Sustainability Science (2018) 13:1245–1263
https://doi.org/10.1007/s11625-018-0565-2

SPECIAL FEATURE: ORIGINAL ARTICLE

People, Technology and Governance for Sustainability: The Contribution of Systems and Cyber-systemic Thinking

A system dynamics perspective on a viable systems approach definition for sustainable value

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Received: 30 October 2017 / Accepted: 10 April 2018 / Published online: 21 April 2018

Abstract
Aim of this work is to shed light on sustainable value and develop a model, based on vSa and translated at applicative level through the system dynamics methodology for measuring sustainable value. By adopting vSa perspective, value, characterized by strongly subjective contents, will be considered as a vector quantity, as the result of the subjective weighting of the different dimensions that may change according to the considered organization. Starting from the analysis of system dynamics and vSa, we will implement the theoretical framework into a model developed with system dynamics, hence through a methodology capable of addressing systemic problems which is also an expressive approach to solve issues arising in complex systems (characterized by interdependence, mutual interaction, information feedback, circular causality). In order to translate theory into "action and application" we will develop a model through which it will be possible to exploit the advantages of vSa implemented into an SD model, which ultimately can also be instantiated to specific cases and then simulated for further quantitative insights. Currently, there is no theoretical/practical approach to sustainable value measurement for business organizations that simultaneously considers the dimensions of the triple bottom line together with the subjective perspective of decision-makers. From these considerations, we derived the idea to integrate vSa and system dynamics with the aim of analyzing the issue of sustainable value, whose triple dimension is usually (erroneously) seen under a perspective that does not consider the interactions among those three dimensions. The integration of the subjective perspective within a model for calculating sustainable value can be seen as considering vSa as the theoretical framework, and system dynamics as the methodology that allows translating such an approach into a model that can later be simulated. It is also worth mentioning that through the application of the vSa theory to the case of sustainable value, by means of a transcoding approach like the system dynamics one, we are somehow trying to "redefine", or better "enhance", the vSa theory itself, by "operationalizing" it.

Keywords Viable systems approach · System dynamics · Sustainable value

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Introduction

The concept of sustainability has acquired a growing central role in the definition of the governing processes of organizations and, in particular, business organizations.

Since the definition of sustainable development given by the Brundtland Commission in 1987 ("sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs") has become the reference definition about sustainability, the focus of the international debate has continuously shifted towards multi- and trans-disciplinary approaches (Komiyama and Takeuchi 2006). Accordingly, it has derived a spread interest in sustainability that has progressively involved different scientific domains, overcoming the initially prevailing environmental perspective, and including more and more the social and economic perspectives (Barile et al. 2014, 2015).

Starting from these considerations, this work proposes the adoption of a systemic approach to sustainability (Farioli et al. 2018; Barile and Saviano 2017; Barile et al. 2017), intended as the analysis of the effects that derive from the synergic and contemporary consideration of the instances that derive from each of the three dimension that traditionally define sustainability (i.e. environmental, social, economic).

The adoption of a holistic view of sustainability, and of the interactions occurring between its three dimensions, finds in the systems paradigm a valid interpretative support, as it allows to highlight critical issues and guidelines that can be useful to orient decisions and behaviors of organizations (Saviano 2016; Saviano et al. 2017a, b; Scalia et al. 2016).

This is particularly relevant in terms of value, as it tries to go beyond the notion that value is a simple the 'sum' deriving from the results of the dimensions identified, focusing on the virtuous dynamic of interaction that these dimensions can generate and on the subjective perception of value itself. This shift implies the abandon of a reductionist view, which is oriented to focus on the single areas, in favor of a view that considers the whole processes involving the three dimension, thus integrating them and exploring how, as said, they are subjectively perceived by the actors who observe them.

Accordingly, aim of this work is to shed light on sustainable value and develop a model, based on some insights of the viable systems approach (vSa) and bridged at the applicative level through the system dynamics methodology. The approach used here considers the value as characterized by strongly subjective contents; this means that value is not predictable and objectively determined, rather it is perceived specifically in the use, it changes in different contexts and evolves during the time, as many scholars of service community deal with. By this, in order to analyze properly nowadays business and organizational dynamics in current scenarios it is necessary to identify the perspective of the user to which any valuable solution is created and proposed (recipient) relating with the perspective of who is concerned with the measurement of the sustainable value (decision-maker). This assumption links each actor's own context and the measure of the value that he or she is interested in determining.

In this way, the concept of value is characterized by having a multiple dimension, because it involves a multiplicity of recipients and, consequently (Gladwin et al. 1999; Hillman and Keim 2001), any decision-maker (aimed at the survival of its organization) must include, among those involved by his government decisions, a set of actor, with different expectations and different degrees of satisfaction.

In this sense, value is intended as not exclusively targeted at categories of privileged subjects (generally, shareholders), but includes, in its determination and destination, different aspects and expectations that affect the system dynamics, thus requiring a wider perspective. The reference here is to what Porter and Kramer defined as "shared value" (2011), proposed by such a firm that could be shared by individuals and organizations operating in the same context, distributed and then diffused. This perspective is being now applied to the sustainable value and implies the integration of social and environmental instances within the dynamics of organizations, with specific reference to businesses. The need to consider these elements emerges from the efforts of International Organizations to set up methods, techniques and tools for evaluating companies that also include social and environmental elements. The reasons that inspired this paper derive from the consideration that, currently, there is no theoretical/practical approach to sustainable value measurement for business organizations that considers, at the same time, the dimensions of the triple bottom line together with the subjective perspective of the decision-makers. Accordingly, the model that this work outlines responds to such instances. In fact, based on the vSa notion of Relevance, that is the importance attributed by the decision-maker to the other systems with which it interacts, the model allows to recover the subjective dimension of value by expanding the latter to the size of sustainability.

Starting from a review of the concept of sustainable value, we refer to some of the main conceptualizations proposed by vSa. Further, these concepts will be the basis for the definition of a vSa-based system dynamics (SD) model. Given the inherent capability of SD to grasp the intrinsic complexity of systems and the presence of articulated feedback loops, we decided to adopt such a methodology given also its circular nature in the process of learning and understanding, as well as of knowledge acquisition when dealing with a complex issue, like the one of sustainable value. Finally, we will propose an SD theoretical model for sustainable value based on vSa.

Sustainable value or values?

The concept of value is dynamically changing and becoming something more and more subjective, and totally codeterminated by actors' interactions (Barile et al. 2013a; Åkesson et al. 2014).

In order to achieve its own final goal, any organization (including business) must consider a variety of perspectives, and this issue has been just investigated in last decades worldwide, following the increasing importance given to values (as personal sentiments and specific mode in actions) that influence the relationships between all the actors effecting the survival of the organizations (Barile et al. 2012a, b; Polese et al. 2016).

In a sustainable meaning of value, in general we must include the collective evaluation of every value-proposition. The logic of co-creation, indeed, is based upon the mutual interest of many actors in being part of the same process while they operate in a specified context (as it is perceived subjectively), in which the service is experienced (Barile et al. 2013a).

For instance, in a destination characterized by special attractions, citizens, tourist players, business organizations, leisure tourists, institutions, all are involved in the provision of the global service in which everyone takes part, has a role, is able to contribute to the emerging value co-creation, actively or not, positively or not, consciously or not. This is based on S-D logic assumptions (Fps and Axioms) and it overcomes traditional model and reflections on value creation, allowing and fostering the resource integrations and the mutual benefit of cooperation (Vargo et al. 2017).

Further, the value is no more based on the transaction costs (value-in-exchange) but even in the use of users; in this sense customers (at any level) become active source of value co-creation because of their active participation in it (value-in-use) (Vargo and Lusch 2011).

In the same way, the personal perception of valuable solutions is influenced by the place and the time in which customers are; moreover, the value could be intended as different if frame-worked in other situations or conditions (value-in-context) (Vargo et al. 2017).

The opportunity to consider sustainability as a multidimensional phenomenon affecting economic, social and environmental aspects has led, in the last decades, several international organizations to build models in the attempt to measure it, according to objective and shared parameters that make reference to more or less large and articulated contexts. These models are based on a number of Indicators organized in turn in Indexes and ratios that, on the one hand, can achieve comparable results in time and space by monitoring the nature and evolution of the phenomena associated with the indicators and, on the other, they orient environmental policies by fostering the knowledge of the results obtained for users, as well as for "non-executives".

The goal of creating value, coupled with ethical and responsible imperatives, leads to the exclusion of a privileged prospect in an almost exclusive way (generally that of shareholders). Sustainability management, therefore, reconceptualizes the value as something that should be shared, underlining the single and personal priorities to the government of the society as a whole (Porter and Kramer 2011; Sen 1999).

Concerning business organizational model, there are lots of instruments and procedure not totally agreeing the multidimensional view of the value. The following are the main documents that companies voluntarily draw up, together with the balance sheet, and which cover the social, environmental and sustainability dimension in general. These documents leave to every actor the possibility of interpreting the contents, so that the single recipient must recompose the individual "information fragments" that derive from a multiplicity of sources to a single, necessarily subjective, measure of the value created by the enterprise. The difficulty that arises in the single system, therefore, is to bring to the unity a measure of value which is, as stated before, multidimensional. This gap seems to appear when we check that organizations mostly have only standard value measures that do not consider individual prospects (social balance, environmental balance), as opposed to a dynamic interaction of the same. This issue is also the basis of the elaborated model, whose methodological features will be outlined later. Table 1 reports the most common frameworks and tools for measuring sustainability at the organizational level.

