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SPECIAL FEATURE: ORIGINAL ARTICLE

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

Governance for sustainability: a triple-helix model

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Abstract

In the last decades much attention has been dedicated to the interpretation of relevant phenomena in the socio-economic field, highlighting the need of general frameworks of reference for the governance of sustainability and often recurring to the Elkington's triple bottom line and the Etzkowitz's triple-helix representations as reference models. In front of a massive scientific production that points out criteria and method of the model, the theory could seem less rich of applications and examples, especially in the field of the inquiry defined by sustainability. In this work, our aim is to provide a little contribution to cover this gap by (1) drawing a more general view from the triple bottom line; (2) highlighting a 'triple-helix' functioning in the triple bottom line as represented in the triple helix of sustainability; (3) providing an example, very actual and important, and some general reasoning related to the use of the model as a possible reference in the basic understanding of the complexity of governance for sustainability.

Keywords Sustainability · Anthropocene · Governance · Triple bottom line · Triple helix model

Introduction

In the last decades much attention has been dedicated to the interpretation of relevant phenomena in the socio-economic field, highlighting the need of general reference models that could support the understanding of the complexity of sustainability (Barile and Saviano 2017) and often recurring to the triple-helix model (Etzkowitz 1998; Etzkowitz and Leyesdorff 2000). It should be said, indeed, that the triple-helix theory is born in the terrain of social and economic disciplines, with the original aim of sustaining the so-called "third mission" of Universities in the governance of socio-economic innovation. The model, however, has been used and elaborated in several disciplinary domains also including a sustainability perspective (Leydesdorff and Etzkowitz 2003; Carayannis et al. 2012; Lombardi 2012).

In front of a massive scientific production, which points out criteria and method of the model, the theory could seem less rich of examples and applications, especially in the field of inquiry defined by sustainable development (Pearce et al. 1994; Komiyama and Takeuchi 2006; Takeuchi 2010; Komiyama et al. 2011). This possible disproportion sometime causes a smile, a bit ironic, by researchers of other disciplines: an unmarried theory by effects. It is not true;

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however, also as a reply to this kind of criticism, we want to give, by this work, a little contribution with an example, very actual and important, and some general reasoning related to the use of the model as a possible reference in the basic understanding (and future development) of a governance model for sustainable development.

Our work moves from a simple but powerful evidence: the 'kinematic' functioning of the model—the movement of its three blades strongly recalls a known theorem of Mechanics, which states that every 'act of motion', of every kind of motion, is a helical motion. For "act of motion" one refers to an observation relative to a very small interval of time—an "elementary" interval as Physicists say, an "infinitesimal" interval as Mathematicians say—and the meaning of the theorem is that if we consider a motion during this small interval of time, whatever the motion, it is not distinguishable from a helical motion, that is, the product of a translation, along an axis, for a rotation around the same axis.

This 'kinematic' functioning in our view is the key for interpreting fundamental dynamics that occur in the intertwined contexts of environment, society, and economy, which are the well-known three dimensions of sustainability, as represented in the triple bottom line model of Elkington (1997).

The "vortex" effect of the interactions among environment, society and economy takes place in a context that is changed by the interaction itself, although in turn it generates multiple mechanisms of influence on the same "dynamic". In particular, the interaction is generated by the joint action of two forces (Barile and Saviano 2013; Barile et al. 2017):

- An *impulsive force* that is linked to the action of decision makers, which, through a set laws, rules and regulations, affects the action of the communities included in systemic contexts. This action is guided by the desire to optimize the performance in relation to the expectations of the relevant parties within the context.
- A *field force* that emerges from a sense of collective belonging of actors and communities, and is inspired by a common pursuing of shared objectives, which becomes an independent, autonomous flow.

The theory and the models bring, visibly, the signs of a reference to Mechanics, at the level that, apart from some criticism about a reductionist point of view, underlying to the model, the masters of the theory are engaged with the problem of how to provide a dynamics to the model, i.e., to give an answer to who is the agent that makes the blades moving; evoking, in this perspective, the Aristotelian concepts and the distinction between the meaning of 'potential' and 'virtual'.

