

Chapter 10

Cultural and Biological Evolution



Although there is no necessary relation between “big data” and “monism”—the program of reducing cultural and mental processes to computational and biological principles—both these programs reject a dualism between *res extensa* and *res cogitans*. Opposing this philosophy of science, I have argued in the above chapter that a second contingency of possible relations and expectations feeds back on the manifest relations. This second contingency cannot be studied from a natural-science or life-sciences perspective, but is the proper domain of the social sciences, where the focus is on what things *mean* as different from what they *are*. Next-order selection mechanisms can take evolutionary control. The complexity of the communication evolves against the arrow of time in terms of interacting codes, which generate redundancies and therefore new options. As human beings, we can follow the potentially unintended consequences of the communication dynamics reflexively. Both consciousness and communication are self-organizing and thus resilient against steering.

10.1 Monism versus Dualism

In his book *Descartes' Error*, Antonio Damasio (1994) made an argument for monism. In this author's opinion, Descartes' statement *Cogito ergo sum* (“I think therefore I am”) has been a major source of error in Western philosophy. Damasio formulated as follows: Taken literally, the statement illustrates precisely the opposite of what I believe to be true about the origins of mind and about the relation between mind and body” (p. 245).

Although there is no necessary relation between “big data” and “monism”—the program of reducing cultural and mental processes to computational and biological principles—both these programs reject a Cartesian dualism between *res extensa* and *res cogitans*. In a paper entitled “The End of Theory,” Anderson (2008), for example, formulated the program of “big data” as follows:

This chapter is partly based on: Leydesdorff, L., & Hoegl, F. (2020). The Evolutionary Dynamics of Expectations: Interactions among Codes in Inter-Human Communications. *Biosystems*, 198, 104236. <https://doi.org/10.1016/j.biosystems.2020.104236>

This is a world where massive amounts of data and applied mathematics replace every other tool that might be brought to bear. Out with every theory of human behavior, from linguistics to sociology. Forget taxonomy, ontology, and psychology. Who knows why people do what they do? The point is they do it, and we can track and measure it with unprecedented fidelity. With enough data, the numbers speak for themselves.

In a similar spirit—but with another methodology—Ramstead, Badcock, and Friston (2017), for example, presented “a hierarchical multiscale free energy formulation [...] that offers the sciences of life, mind, behaviour and society with a principled, computationally tractable guide to discovery” (p. 13). In this ontology, the system levels self-organize into a hierarchy. *Homo sapiens sapiens* is then placed at the top of this hierarchy as “the world’s most complex living system.” Humans are said to generate “(epi)genetically-specified expectations that have been shaped by selection to guide action-perception cycles toward adaptive or unsurprising states” (p. 12; cf. Leydesdorff, 2018).

These various authors have in common that their program is to *reduce* cultural phenomena to biological and computational principles (Porankiewicz-Żukowska, 2017). My argument in this study has been that the exchanges of and interactions among expectations are *not* epi-genetic, but shape a cultural layer with a dynamic operating as a feedback on the (human) carriers of this cultural evolution. Unlike biological evolution which follows the entropy flow, codes in the communication can generate redundancies; for example, by refining distinctions. In this model, however, humans are not at the top of “the” hierarchy, but can function as infra-reflexive linchpins among hierarchies and heterarchies of variably codified communications. Not *Homo sapiens sapiens* but the complexity of the communication among humans is further evolving in terms of new recombinations and differentiations among codes.

10.1.1 *Descartes’ Error*

In my opinion, Damasio’s rejection of *Cogito ergo sum* in favor of monism is based on a misreading of Descartes (cf. Gluck, 2007). This misreading, however, is more wide-spread: the sociologist Schutz (1975, at p. 82), for example, criticized Husserl’s ([1929] 1960) *Cartesian Meditations* in a similar vein, as follows:

[...] As a result of these considerations we must conclude that Husserl’s attempt to account for the constitution of transcendental intersubjectivity in terms of operations of the consciousness of the transcendental ego has not succeeded. [...] As long as man is born of woman, intersubjectivity and the we-relationship will be the foundation for all other categories of human existence. The possibility of reflection on the self, discovery of the ego, capacity for performing any epoch, and the possibility of all communication and of establishing a communicative surrounding world as well, are founded on the primal experience of the we-relationship.

Schutz (1975, p. 72) opposed Husserl's position that all communication is constituted by communication. Schutz argued that the "we-relationship" remains fundamental. In other words, one can consider Schutz's (micro-)foundation as existential—grounded in relations—whereas Husserl grounded intentionality in interpersonal expectations.

