the stimulus behind the Santa Fe Institute.”⁵⁶ In a parallel way, Spiegel is described by Knapp as “very important in getting the Institute off the ground.”⁵⁷ The archives are full of letters that he had sent to notable contacts in Santa Fe – entrepreneurs and managers in all domains, as well as scientists and local art dealers – to invite them to the first fund raisings.⁵⁸ First year SFI budget was of about 100.000 dollars, mainly due to Spiegel’s activity and to Senior Fellows’ donations.⁵⁹ The importance of the founders’ social and symbolic capitals in launching the institute is exemplified in the friendship relation uniting Cowan to Spiegel.⁶⁰

The two had met in 1958 at a private dinner at the house of some common friends in Los Alamos. Their first collaborations focused on the animation of cultural activities in order to “compensa[te] for Los Alamos minimalism.”⁶¹ The neighborhoods of what had been the headquarter of the Manhattan Project during WWII were indeed a relatively desertic area, which had been developed since then around and by the scientists. To get SFI begin, LANL fellows activated their personal networks at several levels.

In 1986, SFI’s members transited from eight to seventeen. That same year, Ginger Richardson was hired by Cowan as polyvalent secretary in order to organize the first

⁵¹ SFI, “The Bulletin of the Santa Fe Institute,” 9, 2 (1994), p. 0.

⁵² Interview with Ginger Richardson, 5 March 2017.

⁵³ SFI, “The Bulletin of the Santa Fe Institute,” 9, 2 (1994), p. 16.

⁵⁴ *Ibid.*, p. 17.

⁵⁵ George Cowan, *Manhattan Project to the Santa Fe Institute. The Memoirs of George A. Cowan* (Albuquerque: University of New Mexico Press, 2010), pp. 72-73.

⁵⁶ SFI, “The Bulletin of the Santa Fe Institute,” 9, 2 (1994), p. 3.

⁵⁷ SFI, “The Bulletin of the Santa Fe Institute,” 5, 2 (1990), p. 9.

⁵⁸ SFI, “Letters of Arthur Spiegel, 1985,” box “SFI Early Docs Development Archives.”

⁵⁹ SFI, “The Bulletin of the Santa Fe Institute,” 19, 2 (2004), pp. 8-9.

⁶⁰ Cowan, *Manhattan Project*, p. 143.

⁶¹ *Ibid.*, p. 72.

scientific events and write the first research projects.⁶² She later became responsible of public relationships and supervisor of the institute education sector.⁶³ In the meanwhile, Cowan was assisted by three vice-presidents, by the president and vice-president of the Board of Trustees, as well as by the secretary.⁶⁴ In 1987, the Board of Trustees counted 27 members, among whom scientists, entrepreneurs, and ex-politicians. The Scientific Advisory had 40 members, some of which overlapped the Board.⁶⁵ That year, the institute started the “Visiting Fellows” program, with six members (among whom some of the founders). The program would last one to twelve months and provide fellows with an accommodation allowance, an office, a research fund support, and a salary. The number of associates increased gradually to reach the hundred members in 1993 – this number stayed constant until today.⁶⁶ The visiting fellows’ only obligation has always been to spend at least one week per year at the institute – mostly in coincidence with an integrative workshop. Some people stay longer, even a year for those in sabbatical break. Among the represented nationalities, Anglo-Saxons, French, German, and Indian were the first ones. Rapidly, new entries came in from Europe, Latino-America, and Israel. In 2007, the “External Faculty” represented eighteen different countries.⁶⁷ Despite SFI’s “community was highly influential in East Asia” and in particular in China,⁶⁸ no member ever came from that area.

To do an assessment of the first years of the institute, Cowan wore the hat of the sociologist:

The issue of complexity has been popping up everywhere. The Santa Fe Institute has given it a little more credibility, I think, because the names attached to it are prestigious. We have a roster of National Academy types and Nobel winners, which suddenly did something very important for the whole notion, that is, to make it look more respectable.⁶⁹

SFI’s founders were conscious of their strategic usage of their social, symbolic, and economic capitals: “We were picking the people, not the topics.”⁷⁰ During one of the founding meetings, Metropolis subordinated the success of their scientific enterprise to

⁶² Interview with Ginger Richardson, 5 March 2017.

⁶³ SFI, “The Bulletin of the Santa Fe Institute,” 3, 1 (1988), p. 20.

⁶⁴ SFI, “The Bulletin of the Santa Fe Institute,” 1, 1 (1986), p. 14; SFI, “The Bulletin of the Santa Fe Institute,” 5, 1 (1990), p. 8.

⁶⁵ SFI, “The Bulletin of the Santa Fe Institute,” 2, 1 (1987), pp. 12-14.

⁶⁶ SFI, “The Bulletin of the Santa Fe Institute,” 8, 2 (1993), p. 38.

⁶⁷ SFI, “Santa Fe Institute 2009 Annual Report,” (2009), p. 6.

⁶⁸ Interview with William Tracy, 5 October 2016.

⁶⁹ SFI, “The Bulletin of the Santa Fe Institute,” 3, 2 (1988), p. 5.

⁷⁰ SFI, “The Bulletin of the Santa Fe Institute,” 19, 2 (2004), p. 8.

the only presence of some very famous people.⁷¹ The symbolic capital often goes hand in hand with the social one: “[Gell-Mann, Pines, etc.] knew everybody. They could just pick up the phone.”⁷² Moreover, some of these scientists were also entrepreneurs and have often directed substantial sums to the SFI to secure its functioning – Cowan for instance had founded a private bank in Los Alamos and had become millionaire.

SFI and media reflectors were pointing the “stars.” But what about the other members’ prosopography? As soon as SFI opened up to postdocs, the researchers coming in were difficult to categorize in some established field. For the first ten or fifteen years, most of them found in complexity science a living, strategic, temporary, and sometimes perennial shelter. SFI unconventional environment was constantly praised by its associates, who declared that in comparison they had always felt tight and inhibited in traditional academic spaces.⁷³ Such a self-representation and narrative of the institute vehiculated fascination in students and the general public.