The main limitations of these traditional tools lie in their calculation of sustainable value in an exclusive efficiency optic, partially ignoring the dimension of effectiveness which includes many other variables associated to the involved actors. These tools, in fact, do not consider the need of business organizations to move to more enriched formulations for the calculation and communication of their process of sustainable value creation (as co-created in the logic described above), nor do they consider the call for the consideration of the subjective perspective that comes from both academic and professional world.

This means that they are not consistent with the theoretical approach proposed herein, as they tend to privilege one perspective over the others.

Starting from these considerations, it emerges the need of considering value with a wider perspective, that is multidimensional, dynamic, and vectorial, able to include all the expectations of the different actors involved in the value co-creation (and distribution) processes.

Decision-makers should update models and strategies with the aim to fit adequately with customers' needs and wants (Payne et al. 2008; Napoletano and Carrubbo 2010; Carrubbo et al. 2017). Recent advances in literature worldwide on the issue of subjective value let scholars and practitioners to understand and interpret modern operations and business behaviors by using different lens. Decision-makers are influenced by own experiences and backgrounds, then their understanding and decisions are subjective too; they must work in a logic of long-run, trying to match users' evolving expectation and typically, for all these reasons, the new approach is win–win based, service-centered,

Table 1 Most common frameworks/tools for sustainable value at the organization level

Tool	Brief description	Dimension
Standards of accountability	By targeting business decision-makers in the definition and formalization of the actions of government, concern the certification of ethical conduct by business organizations	Primarily social
Global compact	sets out 10 principles in 4 main areas (human rights, labor, environment and anti-corruption measures)	Social and environmental
Social report	The certification of an ethical point of view that legitimizes the role of an organization as an economic entity that, in pursuing its own interests, should contribute to improving the quality of life of the members of the society in which it is inserted	Social
Environmental report	Contains different types of indicators for what concerns environmental management; environment in general; environmental performance; potential impact; environmental effect	Environmental
Sustainability balanced scorecard (Figge et al. 2002)	Identifies the environmental and social issues that are strategically important for the business organization's business units of reference	Primarily social
Sustainable model (Figge and Hahn 2005)	Based on the concept of negative externalities, provides a measure of sustainable value calculated according to the environmental cost of the emissions of considered business organizations	Primarily environmental
Sustainability report	Drawn up according to the guidelines identified by the Global Reporting Initiative (GRI), consist of a set of indicators individually set for each dimension and in a set of guidelines for the reporting and compilation of financial sustainability	Economic, social, and environmental

Source authors' elaboration

information-driven, modular and adaptable (Barile et al. 2012a, 2013b, 2013c; Polese et al. 2017a, b).

Of course, it is also worth mentioning, in this paragraph, about the links between the system dynamics approach and the general concept of sustainability. This is pretty much easy to do, as in fact the system dynamics approach was designed by Forrester in 1961 in his first seminal book "Industrial Dynamics" (Forrester 1961) where he was basically arguing how a company can achieve a sustainable growth only by considering the interdependencies between the economic and social systems, that is by putting what were called "soft" variables (typical of human behavior in decision making) at the center of a systemic and behavioral view of the firm. This of course is strictly connected to the important work done in the early 1960s at Carnegie Mellon on organizational theory, for example by Cyert and March, "The Behavioral Theory of the Firm" (Cyert and March 1963), from which Forrester later formalized the delay between information and action. The intrinsic and two-way relationship between system dynamics and sustainability has then probably found its peak in the masterpiece written by the SD-Group at MIT (Forrester's boys) in the early 1970s for the Club of Rome, "Limits to Growth", where Meadows (Dennis and Dana), Randers and Behrens developed an SD Model through which they were able to assess (basically with an anticipation of 40 years or so) how the human footprint would have affected the sustainable development of our planet in the years to come! (Meadows et al. 1972). The value of their predictions proved true in the years, and at a certain extent, the situation is also possibly worse that what they predicted, against a myriad of critiques of researchers, politicians and other influencing subjects that did not want to accept this perspective and continued to state that things were not going to be that bad, etc. This is just to say that in the last 46 years, after the "limits to Growth" was published, the link between system dynamics and sustainability has always been very tight, and the available literature is very rich. At this stage, it is probably worth mentioning a few of them, though. For example, it is interesting to mention the work done into a special issue of the "Sustainability" Journal, edited by Richard Dudley and Allysonn Beall King, where the same Guest Editors, in their editorial state that when it comes to discussions on sustainability, different opinions from different stakeholders can bog down the discussion, For this reason, they argue that "if such discussions can be carried out within a clear, agreed upon, framework, then the ability to reach reasonable consensus can be enhanced." They also continue by identifying SD as a valuable "linguistic" tool over which to build a shared understanding: "Of the tools available to build that framework, system dynamics modeling stands out. It is well established, is based on a solid mathematical footing, is flexible, and has well developed protocols for model building, verification, and analysis. In particular, system dynamics modeling is an ideal tool for examining complex systems characterized by feedbacks and delayed effects, characteristics that underlie so many sustainably issues. System dynamics modeling was first used to address sustainability in the Limits to Growth models of the early 1970s. Since then system dynamics modeling has become more sophisticated and easier to use. Over the same period sustainability has become an influential paradigm for examining possible future scenarios". Other relevant references in the field from relevant authors of the systems thinking and system dynamics community include the work done by Peter Senge (Senge et al. 2007), arguing how collaboration can lead to sustainable and systemic change, and John Sterman (Sterman 2012) in an important work where he describes system dynamics as the founding element for the creation and design of a new systems science inside a fragmented academy and polarized world, hence also arguing that SD can constitute an esperanto for systems researchers in talking the same language.

vSa and system dynamics: definitions

Viable systems approach (vSa)

vSa is a theoretical approach that starts from Beer's viable system model (Beer 1972), according to which a system is viable if it "survives, remains united and is integral, is homeostatically balanced both internally and externally and possesses mechanisms and opportunities for growth and learning, development and adaptation, which allow it to become increasingly effective within its environment" (Beer 1985).

Starting from Beer's conceptualizations, vSa proposes some advances that refer to the simultaneous observation of phenomena, both from a structural perspective (static) and from a systemic perspective (dynamic), and defines viable the system that is also able to survive in its context of reference (Barile 2009; Barile and Saviano 2011). In this sense, survival is the ultimate purpose of the system and it depends on its ability to establish relationships of harmony and positive interactions with the relevant entities present in its context (Golinelli 2002; Barile 2008, 2009).

Moreover, according to vSa, a viable system has a substantial equivalence (isomorphism) with an information variety, that can be defined as the 'knowledge patrimony' that it owns and is articulated in three dimensions: values categories, interpretation schemes and information units (Barile 2009).

Information units are the most exterior level of the information variety and express the "structural composition of knowledge" (Barile 2009); they represent everything that can be *perceived* by the senses, or elaborated from the outside by the viable system, that is, from its specific context of reference. These data that come from the external, through elaborating processes, become information.

Interpretation schemes are the intermediate level of the information variety, i.e. the "forms" of knowledge (Barile 2009) that enable each viable system to rationally organize information. They represent the way information units are 'filtered' and transformed into information.

Value categories represent, for a system, its strong beliefs, the system of values that orientate it in the decision-making processes and from which they cannot be excluded. They are, therefore, also the "resistance" that knowledge possesses opposes to change (Barile 2009) and are responsible for the acceptance or refusal of messages, elaborations, etc, as they represent a subjective filter, and are the deepest level of the information variety.

With these premises, information variety can be represented as follows (Barile 2009):

$$\boldsymbol{V}_{\boldsymbol{inf}}(\boldsymbol{k}) \;=\; \left(\boldsymbol{U}_{inf},(\boldsymbol{k}),\; \boldsymbol{S}_{\boldsymbol{int}}(\boldsymbol{k}),\; \boldsymbol{C}_{\boldsymbol{val}}(\boldsymbol{k})\right),$$

where $\boldsymbol{V}_{\boldsymbol{inf}}(\boldsymbol{k})$ is the a information variety of a viable system K; $\boldsymbol{U}_{\boldsymbol{inf}},(\boldsymbol{k})$ is the information units of the information variety of viable system K; $\boldsymbol{S}_{\boldsymbol{int}}(\boldsymbol{k})$ is the interpretation schemes of the information variety of viable system K; $\boldsymbol{C}_{\boldsymbol{val}}(\boldsymbol{k})$ is the value categories of the information variety of viable system K;

We can identify the possible evolutionary paths of the information variety of a viable system, when interacting with one or more Information Variety/ies, with the concepts of consonance and resonance (Barile 2009). Consonance can be defined as the potential condition of compatibility and/or complementarity between interacting entities; resonance represents the consequent effects of harmonic interactions between two or more systemic entities and is related to preexistent conditions of consonance (Barile 2009). Consonance and resonance are the two drivers that orient viable systems' behaviors in their dynamics of knowledge and, therefore, in their behaviors.