In my opinion, both Schutz and Damasio misread Descartes from a present-day perspective: the words are provided with empirical meanings that are different from their philosophical meanings at the time. Descartes did not wish to make an empirical inference about thinking and being, or the genesis of consciousness in the mother-child ("we"-)relationship. *Cogito ergo sum* is meant to be the formulation of a "first principle" in Descartes' philosophy. Although Damasio (1994) mentioned this alternative interpretation as possible (at p. 249), he did not elaborate on it.

Descartes (1637) specified *Cogito ergo sum* in *Discourse on Method* (Part 4), and formulated as a conclusion¹:

[...] the mind by which I am what I am, is wholly distinct from the body, and is even more easily known than the latter, and is such that even if the latter were not, it would still continue to be all that it is."

The "mind by which I am what I am" is not an empirical subject of study, but a philosophical grounding which "is even more easily known" than the body, because the body can be an empirical object of study. *Cogito*, however, is not empirical; it belongs as a first principle to what the Greek philosophers characterized as "the mathematical." *Cogito ergo sum* is a statement with a status similar to "two plus two is four" (cf. Hoegl, 2003). The statement can be made on the basis of a priori reasoning. Heidegger ([1962], 1970, p. 70), for example, explained the text as follows:²

The formula [...] "*Cogito ergo sum*" suggests the misunderstanding that it is here a question of inference. That is not the case and cannot be so, because this conclusion would have to have as its major premise: *Id quod cogitat, est*—"that which thinks, exists." [...] Descartes himself emphasizes that no inference is present. The *sum* is not a consequence of the thinking, but vice versa; it is the ground of thinking, the *fundamentum*. In the essence of positing lies the proposition: I posit. [...] The I is the *subjectum* of the very first principle. Before Descartes everything present-at-hand for itself was a "subject"; but now the "I" becomes the special subject, that with regard to which all the remaining things first determine themselves as such. ([at p. 82], p. 69f.)

Descartes' ontological proof of the existence of God became unconvincing with the further development of the sciences, epistemology, and the precursors of the philosophy of science in the course of the eighteenth and nineteenth centuries. As noted in Chap. 9, Kant concluded that one can remain agnostic about the existence of God or a transcendental reality. However, one cannot remain indifferent in one's relations to others. The relation of *Ego* to other human beings is discussed by Kant (1788) in the *Critique of Practical Reason* from an ethical and moral perspective.

¹https://www.literatureproject.com/discourse-reason/discourse-reason_4.htm. I have used this translation with minor changes.

²On the moral issue of using Heidegger's writings, see, for example, Bernstein (1995, pp. 79–141).

10.2 The Secularization of Alter

Can the contingent *relations* with *Alter* as “another human being” offer an alternative foundation of *Ego*? Can “God” be replaced with “intersubjective intentionality”? By thus secularizing the transcendental relation to God into expectations of contingent relations with other human beings, the domain which transcends the individual becomes a *second contingency* in which human beings provide meanings to things and events.

As against the study of behavior in the first contingency, interactions of judgements and expectations in the second contingency are not directly observable. However, these second-order relations can be expected to leave observable effects in the first contingency, such as cultural artefacts. In the first contingency one can touch, feel, observe, and directly relate to other human beings. In the second, one provides meanings by *partaking* in the social (re)construction of meanings among humans.

Meanings can be expected to loop in cycles on top of the entropy flow. The two contingencies can operate in parallel or in an intermingled process; the repetition in the loops can be expected to generate redundancy, and thus span another domain. A number of authors from approximately 1900 onwards (Durkheim, Freud, and others) began to formulate theories about the social as a qualitatively different domain. The constitutive role of the *Other* in the shaping of the *I* was elaborated, for example, by the American pragmatists. George Herbert Mead (1934), for example, formulated as follows:

If one is to speak of a transcendental “consciousness in general,” if I, this singular, individual ego, cannot be the bearer of the nature-constituting understanding, must I not ask how I can have, beyond my individual self-consciousness, a general, a transcendental-intersubjective consciousness? The consciousness of intersubjectivity, then, must become a transcendental problem; but again, it is not apparent how it can become that except through an interrogation of myself, [one that appeals to] inner experience, i.e., in order to discover the manners of consciousness through which I attain and have others and a fellow mankind in general, and in order to understand the fact that I can distinguish, in myself, between myself and others and can confer upon them the sense of being “of my kind.”