In the institute’s narrative, its objective was to create the conditions to explore new and risky scientific territories.⁷⁴ In a retrospective interview published on the 2014 bulletin, Richardson considered that the mission had been achieved: “[the] success (...) [of] many (...) SFI postdocs, belies the founders’ early worries that a segue into complexity science could be a career killer.”⁷⁵ In fact, the problem of recruitment of complex systems researchers still is a preoccupation of the SFI’s, and of complexity specialists in general. In his doctoral thesis, Williams mentioned some examples of people who had had “difficulties of reintegration” into academia after an SFI internship for the very reason that they belonged to different domains, and to no one in particular.⁷⁶

Despite its modest size, the SFI is today widely known in the academic environments of several countries in the world – yet it is not always eulogized. *Estimators* show sympathy for the institute and revendicate the imitation of some of SFI’s characteristics in their practices and institutions. *Selective estimators* distinguish between specific people and periods of the institute story, and thus discard and take distance from some of them. Finally *detractors* either criticize the excess of hype around complexity and minimize SFI’s successes,⁷⁷ or blame its dominant masculinist and crypto-Catholic culture,⁷⁸ or denounce SFI’s neoliberal take,⁷⁹ or complains its reductionist approach.⁸⁰

⁷¹ SFI, “Concluding Comments, October Workshop,” box “SFI Board Meetings September 9, 1984-March 9, 1986”.

⁷² SFI, “The Bulletin of the Santa Fe Institute,” 19, 2 (2004), p. 8.

⁷³ SFI, “The Bulletin of the Santa Fe Institute,” 14, 1 (1999), p. 11.

⁷⁴ SFI, “The Bulletin of the Santa Fe Institute,” 18, 1 (2003), p. 3.

⁷⁵ SFI, “The Bulletin of the Santa Fe Institute,” 28, 2 (2014), p. 45.

⁷⁶ Williams, *Modeling*, pp. 166-167.

⁷⁷ John Horgan, “From complexity to perplexity”, *Scientific American*, 272, 6 (1995), pp. 74-79.

⁷⁸ Stefan Helmreich, *Silicon Second Nature*.

During the first years of the institute, Senior Fellows' symbolic capital attracted some quite known researchers to ally them into their enterprise (computer scientist and psychologist John Holland from the University of Michigan, chaos physicists Doyne Farmer and Norman Packard from LANL...). Furthermore, founders' prestige has increased the visibility and credibility of young and marginal researchers all along SFI history (for example computer scientist Christopher Langton, the controversial founder of Artificial Life, and Welsh economist Brian Arthur, known for "complexity economics").

Later on though, the SFI needed to find a new source of symbolic capital, especially after journalist John Horgan had criticized, on the pages of the *Scientific American*, complexity science for being "flaky" and the SFI for being "fact-free."⁸¹ In the mid-1990s, it was clear to the Board of Trustees that Senior Fellows' prestige was no longer enough. SFI hence diversified its strategy and tried to attract rising "stars" in order to boost both the institute and the latter visibility. An ongoing case of this win-win association is that of computational complexity specialist Christopher Moore. Another example is represented by Greek-Brazilian statistical physicist Constantino Tsallis, who had made acknowledged contributions in the field of thermodynamics. Another example is the postdoc stay of the network theory "stars" Duncan Watts and Mark Newman toward the end of the 1990s. The case of the network scientists as the latter who became academic celebrities, is interesting for it contrasts with complexity sciences at large.⁸² These researchers managed to collect so much scientific capital that American universities today compete to have them by offering generous salaries and important responsibilities. This is because they utilized consolidated techniques from statistical physics; they applied these techniques to new, exotic objects (social and genetic networks, epidemics, etc.); publicized their work through general audience canals; had efficacious institutional strategies; and managed to perpetuate their specialty through academic teaching, conferences, and journals. But this is not the case of all complexity specialists. "[S]everal prominent SFI researchers," as Williams wrote in his thesis, "essentially vanished from view when their time there was up"⁸³ – whatever the country, if they want to persist and exist independently of complexity institutes and funds, complexity scientists have to pass traditional disciplinary tests.

The role of media and popular books

⁷⁹ Charles Gere, *Digital Culture* (London: Reaktion Books, 2002).

⁸⁰ Edgar Morin, "Complexité restreinte, complexité générale", Colloque Intelligence de la complexité: épistémologie et pragmatique, Cerisy-la-Salle, 2005: <http://www.learndev.org/dl/BtSM2007/EdgarMorin-FR.pdf>.

⁸¹ Horgan, "From complexity."

⁸² Linton C. Freeman, *The Development of Social Network Analysis: A Study in the Sociology of Science* (Vancouver: Empirical Press, 2004).

⁸³ Williams, *Modeling, Building, Writing*, p. 166.

Most SFI popular books cannot be considered as secondary literature, but rather as what French historian Wolf Feuerhahn has called *indigenous histories* – that is “histories of a discipline produced by the actors of the discipline themselves.”⁸⁴ But what to say about enthusiastic accounts of SFI and complexity science given by certain journalists? Even if, as far as I know, they did not get any benefit from the institute, their stories contributed to entertain a certain narrative about it. In their books, the SFI appears as “the” place for interdisciplinarity and complexity science in the world.

The first book which offers a portrait of some personalities linked to the New Mexican institute (namely physicists Normand Packard, Doyne Farmer, and James Crutchfield) is *Chaos* written by the *New York Times* journalist James Gleick.⁸⁵ Published in 1988, this book has become one of the most sold science books ever.

In 1992, Waldrop published *Complexity. The emerging science at the edge of order and chaos*. One year before he had signed an editorial contract with Simon & Schuster after having reported for *Science* about an Artificial Life conference. According to his testimony, he spent two weeks at the institute in order to have a look at some archives and especially to realize interviews with some of its members.⁸⁶ His book rapidly sold several thousand copies and today topped the 100.000.

In the same 1992, British science writer Roger Lewin published the almost homonym *Complexity. Life at the edge of chaos*.⁸⁷ Like Waldrop, Lewin reported SFI’s self-promotional discourse anchoring his tales to some key personalities.

Williams gives an interesting analysis of these books to explain their success. One of the narrative strategies is, according to him, personalization. Protagonists are often presented as misunderstood geniuses, who are as marginal as inventive, as eccentric as fascinating. They are depicted as rebels, visionaries, explorers, and dynamical people that do not give up before the obstacles of reactionary academia. Protagonists are often presented with their nicknames, in order to create identification and proximity. In some cases, the fascination for complexity is complemented by a bent for mysticism – sometimes Buddhist, sometimes Catholic.