As consonance between two (or more) different information varieties defines the major or minor potential that the two (or more) information varieties have in aligning their knowledge, in terms of the information units used, we represent it as follows (Barile 2009):

$$\boldsymbol{C}_{\boldsymbol{ons}} \;=\; \boldsymbol{lim}_{u1\to u2}\boldsymbol{V}_{\boldsymbol{inf}1} - \boldsymbol{V}_{\boldsymbol{inf}2}/\boldsymbol{u}_1 - \boldsymbol{u}_2 = \delta \boldsymbol{V}_{\boldsymbol{inf}}/\delta \boldsymbol{u}.$$

Resonance, instead, represents the change in the levels of consonance and expresses the intensity with which it can grow or decrease with time. It can be represented as follows (Barile 2009):

$$\boldsymbol{Res} = \boldsymbol{lim}_{u1\to u2}\boldsymbol{C}_{\boldsymbol{ons}1} - \boldsymbol{C}_{\boldsymbol{ons}2}/\ \boldsymbol{u}_1 - \boldsymbol{u}_2 = \delta \boldsymbol{C}_{\boldsymbol{ons}}/\delta \boldsymbol{u}.$$

From the above, consonance can be defined as a line of action for the viable system, and involves the implementation/preservation of the conditions of harmony, correspondence, alignment and dialogue with the context of reference:

it expresses the fundamental need of the system to match the values, cultures and needs of the surrounding society and to find recognition and consideration among the different entities that populate it (Golinelli 2002).

Resonance intervenes in the modification of consonance levels; it represents the way in which an information variety moves dynamically into the context in which it expresses its viability, and the level of sensitivity that it manifests towards the other systems with which it interacts with the perception of new information (Barile 2009). Therefore, resonance, unlike consonance that may exist or not, also has a direction that qualifies, precisely, the evolution of consonance over time: it can be positive, as the change of consonance undergoes an increase over time, or negative, as the consonance undergoes a reduction.

System dynamics (SD)

System dynamics has its roots in systems thinking, it was developed in the late 1950s by Forrester at MIT and was first described at length in Forrester's book industrial dynamics (Forrester 1961) with some additional principles presented in later works (Forrester 1969, 1971). It is a modeling and simulation methodology particularly fit at describing complex, non-linear, counter-intuitive feedback-driven behaviors, also characterized by feedback relationships and delays acting in the system. A central tenet of system dynamics is that the complex behaviors of organizational and social systems are the result of ongoing accumulations—of people, material or financial assets, information, or even biological or psychological states—and both balancing and reinforcing feedback mechanisms.

The concepts of accumulation and feedback have been discussed in various forms for centuries (Richardson 1991). System dynamics (Sterman 2000) is also a computer-based modeling method that makes use of formal models in order to understand the elements of complex systems over time. The main goal of system dynamics is to understand how a system's behavior emerges and uses this understanding to gain insights on how policy changes in that system might alter its behavior. System dynamics uniquely offers the practical application of all these concepts in the form of computerized models in which alternative policies and scenarios can be tested in a systematic way that answers both "what if" and "why" (Tank-Nielsen 1908; Morecroft 1985). Its main elements are *feedback loops* and *delays* that give rise to dynamic complexity, inherent in socio-economic systems and processes, through quantitative simulations (Sterman 2000).

In other words, SD is a methodology for understanding, discussing and simulating complex systems over time (Sterman 2000) and it has been widely used in many management, engineering, social and environmental application areas.

Some of the most important systems dynamics concepts are the following:

- *Stocks and flows* Stocks (or levels) consist of accumulation within the systems while flows (or rates) are the transport of some content of one level to another.
- *Time delays* As levels are changed only by the rates. The rates change is measured in a determined time interval.
- *Feedback loops* A decision alters the state of the world, but at the same time indirectly influences itself, defines the situation we will face in the future, and triggers side effects and delayed reactions. Feedback loops can be positive or negative. Positive loops consist in reinforcing or amplifying what is happening in the system. Negative loops, instead, counteract and create balance and equilibrium.
- *Accumulation* The levels, or stocks, are integrations. These are variables that cannot change instantaneously; they accumulate or integrate during time according the results of actions in the system.
- *Endogenous point of view* It refers to the existence of a closed boundary which means the dynamic behavior arises within the internal feedback loop structure of the system (Richardson 1991).

It is interesting to note that the process of building an SD model is inherently circular, both in its qualitative phase (the Systems Thinking one, where we basically build causal loop diagrams to understand the basic structure of the system under analysis) and in its quantitative one, as in fact, from each phase, one may want to go back to review the hypotheses that were built in previous phases.

Can system dynamics constitute a potential quantitative manifestation for vSa?

In the light of the considerations carried out so far, in what follows we will define the theoretical assumptions on which to build a potential quantitative model (as in this paper we will remain at a level of definition of the simulation model) of the main concepts of vSa through the system dynamics (SD) modeling methodology; the theoretical formulation will be then expanded to the elements that contemplate the dimensions of sustainable value.

Starting from the considerations laid out in previous paragraphs and work (Armenia et al. 2015; Iandolo et al. 2017), we will now argue and try to demonstrate that System Dynamics can be a potential (and quantitative) method to translate vSa concepts into a simulation model; thus, we will now try shaping the foundations of a system dynamics' based systemic structure that is capable of describing the founding vSa concepts, basically by analyzing the process of knowledge creation (Barile 2009).

Starting from previous research on viable systems, according to which learning process is defined as determined both by the organization's structural and value systems (Espejo 1996; Ramage et al. 2014; Espinosa 2015), vSa relates the knowledge creation process to two kinds of decisions, the ones related to problem solving and the ones related to decision-making (Barile 2009). We can define problem solving as the adoption of theories, models, techniques and tools that are already known. In this sense, problem solving is the ability to use the existing knowledge, as the problems decision-maker faces are related to the availability of additional information; decision-making is related to the need to identify or develop new theories, models, techniques, and tools that are not already known to the decision-maker.

Representing a viable system through the decision-making and problem solving activities that characterize the dynamics and the evolution of knowledge acquisition (Barile 2008), makes it possible to identify significant properties belonging to the decision process. The possible paths of resolution of a specific decision-making problem starts from a perception deriving from the external context and from the knowledge owned by each subject. This process, developed through abduction, induction and deduction, can be repeated infinite times, before it gives a solution to the problem that becomes a new interpretation scheme. However, in some cases, this sequence may not bring to a solution to a problem; the possible paths are explained in Fig. 1.

To better explain this process, it can be useful to clarify the concept of deduction, that consists of the appropriate application of established models or simple interpretation schemes to analogous situations. According to the perspective adopted herein, a decision-maker's strong beliefs, convictions, and interpretation schemes are crucial in defining a problem and the dynamics which converge towards a certain choice. A decision consists of prospecting a solution to a problem, but, as we have seen before, is not true in all cases.

From this, it derives that the knowledge creation process, both when referred to a specific phenomenon and to a problem to be analyzed, according to vSa, is intrinsically circular and iterative, characterized by trials and errors, and bringing to several possible outcomes.

The information filtering capability deriving from the so obtained "New Interpretation Scheme" will be also fed back to better address our (as decision-makers) perception of the context as well as to improve our information variety (thanks to a new and upgraded interpretation capability).

This "learning" process goes through a well-known sequence of "trial-error-refinement" and can also be represented as a circular knowledge creation path where the knowledge refinement happens at the end of each cognitive cycle and after having understood and learnt how to modify the model in order to make it more similar to the reality (new interpretation schemes feeding back our capability to understand) hence, to better shape the problem we attempt to solve.

System dynamics models are normally constructed for further understanding a complex system, but they are often misunderstood for predictive models. However, the purpose of the method (and its main strength) is that it can capture

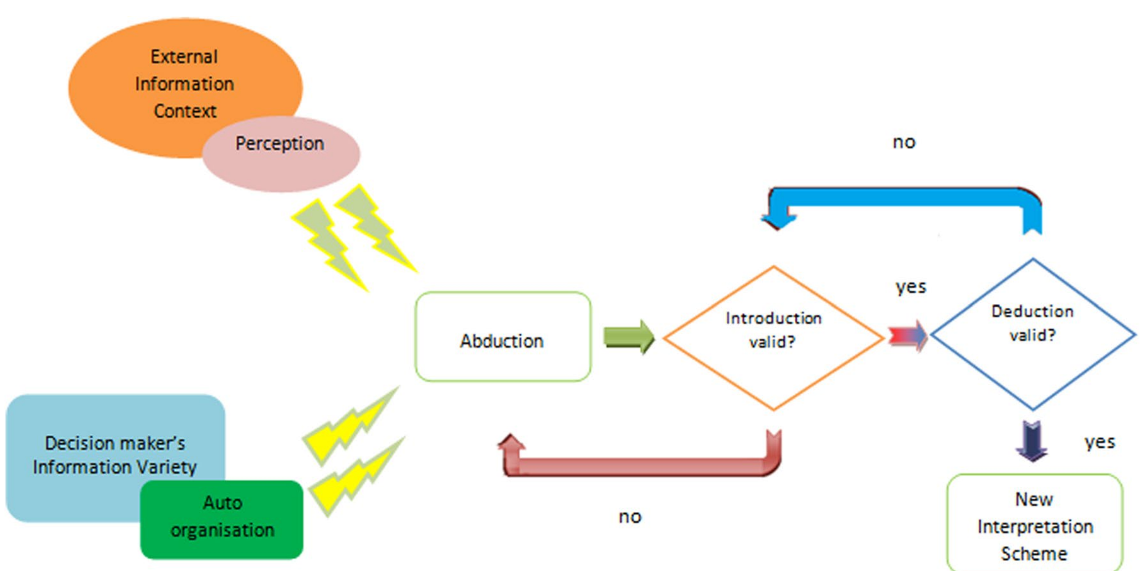

Fig. 1 Possible resolving paths for a decision-making process. Source: http://www.asvsa.org

underlying connections among system elements that cannot be easily perceived, it can identify and represent delays that affect the effectiveness of a policy and finally, it can remove the personal ideology and bias from the actual computations (Sterman 2000).