In my opinion, this second contingency of expectations is *the proper domain of the social sciences and humanities*. In parallel with investigating events in the natural and life-sciences, one can always ask “what do things mean?” Attempts to make this domain the subject of the natural and life sciences in the name of ideals such as “the unity of science,” “monism,” or a “grand synthesis” tend to reduce the social sciences to a relatively irrelevant commentary to the “real” world of science and “hard” scientific facts. On the basis of the philosophical a priori of “monism” and “big data,” the social sciences would no longer be developed as theoretical research programs in their own right; our knowledge about the dynamics of expectations would then remain poorly developed. Accordingly, policy advice about the knowledge-based economy would be based on political economy instead of a model with requisite variety (Ashby, 1958).

10.3 Habermas' Knowledge Interests

The discussion about monism repeats in many respects the older one about positivism (e.g., Adorno et al. 1970; Popper, 1959 [1935]). As mentioned in Chap. 1, Habermas (1968b), for example, distinguished among *three* epistemologically different knowledge interests: (i) the *technological* one of the natural sciences, (ii) the historical-hermeneutical one of *understanding* in the humanities, and (iii) an *emancipatory* interest in social change on the basis of reflection and critique. According to Habermas, one would expect scholars working in these three domains to develop different criteria for “objectivity,” namely: nomothetical, hermeneutic, and ideology-critical, respectively.

The Habermas-Luhmann discussion in the early 1970s made clear (at least to me) that the three epistemic domains of science were not yet properly specified by Habermas (1968a; 1971a and b). While the historical perspective is embedded and its method accordingly hermeneutic, the critical position is potentially *disruptive*. “Critical” refers to “crisis:” the crisis makes it necessary to revise.

The distinction between the second and third knowledge interests can also be framed in terms of historicism *versus* the commitment to value-freeness (e.g., Popper, 1967; Weber, 1917). Value-freeness serves the analysis of values because the analyst avoids an a priori commitment to the values of the subject(s) under study. This distancing does not imply a reduction to explaining behavior; “understanding” (*Verstehen*) can be methodologically secured by value-freeness. Without commitment to value-freeness, “understanding” tends to engagement with the normative and historical perspectives of the subjects under study, and thus to be subjective.

The third (emancipatory) interest is based on distancing oneself from the historical givens on the basis of reflection and reasoning, and is thus part of the second layer of Giddens' so-called “double hermeneutics.” The analytical discourse is theoretically constructed as a system of rationalized expectations feeding back on the communications under study. The substantive and the reconstructing layer can couple on each other. However, these couplings are empirical and thus leave room for empirical research in science and technology studies. The expectation is that the sciences are in important respects different from each other. This includes differences in the relevant couplings with professional practices (Whitley, 1984).

In sum, I suggest reading Habermas—despite his intentions at the time—as committed to values and operating in an historical-hermeneutical approach. The Habermas of the debate in the 1970s was still committed to the neo-Marxist values of the Frankfurter Schule (Horkheimer & Adorno, [1947], 1969). In his later theory of communicative action (Habermas [1981], 1987), other commitments such as unrestricted discussion (“*herrschaftsfreie Diskussion von allen mit allen*”) became normative objectives of the theorizing, leading eventually to a discussion with Pope Benedikt XVI (Benedikt XVI & Habermas, 2006).

Despite his aversion to formal methodology and statistical testing, Luhmann, however, sided with an analytical approach against historicism; for example, he formulated that “[science] cannot offer basic principles, arguments or even certainty.

It can no longer be understood as a theory of the founding of knowledge. The opposite is true: it analyzes the uncertainty of knowledge and gives reasons for it” (Luhmann, 1990a, at p. 81). From this perspective, organized knowledge production does *not* have binding implications, whereas the critique of the technocratic implications of systemic developments was crucial and normatively binding, for example, in Habermas’ (1968b) critique of Marcuse’s (1964) book *One-Dimensional Man*.

Both approaches—historical-hermeneutical understanding and a commitment to value-freeness—go back to Weber, but the commitment to value-freeness is central to Weber’s epistemology of the social sciences; this commitment drives the differentiation between scholarly and normative discourses in social theory. This distinction and the corresponding one between cognitive and normative learning by the carrying agents can be considered as the *differentia specifica* of a cultural evolution that is knowledge-based.