If journalists have a predilection for hagiographic accounts, in their divulgation texts SFI members focus more on theories and models.⁸⁸ Between 1994 and 1999, the books about the institute rarefied, probably as an effect of the critiques this had received. At

⁸⁴ Wolf Feuerhahn, “Instituer les neurosciences sociales. Quelle histoire pour un nouveau label?”, in Bruno Ambroise and Christiane Chauviré (eds.), *Raisons pratiques*, 23 (2013): 115-137.

⁸⁵ Gleick, *Chaos*.

⁸⁶ Interview with Mitchell Waldrop, 2 December 2016.

⁸⁷ Lewin, *Complexity*.

⁸⁸ Stuart Kauffman, *The Origins of Order. Self-Organization and Selection in Evolution* (New York, Oxford: Oxford University Press, 1993); John L. Casti, *Complexification. Explaining a Paradoxical World Through the Science of Surprise* (New York: Harper Collins Publishers, 1994); Brian Goodwin, *How the Leopard Changed Its Spots. The Evolution of Complexity* (New York: Charles Scribner’s Sons, 1994); Murray Gell-Mann, *The Quark and the Jaguar. Adventures in the Simple and the Complex* (London: Abacus, 1994).

the end of the 1990s, complexity became popular again thanks to a new wave of celebrative publications.⁸⁹

Conscious of the importance of such publications, SFI's Direction used Waldrop's book to promote the institute – the correspondence archives gather several letters sent to donors with the book in the attached. In his review of *Complexity* published on the 1992 winter bulletin, SFI biologist Harold Morowitz argued something that confirms William's thesis: "in these days a journalist is also an actor, for support of research is geared to fame, and fame comes in part from inclusion in books of this type."⁹⁰ For example, despite his interlocutors always use the plural, Waldrop's narrative of a singular "complexity science" has had performative effects by suggesting the feeling of a cohesive and coherent community – just as Gleick did with chaos theory. Several representatives of complexity science in the US and in Europe have testified that these texts played a role in their adhesion to the field.

Besides books, SFI has always given attention to media in general.⁹¹ Newspapers, TV, radio interviews, YouTube, and general audience conferences are all venues considered as of capital importance. Media produce cascade effects on funding obtention, on members enrollment, and on the credibility of the institute. A proof of this are the frequent references to the mediatic coverage that the institute has done in its communication material.⁹²

The role of federal agencies, foundations and big enterprises

Because of their social status and their rich biographies, the Senior Fellows had, as a long-standing library staff said to me, an agenda with "lots of connections"⁹³ from federal organisms like the NSF and the DoE (from which the LANL depends), in the world of big fortunes, banks, and enterprises, as well as in that of politics and think tanks (Gell-Mann for example had been counselor to the RAND Corporation for years). At this level of prestige and political proximity, the distinction between professional collaborations, intellectual esteem, personal friendship, and lobbying is hard to make.

The first funding from the NSF came in 1988 as a result of a meeting organized by Cowan between the SFI's founders and Erich Bloch, the director of the agency. For the institute, the advantage of NSF support was its little bureaucratic constraints compared to other federal endowments.⁹⁴ Despite the absence of a dedicated section for

⁸⁹ For more titles, see Williams, *Modeling*, p. 194 (note).

⁹⁰ SFI, "The Bulletin of the Santa Fe Institute," 7, 2 (1992), p. 7.

⁹¹ SFI, "The Bulletin of the Santa Fe Institute," 21, 1 (2006), p. 2.

⁹² SFI, "The Bulletin of the Santa Fe Institute," 9, 2 (1994), p. 16; SFI, "The Bulletin of the Santa Fe Institute," 5, 2 (1990), p. 2; SFI, "Santa Fe Institute 2007 Annual Report," (2007), pp. 28-31.

⁹³ Interview with Margaret Alexander, 20 September 2016.

⁹⁴ Interview with Ginger Richardson, 5 March 2017.

interdisciplinary projects, Bloch found a solution to fund the SFI. As Cowan explained in his memoirs, this consisted in “taxing each of the divisions in order to provide \$250,000 a year in support of the Institute.”⁹⁵ Two more people were crucial in securing NSF funding over the time – physicists Edward Knapp and Robert Eisenstein. The first had been the president of NSF from 1982 to 1984 and the second of NSF Physics Division from 1992 to 1997. Knapp indeed testified that: “Perhaps my connections with the Federal government stemming from my days at the NSF and at [Universities Research Association] helped us.”⁹⁶ In 2004, Eisenstein was appointed as the new SFI president: “[he] brings those qualities to the presidency of an institution he’s known for some 10 years. Early on during his tenure at the NSF, he was responsible for directing many of the funds that came to SFI from there.”⁹⁷

Later on, some of the federal agencies funds came in for the interest these had manifested for computer scientist Christopher Langton’s agent-based simulation called SWARM. In April 1994, the SFI received a scholarship of 323.000 dollars from the ARPA – the military and the intelligence were interested in an application of this platform, in order to solve problems “related to the way troops adapt to changing circumstances on the battlefield. The army wants to know how much local decision-making power troops on the ground should be given and how much of that decision-making power should remain in the hands of commanding officers.”⁹⁸ According to the first librarian of the institute Margaret Alexander, Ellen Goldberg “decided not to take DARPA money anymore, because it was kinda dark and scary.”⁹⁹ In fact, as a mathematician from the institute will tell me, some of the resident scientists will keep responding to DARPA calls on a personal basis, but not without internal resistances – namely from postdocs.¹⁰⁰

Since the beginning, the part of funding coming from foundations was also very important. In 1987, substantial contributions came from the Russell Sage, the Alfred Sloan, the Richard Lounsbery, and the Heinz Company.¹⁰¹ In 1988, John and Catherine MacArthur added up to the list.¹⁰² If some of them became regular donors of the SFI, some others have come in and out. On the overall, the place of foundations’ has gradually decreased to get to 30 percent in 1996.¹⁰³ In 2006, it lowered to a small 6 percent of the total budget.¹⁰⁴ Yet during the 2010s, individual, family, and philanthropic foundations became again very important and constituted up to the half

⁹⁵ Cowan, *Manhattan Project*, p. 145.

