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Mutualism and the Law of Comparative Advantage[1]

Abstract: This paper contributes to the clarification of the emergence of mutualistic relations by means of the Law of Comparative Advantage. Developed in economics and applied metaphorically in biology, this law expresses a typical course of behaviour such as that described in the Second Law of Thermodynamics. It can be conceived as a minutis rectis law and in analogy to the Second Law of Thermodynamics linked to sociology via Max Weber's position.

Keywords: Biological markets, Law of Comparative Advantage, Metaphor, Minutis rectis laws, Mutualism, Reductionism, Second Law of Thermodynamics, Symbiosis, Typicality, Max Weber

Mutualismus und das Gesetz des komparativen Kostenvorteils
Zusammenfassung: Dieses Papier trägt zur Klärung der Entstehung mutualistischer Beziehungen mit Hilfe des Gesetzes des komparativen Kostenvorteils bei. In der Ökonomie entwickelt und metaphorisch in die Biologie übertragen, bringt dieses Gesetz einen typischen Ablauf von Verhalten zum Ausdruck, wie jenen, den der Zweite Hauptsatz der Thermodynamik beschreibt. Es kann als minutis rectis-Gesetz bestimmt und in Analogie zum Zweiten Hauptsatz der Thermodynamik über Max Webers Position mit der Soziologie verknüpft werden.

Schlagwörter: Biologische Märkte, Gesetz des komparativen Kostenvorteils, Metapher, minutis rectis-Gesetze, Mutualismus, Reduktionismus, Symbiose, Typizität, Max Weber, Max, Zweiter Hauptsatz der Thermodynamik

Introduction

The aim of this special issue »Symbiosis as a Sociological Concept« involves a double challenge. This is firstly because the term »symbiosis« is not used uniformly; confusion across disciplines prevails here (Martin/Schwab 2012; 2013; Folkers/Opitz 2019). This is secondly because the term »sociological« is not used uniformly either; sociology is teeming with so-called »paradigms« (Kneer/Schroer 2009; Wagner 2013). We must therefore determine exactly what we want to understand by symbiosis and sociology.

As far as symbiosis is concerned, we can return to the very roots of symbiosis research. Albert Bernhard Frank introduced the term »*symbiotism*« into biology in 1877

1 This is the elaboration of a lecture I gave at the workshop »Symbiotic Collectives« at the University of Marburg on October 25, 2019. I would like to thank Andreas Folkers and Sven Opitz for giving me the invitation to resume earlier research (Wagner 1999). For suggestions and criticism thanks are due to the participants of the workshop as well as Nico Vorster and the editors and anonymous referees of the *ZTS*. Thanks also to Sharon Oranski for polishing my English.

because in his view the term »*parasitism*« commonly used was unsuitable for describing »all cases« of the »living together« of »two different species« (Frank 1877: 195). It is likely that he coined the term himself. Humanistically educated, he will have constructed it in imitation of the term »*parasitism*« from the ancient Greek *syn* or *sym* [before labial consonants such as b] (together) and *bios* (life) in order to produce the »broadest term«, which »does not yet take into account the role that both beings [...] play, i.e. is based on mere living together« (Frank 1877: 195; cf. Höxtermann/Mollenhauer 2007: 234).[2] »*Symbiotism*« was thus conceived as a generic term. Anton de Bary introduced the term »symbiosis« in 1878 (de Bary 1878). He defined it as a »living together of differently-named organisms« and differentiated it by spanning a range between parasitism and mutualism (de Bary 1879: 5).

Not all forms of this range can be considered in this article. We will therefore concentrate on *mutualisms* using the recent definition by Angela E. Douglas, that is, »persistent associations between organisms of different species from which all participants derive benefit« (Douglas 2015: 20). This decision is purely pragmatic. In mutualism research in biology, theories exist which are recommendable for our purpose inasmuch that they have been transferred from the social sciences.