10.4 Meta-Biology and Reification

More than a decade after the Habermas-Luhmann discussion, Habermas (1987) returned to this debate with the argument that Luhmann’s (1984) *magnum opus* had made clear to him that social-systems theory can be considered as a meta-biology. Habermas commented as follows:

In this way, subject-centered reason is replaced by systems rationality. As a result, the critique of reason carried out as a critique of metaphysics and a critique of power, which we have considered in these lectures, is deprived of its object. To the degree that systems theory does not merely make its specific disciplinary contribution within the system of the sciences but also penetrates the lifeworld with its claim to universality, it replaces metaphysical background convictions with metabiological ones. (p. 385).

Following Gumbrecht’s (2006) distinction between Luhman I, II, and III (see Chap. 1), this critique addresses “Luhmann II” as the author of the (1984, 1995) book entitled *Soziale Systeme: Grundriß einer allgemeinen Theorie* [Social Systems: Foundations of a General Theory]. At the time of the discussion between Habermas and Luhmann in the early 1970s, however, “Luhmann I” (1971) made an argument for distinguishing between “meaning” and “information.” Luhmann proposed “meaning” as the basic concept of sociology, when formulating as follows:

What one person takes for granted might be surprising to someone else; and the same is true across time: a book that today is hard to understand and full of needlessly complicated sentences may seem quite informative tomorrow.

In my opinion, this program of studies is dualistic, since a dynamic of understanding (“meaning”) is distinguished from the dynamics of the historical events (“information”). However, Habermas’ (1987) characterization of Luhmann’s work as “metabiology” was a reaction to Luhmann II’s (1984) book which opened upfront by stating the assumption *daß es Systeme gibt* (1984, p. 30; 1995, p. 12). From this perspective, biological, psychological, sociological, and organizational theories of

autopoiesis were considered as species of a *general theory of autopoietic systems* (Luhmann, 1984, p. 16; 1995, p. 2),³ and an evolutionary tree was sketched as a hierarchy among them.⁴

A decade later (that is, after 1990), Luhmann III argued that his general theory could be grounded in a theory of “observation” based on Spencer Brown’s (1978) *Laws of Form*. In my opinion, this argument contains a number of steps which are problematic.

1. Spencer-Brown’s *Laws of Form* is a mathematical study. The laws of form therefore are content-free (as is “information” in Shannon’s mathematical theory of communication; cf. Baecker, 2017). On the last page (p. 76) of this study, however, Spencer Brown formulated as an implication and example that “an observer, since he distinguishes the space he occupies, is also a mark.” Whereas an observer can be considered as a mark, not all marks are also observations. For example, a predator observes its prey by distinguishing and identifying it. As against biology, however, a distinction that is identified in a discourse specifies only *an observational category*. The value of the observation has still to be determined empirically, for example, by measurement (De Zeeuw, 1993). In other words, by identifying a distinction only an *expectation* is specified, but not yet an observation. Since empty, the new boxes add only to the redundancy.
2. The biologist Maturana (1978) stated explicitly that his studies of “the biology of language and knowledge” focus on *observable “linguaging” as behavior* and not on the content of *what* is communicated. Human language, in Maturana’s opinion, is used by “super-observers” (1978, pp. 56f; cf. Maturana, 2000), who are able to take part in a scientific discourse that is *different from* the biological communications under study such as among “linguaging” monkeys, ants, or whales.⁵ Maturana could thus avoid having to argue at the meta-biological level of sociology.

When the communications under study are human, reflexive participants and analysts are able to change roles. This “double hermeneutics” is specific for the study of inter-human interactions (Giddens, 1976, at p. 162). When sociology is reduced to a meta-biology studying observables without the surplus of theoretical understanding, however, the surplus of the social sciences, that is, the study of this *double hermeneutics* and therefore the option to translate meanings among discourses, is lost; the communicative translation is reduced to action.

Biological metaphors are not only misplaced but potentially confusing; the sociological finesse in distinguishing among texts and subtexts disappears. For example, these metaphors may lead to research designs in which observations and expectations are no longer clearly distinguished. Furthermore, the application of biological theory to social systems in “social Darwinism” and socio-biology has historically been a

³A general theory of social systems was suggested by Luhmann (1981).

⁴This tree was further elaborated in Luhmann (1986a, b, pp. 172f.).

⁵Dodig-Crnkovic (2014) argues that theoretical biology has nowadays reflexively abandoned the focus on observing in favor of computational modelling of the construction.

disaster. In the German context, Habermas' critique using the attribution of "meta-biological" is almost offensive. As noted in Chap. 1, Giddens (1984, at p. xxxvii) stated that he deemed it "necessary to repudiate the newer versions of Parsonianism," including both Habermas and Luhmann, for similar reasons. The noted risk of an invocation of "magical explanatory properties of social reproduction" is based on a meta-biological reading of these authors.