⁹⁶ SFI, “The Bulletin of the Santa Fe Institute,” 5, 2 (1990), p. 10.

⁹⁷ SFI, “The Bulletin of the Santa Fe Institute,” 19, 1 (2004), p. 4.

⁹⁸ SFI, *The Bulletin of the Santa Fe Institute*, Winter, 1998, Vol. 13, Number 1, p. 21.

⁹⁹ Interview with Margaret Alexander, 20 September 2016.

¹⁰⁰ Interview with David Wolpert, 6 October 2016.

¹⁰¹ SFI, “The Bulletin of the Santa Fe Institute,” 2, 1 (1987), p. 15.

¹⁰² SFI, “The Bulletin of the Santa Fe Institute,” 3, 2 (1988), p. 2.

¹⁰³ SFI, “The Santa Fe Institute Annual Research Report,” (1997), p. 22.

¹⁰⁴ SFI, “The Santa Fe Institute Annual Research Report,” (2006), p. 97.

of SFI budget.¹⁰⁵ This was mainly due to the decrease in individuals and trustees' gifts, and to investment loss after 2008 economic crisis; the Director of Communications of the SFI explained that “[a]s the economy gets tight, people (...) want more and more tangible results. And we are a theoretical institute and we are never gonna produce tangible results.”¹⁰⁶ As the federal agencies fund raiser explained me, government funds stayed the same before and after the Lehman Brothers' crash thanks to the “American Recovery and Reinvestment Act” from 2009,¹⁰⁷ but if private donors were the main contributors before it, foundations took their place afterwards. Some years following the crisis, the part of private and foundation donations equalized, while the investment income increased its size. The Figure 1 exemplifies and resumes the evolution of funds over three topic dates, including the first phase under Cowan's direction (1991), the second one led by Goldberg's (1997), and the post-2008 crisis (2013).

Less data is available about Senior Fellows and other SFI members relationships with private foundations. It is nevertheless arguable that the founders had tight contacts with that world too. For example, Gell-Mann had strong connections with the MacArthur Foundation – one of the first and most assiduous SFI financiers.¹⁰⁸ From 1979 to 2002, he had indeed directed the organism, with the freedom of giving funds to whoever he thought worthy.¹⁰⁹

¹⁰⁵ SFI, “The Santa Fe Institute Annual Research Report,” (2013), p. 19.

¹⁰⁶ Interview with John German, 23 September 2016.

¹⁰⁷ Interview with Elizabeth Johnson, 28 September 2016.

¹⁰⁸ Caltech, “Caltech Mourns the Passing of Murray Gell-Mann (1929-2019)”, May 24, 2019: <https://www.caltech.edu/about/news/caltech-mourns-passing-murray-gell-mann>.

¹⁰⁹ “Murray Gell-Mann – Conservation. The MacArthur Foundation (182/200)”, YouTube video: <https://www.youtube.com/watch?v=ZfomU1e-HwU>.

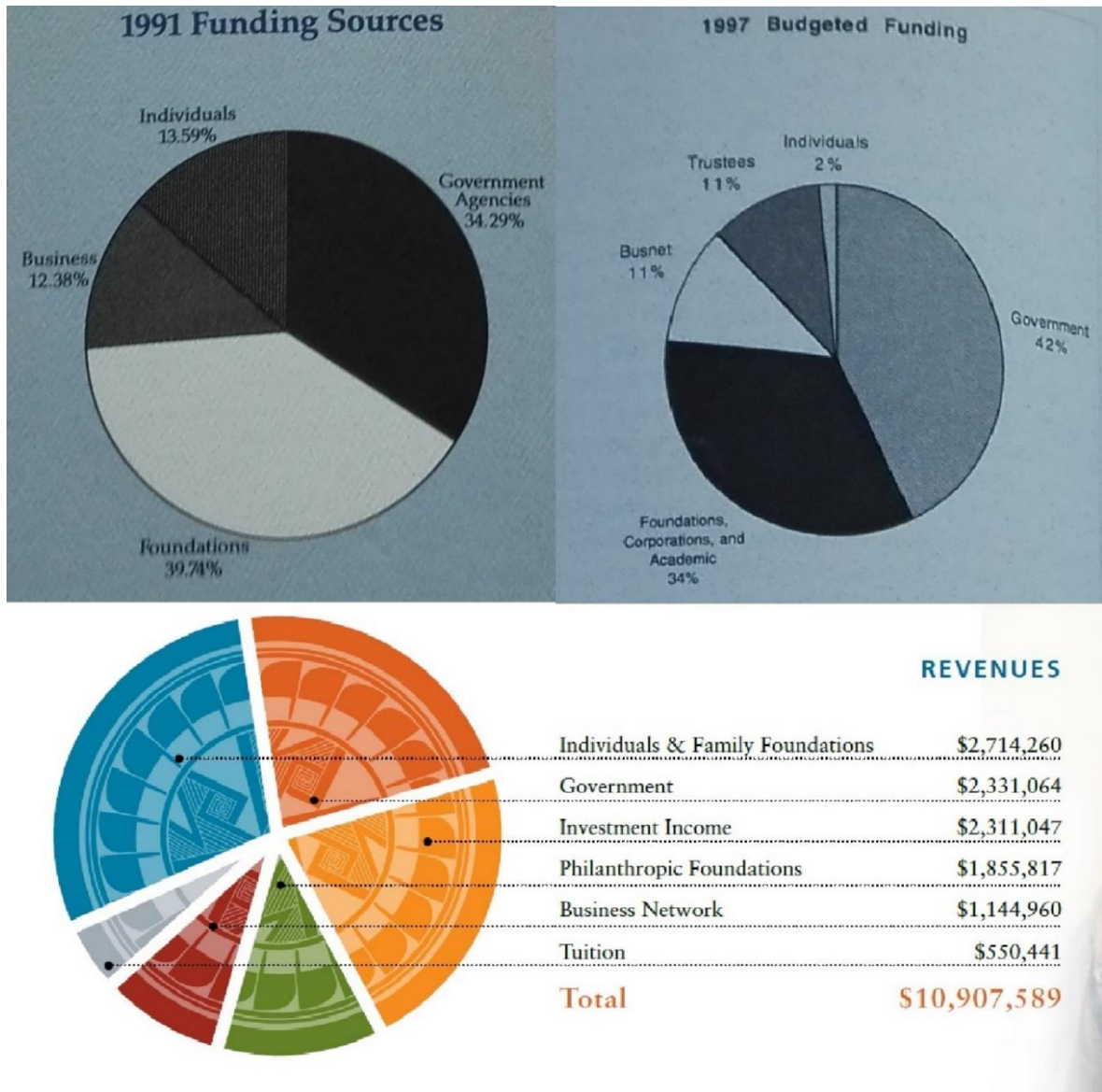


Figure 1. The evolution of SFI funding in three different periods from the 1991, 1997 and 2013 Annual Reports.

