Chapter 6
Service as Entropy Reduction: A Conceptualization of Service for Sustainable Coexistence

Helge Löbler

Abstract Service is ubiquitous. It is a fundamental activity in human coexistence. However, many people are unaware that natural and ecological systems provide service as well. For example, 30% of the food consumed by humans depend on natural services, in particular on the pollination by insects. Clean water is preserved by natural water cycles. Human intentions, interests or desires can obviously not explain the existence of all these different kinds of service. They would exist without humans on earth. Consequently, our understanding of service has to be much broader than just including man-made service. This chapter proposes a conceptualization of service as a fundamental process of coexistence particularly the coexistence of humans, and more important, the coexistence of humans together with nature. Today, humans' ecological footprint on earth results in a resource overshoot already in August. On August 8, 2016, we had used as much from nature as our planet can renew in the whole year. We need a better conceptualization of our coexistence on this planet. Humans cannot survive if they destroy the resources they need. However, the planet can survive without humans. Service is proposed and conceptualized here as an integrated concept for a mutual coexistence of humans together with nature. Once we understand the cyclic intertwinement of human and natural activities, humans can adjust their life to natural cycles without reducing quality of life.

Keywords Service • Resources • Exchange-change process • Entropy reduction • Ecology

H. Löbler (✉)
Institute for Service and Relationship Management, Leipzig, Germany
e-mail: loebler@wifa.uni-leipzig.de

S. Barile et al. (eds.), *Social Dynamics in a Systems Perspective*, New Economic Windows, DOI 10.1007/978-3-319-61967-5_6

6.1 Ubiquity of Services

Service is ubiquitous and it has been written much on service and services. It has been studied and defined in various disciplines and can be understood as a general phenomenon in human coexistence. Following the service-dominant logic, service is "the application of skills and knowledge for the benefit of another party" (Vargo and Lusch 2004, 2008). Both, service-dominant logic as well as service science the conceptualization of service is limited to the man-made world: "[Service science] restricts its attention to artificial, in the sense of being real human-made, worlds, and is ran thus a specialization of systems science" (Spohrer 2009, p. 13). Accordingly, service is understood as a means to "value co-creation". Therefore people wants and/or needs explain the phenomenon of service in the human spere. Service is understood as based on needs and desires, as intentional acts and intentional processes made by humans or their technologies (Akaka and Vargo 2014). As far as this relates to the man-made world, there is nothing wrong. However, service is not just a man-made phenomenon, it also exists in the natural world, for example, between organisms and lower or higher developed species. There are other disciplines of service research outside of management, IT, service management and marketing such as biology and ecology, which cover this natural service. For instance, symbiosis research focuses on service not related to humans (Boucher 1985b; Douglas 1994, 2010) and addresses the question of why "different types of organisms help each other" (Boucher 1985b, p. 1). Another field of research where service plays an important role is the field of ecology (Boyd and Banzhaf 2007).

Ecological services are (not intentionally) offered to humans by the ecosystem (Boyd and Banzhaf 2007), for instance in form of food and fresh water. Thirty percent of the food consumed by humans depend on natural services (in particular on the pollination by insects). The services of nature are by far older than the man-made service, as they already existed before humans were on earth. This means, however, that as a general phenomenon (not only limited to humans), service cannot be explained by human motives or intentions.

For an explanation of service in a general way, a superordinate cause or a superordinate concept is needed. While, on the one hand, such a concept has to exceed the previous focus on the human sphere, it should, on the other hand, not marginalize the research that has emerged in the field of human services provided in the various disciplines. Furthermore, this concept has to explain service by other causes than human wishes, motives or intentions, since these explanations do not hold for simple species let alone organisms.

I start to develop such a concept by distinguishing four areas of service between the human and non-human sphere. The following section describes common features of service, as they are found in the biological, ecological and human service literature. Hereafter, I propose a conceptualization of service and a definition respectively which is an extended version of Hill's fundamental definition of service (Hill 1977, 1999). This definition focuses on service as a process of change, however, not every change can be understood as service. If so, the term service

would not draw a useful distinction between what service is and what it is not and every change or transformation, positive and negative ones, would be service. Hence, a further specification is needed which is applicable to natural and human service.

For this specification the concept of entropy will be used. The concept of entropy is here used as a measure of disorder and negentropy is used as a measure of order. The core idea of the concept of service, as presented here, is that if service did not exist, disorder would increase according to the second law of thermodynamics. Therefore, service is defined as a process to maintain or increase order against forces of disorder. The reduction of entropy against forces of disorder (for example through maintaining or increasing order) requires open systems in which low entropy states can be achieved by exchanges with the relevant environment. Entities enabeling states of low entropy emerge either in dissipative structures (Prigogine and Nicolis 1967; Prigogine and Leferver 1968) or through autocatalytic hypercycles (Eigen and Schuster 1979) far from equilibria and they are maintained by all living entities as they are open systems (Schrödinger 1944). We usually see human wishes, interests and intentions to be the forces against disorder. However, one can doubt that in the human sphere wishes or interests are intended deliberately if one follows Schopenhauer's statement: "You can do what you want, but you cannot want what you want" (Schopenhauer and Ebeling 1978–1979). Finally, I will describe and calculate entropy reduction through service.

6.2 Four Realms of Services

Although humans are part of nature, I distinguish humans from nature whereby nature is the part which would exist without humans. By doing so, four realms of service can be distinguished: Service exchanged between non-human beings (nature to nature); service provided by nature to humans (e.g. ecosystem service), service exchanged between humans and finally service by humans for nature (see Fig. 6.1).

The first realm of service includes all services transferred by non-humans; this service is provided by nature for nature and often discussed under the term symbiosis (Lewis 1985; Janzen 1985; Boucher 1985a). Different categorical systems have been used to describe different kinds of symbiosis (Starr 1975; Lewis 1985; Connor 1995). Authors agree that in these kinds of interactions, "one of the species provide some kind of 'service' that its partner species cannot provide for itself" (Yamamura et al. 2004, p. 421).