In fact, symbiosis research has been working with metaphors from the interpersonal domain since its beginnings (Frank 1877). This also applies to the term »mutualism«, which has been used since the 1820s by labour movements and utopians such as Pierre Joseph Proudhon in their social concepts (Boucher 1985: 11–15; Sapp 1994: 17–18; Töpfer 2011: 432–434). Under the impression of the failure of the Paris Commune, Pierre Joseph van Beneden introduced it into biology in 1873 to describe the relationship between different organisms »which render to one another mutual services« (van Beneden 1873: 790; 1876: xxiv). It is remarkable how he shifted the »chevalier d'industrie«, leading the life of a »great nobleman«, into the vicinity of »pickpockets« and »brigands« in order to distinguish »relations of mutuality«, which are supposed to be found analogously in the non-human realm (van Beneden 1873: 783–785, 790; 1876: xvii-xviii, xxiv).

In recent times, market models have been transferred from the human to the non-human domain (Noë/Hammerstein 1994; 1995; Noë et al. 2001; Raguso 2008; cf. Akçay 2015). This is self-evident because the interactions that constitute mutualism consist by definition of the exchange of resources and services with costs and benefits for the participants. In addition, it is accepted that in the human domain it is a matter of actors from the same species, while in »biological markets« actors from different species are involved (Barker et al. 2017).

In this way, David Ricardo's Law of Comparative Advantage (LCA) has also been transferred from economics to biology in order to explain the emergence of mutualistic relationships in the plant and animal world (Ricardo 1817; Schwartz/Hoeksema 1998; Hoeksemsa/Schwartz 2001; 2003). Because Ricardo's law was empirically proven in eco-

2 Whether Frank knew the use of the term symbiosis in the political philosophy of Johannes Althusius published in 1603 (Althusius 1964) would still have to be clarified. On the topicality of Althusius see Vorster (2015).

nomics (Costinot/Donaldson 2012; Deardorff 2005) and the metaphorical transfer of this law into biology is empirically plausible (Kiers/van der Heijden 2006; Leigh 2010), we have before us a law which applies to interactions in both the human and the non-human domain.

Such a law ought to be of particular interest for developing a sociological concept of symbiosis, provided that »sociology« is understood in the sense of a science concerned with the formulation of laws. This is how Max Weber understood it (Weber 2004: 324-325; 2002: 9). His position corresponds with our purpose for two more reasons. Firstly, for him, laws from economics, such as »Gresham's law« that »bad money ousts better money«, were models for sociological laws (Weber 2009: 617, 626; 2004: 318, 324; 2002: 5, 9). Secondly, he anticipated an understanding of lawfulness that is a subject of the current philosophy of science debate.

In the following, we will first briefly explain the explanatory potential of metaphors, which symbiosis research has always claimed for itself and which we also want to claim. We will then present LCA in the fields of economics and biology and assign to it a version that corresponds to current philosophy of science and can be linked to sociology via Weber's position. Finally, some starting points for a closer treatment of the validity of this law in the field of sociology are mentioned.

1 The Interaction View of Metaphor

The most interesting metaphor theory for our purpose was formulated by Max Black (Black 1962; 1977). It is known as the »*interaction view*« and has become very influential. Arthur I. Miller used it to elucidate the connection between metaphors and scientific creativity (Miller 2000) and Mary Hesse to present an »explanatory function« of metaphors (Hesse 1966: 157–177).

Black conceived a metaphor as a statement with two components, e.g. »Man is a wolf« (Black 1962: 39-40): The first component – »man« – is the »principal subject« and the second – »wolf« – the »subsidiary subject«. We associate both components with »*commonplaces*«, which we talk about in literal terms. In a metaphor, commonplaces of the »subsidiary subject« are transferred to the »principal subject«. The »principal subject« is seen in the light of the »subsidiary subject«. This highlights certain properties and neglects others: »Any human traits that can without undue strain be talked about in ›wolf-language‹ will be rendered prominent, and any that cannot will be pushed into the background. The wolf-metaphor suppresses some details, emphasizes others – in short, *organizes* our view of man« (Black 1962: 41). This transfer also has consequences for the »subsidiary subject«: »If to call a man a wolf is to put him in a special light, we must not forget that the metaphor makes the wolf seem more human than he otherwise would« (Black 1962: 44). Because of this reciprocity, Black spoke of an »*interaction view* of metaphor« (Black 1962: 38).