In other words, system dynamics is a valuable quantitative approach to delve into understanding how a system works, what are its key/high-leverage points and how it can react to certain badly-designed policies by resisting change (just because the change effort was directed towards the points with the lowest capability to change) and thus present some counter-intuitive behaviors which is a way to demonstrate how humans are characterized by bounded rationality, unable to manage too many "interdependencies" and correctly and coherently forecast the overall system behavior.

In the system dynamics methodology, the structure of a system can be initially conceptualized qualitatively through a Causal Loop Diagram (CLD), which is a map of the feedbacks present in the system. As feedback is one of the core concepts for understanding systems, the CLD is a valuable tool for representing the feedback structures of a system. These diagrams consist of variables connected by links representing causal influence among them, which is assigned a polarity indicating how they influence each other (see Fig. 2). A feedback loop is a closed chain of link connections, through a set of decisions, rules or actions that are dependent on the state of the system. The most complex behaviors usually arise from the interaction of two basic types of feedback loops: balancing (B) and reinforcing (R). We will extensively use CLDs representation in this paper, for a full treatment of such an approach see the works from Senge (1990) and Sterman (2000). It is worth mentioning that a structure represented with such an approach can be classified according to the way feedback loops interact with each other, producing sometimes a few clearly recognizable structures, called system archetypes, that display a typical behavior, which thus can be inferred (at least qualitatively) from the evidenced systemic structure of a system.

A system dynamics model consists of an interlocking set of differential and algebraic equations developed from a broad spectrum of relevant measured and experiential data. A completed model may contain scores or hundreds of such equations along with the appropriate numerical inputs. Modeling is an iterative process of scope selection, hypothesis generation, causal diagramming, quantification, reliability testing, and policy analysis. The refinement process continues until the model can satisfy requirements concerning its realism, robustness, flexibility, clarity, ability to reproduce historical patterns, and ability to generate useful insights. These numerous requirements help to ensure that a model is reliable and useful not only for studying the past, but also for exploring possible futures (Forrester and Senge 1980; Homer 1996).

In SD, the system can also be analyzed through a simulation, which is possible after the construction of a Stock and Flows Diagram (SFD). A SFD is a quantitative assessment of the system. The dynamics are pictured in the SFD and the model formulation is done by the elaboration of equations that expresses how the variables are interconnected with others and how the accumulation process is determined by the change in the flows altering the state of the system levels (Fig. 3).

To quantify the system, stocks and flows are used and the subsequent model is simulated with the use of computer software. A general representation of stocks and flows is illustrated in Fig. 4:

The structure above corresponds to the following differential equation:

$$\text{Stock}(t) = \int (\text{inflow}(t) - \text{outflow}(t)\text{d}t + \text{stock}(t_0)).$$

Armenia et al. (2013) describe how issues such as those just depicted are key challenges for policy makers, which need effective tools to reduce uncertainty and understand the

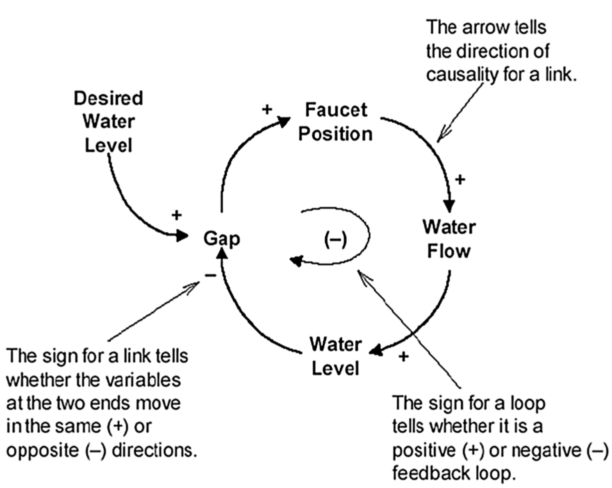

Fig. 2 A Causal Loop Diagram (CLD) depicting a negative feedback-loop. Source: The Fifth Discipline, Senge (1990)

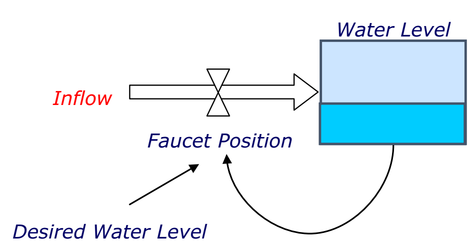

Fig. 3 A diagram that translates (into Stocks & Flows notation- SFD) the CLD in Fig. 1. Source: authors' elaboration

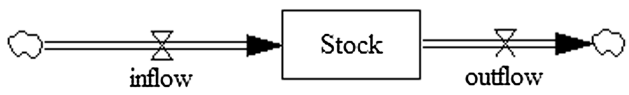

Fig. 4 A stock accumulates the difference of its flows (input–output)

possible impacts of their policies, ensure long-term thinking, effectively manage crisis and the "unknown unknown", effectively communicate the reasons for certain decisions as well as their impacts (thus generate involvement), ultimately encouraging behavioral change and uptake through cooperation and systems thinking, ultimately creating not only a shared better knowledge but also providing the basis for a sort of social wisdom.

Given the above, as also reported in Armenia et al. (2015), the authors believe that the SD methodology can constitute an effective way to support building quantitative models that are described according to the vSa approach, also given the intrinsic systemic nature of the vSa approach itself and the inherent capability of SD to be able to model even the most complex and abstract concepts, nonetheless a framework which is born by the considerations that revolve around the concept of knowledge creation.

The model depicted in Fig. 5 describes the way in which an individual takes decisions (acts), observes the results of his actions so to be able to control, at short-term, the outcomes by adapting decisions, and on a longer perspective, to adapt his mental models, hence even radically changing his basic assumptions, and thus implementing radical changes in his strategies.

Understanding how a systems work is a key task in order to be able to act on those high leverage points that are capable of bringing to consistent and permanent change. A generalization of Sterman's learning structure (depicted in Fig. 5) can be found in the model formulation of Pierce's system of inquiry, depicted in the next Fig. 6, where events are observed, hypotheses formed and then developed so to be tested, and once tested, their outcomes are evaluated and matched to the originally observed events. In this main feedback process, there are two lower dominance control loops (one to support hypotheses formation and one to monitor tests implementation).

The Causal Loop Diagram representation of the qualitative model reported in Fig. 6 has been depicted through the use of the Vensim® software and is reported in the following Fig. 7 (note: the negative links will generally be highlighted with red arrows while the positive links with blue arrows).

In particular, we can also develop the SFD of Pierce's system of inquiry, which has been depicted, through the use of the Vensim® software, in Fig. 8.

In other words, Pierce states that by gathering information while observing events outcomes (i.e. the system's behavior), we usually generate new hypotheses regarding what might have given rise to them. Once these hypotheses are generated, they need to be tested in order to determine its validity (hence, in SD terms, they accumulate in a stock, waiting to be tested). Testing such hypotheses, in turn, generates new information (which is related to the tests' outcomes). This information gets accumulated too, and matched/confronted with the initial information that generated the hypotheses: the resulting informational gap is used to eventually drop any hypotheses which has been ascertained as non-applicable (because they do not produce appreciating results), thus supporting the process of new hypotheses generation. But on the other hand, this generates a new understanding about the system structure and the world around itself. Such an understanding brings to learning and hence to new knowledge through which it is possible to perform a better events selection (events' refinement, basically thanks to new interpretation schemes, to say it in vSa terms). So far we have showed how to translate into SD terms a model describing the process of knowledge creation. If we now move to consider the vSa theory, this shows us a

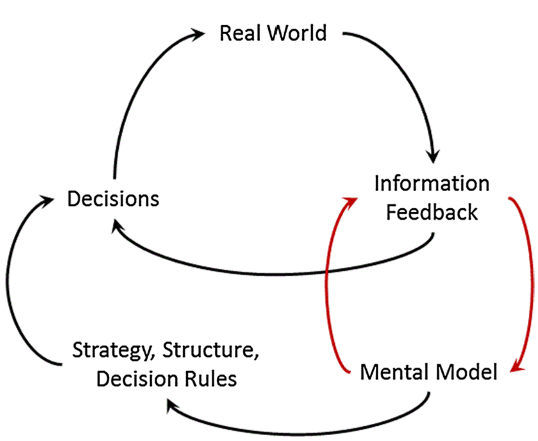

Fig. 5 Sterman's Business Dynamics (2000). Source: Business Dynamics (Sterman 2000)