The reference to Mechanics, however, stops abruptly if one expects that the theory can provide some kind of previsions on the evolution in time of the single component or of the interactions among the parts of the whole system, just as it can be done in some realm of Physics. Neither more complex models founded on more than three helices can obtain such a result, like it is inferable if one thinks of the greater complexity, with respect to Physics, of the domains—environment, society, economy—which are the objects of investigation. This feature—the impossibility of doing reliable predictions on the evolution in time of a system on the contrary to what is allowed to the so-called "normative sciences"—is common to all social and economic sciences as well to the most of life sciences and, mainly, to the climate science; and the latter assertion will be underlined with an example linked to a "simple" model introduced to explain the transition from stability to instability at the base of current climate change.

Thus, we apply the triple-helix in the field of study of sustainability, trying to show in what manner the three blades have been working in the process that has had a first conclusive step, the 12th of December 2015, with the "Paris agreement" about the policies to be assumed to mitigate climate change (United Nations, United Nations Treaty Collection 2016). Despite different evaluations on that agreement, it would be an error not to highlight its historical importance; and our attention has been driven on this subject because the climate change has been defined "the greater threat of this century" (Nature, 2012), and we ourselves have focused on this issue also in some recent works about the severe double crisis of economy and environment (Angelini et al. 2015, 2016; Scalia et al. 2016).

The interpretation of the happenings that have led to the Paris Agreement in terms of a triple-helix model of sustainability (Saviano 2015; Golinelli et al. 2015; Barile et al. 2016; 2017; Saviano et al. 2017a; Farioli et al. 2018) and the highlighting, to this aim, many events which have been almost ignored, surely in Italy by our big media system, gives reason in somewhat manner to the "dynamic" of the blades. At the same time it provides, we think, a reference model for the governance of sustainable development in the "Anthropocene" (Espejo 2014, 2015; Espinosa 2015; Schwaninger 2015).

In fact the developed model tries to explain how sustainability can be reached when key actors interact in a virtuous way. The provided example shows how the governance can act in terms of policies and actions about sustainability, climate change and more conscious industry policies and how a sustainable "stationary state" can be reached when virtuous interactions among its economic, social and environmental dimensions occur.

The global change through the lens of a helix model

The most important character of the global change occurring in our 'Anthropocene' era is, luckily not only as our opinion, the crossing of two crises which are the two sides of a same coin: capitalism crisis and environment crisis. While social damages of the economic crisis are dramatically evident to the public opinion, the upsetting consequences of the environmental crisis are struggling to become part of public knowledge and awareness of both the individuals and the human society; even though the environmental crisis is generated by the predation and pillage of natural resources, characteristic of the capitalist mode of production and consumption, even more devastating in its current phase of "hyper-liberalism" (Scalia et al. 2016). It then becomes necessary a general reflection about the "entanglement" of these two themes, a very demanding one, that is beyond our reach; here we limit ourselves to provide a contribution that, via a helix model, re-read through a systems perspective (Clayton and Radcliff 1996; Barile et al. 2014, 2015; Saviano et al. 2017a, b), is aimed to show how the connections among key actors for development have represented in the ten past years a very significant path towards sustainability, more precisely a tentative but serious answer to the dramatic character of climate change, or rather, to the consequences of the transition already occurred to climatic instability.

"The triple bottom line" is a fair example, if not of serendipity, surely of the so-called "heterogenesis of purposes"; in fact, John Elkington coined the phrase in 1994 to argument that companies should be preparing three different (and quite separate) bottom lines. One is the traditional measure of corporate profit—the "bottom line" of the profit and loss account. The second is the bottom line of a company's "people account"—a measure in some shape or form of how socially responsible an organisation has been throughout its operations. The third is the bottom line of the company's "planet" account—a measure of how environmentally responsible it has been. The triple bottom line (TBL) thus consists of three Ps: profit, people and planet. It was aimed to measure the financial, social and environmental performance of the corporation over a period of time. Only a company that produces a TBL is taking account of the full cost involved in doing business. Born in this way, TBL has become along the time a sort of pillar of much reasoning and models of sustainability, where the three dimensions—Environment ("planet"), Society ("people") and Economics ("profit")—can interfere two by two, in that order, to represent a path towards sustainability (Elkington 2008).