Hesse adopted this approach (Hesse 1966: 157–158).[3] She too assumed a statement with two components – a »primary system« and a »secondary system« – which are used to associate ideas spoken about in »literal language« (Hesse 1966: 158–159). If ideas that belong to the secondary system are transferred to the primary system, a metaphor is created. A metaphor now has an »explanatory function« insofar as the primary system can be understood as the »explanandum« and the secondary system as the »explanans«. The transfer of ideas belonging to the secondary system to the primary system is a »metaphoric redescription of the domain of the explanandum« (Hesse 1966: 171). The basic idea is to use something more familiar to illuminate something less familiar, whereby that which is more familiar can be formulated in very different ways. The spectrum ranges from »observation language« to a »familiar theory« (Hesse 1966: 158).

Hesse argued that an arbitrary secondary system cannot be associated with a given primary system but instead only such systems can be associated between which an »antecedent similarity« in the sense of an »analogy« can be identified (Hesse 1966: 162). Black was more liberal in this respect because he also wanted to address cases where similarities are not immediately apparent: »It would be more illuminating […] to say that the metaphor creates the similarity than to say that it formulates some similarity antecedently existing« (Black 1962: 37).

Hesse explained her position using the example of »gas molecules« and »billiard balls«, where a similarity with regard to the properties »[m]otion and impact« can be seen, so that the knowledge about the behaviour of billiard balls, which is contained in the laws of mechanics, can be transferred to the behaviour of gas molecules (Hesse 1966: 8). It is less obvious that there is a similarity between the behaviour of gas molecules in a closed container and the occurrence of measurement errors when observing celestial bodies. Yet the theorem of the velocity distribution of gas molecules that enabled the formulation of the Second Law of Thermodynamics (SLT) is based on the transfer of knowledge from astronomy: »the velocities are distributed among the particles according to the same law as the errors are distributed among the observations« (Maxwell 1860: 23).

Black's position is more heuristically fruitful, as we will also see later when we associate the emergence of mutualistic relations in the human domain with the behaviour of gas molecules. However, Hesse also took heuristics into account. She differentiated between positive, negative and neutral analogies (Hesse 1966: 8-10). Positive analogies name similarities, e. g. properties of billiard balls like motion and impact which are also found in gas molecules. Negative analogies name differences, e. g. properties of billard balls like colours and numbers which are not suggested to be found in gas molecules. Neutral analogies name properties, where it is unknown at the beginning whether they are similarities or differences. They are heuristically most interesting.

3 A rough sketch of Hesse's theory is sufficient for our purpose. For more detail see Rentetzi (2005).

The Law of Comparative Advantage

Following on from the metaphor of »biological markets«, Mark W. Schwartz and Jason D. Hoeksema have shed light on the emergence of mutualistic relations in the non-human domain (primary system) by transferring LCA formulated by Ricardo for foreign trade (secondary system) from economics to biology (Schwartz/Hoeksema 1998; Hoeksemsa/Schwartz 2001; 2003). In fact, positive analogies are recognizable. Ricardo also wanted to explain the *emergence* of interactions and in both cases these interactions consist of an exchange of resources and services.

Ricardo explained the emergence of foreign trade relations with this »rule«: »Under a system of perfectly free commerce, each country naturally devotes its capital and labour to such employments as are most beneficial to each« (Ricardo 1817: 133). He based his explanation on a model in which two countries that do not have trade relations with each other produce the same units of two goods in the same time at different costs. England needs 100 workers to produce a particular unit of cloth and 120 workers to produce a particular unit of wine. Portugal needs 90 workers for the same unit of cloth and 80 workers for the same unit of wine. Assuming an equivalence in the production of the units of cloth and wine, Ricardo argues that it is advantageous for both countries to specialize in the one of the two goods that it can produce more efficiently than the other and to import the second.