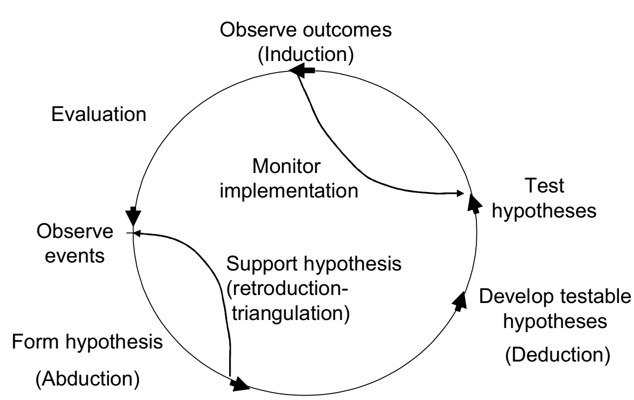

Fig. 6 Pierce's system of inquiry

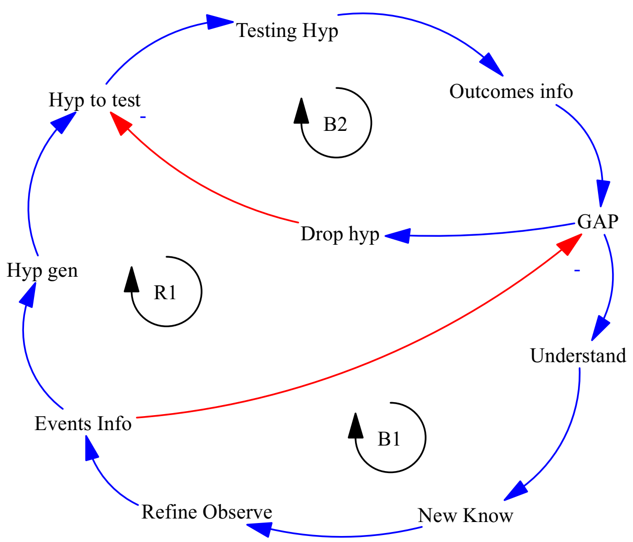

Fig. 7 CLD of the model in Fig. 6. Source: authors' elaboration

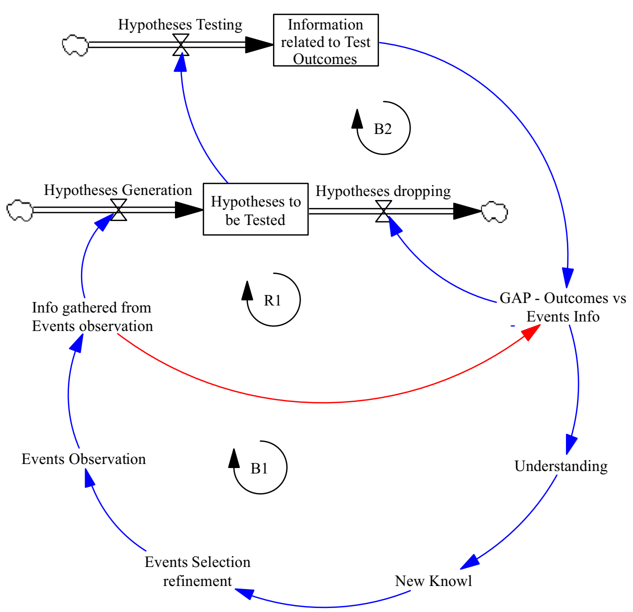

Fig. 8 Translation of Pierce's system of inquiry into a first SFD. Source: authors' elaboration

slightly different reading of Pierce's model on Inquiry which can be summarized through the following diagram (Fig. 9).

In fact, new hypotheses are formed through an Abduction process (trial & error type) up to a tipping point where Induction helps developing testable hypothesis, which, if successful, lead to a deduction process through outcomes observation that will lead to new knowledge. This process is inherently dynamic and circular (converging in spirals to an ultimate situation in which we are satisfied with the generated understanding, learning and new knowledge),

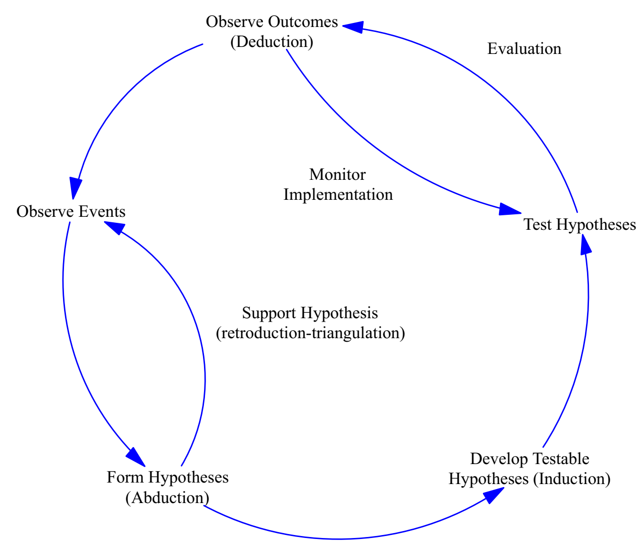

Fig. 9 vSa reading of Pierce's approach to Inquiry. Source: authors' elaboration

so deduction could lead also to drop previous hypotheses (which however constitute new information, understanding and knowledge) and start all over developing new ones by observing again events and systems' behaviors through a new approach filtered by the newly obtained knowledge.

Each of these processes (abduction, induction, and deduction) is influenced by information variety. value categories allow abductive reasoning, being, as said, the deepest level of knowledge: strong beliefs and values can orientate decision-makers when they face chaotic and complex issues. Interpretation schemes allow inductive reasoning, being responsible of organizing information in less complex or complicated issues. Deductive reasoning is related to the availability of additional information, and to less complicated or certain issues.

Should we define a graphical 2-dimensional behavior curve for such a process, we could use the one depicted in Fig. 10, which is basically the product of two functions, one representing the trial & error dynamics ($y = ax$) and the other the process of induction/deduction following the progressive understanding of a problem through the development and testing of hypotheses ($y = e - x$).

If we match Pierce's system of enquiry with the VSA process of new knowledge creation, knowledge alignment, capability to create new hypotheses on the problem to be solved and hence new information which in turn produces a new understanding and hence, again, new knowledge, we can easily redesign Pierce's derived CLD and SFD into the VSA SFD, that follows (Fig. 11).

where actual valid information = knowledge patrimony = $\mathbf{V_{inf}}$; actual knowledge = knowledge alignment

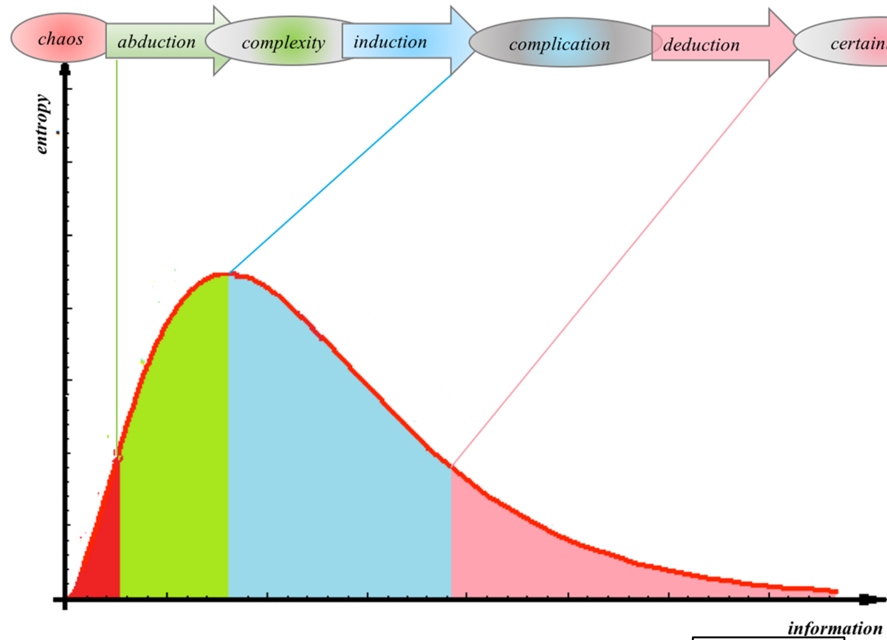

Fig. 10 vSa 4Cs curve. Source: Adaptation from Barile, 2009, http://www.asvsa.org

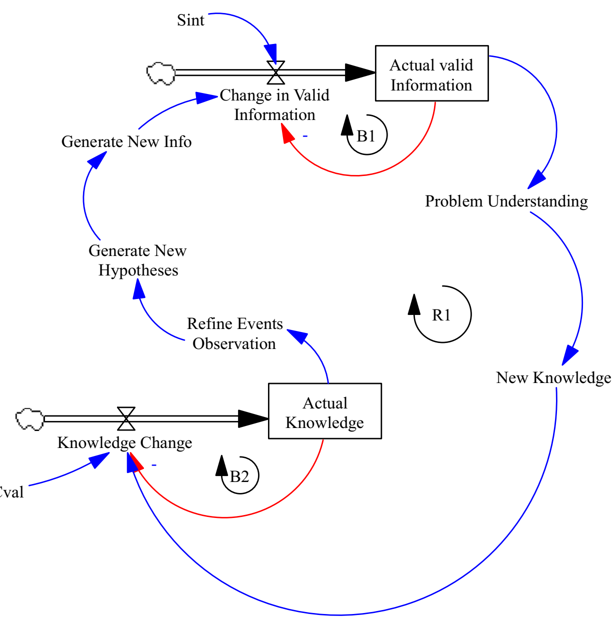

Fig. 11 An SD-description of the vSa-based model on knowledge. Source: author's elaboration

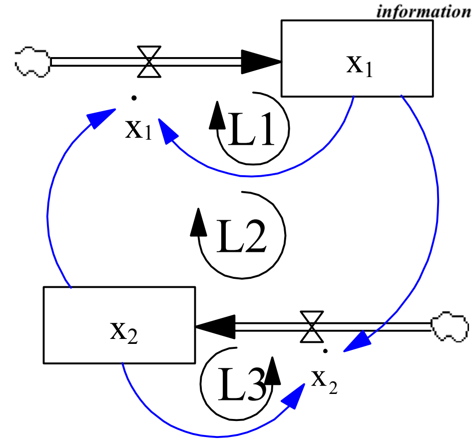

Fig. 12 Generic SD model describing a second-order system. Source: Guneralp

$=(\mathbf{dV_{inf}/du}) = \mathrm{C_{ons}}$; knowledge change = change in knowledge patrimony = $(\mathbf{dC_{ons}/du}) = \mathrm{R_{es}}$.