It is noteworthy that the purposes were only apparently "heterogeneous" because Elkington, already in 2004, was reported by *Business Week* as "a dean of the corporate responsibility movement for three decades." And his TBL has gone far beyond its initial borders, also by virtue of his contributions (Elkington 1997; Elkington and Fennell 1998), to become one of the most quoted model by all researchers that are theorizing an approach to sustainability in relationship with Environment, Society and Economics.

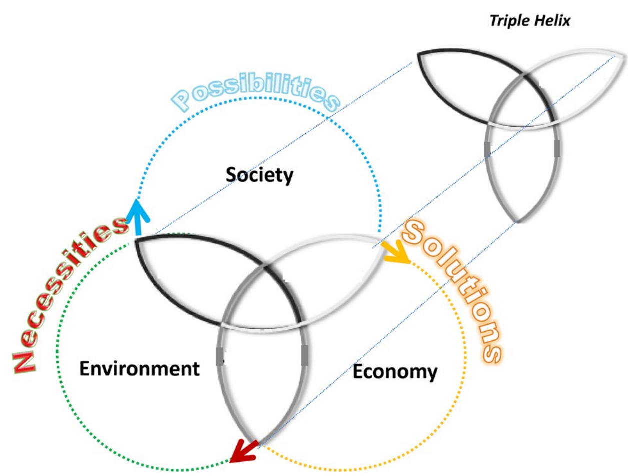

Fig. 1 The triple helix of sustainability. *Source*: Barile and Saviano (2015), http://www.asvsa.org

But also inside the business world the idea enjoyed some success in the turn-of-the-century *zeitgeist* of corporate social responsibility, climate change and fair trade. After more than a decade in which cost-cutting had been the number-one business priority, the hidden social and environmental costs of transferring production and services to low-cost countries such as China, India and Brazil became increasingly apparent to western consumers. These included such things as the indiscriminate logging of the Amazon basin, the excessive use of hydrocarbons and the exploitation of cheap labour. Thus, TBL began to be considered a bit more devoutly by corporations also in the market competition.

It should be emphasized that a more general view can be drawn from the triple bottom line model and its dimensions (Fig. 1). Environment is the complete set of all the resources that earth makes available for us, a potential—*airesis* might have said Aristotle—that is, the bundle of all possibilities among which Society can operate its choices. These choices reduce the bundle to the intersection between the two dimensions (spheres in the elaborated representation), the first blade; it is the reign of virtuality, if one wants to refer always to Aristotle. When the choices become concrete actions, able to transform and use what environment has granted, virtuality decays in actuality thus producing another reduction, the second blade as intersection of the sphere of society with the economic sphere. Not all real actions have measurable consequences on environment and this further final reduction is the third blade of the helix (Barile et al. 2017; Saviano 2015).

In Fig. 1, focus is on interaction among the three dimensions represented as a 'helix' whose dynamic changes over time modifying the dimensions of the spheres by impacting on economy, environment and society. The model focuses on the *inter*action between the roles and actions of key actors that are responsible of relevant effects on the three dimensions of sustainability. In particular:

- *Intersection between society and environment*: 'governing' actors, typically policy makers, but also associations and other organizations capable of influencing government decisions, are responsible for defining rules and constraints to comply with when using the resources that are available within the general environment; hence, in this area, the set of *necessities* as what is necessary to protect the equilibrium of the three dimensions of sustainability, is defined;
- *Intersection between society and economy*: 'thinking' actors, typically the scientific, academic and education world leading the knowledge creation processes, given the set of available resources, on the one hand, and the defined rules and constraints, on the other hand, are responsible of defining/creating the *possibilities* in terms of all the possible evolutionary paths of development that can be followed;
- *Intersection between economy and environment*: 'economic' actors, starting from all the possible development trajectories identified by the thinking actors, selects those more feasible and profitable to develop effective solutions, so complying with the necessity of harmonizing the social, economic and environmental dimensions of sustainability (*effectiveness*).