England is more efficient in the production of cloth than in the production of wine and therefore it is in its interests »to import wine, and to purchase it by the exportation of cloth« (Ricardo 1817: 135). Portugal is more efficient in the production of wine than in the production of cloth and, although it can also produce cloth more efficiently than England, »it would be advantageous to her rather to employ her capital in the production of wine, for which she would obtain more cloth from England, than she would produce by diverting a portion of her capital from the cultivation of vines to the manufacture of cloth« (Ricardo 1817: 135). Both countries will therefore enter into a form of trade relations that is beneficial to both because »it distributes labour most effectively and most economically: while, by increasing the general mass of productions, it diffuses general benefit, and binds together by one common tie of interest and intercourse, the universal society of nations throughout the civilized world« (Ricardo 1817: 134).

In the model of Schwartz and Hoeksema, vascular plants and mycorrhizal fungi play the roles of England and Portugal (Schwartz/Hoeksema 1998; Hoeksemsa/Schwartz 2001; 2003). Both organisms extract the two vital resources phosphorus and carbon from their environment. On the basis of empirical data, Schwartz and Hoeksema argue that each organism, on condition that there is a difference in the effort it requires to extract the two resources, specializes in the resource it can extract more efficiently and obtains the other resource through exchange. As modelling shows, specialization and exchange can occur even under the condition that there is no difference in the effort an organism requires to extract both resources, provided that it is more efficient than the other in terms of both resources. The only condition under which no relationship is established is

when there is no difference in the effort an organism requires to extract both resources and is less efficient than the other in terms of both resources.

Ricardo's law has been empirically proven and elaborated in economics (Costinot/Donaldson 2012; Deardorff 2005). The Schwartz and Hoeksema model has also proved empirically plausible in biology (Kiers/van der Heijden 2006; Leigh 2010). Indeed, according to the »*interaction view* of metaphor« (Black 1962: 38), the analogous relations in economics are also referred to as mutualistic. This is what a study by Egbert G. Leigh says about the emergence of mutualism: »The exchange of goods or services is as central to natural as to human mutualisms: indeed, David Ricardo's principle of comparative advantage governs the evolution of mutualism as it does the patterns of local or international trade« (Leigh 2010: 2508). We thus have a law that applies to interactions in both the human and the non-human domain. We can reformulate this law as compactly as Gresham's Law that bad money displaces good money: *Different costs in generating things produce specialization and exchange*.

This law applies to organisms without further ado because organisms behave in the true sense of the word, to which the »selfish interest of individuals« is even ascribed (Kiers/van der Heijden 2006: 1627).[4] This law does not apply to countries without further ado because countries are only actors in a metaphorical sense. It is not »England« and »Portugal« which specialize and enter into exchange relationships but English and Portuguese »capitalists« (Ricardo 1817: 136). We must take this fact into account if we want to determine this law more precisely and link it to sociology.

The Nomological Status of Typical Behaviour[5]

In Schwartz and Hoeksema as well as in Leigh, the idea of probability appears in conjunction with the emergence of mutualism. Leigh talks about »factors that most vitally influence the likelihood of mutualism« (Leigh 2010: 2509). Schwartz and Hoeksema ask »why does [relative advantage] make the evolution of [...] stable mutualisms likely« (Schwartz/Hoeksema 1998: 1030). That condition under which no mutualistic relationship emerges is for them an »unlikely scenario« (Schwartz/Hoeksema 1998: 1033).

In philosophy of science, probability is currently also discussed under the keyword »typicality« (Frigg 2009; Goldstein 2012; Lazarovici/Reichert 2015; Volchan 2007). This term refers to behaviour that occurs in a certain way, although it could also occur differently.[6] For example, it is typical that in a closed container with gas molecules the entropy increases and attains its maximum value in an equilibrium state, although a decrease would be possible. This behaviour is expressed by SLT. However, typicality is not limited to behaviour of interest to physics. It also seems typical that in a »system of perfectly free

4 This attribution is obvious for authors who work with market models. In biology, of course, there are other notions of individuality; see Gilbert et al. (2012) and Sapp (2016). For concepts of individuality in other sciences see Guay/Pradeu (2015).