This is a typical SD structure formed by one main, high-dominance, feedback loop with two lower dominance feedback loops, which can be matched against the following one (Fig. 12).

This is a well-known second-order feedback structure, displaying two stocks, each feeding the other one's flow.

The state-space representation of this system structure is the following:

$$\dot{x}_1(t) = a_{11} \times x_1(t) + a_{12} \times x_2(t),$$
$$\dot{x}_2(t) = a_{21} \times x_1(t) + a_{22} \times x_2(t),$$

with the following matrix notation:

$$\dot{\mathbf{X}}(t) = \mathbf{A}\mathbf{X}(t),$$

where the gain matrix **A** is:

$$\mathbf{A} = \begin{matrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{matrix}$$

This can be further generalized by the following structure (Fig. 13).

By simplifying the model (2 loops, d = 0—that is the case for which there is no confrontation with previously available knowledge, rather the new knowledge gets just to integrate the old one in a process of continuous growth of knowledge—which is a reasonable assumption) we have the following:

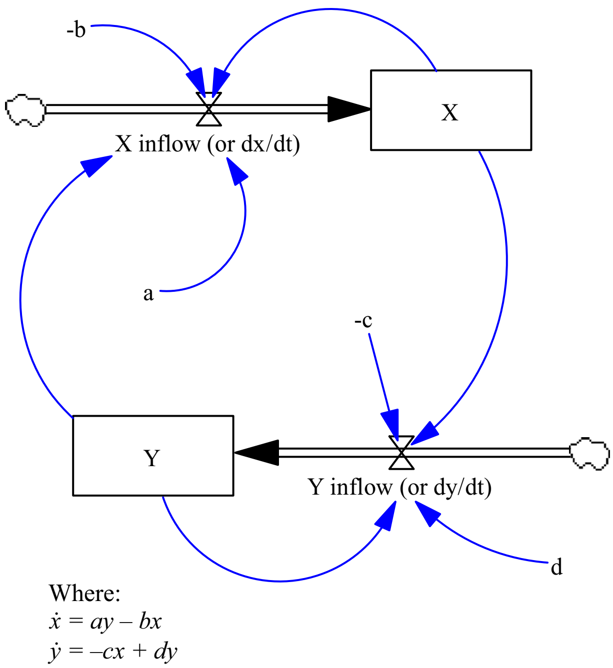

Fig. 13 Further generalization of model in Fig. 12. Source: authors' elaboration

$$\ddot{x} = ay - bx,$$

$$\dot{y} = -cx,$$

$$\ddot{x} = a\dot{y} - b\dot{x} = \left(a\frac{\dot{y}}{\dot{x}} - b\right)\dot{x} = \left(\frac{acx}{ay - bx} - b\right)\dot{x},$$

$$\ddot{x} = acx - b\dot{x},$$

$$\ddot{x} + b\dot{x} + acx = 0.$$

That is:

$$a(\mathrm{d}^2y/\mathrm{d}x)(x) + b(\mathrm{d}y/\mathrm{d}x)(x) + c(x) = 0.$$

If we use the typical VSA concept to substitute for the constant a, b and c, we have the following:

- $\mathbf{a = C_{val}}$
- $\mathbf{b = \text{-} S_{int}}$
- $\mathbf{c = \text{-} K}$

Adopting a system dynamics perspective for the viable systems definition of sustainable value

A representation of sustainable value based on vSa

The elements outlined above are fundamental to the understanding of the competitive dynamics of viable systems and, consequently, their value creation processes and constitute a necessary premise for the development of the model presented herein.

However, the isomorphism between a viable system and an information variety requires further clarification, especially about the foundations of the model presented. In particular, by recalling the above-described information variety, it is necessary to identify the equivalent of the information resource, which constitutes an element necessary for the survival of the viable system.

The focus on value derives from the consideration that, beyond being one of the main business concepts, it has traditionally been defined as something objective and defined a priori; in this paper, instead, we consider it as characterized by a multidimensional nature and by strongly subjective contents. Starting from this, we further focus our attention on sustainable value, intended as the result of the concurrent consideration of three dimensions: economic, social and environmental.

By adopting the vSa perspective, we introduce a subjective weighting of the different actors that may change according to the considered organization, this means that sustainable value can be defined as the result of the composition of several values that, in turn, are the result of the composition of several 'subjectivities'.

By making a comparison between information variety and value, we will adapt the knowledge model proposed by vsa to the proposed subjective consideration of value (Barile and Calabrese 2009; Barile et al. 2013a, b; Iandolo 2013; Armenia et al. 2015).

In order to develop the model, we will make a comparison between what constitutes a resource for the knowledge process and what constitutes a resource for the value creation process in business organizations. Among all the measures considered, we believe that the one that most satisfies the above-mentioned characteristics is equity.

The equivalence between the information resource for a viable natural system and productive resource for a viable business system needs to be based on the identification of some specific features that should characterize this quantity (Barile 2009; Iandolo 2013):

- its variation capacity must not be linearly linked to the quantitative increase in perceived resources;
- it provides for the possibility of enhancing the resources that are necessary for the optimization of operational processes;
- it is characterized by greater sensitivity with respect to resources from supra-systems or higher-level systems;
- it possesses the predisposition to self-modify through the internal processing of resources;
- it has the tendency to the progressive qualitative-quantitative accumulation of the acquired resources.

To identify which is the quantity within business organizations that meets these requirements and is appropriate for the equivalence, it is possible to consider all those that constitute the capital assets of the company: current assets, total net assets, invested capital, equity, rather than operating income, equity, etc. Among all these variables, it was considered that the one that most satisfies satisfactory correspondence with the characteristics listed above is equity. The latter, in fact, is a set of components linked to each other by functional relationships, has an instrumental value to the management functions, is also linked for non-transitory destination to the life of a specific organization. Moreover, it expresses the consistency of long-term assets linked to the organization's activity, and considers also the sources of internal financing, ie those sources coming directly or indirectly from the subject or from the subjects that make up and promote the company.

Based on these assumptions, we can define the following relationships (Iandolo 2013; Armenia et al. 2015):

Information unit => (productive) resource

Information variety => equity.

This means that, as information unit can be defined as the basic resource of an information variety and participates to knowledge generating process, the productive resource can be defined as the basic resource for every activity of business organization, and contributes to the generation of equity.

The identification of the correspondence/equivalence between the independent variable (information unit/ (productive) resource) and the dependent variable (information variety/equity), allows to redefine the concepts of consonance and resonance according to resources and equity. In this sense, consonance can be defined as the variation in equity after a variation in resource, that is the *ability of a* resource to influence equity, and represented as follows (Barile and Calabrese 2009; Iandolo 2013):

$$\mathbf{C_{ons}} = \frac{\left(\mathbf{E_2} - \mathbf{E_1}\right)}{\mathbf{r_2} - \mathbf{r_1}}, \tag{1}$$

where $\mathbf{E_2} - \mathbf{E_1}$ is the variation in equity; $\mathbf{r_2} - \mathbf{r_1}$ is the variation in (productive) resources.

Resonance, then, can be defined as the variation of consonance in relation to the variation of the considered resource and represented as follows (Barile and Calabrese 2009; Iandolo 2013):

$$\mathbf{Res} = \frac{\left(\mathbf{C_{on2}} - \mathbf{C_{on1}}\right)}{\mathbf{r_2} - \mathbf{r_1}}, \tag{2}$$

where $\mathbf{C_{ons2}} - \mathbf{C_{ons1}}$ is the variation in consonance; $\mathbf{r_2} - \mathbf{r_1}$ is the variation in (productive) resources.

In this sense, value can be defined as the change in equity that occurs according to the specific relevance of the actors present in the system's context of reference (Barile et al. 2013a, b; Iandolo 2013; Armenia et al. 2015):

$$\boldsymbol{Val_{Ssk}} = \boldsymbol{Rel_{Ssk}} \times \left(\boldsymbol{E}_2 - \boldsymbol{E}_1\right), \tag{3}$$

where $\boldsymbol{Val_{Ssk}}$ is the value for the system k; $\boldsymbol{Rel}_{\ Ssk}$ is the relevance, that is the ability to affect the system's survival, strongly linked to subjective elements; $\boldsymbol{E}$ is the equity, intended as the composition of tangible and intangible elements that characterize a firm (equity, knowledge, trust, etc.).

Equation (3) represents value expressed as the variation of equity with a subjective weight, given by relevance, that can be defined as the 'importance' attributed to the specific system that has released the resource that has led to the change in equity. As an example, the value of extraordinary work, and the relative compensation for it, will be related to the relevance attributed to the system ($_{Ssk}$) "work". Therefore, in a market where labor supply is excessive the relevance of the work system is low; consequently, its assessment will be less than the value generated by the reverse case, where poor human resources give a high relevance to the work system. Relevance can be expressed as follows (Barile 2009):

$$\mathbf{Rel_{Ssk}} = \mathbf{Crit_{Sk}} \times \mathbf{Inf_{Sk}}, \tag{4}$$

It is expressed as the composition of criticality and Influence. Criticality is the 'structural' component of relevance, and can be objectively determined and is an important weighting factor. Influence is the 'systemic' component of relevance and depends on the effective ability of another system to influence a system's process or activity. Therefore, criticality is related to a relationship that is established with a subject and depends on the very nature of the resource concerned and the net relational benefits that will result from an exchange. Influence affects the entity with which the system establishes a relationship and depends on the level of constraints and rules present and the ability of control, feedback and intervention (Golinelli 2002). Due to its systemic nature, influence can be can be expressed as the variation of consonance given the variation of the considered resource. So, it can be approximated to resonance (Barile 2009):

$$\mathbf{Inf_{Sk}} = \frac{\left(\mathbf{Con_2} - \mathbf{Con_1}\right)}{\mathbf{r_2} - \mathbf{r_1}} = \mathbf{Res_{Sk}}. \tag{5}$$

From the above, we can re-write the equation of value as follows:

$$\boldsymbol{Val_{ssk}} = \boldsymbol{Crit_{Sk}} \times \boldsymbol{Res_{Ssk}} \times \left(\boldsymbol{E}_2 - \boldsymbol{E}_1\right). \tag{6}$$

Equation (6) expresses the value generated by the resource of the k-th system. Value is expressed in the perspective of the decision-maker and is, therefore, weighted based on the relevance attributed to the k-th system. The objective measurability of the factor $\boldsymbol{Crit_{Sk}}$ could lead to hypothesis that the value attributed to the system is always the same, regardless of the decision-maker. However, the consideration of the subjective factor $\boldsymbol{Res_{Ssk,}}$ that is attributable to an explicit valuation prerogative of the decision-maker, introduces the character of subjectivity to the value attributed.