Even though the above general vision we have briefly sketched generates an appearance of motion, it is only a logic chain, the well-known Venn diagrams in the elementary set theory; but, just because we are logically speaking, this triple-helix does not necessarily implies displacements in time, not virtual even less real, neither in the model space where time cannot be explicitly present, as it happens in the diagrams of autonomous dynamical systems despite all represented quantities vary in time with a known law. In short, logic operations do not yield a motion, and this is true also for other triple-helix models that have been proposed over these years.

Is this static nature of a theory or of a model a sin? Surely not, mainly if we are thinking of Logic, Probability, Philosophy; but everyone knows the sufferings of many economists which would like to describe the evolution in time of phenomena under their observation as due to a "cause" of that evolution. It is notoriously not possible, generally, to derive laws and behaviors like those of Physics for Economics, mainly a dynamic like that of Newton, apart from some noble but unsuccessful attempts. And remaining in the domain of sustainability, do not we speak, when we are pursuing that goal, of paths, processes that we would be glad of representing as trajectories in time? Predictability is an obscure object of desire for many researchers, but it unavoidably implies some time law. And we too belong to the class of researchers that would like to be able to construct time-depending models for a deeper insight of what we are talking about, but we also know how difficult is a such objective.

An attempt in this sense has been performed looking at the helix model as representing the "vortex" effect of the dynamic of interaction among environment, society and economy that always takes place in a context that is changed by the interaction dynamic, although in turn it generates multiple mechanisms of influence on the same dynamic. In particular, the interaction is generated by the joint action of the two forces introduced in "Introduction" (Barile and Saviano 2013): the *impulsive force* linked to the action of decision makers, which, through a set laws, rules and regulations, affects the action of the communities included in systemic contexts; the *field force* emerging from the sense of collective belonging of actors and communities, inspired by a common pursuing of shared objectives.

Accordingly, the proposed interpretation key of sustainability is based on the fact that the helix must rotate to create a driving force; however, to do that, 'it' has to understand the context in which it is immersed, i.e., to identify the *field* forces.

The nearest reference to what we will try to show hereafter is, undoubtedly, the triple-helix theory. However, we are aware that also in this vest the proposed models suffer of being static, for the same above reasons, even though the illusion of a motion is doubly pushed: on one side because the same image of a helix with its blades evokes "propulsion" in some medium—air, sea, earth if we are thinking of Jules Verne's book; on the other hand, because the proposition of the Etzkowitz's triple-helix describing the AIG interaction among knowledge (Academy), economics (Industry) and politics (Government) is arranged, not completely naively, in such a way that it seems not arbitrary to think that the blade of knowledge communicates through technology an impulse to industry and market, which in turn shifts the blade of political decisions (Komiyama and Takeuchi 2006).

As mentioned in "Introduction", the theory and the models bring the signs of a reference to Mechanics, at the level that the masters of the theory are engaged with the problem of how to give an answer to the question: who is the agent that makes the blades moving? In the applications we know the problem is implicitly solved, as we remarked above: in short, the initial impulse, the "cause" of the motion is in the

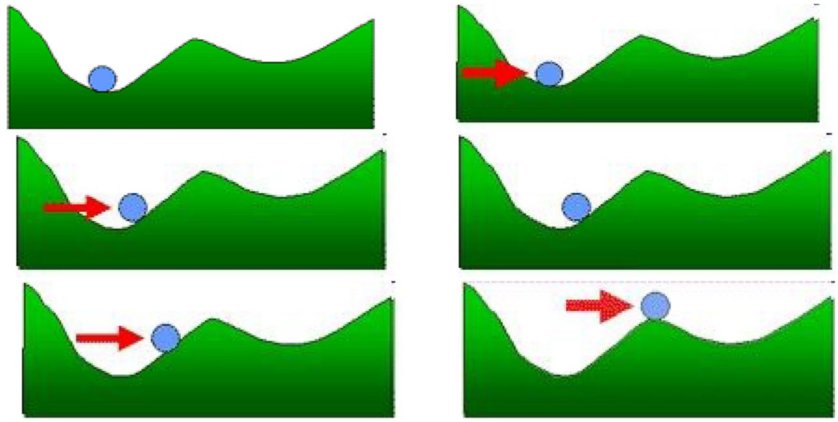

Fig. 2 Transition from stability to instability. A threshold effect. *Source*: Scalia et al. (2016)