5 The following draws on Chapter »Physics« in Wagner (2020a).

6 Any other behaviour would also be in accordance with the underlying laws.

commerce« (Ricardo 1817: 133) specialization and exchange increase and lead to an universal society of nations throughout the civilized world. This behaviour is expressed by LCA.

Ludwig Boltzmann, who is regarded as the discoverer of typicality (Boltzmann 1896: 394–395; 1898: 252), has shown, that the macroscopic regularity expressed in SLT is determined entirely by its microconstituents and the laws which determine their behaviour.[7] The microconstituents are moving molecules whose locations and velocities are constantly changing. The movements of the molecules are determined by the fundamental laws of motion formulated in Hamiltonian mechanics. With each configuration of molecules, the gas is in a different microstate which marks a point in the space of all possible microstates called phase space. Measured by the Liouville measure, most of all possible microstates have the property to evolve to an equilibrium state, while only very few have properties to evolve to other states. The behaviour expressed in SLT is typical because the microstates which realize it are typical in that they all have the property to evolve to equilibrium.

The fundamental laws of motion are strict laws which hold without exceptions (Loewer 2008: 154–155). SLT may have exceptions, even though they may be very rare. Laws that have exceptions are usually called *ceteris paribus* (*cp*) laws (Reutlinger et al. 2019; cf. Schurz 2002; 2014). Such laws hold only under certain conditions which are fixed in the *ceteris paribus* clause. Exceptions arise through the violation of this clause. Accordingly, the assumption is made that SLT »is a *ceteris paribus* law since it holds only as long as the system is approximately energetically isolated« (Loewer 2008: 156).

In contrast, Luke Fenton-Glynn argues that not all exceptions arise due to the nonfulfilment of *ceteris paribus* clauses: »*Even assuming an ideal isolated system*, exceptions to SLT may arise just as a consequence of certain unlikely microphysical realizations of the system's initial thermodynamic state« (Fenton-Glynn 2016: 278). In such an isolated system, »the majority of points in the system's phase space (measure ≈ 1) are on non-entropy-decreasing trajectories. However, there are a very few (measure ≈ 0) that are on entropy-decreasing trajectories. SLT only holds if the initial macro-state of the system is realized ›in the right way‹ – viz. by one of the ›usual‹ points in phase space that is on a non-entropy-decreasing trajectory« (Fenton-Glynn 2016: 279). Exceptions may therefore result »just as a consequence of the properties that they concern being realized in the ›wrong‹ way« (Fenton-Glynn 2016: 279). Fenton-Glynn calls laws that admit such exceptions ›*minutis rectis* (*mr*)‹ laws: that is, laws that hold only when the properties that they concern are realized in the right way« (Fenton-Glynn 2016: 278–279).

It is not necessary to decide whether or not SLT is a *cp* law. Fenton-Glynn points out that »many special science generalizations hold *both* only cp *and* only mr« (Fenton-Glynn 2016: 279). What we must do, however, is to connect typical behaviour and *mr*

7 Boltzmann tried to reconcile the irreversibility of this thermodynamic process with the reversibility of the underlying mechanical laws which were the basis of the deterministic world view of nineteenth century (Lazarovici/Reichert 2015: 696; Volchan 2007: 807). For our purpose it is not necessary to go into the subject of determinism and causality.

laws. If SLT is the definitive case of typicality and if *mr* laws can be explicated by means of this case, then we can conceive a typical behaviour as a *mr* law. The next step is to show that LCA can also be conceived as a *mr* law.

The Payoff for Sociology[8]

Boltzmann claimed that »each molecule goes its own way independently like an individual who acts independently« (Boltzmann 1886: 34). This is where Weber comes into play. Weber placed his sociology in the tradition of the typicality approach which he knew from his reading of Johannes von Kries's *Principles of Probability Calculation* (von Kries 1886; Weber 2012a: 171; 1982a: 269).[9] Accordingly, he claimed that sociology seeks »*general* rules in events«, i.e. »typical [*chances*]«[10] »that under [certain] circumstances we might *expect* a [...] [course] of social action which can [...] be *understood* in terms of the typical motives and typical intentions of the [actors]« (Weber 2004: 324–325; 2002: 9).