What Figure 1 shows but does not explain are companies' gifts. Since the first important workshop organized by the institute to put physicists and economists to work together on financial economics, the SFI entertained excellent relations with big corporations like Citigroup. Its CEO John Reed was indeed one of the first most important funders of SFI's research projects with his "\$250,000 to study the global economy."¹¹⁰ Cowan explained that, in 1987, Robert Adams – a member of SFI board and head of the Smithsonian Museum in Washington – spoke with Reed about the institute suggesting him to "come to Santa Fe with a few of his staff to talk about some of the problems in international finance that his company was attempting to solve."¹¹¹

¹¹⁰ SFI, "The Bulletin of the Santa Fe Institute," 19, 2 (2004), pp. 9-10.

¹¹¹ Cowan, *Manhattan Project*, p. 148.

Reed was keen for new mathematical models to avoid loss from economic crises and stock exchange crashes.¹¹²

According to SFI's philosophy, "[c]ompetitive 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."¹¹³ Another opening to the world of enterprises occurred in 1988 with the entry of some new members in the Board of Trustees from the oil and weapon sectors.¹¹⁴ Here again, contacts preexisted SFI birth. Trustees were coopted among the founders' friends, as it was the case for Robert Anderson from Hondo Oil Company who was brought in by Cowan.¹¹⁵ In 1989, other funders added up to the list – among them Barclay's and Trinity Capital Corporation.¹¹⁶ In 1990, the number of foundations was nine and that of companies twelve, with some new entries, such as IBM, Morgan Stanley, and Volvo.¹¹⁷ That same year, the Board of Trustees got new members from the sectors of aeronautics, finance, and informatics.¹¹⁸ For several years, most of SFI trustees stemmed from the Silicon Valley and Wall Street.¹¹⁹ Yet, it is under Goldberg's presidency (1996-2002) that private and business donations became the two thirds of the institute's funding.

Today the institute is provided with a "strategic partnership" office, which operates in three sections. One is in charge of collecting public funds from federal agencies through the search of new scholarships and the writing of projects to respond the calls. Another one is in charge of searching for and keeping contact with individual contributors. The third fund raising tool is the "Business Network for Complex Systems Research" (or BusNet): even if the SFI Mission Statements of 1986 stated that one of the objectives of the institute should be to "serve the industry,"¹²⁰ the BusNet was not created before 1992. In 2015 it was renamed "Applied Complexity Network" (or ACTioN) by the current president David Krakauer.¹²¹ Its task is to provide consulting services to enterprises, NGOs', and administrations.

The role of scientific publications

¹¹² SFI, "The Bulletin of the Santa Fe Institute," 24 (2009), p. 27.

¹¹³ SFI, "Santa Fe Institute 2009 Annual Report," (2007), p. 60.

¹¹⁴ SFI, "The Bulletin of the Santa Fe Institute," 3, 1 (1988), p. 8.

¹¹⁵ SFI, "The Bulletin of the Santa Fe Institute," 4, 2 (1989), p. 10.

¹¹⁶ SFI, "The Bulletin of the Santa Fe Institute," 4, 1 (1989), p. 31.

¹¹⁷ SFI, "The Bulletin of the Santa Fe Institute," 5, 1 (1990), p. 27; SFI, "The Bulletin of the Santa Fe Institute," 6, 1 (1991), p. 26.

¹¹⁸ SFI, "The Bulletin of the Santa Fe Institute," 5, 2 (1990), p. 6-7.

¹¹⁹ SFI, "The Bulletin of the Santa Fe Institute," 7, 2 (1992), p. 47; SFI, "The Bulletin of the Santa Fe Institute," 8, 2 (1993), p. 4.

¹²⁰ SFI, "SFI Mission Statements, 1986," box "SFI Concepts Mission Statements 1984-1989."

¹²¹ SFI, "ACTioN. Applied complexity network @ the Santa Fe Institute", box "2015-2016 SFI Promotional material."

In March 1987, the SFI started a collaboration with the Addison-Wesley Publishing Company, with the aim of getting out a series of books under the collection “Santa Fe Institute Studies in the Sciences of Complexity.”¹²² The series included conference and summer school proceedings, as well as individual and collective monographies.

In a 1989 bulletin, the responsible of scientific editions Ronda Butler-Villa explained the importance of such publications in an article entitled “Getting the Word Out:” “the publications program provides the only tangible evidence of what is being accomplished [at the SFI].”¹²³ Butler-Villa explained that volumes were generally printed in 1500 copies, half of which were commonly sold in the first six months, while the other half was exposed in bookshops. No-one of these volumes has ever overcome the symbolic bestseller threshold of ten thousand copies.