The second realm of service describes all service provided by nature for humans; these are ecosystem services (not to be confused with service ecosystems). Ecosystems provide service such as storm protection and pollination. Pollination of crops by bees is required for 15–30% of U.S. food production; most large-scale farmers import non-native honey bees to provide this service. (Kremen 2005). "Ignoring these services in public and private decision making threatens our ways

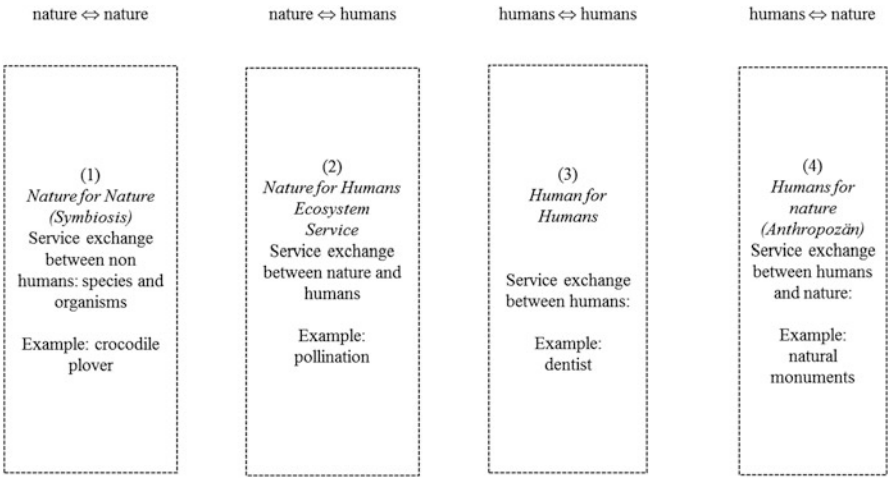

Fig. 6.1 Realms of service

of living and impedes our ability to achieve our aspirations for the future" (Ranganathan et al. 2008, p. 2). Humans benefit from a manifold of resources and processes that are offered by natural ecosystems. While environmentalists have discussed ecosystem services for decades, these services were popularized and their definitions formalized by the United Nations 2004 Millennium Ecosystem Assessment (MEA) (2005), a 4-year study involving more than 1300 scientists worldwide.

The third realm, service exchanged between humans, is not described here, because it is the best known realm.

The fourth realm does not only include preservation of natural heritage, it also covers those natural service, which is now replaced by human's work in specific regions. In Europe, for example, already 40% of the bee colonies have disappeared. In China, there are only 10% left. People there take this threat seriously for man and nature and have started trials for artificial pollination. What are the common denominators of all these different kinds of service?

6.3 Similarities of Human and Natural Services

An extended review of different streams of literature served for identifying four joint denominators for human and non-human service, for instance (Douglas 2010) for symbiosis, (Boyd and Banzhaf 2007) for ecosystems (Vargo and Lusch 2004, 2008, 2011) as well as (Maglio and Spohrer 2008) for human service.

The term service in the field of biology and ecology (Cushman and Whitham 1991; Herre et al. 1999; Yamamura et al. 2004; Ollerton 2006) is firmly established. In these disciplines, the exchange of services is sometimes not distinguished from the exchange of goods: "Mutualisms usually involve the direct exchange of goods

and services (e.g. food defense and transport)" (Herre et al. 1999, p. 49). Since service-dominant logic has not yet been integrated into the biology and ecology, this distinction is very similar to the previous distinction between goods and services in the goods-dominant logic (Vargo and Lusch 2004; Vargo et al. 2010).

Using goods-dominant logic language, goods and services in connection with symbiosis can be closer described as follows:

- Services: distribution of seeds, etc., protection, defense, bioluminescence, cleaning etc.
- Goods: carbohydrates, nitrogen, inorganic components, organic components, water etc. (Ollerton 2006)

In service-dominant logic terminology, however, these are only two types of service: the direct and indirect service (Vargo and Lusch 2004, 2008). The goods can thus be understood as indirect service and the "services" as direct service.

6.3.1 Resource Integration

Getting access to resources is one of the most important foundation of the evolution of symbiosis (Kiers and Denison 2008; Kiers et al. 2010). All natural processes are integrating resources without which they would not exist (West et al. 2007; Paszkowski 2006; Noe and Hammerstein 1995).

The notion of resource integration is also a fundamental concern in service-dominant logic as written in FP 9 (Vargo and Lusch 2004, 2008): All (economic and social) actors are resource integrators. There cannot be an activity without resource integration. Resource integration is an ongoing process, "a series of activities performed" (Payne et al. 2008) by an actor and often, but not necessarily, going hand in hand with value co-creation (Ngo and O'Cass 2009; Berghman et al. 2006; Golfetto and Gibbert 2006; Löbler 2013; Peters et al. 2014).

Resources are highly dynamic functional concepts; **they are not, they become,** they evolve out of the triune interaction of nature, man, and culture. Here nature sets outer limits, but man and culture are largely responsible for the portion of physical totality that is made available for human use (Zimmermann 1951, pp. 841–851; Vargo and Lusch 2004).

Whereas Zimmermann refers to physical entities, Vargo et al. extend his view to non-physical entities: "In fact, resources such as time, weather and laws, which are often considered exogenous and uncontrollable by individuals and organizations, are often integrated—if not relied on—in the value creation process by all service systems" (Vargo et al. 2010, p. 148).

Hence, everything in an actor's environment can become a resource depending on the context in which the actor acts. Things become resources, if they are integrated by interaction (Ballantyne and Varey 2006) or other activities. All activities, service in particular, are recourse dependent on resources and can hence only be performed if resources are integrated. This fundamental principle

is not limited to the man-made world. Hence, natural processes and human activities are based on resources and their integration and with them all kinds of service. Therefore, the first common denominator is:

Use or Integration of Resources All kinds of service can only be performed by using some kind of resource whether these resources are material (land, seeds, food, etc.) or immaterial (sunlight, information, wind, etc.).

6.3.2 Transfer or Exchange

If natural processes and human activities depend on resources, natural or human actors must be able to have access to these resources. Access to resources (if the actor does not produce it himself) is possible either through an exchange with other actors or through a transfer directly from the environment. The resources obtained from the environment are also produced or provided by other natural or human activities: "[. . .] mutualisms usually involve the direct exchange of goods and services (e.g. food defense and transport)" (Herre et al. 1999, p. 49). Access to oxygen is consequently an exchange of resources:

It needs no further comprehensive remarks that the concept of exchange, both in economics and marketing, plays a central role. Without exchange, no coexistence is possible. Service-dominant logic focuses on the concept of exchange by notions like "service-for-service exchange" and service "the fundamental unit of exchange" (Vargo and Lusch 2004, 2008; Vargo et al. 2008). Therefore, exchange or transfer forms are another defining characteristic of service.

Transfer/Exchange of Resources Getting access to resources through exchange of resources between the actors and/or with the environment.