This means that different decision-makers, with the same accounting result in terms of equity, can reach totally different determinations of the dyadic value determined by the productive resource released by a specific system. This suggests that the proposed criterion recovers a typical limitation of the more consolidated valuation systems that, although using third-party metrics to the enterprise, rely on the adoption of models that come to objective measures, or at least shared by a community of reference, of value, omitting entirely its subjective component.

In what follows, we will design an SD model for sustainable value based on vSa concepts.

Defining an SD model for sustainable value based on vSa

Given the definitions provided in the previous section of consonance (1) (variations of a company's Equity given a certain variation of its resources) and resonance, (2) (variation of Consonance, with respect to a variation in resources) related to the concepts of sustainable value, we can build a system dynamics model (Stock&Flow Diagram—SFD) where we have 4 main stock&flow structures that represent the updating of the new value of resources, consonance, equity (or patrimony) and value (Fig. 14). The new value of each such variable gets confronted with the old one, so to determine the gap (i.e., change in resources, change in consonance, change in value, change in equity) over which the calculation of consonance and resonance (with respect to a variation in resources) and Value (with respect to a change in equity and influence—or resonance) is carried out.

It is worth noticing that the structure just depicted, displays, similarly to the structure designed in Fig. 12 (and following ones), a structure where we can identify two main feedback loops connecting three stocks (Figs. 15, 16).

This is again a second-order system, which is described by a quadratic relationship putting into relationship consonance and value, where the change in value is updating the consonance value and, through Relevance and a change in resources, consonance in turn gets to update value.

The two feedback loops are named R1 (reinforcing, in blue color) and R2 (reinforcing, in red color, to distinguish it graphically from R1).

R1 is conceptually linked to the growth of Value over time, provided that there's a growth (rate of change) in the firm's equity, while R2 represents an acceleration (or mitigation) effect of such a well-known dynamic by addressing the impact of consonance (over time), and given a change in resources allocated by the company, on value itself. Note that we have represented the consonance as a stock, that is something that can be built or decreased over time.

Figure 16 is a Causal Loop Diagram representation of the very same Stock and Flow diagram in Fig. 17, and introduces also lower dominance loops (loops with a lower impact on the overall dynamics—or behavior over time—of the system).

To conclude, through a sound modeling approach like the system dynamics methodology, we could "translate" the vSa theory, by means of one of its applications to the concept of Sustainable Value, into a theoretical SD model which somehow constitutes an operationalization of such a Theory. The leap beyond the state of the art on vSa is clear: there has not been no prior attempt to operationalize in a systematic way its theory, and we have demonstrated that the founding equations determining the intrinsic nature of vSa also intrinsically "hide" a well-known system dynamics structure. We expect, in future developments, to be able to move further on this path by applying such an archetype to specific quantitative cases, where by means of simulation (now, with a system dynamics model, we can…) we will be able to infer the effective value of the vSa approach. Finally, an initial instantiation of such an operationalization has been done by taking into account the vSa definition of sustainable value, which has proved an excellent case to prove our thesis.

Theoretical and managerial implications

The theoretical model outlined in the previous section allows making relevant considerations regarding its use in an enlarged perspective that considers the economic, social and environmental instances that derive from including sustainability in value processes.

The process of creating value as it emerges in this work is, in fact, the ability of organizations to meet, in different ways, the needs of the different systems that belong to their context, which, in different ways, provide the resources the system needs for its activity. The goal of value is a long-term goal and is, therefore, tied to the choices and decisions of the decision-maker. The latter, as said, delimits the boundaries of action of the system dynamics when he defines subjectively the specific context within which the system itself will perform its dynamics. The concept of relevance, therefore,

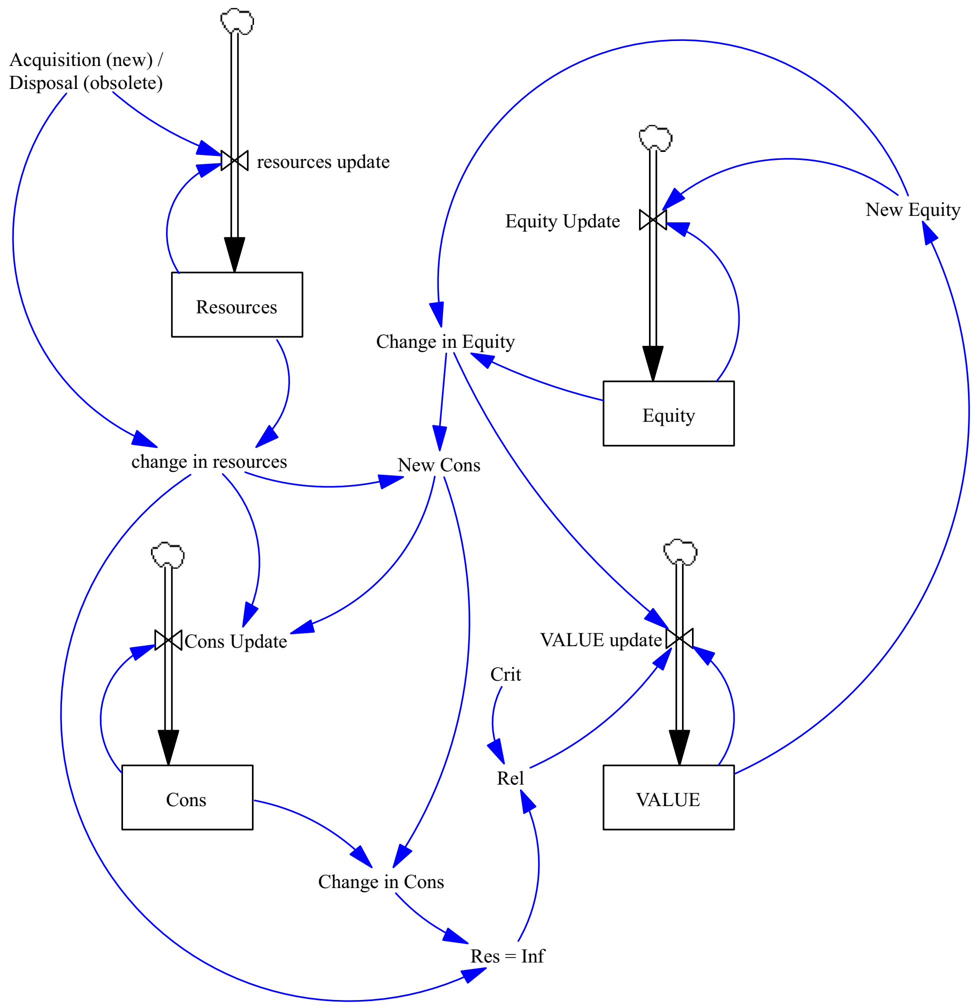

Fig. 14 SFD model of value change. Source: authors' elaboration

by recalling the characteristics of resonance, appears to be the central element of this new approach. It, in fact, contemplates, in its composition, a structural element, which is criticality, and one of a systemic nature, which is the influence. The different composition of these two forces leads to a measure of subjective value, as it faithfully reflects the decision-making paths and choices of the single decision-maker.

If expanded to the three dimensions of sustainability, this theoretical proposal confirms its validity. In fact, it is possible to determine the value that each of the three dimensions concurs to create, inserting into the model just presented the traditional indicators used in the measure of each of the three areas. Each of the dimensions described is, in fact, one or a set of the other systems whose relevance can be calculated in terms of criticality and influence. The composition of the different instances from each of the three dimensions will allow to reach a measure of sustainable value, specifically constructed and determined with respect to the single system.

In this sense, the theoretical contribution of this model lies in considering sustainability as an effective driver of organizations performances beyond efficiency and effectiveness (Barile et al. 2013b), as it includes, in value creation measures, all the actors and dimensions that contribute to the lifecycle of organizations.

Moreover, from a managerial viewpoint, this theoretical model could facilitate decision-makers to have a specific measure of sustainability value created in the perspective of each of the three dimensions, thus orienting their behaviors and choices, in issues that can be defined as complex (Aguiari and Di Nauta 2012; Barile et al. 2016a; Sciarelli and Rinaldi 2016). Every organization, in fact, can attribute different weights to each of the three cited dimensions that contribute to create sustainable value. In other words, according to their specific activity, some organizations could give more importance to the social dimension, while others could be more interested in the environmental dimension, given the essential role of the economic dimension, especially for business organizations.