The editorial strategy was called to change in 1992, with the perspective of reducing the printing costs and increasing the efficacy of such publications.¹²⁴ In 1994, the number of the titles was fifty, but the high cost of production gradually dissuaded both SFI and the editor from adding new ones.¹²⁵ Even if, in 1998, the contract with Addison-Wesley was replaced by a new one with the Oxford University Press,¹²⁶ Richardson explained “these volumes lost with time their value. (...) As time went on, there were many new ways to spread the word.”¹²⁷

A section of the SFI bulletin has often been dedicated to scientific articles announcements. In the 1991 fall-winter issue, the institute mentioned the increasing number of specialized publications authored by its affiliated members: twenty-eight in 1990, thirty-one in 1991.¹²⁸ In 2007, Geoffrey West highlighted the scientific excellence of SFI members by pointing at the prestige of the journals in which they publish: “Although SFI is dedicated to risk-taking and supporting more speculative investigation, our researchers continue to be published and recognized in leading scientific journals;”¹²⁹ “[o]ur researchers routinely publish in top journals including *Science*, *Nature* and the *Proceedings of the National Academy of Sciences*. In fact, in 2007, we had more than 100 publications in such journals.”¹³⁰ In their turn, *Nature* and *Science* roundly shared their enthusiastic support to SFI and contributed to its scientific legitimacy by regularly dedicating their journalistic and promotional sections to its activities: “The journal *Nature* touted SFI as a place where ‘through the interaction of talented people there may well arise new visions of how the world is put

¹²² SFI, “The Bulletin of the Santa Fe Institute,” 2, 1 (1987), p. 10.

¹²³ SFI, “The Bulletin of the Santa Fe Institute,” 4, 1 (1989), p. 3.

¹²⁴ SFI, “The Bulletin of the Santa Fe Institute,” 7, 2 (1992), p. 13.

¹²⁵ SFI, “The Bulletin of the Santa Fe Institute,” 9, 1 (1994), p. 24.

¹²⁶ SFI, “The Bulletin of the Santa Fe Institute,” 13, 1 (1998), p. 6.

¹²⁷ Interview with Ginger Richardson, 5 March 2017.

¹²⁸ SFI, “The Bulletin of the Santa Fe Institute,” 6, 2 (1991), p. 35.

¹²⁹ SFI, “The Bulletin of the Santa Fe Institute,” 22, 1 (2007), p. 1.

¹³⁰ SFI, “Santa Fe Institute 2007 Annual Report,” (2007), p. 7.

together,’ and *Science* described it as an intellectual playground where scientists knocked around new ideas ‘like volleyballs.’”¹³¹

It is important to note that not all of these articles regarded the field of complexity sciences – the reference is thus to *any* scientific article published by SFI members, so to realize a form of transfer of capital from more established fields to the emerging one.

The role of summer schools

As sociologists of sciences Kate Bulpin and Susan Molyneux-Hodgson have shown, educative devices are important in the creation of new technoscientific domains.¹³² In the case of complexity sciences, a specific Bachelor does not exist while masters and PhDs are very rare.¹³³ The device that importantly contributed to get complexity science into existence was the Complex Systems Summer School (CSSS).

These were conceived by Peter Carruthers and first launched in 1988.¹³⁴ Mike Simmons, one of their kingpins, described CSSS as an occasion to fasten the academic existence of the institute and to “maintain SFI’s position in the forefront of this exciting new field of complexity.”¹³⁵ At the beginning the target was the United States. With time, the public diversified in terms of nationalities represented.¹³⁶

The first CSSS was organized with the support of several research centers, universities, and federal agencies. For the second edition, some Silicon Valley companies provided computer material for free.¹³⁷ For several years the event took place at local Saint John High School.¹³⁸ The first students were in number of five and had been mainly brought in by physicist Philip Anderson.¹³⁹ A workshop session in order to ensure that participants could all handle modeling software was also organized. The school remained without charge for unconfirmed scientists until 2008, after which it became paying. Today students, post-docs, and faculty pay 4,500, while professionals 6,000.

¹³¹ SFI, “The Bulletin of the Santa Fe Institute,” 19, 2 (2004), pp. 4-5.

¹³² Kate Bulpin and Susan Molyneux-Hodgson, “The disciplining of scientific communities,” *Interdisciplinary Science Reviews*, 38, 2 (2013).

¹³³ The Open University in Milton Keynes (UK) offers one, with a focus on design and engineering; the Vermont Complex Systems Center at the University of Vermont (USA) proposes another one with a focus on data science; only the Department of Information Science and Technology at the University Institute of Lisbon seems to offer a program which resumes the main SFI’s theories and tools.

¹³⁴ SFI, “The Bulletin of the Santa Fe Institute,” 13, 1 (1998), p. 4.

¹³⁵ SFI, “The Bulletin of the Santa Fe Institute,” 3, 1 (1988), pp. 16-18.

¹³⁶ SFI, “The Bulletin of the Santa Fe Institute,” 8, 2 (1993), p. 24, p. 26.

¹³⁷ SFI, “The Bulletin of the Santa Fe Institute,” 5, 2 (1990), p. 12.

¹³⁸ SFI, “The Bulletin of the Santa Fe Institute,” 3, 2 (1988), p. 19; the venue has changed recently: <https://www.santafe.edu/engage/learn/schools/sfi-complex-systems-summer-school>.

¹³⁹ Interview with Daniel Stein, 8 September 2016.

Since the beginning, the institute attributed to this educational device an important place. First to produce new complexity adepts in America and around the world, and second to fix the international standards of complexity science: “the [SFI Lectures in Complex Systems] series’ cumulative effect is not only to record what has already been done in the field but also to contribute to defining complexity’s future evolution.”¹⁴⁰

CSSS lectures were published as proceedings at the Addison-Wesley. In the whole, SFI published half dozen volumes as a result of them, before it considered that was not viable anymore.¹⁴¹ CSSS and their publications were important for the establishment of some common ground for complexity science inquiry tools.¹⁴² These varied through time and scientists were invited to innovate by creating or bringing in other inquiry means. CSSS were also a place for socialization: “Well over a thousand students have participated since its debut in 1988, he explains. ‘Each brings the SFI mode of thinking back to his or her home institution.’”¹⁴³

The success of the summer school led the institute to organize a winter version in January 1992 at Tucson (Arizona), the first of a long series that, through the “International Outreach Program,” touched China, Eastern Europe, and South America.¹⁴⁴ The program was reinforced in 2013 with the implementation of a series of Massive Open Online Courses.¹⁴⁵

The role of pedagogical projects

Another pedagogical device that SFI put in place at the beginning of the 1990s had an even longer-term perspective – it concerned students from secondary level to postdoc.

The first program of this kind was organized in spring 1990 and involved undergraduates.¹⁴⁶ Students could participate to one of the research programs held by the institute, or spend a study period under the guidance of an SFI member.¹⁴⁷

In 1991, the institute opened up the possibility to PhD candidates to write their thesis under the supervision of one of its members.¹⁴⁸ In 2002, the program was financed by

¹⁴⁰ Ibid., p. 14.