6.3.3 Transformation or Change

Transformation or change is another denominator of service. Riddle, in explaining Hill's definition of service (Hill 1977, 1999), identifies service as activities for change: "Service are activities that produce changes in persons or the goods they possess" (Riddle 1986). The integration or use of resources 'produces' changes in the state of the receiver of these resources. This concept of service goes back to Hill:

"The service may be defined as a change in the condition of a person or other goods belonging to the same economic unit, which is brought about is the result of the activity of some other economic unit, with the prior agreement of the formal person or economic unit" (Hill 1977, p. 318).

In the same vein, Sampson (2010) as well as Fromm and Cardoso (2015) define service as a change in the state of the service receiving entity. Although 'change' or

'transformation' is mentioned incidentally in service-dominant logic and service science, there is neither a reference to Hill nor to Riddle let alone a discussion of this concept as being central to the understanding of service. Examples are: Resources are an "ability to cause desired change" (Vargo and Lusch 2008, p. 7), or: "Service systems are value-creation networks composed of people, technology, and organizations. Interventions taken **to transform** state and coproduce value constitute services" (Maglio et al. 2006, p. 81). However, this concept goes back to Hill and is not taken into account by service-dominant logic. Service-dominant logic defines service "as the application of skills and knowledge for the benefit of another party". That the benefit may be caused by a change in the state of the service recipient is not mentioned or discussed in service-dominant logic.

So far the condensed components from social sciences' literature, marketing and IT in particular for a service definition are exchange and change. Thereby, exchange is neither limited to goods, activities or rights, nor is change limited to persons or things. It may be helpful to think of different kinds of service in day-to-day life:

- Haircut: The hairdresser exchanges the application of his/her skills and knowledge for the client's money and changes the appearance of the client.
- Transportation (a bus ride): buying transportation, exchange of a right to use transportation for money, and the transportation changes the place of people.
- Software: Buying the software is exchanging a right (and perhaps some material object) for money and working with the software changes the process of a user's work.
- Car: Buying a car means exchanging a car for money, it changes the owner's situation as she can now driving the car, talking about the car and looking at the car. Here we see how the indirect service (masked by goods) works.
- Renting a flat: Exchanging the right to use the flat for money; change of life conditions.
- Consulting: Exchanging the right of using information or getting information for money; changing the way of thinking or deciding.

In symbiosis research, Douglas (1994, 2010) has summarized the *outcomes* gained by service and Ollerton (2006) has described the *services exchanged* in symbiotic relationships. The detailed description of these resource integrations (Douglas 2010, p. 12; Ollerton 2006, p. 413) show that they are all used for changes and/or transformations in/of organisms or other entities like fixation, respiration, degradation, production, protection, removal etc. (Douglas 2010, p. 14).

Transformations are realized by integrating resources received from another party. Resources are used to transform the state of the receiver compared to the state without integrating or using those resources. Value may or may not emerge if a transformation is realized depending on the context. A third mutual characteristic of man-made and non-man-made service therefore is that resources are integrated for a specific transformation or change. Whether the transformation is beneficial for an entity is determined by the context and not by the resources or by the transformation. Transformation or change is always defined in relation to a situation without

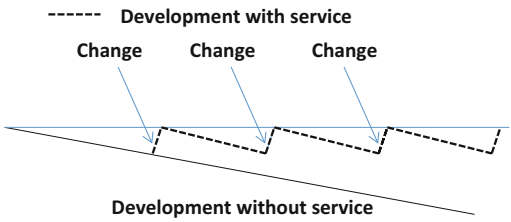

Fig. 6.2 Relative notion of change

the service in question. Hence, if, for example, a service is a maintenance service, maintenance is a transformation/change compared to the situation without the maintenance service.

A second important point has to be mentioned: One might think that innovation has no place in this frame, however, innovation can be simply conceptualized as second order change that is a change of change or a transformation of a transformation. When typewriting was invented, it was a change of the way in which ideas were transformed into letters (Löbler and Lusch 2014). Hence, innovation is a second order change.

One has to be aware that change is never absolute, but always relative. If a condition of a service receiver is getting worse without a service, than a service keeping the condition constant would be a relative change compared to letting the condition get worse. It is usually done in small steps as indicated in Fig. 6.2.

In general, whenever one wants to identify or measure change, one needs a dimension of description or a scale which remains unchanged.

Transformation (Change) of the Receiver's State by the Use of Resources Resources are not integrated (used, consumed) for their own sake but for a transformation/change in a service receiver's state, whereby the receiver usually (but not always) also transforms (consumes or wears down) the resources.

6.3.4 Context Dependence of Value and Survival

In a human world (co-)creation of value is the ultimate reason or goal of service (Vargo and Lusch 2011) and service science is understood as "the study of value co-creation" (Spohrer and Maglio 2010, p. 158).

Simultaneously, it is argued that the application of skills and knowledge can only offer value propositions but cannot deliver value itself (Vargo and Lusch 2008, p. 8): "Enterprises can offer their applied resources for value creation and collaboratively (interactively) create value following acceptance of value propositions, but cannot create and/or deliver value independently" (ibid, p.7). Service providers may intend to deliver value but value can neither be delivered nor can it be determined by the service provider. "Value is always uniquely and phenomenologically determined by the beneficiary" (ibid, p.7.). Value emerges out of the use in a specific context (Chandler and Vargo 2011). Hence, value is contextual and not a

defining trait of service, which is rather the application of skills and knowledge. Although value appears as the ultimate reasoning for service, and although the potential of concepts such as value in use (Vargo and Lusch 2004, 2008, 2011) or value as a function of human experience (Ramaswamy 2011) are recognized as important, they are still in their "research infancy" (Ostrom et al. 2010, p. 26). The notion of value-in-context recently introduced by (Vargo and Lusch 2008, 2011) and Chandler and Vargo (2011) emphasizes the context dependency of value. By doing so, value is not understood as inherent or defining characteristic of service. Service may be a necessary condition for value creation, but it is not sufficient to co-create value. This is supported by an emerging interest in the literature on value (co-)destruction (King and Burgess 2008; Plé and Chumpitaz 2010; Echeverri and Skalén 2011) pointing out that value does not necessarily go hand in hand with service. "Following Plé and Chumpitaz (2010), it suggests that service relationships or exchanges, as defined in S-D logic, do not necessarily result in value co-creation, but that value co-destruction may occur too." (Lefebvre and Plé 2011) Hence, value co-creation is not defining element of service as it can also turn out as value "co-destruction". As a consequence of its contextuality, value and value co-creation are not an inherent characteristic of a man-made service. It can emerge with service, but not necessarily. Consequently, value and value co-creation can now, in a first step, be excluded from a service definition of the man-made service. As it is now demonstrated, the same applies for a definition of non-man-made service; the service in nature.