Undoubtedly aware of these critiques, it is somewhat surprising that Luhmann never⁶ problematized the abuse of biological metaphors in Nazi Germany (e.g., Weingart, Kroll, & Bayertz, 1988).⁷

10.5 Towards a Calculus of Redundancy

In an email to the list of the American Cybernetics Society, Krippendorff (9 June 2010) distanced himself from systems theory as a theory of everything with roots in biology; he claimed another *epistemology* for cybernetics (Ashby, 1947), when he formulated as follows:

[...] cybernetics starts with conceptualizing all possible systems, *regardless of whether they exist*, and it is informed when some of them cannot be built or found in nature. [...] Conceptualizing all possible systems before enacting some of them implies both creativity and action in a circular relationship. [...] Cybernetics paints a reflexive picture of the world of active participants, not of a holistic system of subsystems. (italics added, L.)

Cybernetic models are content-free; they allow for translating models developed in one substantive domain into another as *hypotheses*. On the basis of specific hypotheses, observations can corroborate the assumptions. In other words: analytical distinctions have priority, and the hypothetical status of knowledge remains assumed. As Popper (1972, pp. 259f.) put it: "observation comes after expectation or hypothesis."

The empty boxes generated by distinctions add redundancy to the maximum capacity. The empty boxes can be filled with values on the basis of observations. In his book *Incomplete Nature*, Deacon (2012, at p. 3) called for a focus on the zeros:

What is absent matters, and yet our current understanding of the physical universe suggests that it should not. A causal role for absence seems to be absent from the natural sciences.

[...] This something-not-there permeates and organizes what is physically present in these phenomena. Its absent mode of existence, so to speak, is at most only a potentiality, a placeholder. [...] Zero is the paradigm example of such a placeholder. (p. 10.)

⁶The exception are some statements about antisemitism in interviews (Klaus Dammann, *personal communication*, 8 November 2019; cf. Dammann, 2014, p. 171). Of course, the issue is sensitive.

⁷Luhmann was obliged to enlist the Hitlerjugend in 1944 at the age of 17. Before that date, he applied (perhaps non-voluntarily) for membership in the NSDAP with the number 9935113, 20 April 1944; that is, on the occasion of Hitler's 55th birthday (*Der Spiegel*, 25 July 2007, pp. 134 f.; Dammann, forthcoming).

The biologist Ulanowicz (2014) argued that the *apophysis* (A)—redundancy—cannot teach us anything about historical events. A biological system with more options than are realized ($A > D$) is vulnerable to perturbations to the extent that a catastrophe would be unavoidable (Ulanowicz, 2014, p. 26; see also Ulanowicz, 1986, p. 92). In my opinion, the codes in the communication provide support to psychological and social systems and enable them to operate with volatility “at the edge of chaos” on top of biological systems such as bodies and populations.

Unlike biological systems, systems of expectations do not need to be materialized. Reflexivity can provide these systems with other types of operation (e.g., incursivity; see Chap. 8) and next-order buffering capacities (hyper-incursivity) so that their identities can be maintained beyond the historically observable stability or instabilities. Whereas psychological (action) systems are supported by their carrying bodies, the codes in inter-human communications provide additional stability by structuring the communications from above (at the supra-individual level). The codes refer to horizons of meaning. Beyond stabilization in history, globalization can operate as a selection mechanism in a regime of expectations.

Ulanowicz’s “*apophysis* minus *didactics*” ($\Phi = D - A$) can perhaps be considered as another formulation of the trade-off between information and redundancy generation discussed as the Triple-Helix indicator in Chaps. 4–7. However, I have taken these programmatic statements further by proposing a calculus of redundancy in analogy to Shannon’s (1948) calculus of information (Bar-Hillel, 1955). Against the idea that the zeros and the missing cases are not informative, I submit that the social sciences not only construct the empty boxes and fill out the zeros by specifying values; they can also provide us with insight into the potentially negative values of the intangibles that organize our understandings into discourses.

10.6 Consequences for Evolutionary Economics

When selection is no longer considered as “natural selection,” selection mechanisms have to be specified on theoretical grounds. Case descriptions by historians—or, in the terminology of evolutionary economics, “stylized facts” (e.g., Malerba, Nelson, Orsenigo, & Winter, 1999)—and indicators generated in quantitative science and technology studies provide mainly descriptive statistics. However, one is not allowed to infer from observable variation to selection mechanisms.