Like Boltzmann, Weber distinguished from the beginning, when he worked as an economist (Wagner 2018), between micro and macro and took a reductionist position: »›Law‹ merely = Reduction of economic processes to *normal* consequences of human behaviour which we *understand* and consider to be *normal*« (Weber 2009: 362).[11] Just as the macroscopic regularity known as SLT is reduced to the behaviour of molecules, the macroscopic regularity known as LCA is reduced to the behaviour of individuals which Weber conceived as (social) action (Weber 2004: 312; 2002: 1).

Regarding the microconstituents, in the physical system we are dealing with the locations and velocities of molecules, whereas in the system of perfectly free commerce we are dealing with the »motives« and »intentions« of individuals (Weber 2004: 324; 2002: 9). As concerns the laws, the movements of the molecules are determined by the fundamental laws of motion, whereas the actions of the individuals are determined by laws that Weber was hesitant to term »psychological«. However, he assumed that individuals are goal-oriented actors: »The more ›freely‹ the acting person ›decides‹ – that is to say: the more [the ›decision‹] is based on [that person's] ›own‹ ›*deliberations*‹, which have not been blurred by ›external‹ constraint[s] or irresistible ›affects‹, the more completely [...] will the motivation [ceteris paribus] fit into the categories of ›end‹ and ›means‹« (Weber 2012b: 85; 1982b: 132).[12]

8 The following draws on Chapter »Sociology« in Wagner (2020a), in which Gresham's Law serves as an example.

9 Like Boltzmann and von Kries, Weber was a follower of the deterministic world view. For his ideas on determinism and causality see Wagner (2020b; 2020c).

10 Unfortunately, existing English translations of Weber's texts are not always precise enough to allow an adequate understanding of his thought. For this reason, I have altered inaccurate English translations and marked them as [altered by author]. In addition, the German source is always cited.

11 Weber used the term »normal« synonymously with the term »typical« (Weber 2004: 334; 2002: 15).

12 We concentrate on this law, assuming that other microlaws are also involved in the production of the macrostate. For a critical view of the emphasis on rationality see Thaler (2015).

It is not surprising that Weber understood this law as a *cp* law. The term »ceteris paribus« emerged in nineteenth century economics (Reutlinger et al. 2019: Ch. 2.1). In philosophy of science, this law is really classified as a law of »psychology«: »*Ceteris paribus*, people's actions are goal-oriented, in the sense that if person *x* wants *A* and believes *B* to be an optimal means for achieving *A*, then *x* will attempt to do *B*« (Reutlinger et al. 2019: Ch. 3.1; Schurz 2002: 353). Therefore, a »*negative analogy*« (Hesse 1966: 8) in our scenario is that the fundamental laws of motion are strict laws, whereas this law is an »exclusive« *cp* law (Reutlinger et al. 2019: Ch. 3.1; Schurz 2002: 353). It holds only under the condition that »›external‹ constraint[s] or irresistible ›affects‹« are excluded (Weber 2012b: 85; 1982b: 132). Nevertheless, it is assumed to determine behaviour in a way that leads to macrophenomena.

With each configuration of the molecules, the physical system is in a different microstate. Something similar applies to the system of perfectly free commerce. The molecules collide with each other and the walls of the container, whereas the individuals orient themselves to each other and to economic and political institutions and legal frameworks (Weber 2004: 335-341; 2002: 16-20). The motives and intentions of individuals may not change as quickly as the locations and velocities of molecules, but they do change or at least they increase or decrease in intensity and immediacy, which also results in different microstates.

The measurement of the microstates of the physical system is performed with the Liouville measure (Boltzmann 1898: 252). Regarding the system of perfectly free commerce, there is no standard practice. However, the social sciences have a rich fund of methods to measure »attitude[s]« and »expectations« (Weber 2004: 334; 2002: 15; cf. Lavrakas 2008).