Research on symbiosis analyzing the benefits and harms of symbiotic relationships is aware of the contextuality of these benefits and harms: A "fundamental problem is the variability of real associations, such that benefit is not a fixed trait of some relations but varies with environmental circumstance" (Douglas 2010, p. 6). Organisms which are usually harmless or beneficial can be deleterious to their partners, depending on the context they live in (Douglas 2010). Examples are the fungus Colletotrichum magna which was first identified as a virulent pathogen of certain plant species. However, its impact on plant growth was found to depend on plant species and even cultivar (Redman et al. 2001). In the same vein the Helicobacter pylori, a bacterium in the human stomach, can cause ulcers and gastric cancer especially in older people, but can be beneficial in children providing protection against diarrhea and asthma (Blaser and Atherton 2004). Thus benefit and value are contextual. In the biological as well as in service-dominant logic's understanding of service benefit and/or value are/is dependent of the kind of use and the context of use.

Contextuality of Value (Benefit) of Service Value or benefit is not inherently a service characteristic. Value can emerge via resource integration depending on the relationship between a service receiver and its environment. Hence, value as well as survival is contextual.

Since value is firstly context dependent in the human sphere and secondly an anthropocentric attribution to nature made by humans, it is not taken as a defining characteristic of service as understood here.

So far, the three common characteristics of natural and human service can be condensed into the following sentences: The main function of service is a change of state of a specific entity emerging through resource integration, where these resources are acquired by exchange. Thereby, not only the state of the specified entity is changed, but also the resources which are used in the process of change. Humans transform natural resources into resources which are used by other humans or which are transformed into waste. Fortunately, nature often transforms our waste back into resources, but unfortunately not always. There is an ongoing process of exchange of resources between humans and between humans and nature. It is important to understand the ties between those entities that perform the activities. I use the term 'entities' because not only people are executing activities (transformations and changes) but also animals and plants and also the physical part of nature, for example wind and rain. The ongoing process of transfer or exchange is complemented by a process which happens between the exchanges or transfers. It is complemented by transformation or change.

However, not all transfer-transformation or exchange-change processes are service. If so, the term service would not draw a useful distinction between what service is and what it is not. In this case, everything or every process would be service. Hence, a further specification is needed which is applicable to natural and human service. This will be discussed in the next section.

6.4 Specific Exchange-Change Processes as Service

For practical purposes, I call those processes in which an exchange (transfer) and a transformation of resources, which changes the state of an entity, takes place, an exchange-change processes (ECP). As mentioned above, not all ECP can be defined as service. If all ECPs were defined as service, no processes would be excluded by the definition. A definition that includes everything would lose meaning. Therefore, only certain ECPs are understood as services, and these processes have an additional characteristic. Such additional characteristics can be discovered in various ECPs.

Human and nature are similarly integrated in such ongoing ECPs. Many of them are so common that we are often not aware of them. For instance, the carbon dioxide-oxygen cycle is an ongoing process in which plants provide resources for humans and animals, while humans and animals provide resources for plants in return. CO_2 (carbon dioxide), H_2O (water) and energy (sunlight) are converted during the photosynthesis in O_2 (oxygen) and $C_6H_{12}O_6$ (glucose) (see Fig. 6.3). Oxygen and glucose are the most important resources for humans and animals. Humans and animals use this resource and convert it into carbon dioxide and energy (work) in return. Other ongoing transfer-transformation processes are, for example, the carbon, nitrogen and water cycle. This clearly shows that without transformations or changes between the transfers, a world would have quickly exchanged all resources.

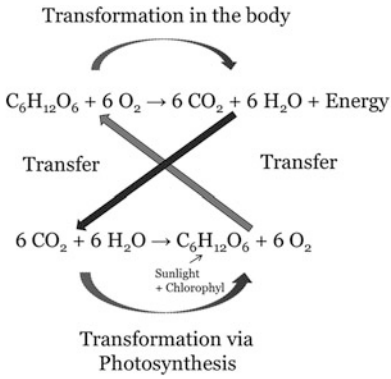

Fig. 6.3 Exchange-change cycle

The transformations in these ongoing ECPs are life-sustaining. The entities, for which the transformations are taking place, use the resources to maintain their inner structure. They are open to integrate resources and they are closed with respect to the structure they maintain. If they were closed with respect to resources, they would not be able to maintain their inner structure. To maintain their inner structure means to also defend the inner order against destroying forces. To do so, they use and need resources they obtain from other entities or from their environment. In short, the resources received from others or from the environment are used to maintain an ordered state. Hence, all transformations and changes can now be distinguished according to whether they maintain or increase order, or whether they reduce it.

Those EPCs, that maintain or increase order, are defined as service. Service thus means to act against disorder or decay in well-defined entities through a transfer and a transformation of resources which is an ECP. So not all ECPs are service; only those which oppose disorder or decay. Service are those ECPs, which counteract disorder or decay in a well-defined entity.

A general measure of disorder caused by a process in an entity is entropy. Entropy can be used as an instrument for the measurement of information (Shannon 1949/1998). Furthermore, entropy can be a measurement of that part of energy, which cannot be converted back—the part, which is irreversible. An intuitive interpretation of entropy is, to use it as an indicator of disorder (Sethna 2011): According to the second law of thermodynamics, closed systems strive for a state of maximum entropy. In an open system, however, entropy can be reduced by increasing the entropy of the environment through the integration of resources.

Following this logic, service is now understood as an entropy reducing transformation or change. Entropy as a measurement can thus be used to characterize the service transformation in detail. With this in mind, services can also be defined as an exchange-change processes that counteract the entropy production in certain entities. One can say that for such entities, the entropy reducing change (transformation) is a service.

6.5 Exchange-Change Processes and (Dis)order

If entities like people, organisms or other creatures would be left without access to resources, they would not be able to counteract decay or disorder. For practical purposes, those forces, which promote decay or disorder, are called disturbances, because they disturb order. For example, the incidence of hunger feelings is such a disturbance, which can be overcome by integrating resources in form of food. Also fatigue is such a disturbance that can be overcome by sleep.