¹⁴¹ Interview with Daniel Stein, 8 September 2016.

¹⁴² When using different sources (CSSS, research projects, interviews, and international conferences), one can dress the following list of the most common tools of complexity science: 1. Dynamical systems, fractals and chaos; 2. Cellular automata; 3. Statistical physics; 4. Spin glasses; 5. Neuronal networks; 6. Genetic networks; 7. Network theory; 8. Graph theory; 9. Agent-based models; 10. Self-organized criticality; 10. Genetic algorithms; 11. Game theory; 12. Machine learning; 13. Statistical tools for Big Data.

¹⁴³ SFI, “Santa Fe Institute 2010 Annual Report,” (2010), p. 14.

¹⁴⁴ SFI, “The Bulletin of the Santa Fe Institute,” 16, 1 (2001), p. 27; SFI, “The Bulletin of the Santa Fe Institute,” 20, 1 (2005), p. 12; SFI, “Santa Fe Institute 2008 Annual Report,” (2008), p. 17.

¹⁴⁵ SFI, “Santa Fe Institute 2012 Annual Report,” (2012), p. 12.

¹⁴⁶ SFI, “The Bulletin of the Santa Fe Institute,” 5, 1 (1990), p. 17.

¹⁴⁷ Ibid.

¹⁴⁸ SFI, “The Bulletin of the Santa Fe Institute,” 6, 1 (1991), p. 17.

the NSF and gave freedom to candidates to choose their topic. The latter had to spend two months and a half in residence.¹⁴⁹

The postdoctoral device started in 1989 and used to last one to three years.”¹⁵⁰ eBay’s founder Pierre Omidyar became one of the strongest supporters of SFI postdocs. Besides his gifts to the institute and his participation to the Board of Trustees, Omidyar implemented in 2008 a funding program for some postdoctoral scholarships for which candidates can freely choose their topic¹⁵¹ and are supposed to become complexity science ambassadors.¹⁵²

During 1992-1993, the SFI launched its first education program in high schools.¹⁵³ With the support of a grant from the Pinewood Foundation, around sixty students from all Santa Fe high schools participated into a cycle of conferences held by a few members of the research center. The one hour and a half meetings were organized once a month and scheduled a question-time to answer students’ interrogations. Another device started in 1998 and lasted several years. It implied the usage of agent-based models in order to teach students the basis of coding and a decentralized way of thinking.¹⁵⁴

Some years later, the SFI extended its pedagogical activities into secondary level schools and deployed resources to form hundreds of teachers to the usage of computational tools so that they could transmit SFI’s approach to 6-12 years old children. The program was called the “New Mexico Adventures in Modeling.”¹⁵⁵ In the light of the political interest for STEM, the SFI anticipated that complexity sciences would become pivotal in the XXI century.¹⁵⁶

The role of integrative workshops

The integrative workshops have represented the sole activity of the institute until 1986 and are still organized today. Halfway between a conference and a summer school, this kind of event can last one or two weeks, and gather two to three dozen participants. Each attendant is a speaker and contributes by teaching – during a brainstorming phase – the others members how the chosen study object is approached in his/her discipline. In the phase of synthesis, attendants propose possible bridges between different disciplines.¹⁵⁷

¹⁴⁹ SFI, “The Bulletin of the Santa Fe Institute,” 17, 1 (2002), p. 15.

¹⁵⁰ SFI, “The Bulletin of the Santa Fe Institute,” 11, 1 (1995-1996), p. 16.

¹⁵¹ SFI, “The Bulletin of the Santa Fe Institute,” 24, (2009), p. 51.

¹⁵² SFI, “Santa Fe Institute 2010 Annual Report,” (2010), p. 9.

¹⁵³ SFI, “The Bulletin of the Santa Fe Institute,” 7, 2 (1992), p. 34.

¹⁵⁴ SFI, “The Bulletin of the Santa Fe Institute,” 13, 2 (1998), p. 3.

¹⁵⁵ SFI, “The Bulletin of the Santa Fe Institute,” 19, 1 (2004), p. 7.

¹⁵⁶ SFI, “The Bulletin of the Santa Fe Institute,” 24 (2009), p. 42.

¹⁵⁷ SFI, “The Bulletin of the Santa Fe Institute,” 5, 1 (1990), p. 10.

Since its first research projects in 1986, the SFI claimed to work on “complex adaptive systems” or CAS, in reference to the evolutive aspect of living and social systems. The founding workshop of CAS was held in 1986 with the support of the Alfred Sloan Foundation.¹⁵⁸ If until the mid-1990s the integration was mainly sought for building a general theory of complexity, after Horgan disruptive article and under Goldberg’s presidency the interdisciplinary efforts were redirected toward local general theories.¹⁵⁹ Some workshops in particular contributed to provide visibility to the institute. It is the case of the 1987 meeting between physicists and economists entitled “Founding workshop on Evolutionary Paths of the Global Economy.”¹⁶⁰

More or less multidisciplinary, such workshops have covered a vast array of subjects and, as soon as the institute arrived at full speed, they were organized in more than twenty per year.¹⁶¹ They have been the place to weave collaborations, establish new fields of research and specialties, and contribute to create the myth of the SFI as an open-minded and stimulant intellectual environment.¹⁶²

The role of scientific journals

To found a new domain, it is not possible to prescind from the creation of a scientific journal. In 1990, Simmons announced the foundation of *Complexity. An International Journal of Complex and Adaptive Systems*.¹⁶³ The first editorial director was biologist Harold Morowitz. Mathematician John Casti assisted him as executive editor.¹⁶⁴ Simmons explained the reason of the journal as follows: “Even as complexity is emerging as a new field of research, it is in danger of fragmenting into a number of disjoint subfields that will not communicate adequately with each other because each will be served by its own specialized journals.”¹⁶⁵ *Complexity* was conceived as a space of integration between different models in the perspective of founding a common theory of complex systems. Firstly published in 1995 by John Wiley, it was conceived as a trimestral, international, and electronic journal. But it never benefitted of great visibility and reputation, especially in the light of the abandonment of the project of an integrated theory of complex systems by the SFI itself after Horgan’s article. Several of my interviewees explained me they prefer to publish their best articles in traditional disciplinary journals, which also have higher impact factors.