In the physical system, most of all possible microstates have the property to evolve to an equilibrium state. Because these microstates are typical in this sense, they lead, together with the fundamental laws of motion, to the typical behaviour known as SLT. In the system of perfectly free commerce, most of all possible microstates have the property to evolve to a state characterized by specialization and exchange. Because these microstates are typical in this sense, they lead, together with psychological laws, to the typical behaviour known as LCA. Weber described the initial conditions that produce the microstates of the system of perfectly free commerce as »typical motives and typical intentions«, which make the microstates typical as well (Weber 2004: 324; 2002: 9).

Using the example of economic actions Weber has best illustrated the interplay of typical initial conditions and the psychological law known to us in producing a macroscopic regularity. In a market, individuals »[orient their behaviour, as a ›means‹, on their own *typical* subjective economic interests as an ›end‹ and on the equally typical expectations which they have of the prospective behaviour of others as ›conditions‹ for achieving that end. By acting in this way, *the more strictly* rational their manner of acting is, the more similarly they react to given situations, similarities, regularities and continuities of attitude and action are created]« (Weber 2004: 334; 2002: 15).

There is no doubt that a typical interest of market participants is to increase their profits. Given different costs in generating things, they can achieve this end by means of

specialization and exchange. By specializing and entering into exchange relationships, the typical behaviour known as LCA occurs: »Actual regularities can be observed within social action, i.e. regularities whose *intended meaning* is typically similar in actions repeated by the same actor, in actions replicated by many actors, or in both of these at the same time« (Weber 2004: 333; 2002: 14). Like SLT, LCA, therefore, can be conceived as a *mr* law. It holds only when the property to evolve to a state characterized by specialization and exchange is realized in the right way, i.e. in most of all possible microstates.

In the case of SLT, we had left it open whether it is also a *cp* law. However, LCA is one of those special scientific generalizations which »hold *both* only cp *and* only mr« (Fenton-Glynn 2016: 279). Weber conceived rules as typical chances that »under [certain] circumstances« we might expect a certain course of social action (Weber 2004: 324; 2002: 9). This suggests that he had *cp* laws in mind. It is not clear whether he was thinking of the *cp* clause that should apply to the psychological law that people's actions are goal-oriented or whether he was thinking of other conditions. However, it is easy to see that certain macro conditions must also be met. Interferences from outside, such as wars, pandemics or ecological disasters, must be excluded.

Conclusion

As a result, it can be stated that LCA used in economics and biology can be determined in a way that corresponds to current philosophy of science and can be connected to sociology. With this, a theoretical building block is available for further exploring the emergence of mutualism as a form of symbiosis in the interpersonal domain. First of all, the other micro-laws must be identified that contribute to the emergence of mutualistic relations. To this end, the term mutualism must be distinguished from terms such as »altruism«, which are also often used synonymously in biology (West et al. 2007), and concrete social conditions must be identified in which comparative advantages come to bear. In this respect, there are preliminary studies in economics that are sociologically relevant, for example on the formation of peer groups (Cicala et al. 2018), on the integration of migrants (Peri/Sparber 2009), or on «moral trade» (Ord 2015), and there are also attempts at a »sociological reformulation of the theory of cross-national comparative advantage« (Woolsey Biggart/Guillén 1999: 723) as well as other sociological definitions of the concept of symbiosis (Raub/Weesie 1993).

In all this, contact with biology should not be abandoned, especially since it still works with other theories known in the social sciences, such as network theory (Bascompte/Jordano 2014), and there are efforts on its part to transfer its findings from the non-human to the human domain by metaphors (Mars et al. 2012; Mars/Bronstein 2018). Symbiosis seems to be an object requiring an »interfield theory«: »Interfield theories are likely to be generated when two fields share an interest in explaining different aspects of the same phenomenon and when background knowledge already exists relating the two fields« (Darden/Maull 1977: 43; cf. Nathan 2017). If the »biosocial« LCA is also applied here, i.e. between two disciplines, a mutualistic relationship could emerge.

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