In addition, compared to a desired (but not yet reached) state, the actual state appears as a disturbance that has to be overcome. If the old car is not good enough anymore, it is interpreted here as a disturbance in relation to a new car. A disturbance is always defined in relation to a reference state, which can either be the status quo or a desired state. The desired state can only be reached by the integration of resources. Figure 6.4 shows how resource integration works against disturbances. Disturbances are indicated by D, the resources by R, the change of the state of an entity by C ('C Dis.' indicats a change producing disorder and 'C Ord.' indicats a change producing order) and the states before service and after service are indicated by S_{BS} and S_{AS} respectively. The process shown in Fig. 6.4 starts with a state after a service that is disturbed. Through the disturbance a service is needed; a state which is indicated in Fig. 6.4 as 'before service". Such a service, or in other words, a resource integrating change, then produces a state after a service again. Whereas the disturbance rises the disorder, the service rises order, which is indicated by 'Dis.' and 'Ord.'. The change of the state is accompanied by a change (transformation) of resources. These resources might become either resources or disturbances depending on the entity receiving them.

Resources are therefore necessary to deal with certain disturbances. The term 'state' is used in a very general sense. It does not only cover static situations, but also routine processes operated by the entity. The disturbed status can therefore be understood both as a static state, but also as a dynamic process. For example, if the process of digestion is disturbed, which can manifest itself in stomach pain, then one would like to see a doctor for his/her service. In this case, the disturbance refers to a process. The process is the status quo to be restored by the service. Very often

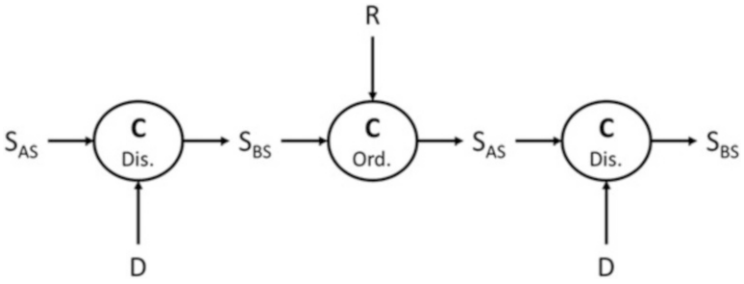

Fig. 6.4 One part of an ongoing process

disturbances relate to processes, such as the precipitation of machines that perform certain operations (processes). The machine is a resource that transforms other resources (materials) and one wants to maintain the machines ability to perform this process. Hence, as long as the machine works, there is no need to change/transform the machine. However, in the case of a machine failure, the machine has to be transformed to work appropriately. In one case, the service is done by the machine, in the other case, it is done upon the machine. Generally, the change of resources and the change of the status of the resource integrating entity go hand in hand. The result is either a changed resource, a changed state of the entity or both.

It is important to understand that Fig. 6.4 represents only a small part of an ongoing ECP. Therefore, in Fig. 6.5 the ongoing process is indicated by two parts.

Figure 6.5 shows that the result of a change in the ongoing ECP can lead to either a new resource or a disturbance depending on the context and entities in question. If, for example, a music-band plays for a garden party, the music is a service for those enjoying the party. Simultaneously, the same music can be a disturbance for the neighbor. Depending on how the neighbor wants to overcome the disturbance, he/she needs specific resources to transform his/her state. The indication of D and R in Figs. 6.4 and 6.5 do not only indicate one resource or one disturbance, but a set of resources or disturbances. The simplicity of the picture should not obscure the fact that humans, other animals or parts of nature, are involved in a variety of ECPs that have been described as service-dominant networks (Löbler 2013). Without change between the exchanges, the exchanges were completed quickly. When resources would only be exchanged but not changed, they would sooner or later all be exchanged and there is no need for further exchanges. This holds for both the static level of the resource exchange as well for the dynamic. Dynamic resources are

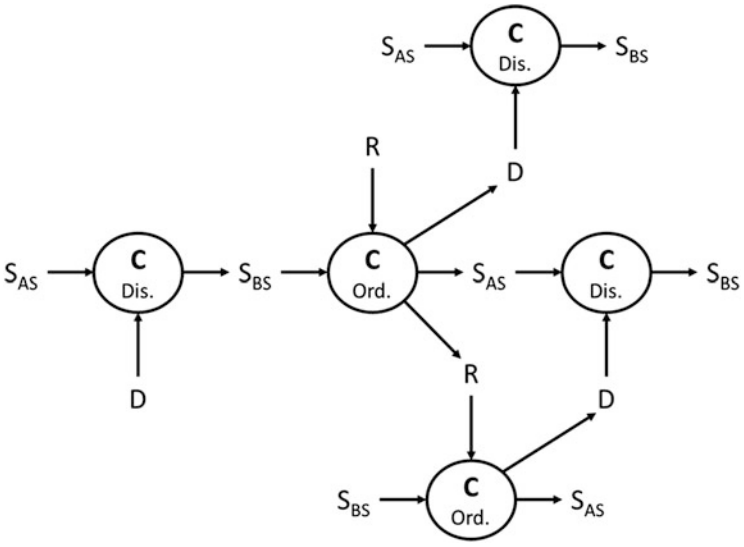

Fig. 6.5 The intertwined ongoing process

processes, which in turn are used as resources. If these processes are changed, it is either a maintenance repair or an innovation. In the first case, the process was disturbed and the status quo as to be restored. In the second case, the improvement of the process serves as a benchmark for an innovation and as a reference state. Compared to this innovation, the old process is a disturbance. In any case, an innovation is the change of a change; or a second order change.

In nature, innovations correspond to mutations, which in turn means a change in the process controlling genes. For all these transformations in an entity, both in an object and in a process, the entropy can be calculated.

6.6 Transformation as a Reduction of Disorder/Entropy

6.6.1 Without Use of Benefit or Value Units

To illustrate the entropy changes of the changed states a change matrix serves as a starting point (see Table 6.1 (a) for human service and (b) for natural service).

On the left hand side there are different disturbances which can be overcome by using the resources on the top of the matrix.

There is no limitation of what disturbances, resources and transformations can be. Table 6.1a shows well known disturbances and options to overcome these disturbances. Table 6.1b shows disturbances that are overcome by nature. In Table 6.1 the results of the transformation are indicated by an 'a' for acceptable and an 'n' for unacceptable. However, each cell of the transformation matrix can contain any kind of result. Each individual cell within the matrix may be further differentiated. So, for example, hunger can be satisfied in very different ways and with very different food. Therefore, resources and outcomes vary accordingly.

Later, we will use concrete numbers indicating values or benefits. But firstly, the entropy of a transformation is calculated without using numbers to indicate value or benefit.

The entities considered here, as shown in Table 6.1 are principally open in respect to entropy reducing resources. Disturbances, as understood here, are all forces that increase the entropy, if the entity does not counteract by using resources.