The specification of selection mechanisms other than the market has been central to evolutionary economics. Nelson and Winter (1977, 1982) first specified the interactions between market and non-market selection environments. In these models, however, selections are made by agents (firms) who are bounded by the rationality of the selection environments (Alchian, 1950; Simon, 1955). If the firms themselves were selecting as agency, however, a theory of the firm would eventually be the unavoidable result (Casson, 1997). In other words, Nelson and Winter (1982) did not specify selection mechanisms, but the selection *environments* of firms.

With a reference to Hayami and Ruttan (1970), Nelson and Winter (1982, pp. 258f.) distinguished these selection environments as production functions at the trajectory level from meta-production functions at the regime level. In their earlier article entitled “In Search of a Useful Theory of Innovations,” Nelson and Winter (1977, p. 49) had taken this broader perspective and distinguished between structures on the technological side (such as trajectories and regimes) *versus* selection environments, as follows:

We are attempting to build conformable sub-theories of the processes that lead up to a new technology ready for trial use, and of what we call the selection environment that takes the flow of innovations as given. (Of course, there are important feedbacks.)

In my opinion, the feedbacks, which were literally bracketed in the above quotation, can be elaborated into a hitherto missing third selection dynamic of communication-based translations and controls. I argued in Chap. 5 how recombinations among differently codified communications can transform political economies into knowledge-based ones (Arthur, 2009). Instead of endogenizing the hypothesized feedbacks into their theory—as was originally the intention—these authors put the knowledge-based transformations between brackets—as an external given—and eventually formulated normative policy-oriented instead of theoretical conclusions. For example, as follows:

We have put forth the proposition that underlying natural trajectories there is a certain body of knowledge that makes the traverse relatively easy, and that in the recent half century formal science has been an important part of that knowledge. The *key question* then becomes: to what extent are the directions in which science advances inevitable, and to what extent can these be molded by conscious policy. (p. 73; italics added, L)

In a critique of these “post-Schumpeterian contributions,” Andersen (1994, pp. 188f.) argued that the main and largely unresolved question remains to specify “What evolves?”

The question (of “what evolves,” L.) is so important that we repeat it in an unforgettable way which is recorded by Boulding, a contributor to post-war non-formalized evolutionary economics, who got fascinated by Schumpeter and economic evolution while he was a pre-war student at Oxford University:

My Oxford philosophy tutor, who had the curious habit of crawling under the table while giving his tutorials, commented in a high British voice coming from underneath the table on a paper I had given on evolution, “It is all very well to talk about evolution, Mr. Boulding, but what evolves, what evolves, what evolves?” (Boulding, 1978, 33) [...]

Forty years after this conspicuous form of pedagogics, Boulding had a ‘glimmering’ of an answer: ‘What evolves is something very much like knowledge.’ (ibid.) While this answer is undoubtedly correct, it is also radically incomplete in relation to the development of an analysis of economic evolution. Especially, we would like to find an evolving substance which has a much less amorphous character than the common-sense kinds of ‘knowledge.’ To be able to give rise to an evolutionary process, the ‘thing’ we are studying should have an aspect of preservability, mutability and selectability.

I have argued in this study that *the complexity of the communication* evolves, and not the bounded rationality in the *behavior* of firms or other agency (Alchian, 1950).

Agents and their behavior are historical phenomena; they make choices and generate new variants. The bounded rationality of their decisions depends on their capacity to learn reflexively and recognize opportunities. However, evolution is taking place in terms of what is genotypically binding (the codes of the communication) and not in terms of variation phenotypically bounded by the codes (Hodgson & Knudsen, 2011). The coordination mechanisms of society have become knowledge-intensive and therefore increasingly transparent and available for reconstruction.

On the basis of the distinction between historically observable developments and the evolutionary dynamics in the background, I distinguished (in Chap. 5) two Triple-Helix variants (Eqs. 9.3 and 9.4): an entrepreneurial and a neo-evolutionary one. The entrepreneurial model shares with Nelson and Winter's models a focus on institutional arrangements and entrepreneurship. The neo-evolutionary Triple-Helix model of wealth generation in industry, novelty production in academia, and governance can be further specified as a manifold—in which synergies can be generated as a result of interactions among both horizontally and vertically differentiated communications. The relationship between innovation and entrepreneurship can be further analyzed from this evolutionary perspective.

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