¹⁵⁸ SFI, “The Bulletin of the Santa Fe Institute,” 9, 2 (1994), p. 16.

¹⁵⁹ George Cowan, *Complexity. Metaphors, Models, And Reality* (Boston: Addison Wesley, 1994); SFI, “The Bulletin of the Santa Fe Institute,” 12, 2 (1997), p. 7.

¹⁶⁰ SFI, “The Bulletin of the Santa Fe Institute,” 1, 1 (1986), p. 12; SFI, “The Bulletin of the Santa Fe Institute,” 16, 1 (2001), p. 24.

¹⁶¹ SFI, “Santa Fe Institute 2007 Annual Report,” (2007), p. 2.

¹⁶² SFI, “The Bulletin of the Santa Fe Institute,” 8, 2 (1993), p. 30.

¹⁶³ SFI, “The Bulletin of the Santa Fe Institute,” 5, 1 (1990), p. 11.

¹⁶⁴ SFI, “The Bulletin of the Santa Fe Institute,” 9, 1 (1994), p. 3.

¹⁶⁵ SFI, “The Bulletin of the Santa Fe Institute,” 6, 2 (1991), p. 17.

The role of prizes and rewards

Yet another strategy to make a field exist is to create specific awards that compensate people working in it, but complexity prizes are very rare in academia.¹⁶⁶ Once more, the SFI has thus leaned on the symbolic capital of other disciplines prizes. That is why in the course of the Bulletin issues, the institute celebrated all its members awards (prizes to the career or for the best article, medals, nominations to the National Academy of Science, scholarships, simple marks of esteem from a newspaper, etc.).¹⁶⁷ The *conditio sine qua non* for scientists to appear in there was their belonging to the institute, not the fact of being prized for research in complexity science.¹⁶⁸

In Bourdieu's terms, this operation can be seen as a form of *capital conversion*: scientists' symbolic capital gained in more traditional frontiers of science has been used to legitimize SFI and its science through a sort of mirror effect.

Conclusion and discussion

There are roughly two phases in the history of complexity sciences. The first one (1984-1995) saw the first members living in the margins of the scientific field, in the shadow of SFI's *Senior Fellows* scientific capital and objective of a general theory of complex systems. In this phase, the domain benefitted of an important mediatic exposition, until Horgan's article. The second one (1995-today) saw the domain regaining in momentum and credibility, thanks to the more sober profile of its exponents, the eviction from the SFI of some of the most hyping scientists, as well as the scientific and mediatic rise of network theory – which largely contributed to the appearance of complex systems institutes and calls for projects in Europe, Asia, and Australia between 2005 and 2015.¹⁶⁹

But if “[t]he central function of the institutionalization of the disciplinary community consists in preserving the permanence of the disciplinary activity through *reproduction* of its potential,”¹⁷⁰ then complexity sciences cannot be considered as a discipline. They have a social existence only in some institutes and in very few, anecdotal, and heterogeneous degree courses, summer schools, masters, and PhDs. At the same time, complexity specialists still have theoretical affinities, show reciprocal acknowledgements, weave research collaborations, and meet in complexity

¹⁶⁶ One is conferred by the Institute for Scientific Interchange in Turin (Italy): https://en.wikipedia.org/wiki/Lagrange_Prize.

¹⁶⁷ SFI, “The Bulletin of the Santa Fe Institute,” 15, 2 (2000), p. 24; SFI, “The Bulletin of the Santa Fe Institute,” 17, 1 (2002), p. 22; SFI, “The Bulletin of the Santa Fe Institute,” 22, 1 (2007), p. 0.

¹⁶⁸ SFI, “The Bulletin of the Santa Fe Institute,” 8, 2 (1993), p. 10.

¹⁶⁹ If one has a look at the some dozens complexity institutes in the world, s/he will notice that most of them focus mainly or exclusively on network theory and statistical physics.

¹⁷⁰ Guntau and Latkau, “On the origins and Nature of Scientific Disciplines,” p. 21.

conferences. After a golden age – lasted from the 2000s to the beginning of the 2010s – of funding dispensed in the US, Europe, Asia, and Australia by public authorities with the aim of developing complexity sciences, these have never managed to create the conditions of their autonomous reproduction. While they continue to have some kind of socio-epistemic existence, it is clear they live in the interstices and in an intermittent fashion.¹⁷¹ Complexity sciences appear as a second, non-essential skin to researchers that revendicate them. Such a secondary existence is typically shown by the fact that researchers’ inscription in the domain comes – if it comes at all – at the second, third or fourth place in their CVs and self-presentations. Also, while industries, banks, and administrations do hire *data scientists*, the jobs of *complexity scientist* are, as far as I know, more unique than rare.

What kind of sociological object are then complexity sciences? In the light of the material exposed in this article, this domain looks like a peculiar kind of meeting space and promissory discourse about interdisciplinarity. Complexity sciences can be defined as an association of fledgling and/or marginalized specialties which ally under the same label – sharing the same tools and views¹⁷² – in order to reach common or similar scientific and institutional objectives. They can be described as a “conglomerate” more than a stable, unique, and coherent entity.¹⁷³ They indeed configure as a socio-epistemic space whose unity is loose enough to embrace variable and pluralistic theories and practices, with the aim of providing a temporary refuge or a perennial home to scientists who may be hardly classable. Domains like complexity sciences perhaps need to be qualified with a new specific term. May this be the object of a forthcoming work.

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¹⁷¹ Even if, as a computational complexity specialist from the SFI told me, “The current culture as I’ve been told by [the current president] David [Krakuer] is that there is no upper bond [to the residency at the institute] if you are still very active and very productive:” interview with Cristopher Moore, 28 September 2016.

¹⁷² Fabrizio Li Vigni, “Le projet épistémique des sciences des systèmes complexes,” *Philosophia scientiæ*, 24, 1 (2020).

¹⁷³ Ioana Popa, “L’attrait d’un label souple. Les ‘aires culturelles’ au prisme des programmes d’enseignement supérieur français après la Seconde Guerre mondiale,” *Revue d’anthropologie des connaissances*, 13, 13-1 (2019).