How does the entropy of a state change, if induced by a disturbance or by a service? If an entity is in a state without any disturbance, this state is denoted by the term 'reference state'. This state can be challenged by disturbances. If this reference state is challenged by one disturbance, then the state of the entity is described by the reference state and the disturbance. The situation is now described by the reference state and one disturbance, a set of two elements. The more disturbances are challenging the reference state, the more elements the set has that describes the situation. In general, the state of an entity is defined as a set $S = \{s_0, s_1, s_2, s_k, .., s_K\}$ where s_0 refers to the reference state an K to the number of disturbances. The cardinality of this set is $|S| = K + 1 = M$.

Table 6.1 Change-Matrix [(a) Example humans and (b) Example nature]

(a) Change-Matrix (Example humans)

			R (resources)		
	C (change)	Hairdresser	Food	Beverage	Medical Doctor
	Hunger	n	a	n	n
D (disturbances)	Old look compared to a desired new one	a	n	n	n
	Thirst	n	n	a	n
	Qualmishness	n	n	n	a

(b) Change-Matrix (Example nature)

			R (resources/ processes included)		
	C (change)	Global hydrological cycle	Photosynthesis	Activity of microorganisms in the soil	Aposematism[a]
	Polluted water	a	N	n	n
D (disturbances)	Too much CO_2 in the air	n	A	n	n
	(Compostable) waste	n	N	a	n
	To become eaten (animals)	n	N	n	a

[a]Aposematism is a widely used function of bioluminescence, providing a warning that the creature concerned is unpalatable

Now this situation is described by the entropy measure by using relative frequencies of the elements of the describing set to calculate entropy of S (Shannon 1949/1998). The entropy of a state described by M unweighted elements is $H(S) = -\sum_1^M \frac{1}{M} \text{ ld } \left(\frac{1}{M}\right)$.[1] In this case $H(S) = \text{ld}(M)$.

Table 6.2 shows the results of entropy rise induced by more and more disturbances.

Reading Table 6.2 from the bottom to the top shows the entropy reduction if disturbances are eliminated or overcome.

In this way, each contribution of a transformation that eliminates or overcomes a disturbance can be described as entropy reduction.

The procedure indicated in the example shows, that the entity's state becomes more ordered the more disturbances are eliminated or overcome by means of service.

Accordingly, entropy can be understood as a measure of the adequacy of a service. Since such entropy calculations are not restricted, it can be applied to all transformations and thus represents a general measure of the adequacy of service as order-creating change of an entity's state. This is an understanding of service being independent of constructs derived from the human sphere like value, benefits or alike. In nature, we cannot identify human sphere categories like value or benefit. However, with entropy we propose a general measure of the adequacy of service. Simultaneously, the calculation of entropy can include human notions as value and benefits, as shown in the next section.

Table 6.2 Entropy of different states

Number of disturbances	Cardinality of the describing set	Formula	Entropy
0	1	ld(1)	0
1	2	ld(2)	1
2	3	ld(3)	1585
3	4	ld(4)	2
4	5	ld(5)	2322

[1] ld(x) denotes $\log_2(x)$, the logarithm to the base 2. To reflect a higher order sensitivity, smaller bases may be chosen, because it is about order and not about information, in which the base 2 assured the unit "bit". When measuring disorder, the basis indicates how strong an increase in the disorder is perceived, when the number of options increases by 1. The base 2 indicates that a doubling of the possibilities increase the "disorder unit" of one. A base of for example 1.5 indicates then one and a half time the options would be perceived as a disorder increase of one "disorder-unit". Since the perceived disorder increases with decreasing gains, the base is always greater than one. One can speak of a diminishing marginal disorder in relation to the number of options. 1 divided by the basis is a measure of the increasing sensitivity to perceive opportunities as disorder. This is evident because a reduction of order from two options to one is relatively much more than a reduction from e.g. ten to nine.

6.6.2 With Use of Benefit or Value Units

As in Sect. 6.6.1 the state of an entity is described by a set of elements which are the reference state and the disturbances $S = \{s_0, s_1, s_2, \ldots s_k, .., s_K\}$. Furthermore, it is assumed that the reference state as well as the elimination or overcoming of the disturbances is evaluated by the entity. Since the disturbances are defined in relation to the reference state, it is reasonable to assume that the reference state is associated with the highest value. The reference state is either a desired state or the status quo, so that its value is always higher, if compared to less desired states. The disturbances are assumed to be independent from each other.

In correspondence with the set of describing elements $S = \{s_0, s_1, s_2, \ldots s_k, \ldots, s_K\}$ the values are

$$W = \{w_0, w_1, \ldots w_k, \ldots w_K\} \text{ with } w_1, \ldots w_k, \ldots w_K < w_0$$

For calculating entropy, we define the following weights reflecting the values: $u_k = \frac{w_k}{\sum_0^K w_k}$.

According to Straathof (2007), the weights u_k can be used like relative frequencies for entropy calculation.

The entropy of a state then is calculated as $H(S) = -\sum_0^K u_k \, \mathrm{ld}(u_k)$.

If, for example, an entity is faced with two disturbances and evaluates the reference state and the disturbances with $w_0 = 500$; $w_1 = 350$ and $w_2 = 75$, the weights u_k are $u_0 = 0.541$, $u_1 = 0.378$ and $u_3 = 0.081$ and $H(S) = -0.541$ ld (0.541) – 0.378 ld(0.378) – 0.081 ld(0.081) = 1.304.

Compared to the situation without values, where the entropy is 1.585, the entropy with values is lower, because the values reveal a preference structure indicating a higher level of order than without a preference structure. If the values for the three elements are equal, e.g. 300, they would not reveal a preference structure and would hence indicate a lower level of order with an entropy of 1.585.

Furthermore, if now the entity can overcome one of these disturbances, the values matter. If the disturbance with the value of 350 can be eliminated, the entropy is $H(S) = 0.559$, whereas if the disturbance with the value of 75 is eliminated, the entropy is $H(S) = 0.977$. If the disturbance valued with 350 remains in the set, the values are 500 and 350, indicating a less clear distinction of the elements compared to set with the values of 500 and 75. The letter case shows a clearer distinction in the revealed preferences and therefore a higher level of order indicated by a lower entropy.

In this way, all possible constellations can be calculated and described using entropy: Both situations in which no benefit or value units are assigned, as well as those cases, in which values or benefits are given. In general, service can be construed as entropy-reducing transformations of resources to overcome

disturbances, referring either to a status quo or to an intended state. The more entropy a service reduces, the more appropriate it is.