The overall process that underlies the model is represented in Fig. 17, with specific reference to the possibility of having, as inputs, the traditional GRI indicators (http://

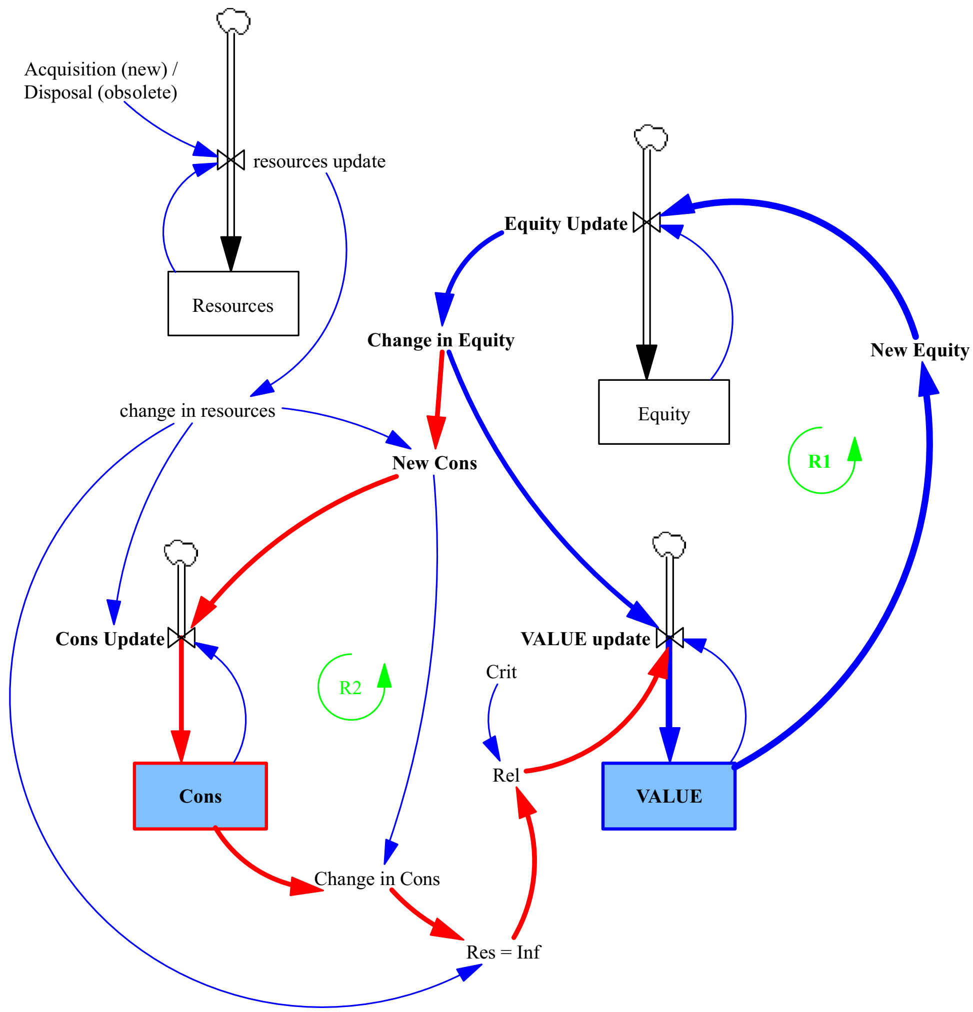

Fig. 15 The proposed conceptual stock and flow diagram for value. Source: authors' elaboration

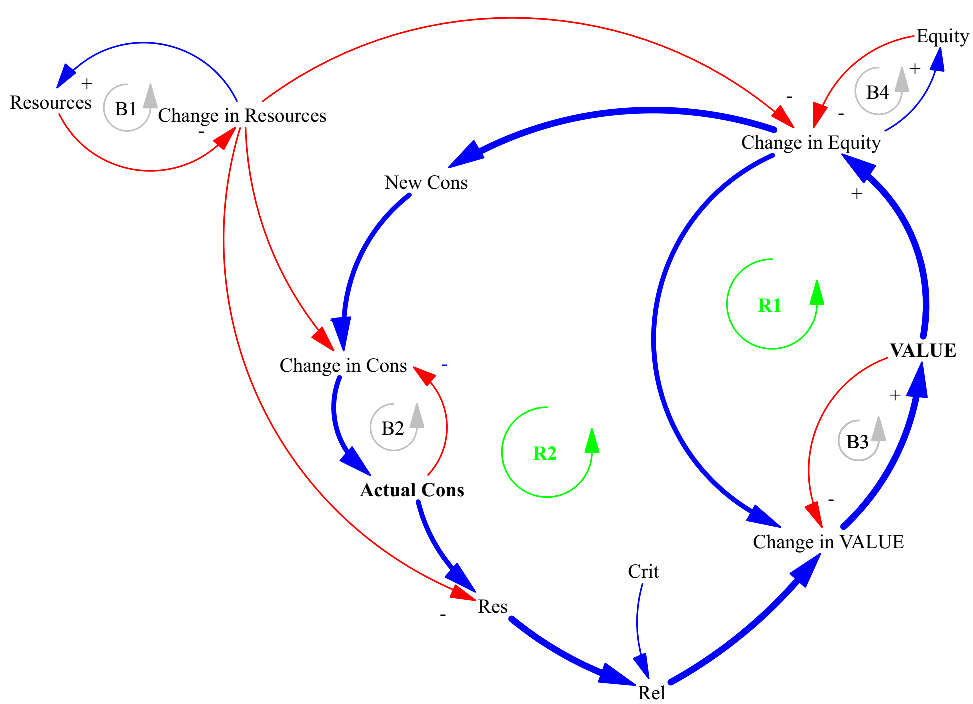

Fig. 16 The proposed conceptual stock and flow diagram for value. Source: authors' elaboration

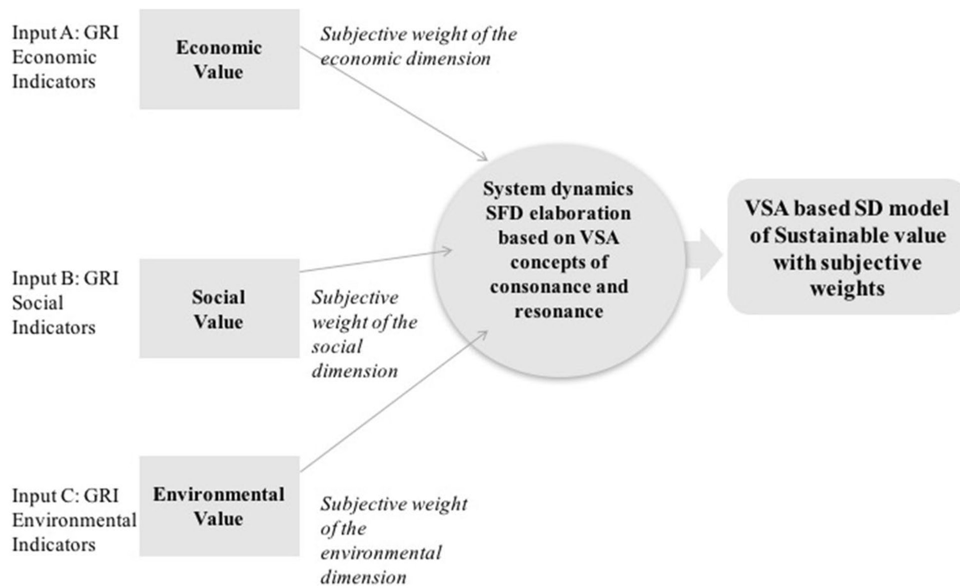

Fig. 17 vSa-based SD-driven model of sustainable value with subjective weights. Source: authors' elaboration on Iandolo, 2013

www.globalreporting.org) for the three dimensions of sustainability that, being according to the weight given by the specific organizations, are considered within an SFD elaboration. The outcome will be a measure of sustainable value that, starting from a shared set of indicators, is specifically designed on the single organization, thus being able to consider the subjective dimension of value.

Additionally, sustainability appears as an all-encompassing element, due to its multidimensional nature (Barile et al. 2016c). In fact, the orientation to sustainability can be seen as the result of the concurrent consideration of all actors' potentialities and needs, combining the current perspective and short-term outcomes with a long-term-based attitude, and considering the value created for each of the specific dimensions as the key leading to behaviors capable of offering valuable outcomes to all the actors in the specific context of reference.

Limitations and future work

As previously stated, in the above we outlined the theoretical and applicative features of the mode, aware that it may set limits on the definition of unique performance measures for individual systems. Nonetheless, it is believed that it can be a good methodological and theoretical basis from which to reach a measure of sustainable value that, including the dimensions relevant for each single system, responds to the multidimensional instances and prospects each approach to value should take into account.

The contribution of this representation lays in being the first attempt to propose a quantifiable SD model for the VSA and for the VSA-based definition of sustainable value.

Matching of vSa and SD allows defining models that can be populated with data and that can be simulated in order to obtain insights on the behavior over time of the variables of interest, thus being able to express, within this model, the dynamics of the organizations.

However, this model is still at a theoretical stage and will have to be further developed and conceptualized. Further works will be focused on clarifying how the three-loop structure determines the typical behavior in knowledge-creation, and how co-creation aspect acts on this model (hence by considering at least two different subjects, with different perspectives, interacting in the same environment). Moreover, from a theoretical point of view, this conceptual model opens to the research stream on sustainable service ecosystems, intended as systems able to promote value co-creation processes in which multiple actors are involved (Barile et al. 2016b), aimed at contributing to a global sustainable development.

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