6.7 Conclusion

This article assumes that service is provided not only in the sphere of human activity. Rather, it takes the view that service is ubiquitous even without humans, as it is discussed in biology and ecology. Therefore, this article intends to understand and to conceptualize service as a general process, which can be explained without reference to constructs of the human sphere like interests, whishes or values. However, this does not mean that those human constructs are excluded in the conceptualization proposed here.

For the theoretical underpinnings of the process of service, it was purposive to locate service between exchanges of resources and to conceptualize it in the vein of Hill's perspective as a change either of the state of the resource receiving entity or the resources themselves. Changes in general can now either rise or reduce entropy. As in closed systems entropy automatically increases, only those transformations/changes are understood as service that reduce entropy in a well-defined entity. Therefore, service is not explained by intentions, desires, or the like, but as energy transformations in open systems which are typically accompanied by matter transformations to protect the entity "from decay" (Schrödinger 1944). This protection, however, is in the non-human sphere a result without human intention. Whether a transformation protects an entity in nature, can be seen only ex-post and not ex-ante. In nature, entropy reducing entities are created in dissipative structures (Prigogine and Nicolis 1967; Prigogine and Leferver 1968) or in autocatalytic hypercycles (Eigen and Schuster 1979) far from equilibrium. Service thus can be understood as a fundamental process of maintaining order (in the broadest sense). Therefore, service is of such fundamental importance, because it counteracts the forces that augment the disorder. It was demonstrated by examples how transformations counteract entropy rising forces and how entropy can be used as a measure of disorder in order to assess such transformations/changes.

Consequently, entropy can be understood and used as a useful concept to assess the adequacy of services; regardless of whether the results are assed by humnas' value or benefit or not.

Furthermore, the broader concept of service as understood here, is a basis for understanding the cycles of humans' intertwinement with natural processes. We, as humans, may become smarter, but we are still a part of nature and we are not independent from natural laws. If humans accept and understand the fundamental laws of coexistence, they can live on earth without damaging and/or exploiting nature. Service as a resource integrating, cyclic activity, as proposed here, is the common ground for coexistence on earth.

References

Akaka, M. A., & Vargo, S. L. (2014). Technology as an operant resource in service (eco)systems. *Information Systems and e-Business Management, 12*(3), 367–384.

Ballantyne, D., & Varey, R. J. (2006). Creating value-in-use through marketing interaction: The exchange logic of relating, communicating and knowing. *Marketing Theory, 6*(3), 335–348.

Berghman, L., Matthyssens, P., & Vandenbempt, K. (2006). Building competences for new customer value creation: an exploratory study: Creating value for the customer through competence-based marketing. *Industrial Marketing Management, 35*(8), 961–973.

Blaser, M. J., & Atherton, J. C. (2004). Helicobacter pylori persistence: Biology and disease. *Journal of Clinical Investigation, 113*(3), 321–333.

Boucher, D. H. (Ed.). (1985a). *The biology of mutualism – Ecology and evolution*. New York: Oxford University Press.

Boucher, D. H. (1985b). The idea of mutualism. In D. H. Boucher (Ed.), *The biology of mutualism – Ecology and evolution* (pp. 1–28). New York: Oxford University Press.

Boyd, J., & Banzhaf, S. (2007). What are ecosystem services? The need for standardized environmental accounting units. *Ecological Economics, 63*(2–3), 616–626.

Chandler, J. D., & Vargo, S. L. (2011). Contextualization and value-in-context. How context frames exchange. *Marketing Theory, 11*(1), 35–49.

Connor, R. C. (1995). The benefits of mutualism: A conceptual framework. *Biological Reviews, 70* (3), 427–457.

Cushman, J. H., & Whitham, T. G. (1991). Competition mediating the dynamics of a mutualism: Protective services of ants as a limiting resource for membracids. *The American Naturalist, 138*, 851–865.

Douglas, A. E. (1994). *Symbiotic interactions*. Oxford: Oxford Science Publications, Oxford University Press.

Douglas, A. E. (2010). *The symbiotic habit*. Princeton, NJ: Princeton University Press.

Echeverri, P., & Skalén, P. (2011). Co-creation and co-destruction: A practice-theory based study of interactive value formation. *Marketing Theory, 11*(3), 351–373.

Eigen, M., & Schuster, P. (1979). *The hypercycle: A principle of natural self-organization*. Berlin: Springer.

Fromm, H., & Cardoso, J. (2015). Foundations. In J. Cardoso, H. Fromm, S. Nickel, G. Satzger, R. Studer, & C. Weinhardt (Eds.), *Fundamentals of service systems, service science: Research and innovations in the service economy* (pp. 1–32). Cham: Springer International Publishing.

Golfetto, F., & Gibbert, M. (2006). Marketing competencies and the sources of customer value in business markets: Creating value for the customer through competence-based marketing. *Industrial Marketing Management, 35*(8), 904–912.

Herre, E., Knowlton, N., Mueller, U., & Rehner, S. (1999). The evolution of mutualisms: Exploring the paths between conflict and cooperation. *Trends in Ecology and Evolution, 14* (2), 49–53.

Hill, T. P. (1977). On goods and services. *Review of Income and Wealth*, (4), 315–338.

Hill, T. P. (1999). Tangibles, intangibles and services: A new taxonomy for the classification of output. *The Canadian Journal of Economics*, (2), 426–446.

Janzen, D. H. (1985). The natural history of mutualism. In D. H. Boucher (Ed.), *The biology of mutualism – Ecology and evolution* (pp. 40–99). New York: Oxford University Press.

Kiers, E. T., & Denison, R. F. (2008). Sanctions, cooperation, and the stability of plant-rhizosphere mutualisms. *Annual Review of Ecology, Evolution, and Systematics, 39*(1), 215–236.

Kiers, E. T., Palmer, T. M., Ives, A. R., Bruno, J. F., & Bronstein, J. L. (2010). Mutualisms in a changing world: An evolutionary perspective. *Ecology Letters, 13*(12), 1459–1474.

King, S. F., & Burgess, T. F. (2008). Understanding success and failure in customer relationship management. *Industrial Marketing Management, 37*, 421–431.

Kremen, C. (2005). Managing ecosystem services: What do we need to know about their ecology? *Ecology Letters, 8*(5), 468–479.

Lefebvre, I., & Plé, L. (2011). *Emergence of value co-destruction in B2B context*. Paper presented at the Naples Forum on Service 2011, Vol. 2011.

Lewis, D. H. (1985). Symbiosis and Mutualism: Crisp concepts and soggy semantics. In D. H. Boucher (Ed.), *The biology of mutualism – Ecology and evolution* (pp. 20–39). New York: Oxford University Press.

Löbler, H. (2013). Service-dominant networks. *Journal of Service Management, 24*(4), 420–434.

Löbler, H., & Lusch, R. F. (2014). Signs and practices as resources in IT-related service innovation. *Service Science, 6*(3), 190–205.

Maglio, P. P., & Spohrer, J. C. (2008). Fundamentals of Service Science. *Journal of the Academy of Marketing Science, 36*, 18–20.

Maglio, P. P., Srinivasan, S., Kreulen, J. T., & Spohrer, J. (2006). Service systems, service science, SSME, and innovation. *Communications for the ACM, 49*(7), 81–85.

Ngo, L. V., & O'Cass, A. (2009). Creating value offerings via operant resource-based capabilities. *Industrial Marketing Management, 38*, 45–59.

Noe, R., & Hammerstein, P. (1995). Biological markets. *Trends in Ecology and Evolution, 10*, 336–339.

Ollerton, J. (2006). Biological Barter: Patterns of specialization compared across different mutualists. In N. M. Waser & J. Ollerton (Eds.), *Plant-pollinator interactions – From specialization to generalization* (pp. 411–435). Chicago: The University of Chicago Press.

Ostrom, A. L., Bitner, M. J., Brown, S. W., Burkhard, K. A., Goul, M., Smith-Daniels, V., & Rabinovich, E. (2010). Moving forward and making a difference: Research priorities for the science of service. *Journal of Service Research, 13*(1), 4–36.

Paszkowski, U. (2006). A journey through signaling in arbuscular mycorrhizal symbioses. *New Phytologist, 172*(1), 35–46.

Payne, A. F., Storbacka, K., & Frow, P. (2008). Managing the co-creation of value. *Journal of the Academy of Marketing Science, 36*(1), 83–96.

Peters, L. D., Lobler, H., Brodie, R. J., Breidbach, C. F., Hollebeek, L. D., Smith, S. D., Sorhammar, D., & Varey, R. J. (2014). Theorizing about resource integration through service-dominant logic. *Marketing Theory, 14*(3), 249–268.

Plé, L., & Chumpitaz, R. (2010). Not always co-creation: Introducing interactional co-destruction of value in service-dominant logic. *Journal of Services Marketing, 24*(6), 430–437.

Prigogine, I., & Leferver, R. (1968). Symmetry breaking instabilities in Dissipative Systems. II. *The Journal of Chemical Physics, 48*(4), 1695–1700.

Prigogine, I., & Nicolis, G. (1967). On symmetry-breaking instabilities in dissipative systems. *The Journal of Chemical Physics, 46*(9), 3542–3550.

Ramaswamy, V. (2011). It's about human experiences. . .and beyond, to co-creation. *Industrial Marketing Management, 40*(2), 195–196. (Special issue on service-dominant logic in business markets).

Ranganathan, J., Raudsepp-Hearne, C., Lucas, N., Irwin, F., Zurek, M., Karen Bennett, K., Ash, N., & West, P. (2008). *Ecosystem services – A guide for decision makers*. World Resources Institute.

Redman, R. S., Dunigan, D. D., & Rodriguez, R. J. (2001). Fungal symbiosis: From mutualism to parasitism, who controls the outcome, host or invader? *New Phytologist, 15*, 705–716.

Riddle, D. L. (1986). *Service-led growth. The role of the service sector in world development*. New York: Praeger Publishers.

Sampson, S. E. (2010). The unified service theory. A paradigm for service science. In P. P. Maglio, C. A. Kieliszewski, & J. C. Spohrer (Eds.), *Handbook of service science, service science: Research and innovations in the service economy*. Boston, MA: Springer US.

Schopenhauer, A., & Ebeling, H. (1978–1979). Die beiden Grundprobleme der Ethik: Behandelt in 2 akad. Preisschr, Philosophische Bibliothek, Bd. 305–306, Meiner, Hamburg.

Schrödinger, E. (1944). *What is life*. Cambridge: Cambridge University Press.

Sethna, J. P. (2011). *Entropy, order parameters, and complexity*. Oxford: Clarendon Press.

Shannon, C. E. (1949/1998). The mathematical theory of communication. In C. E. Shannon & W. Weaver (Eds.), *The mathematical theory of communication* (pp. 29–125). Urbana, IL: University of Illinois Press.

Spohrer, J. (2009). Service science and systems science: Perspectives on social value. Institute of Technology, Tokyo. In *Proceedings of the 5th Symposium of the 21st Century COE Program "Creation of Agent-Based Social Systems Sciences*" (pp. 9–33).

Spohrer, J., & Maglio, P. (2010). Toward a science of service systems – Value and symbols. In P. P. Maglio, Ch. A. Kieliszewski, & J. C. Spohrer (Eds.), *Handbook of service science* (pp. 157–194). New York: Springer.

Starr, M. P. (1975). A generalized scheme for classifying organismic Associations. *Symposia of the Society for Experimental Biology, 29*, 1–20.

Straathof, S. M. (2007). Shannon's entropy as an index of product variety. *Economics Letters, 94* (2), 297–303.

Vargo, S. L., & Lusch, R. F. (2004). Evolving to a new dominant logic for marketing. *Journal of Marketing, 68*(1), 1–17.

Vargo, S. L., & Lusch, R. F. (2008). Service-domiant logic: Continuing the evolution. *Journal of the Academy of Marketing Science, 36*(2), 1–10.

Vargo, S. L., & Lusch, R. F. (2011). It's all Be2B...And beyond: Towards a systems perspective of the market. *Industrial Marketing Management, 40*(2), 181–187.

Vargo, S.L., Lusch, R.F., & Akaka, M.A. (2010). Advancing service science with service dominant logic – Clarifications and conceptual development. In P. P. Maglio, C. A. Kieliszewski, & J. C. Spohrer (Eds.), *Handbook of service science* (pp. 133–156). New York, NY: Springer.

Vargo, S. L., Maglio, P. P., & Akaka, M. A. (2008). On value and value co-creation: A service systems and service logic perspective. *European Management Journal, 26*(3), 145–152.

West, S. A., Griffin, A. S., & Gardner, A. (2007). Evolutionary explanations for cooperation. *Current Biology, 17*, R661–R672.

Yamamura, N., Higashi, M., Behera, N., & Wakano, J. Y. (2004). Evolution of mutualism through spatial effects. *Journal of Theoretical Biology, 226*, 421–428.

Zimmermann, E. (1951). *World resources and industries* (2nd ed.). New York, NY: Harper & Row.