scientific community. And it is a bit astonishing that this reasoning, despite the limits we have already evidenced, fits very well to the story we want to show. This story regards the very complex events that have led from the constitution of IPCC (Intergovernmental Panel on Climate Change) in 1988 to the conference of Rio de Janeiro (1992), to the Kyoto Protocol (1997) and its coming in force (2005), to the objective of three 20% issued by the European Council (2007) up to the recent "Paris Agreement" (2015). What have been the roles for the three "characters"—the three blades—we have chosen for the model?

Energy/climate change: the transition to climate instability

The energy has been becoming, more and more, a crucial and unavoidable theme; further, dramatically shows a deadline to the great industrial strategies, to the policy decisions and the future of the globalized world: the end imposed by the attempts to face timely, if it is possible, the *abrupt character of climate change*, which are caused by the increasingly recourse to fossil fuels, that still feed the world economies for about 80% (Key World Energy Statistics 2015).

Why "the abrupt character of climate change", from which stem the dramatic consequences that are already taking place from time? The report "*Abrupt Climate Change*", published in 2002 by the National Research Council (NRC) of the National Academy of Sciences of the United States after a decade of study and field research, draws the climate history as made of abrupt changes and shows, in contrary to the view hitherto dominant, *the atmosphere is one of the factors of climate modification*. This new paradigm gives reason why there has been for many years a fierce scientific opposition to the role of *greenhouse gases; they habit in the atmosphere, the lowest layer*, but if the main stream assesses that the two principal factors of climate change are the balance of glacier masses and the salinity of ocean currents and *no effect can be produced by atmosphere*, how can greenhouse gases act?

But *now*, questions rising from NRC report are quite different: the atmosphere is one important factor of climate change, can it cause an "abrupt climate change"? The increase of the greenhouse gases concentration in the atmosphere acts like a "forcing action": will be there a value of the intensity of this action, corresponding to which a sudden change in the behavior of climate occurs? Technically, we speak of "threshold value" and "threshold effect" when a continuous variation of a control parameter of a system yields a discontinuity in the behavior of the system. Lets try to better understand this issue by means of a "simple" model, drawn from *Abrupt Climate Change: Inevitable Surprises* (National Research Council 2002).

A "simple" model for better understanding climate instability

The little sphere is the climate (the set of all climate cycles); the red arrow is the intensity of the "forcing action" (the global warming). Under a certain value the effect of the forcing action is that to make the sphere oscillate in the hollow, but at a certain level of intensity the sphere will be pushed from the hollow up to the peak. Both positions are of equilibrium; therefore, what has abruptly changed in the behavior of the climate?

The equilibrium is *stable* in the hollow, while in the peak it is *unstable* because a whatever little push is able to remove sphere from that position. To a continuous and gradual variation of the forcing action corresponds, for a critical value of that action—the threshold—a discontinuity: equilibrium is "broken" beyond the threshold; a sudden change takes place from stability to instability of all climate cycles. This abrupt climate change, triggered by the forcing action, does not depend on time, as it is clear when the forcing action remains over all time under the threshold: no threshold value, no abrupt change (Fig. 2).

Who tells us that the intensity of the forcing action has reached the threshold, upsetting the stability of the climate?

Over the last 650,000 years, the CO_2 concentration in the atmosphere has not exceeded the 290 parts per million (p.p.m.) up to before of our industrial age, in 2014 it reached the 400 p.p.m. But is not so much the impressive level acquired, but the fact that the increase of CO_2 concentration in atmosphere over the last 50 years has been the same as what in the history of the climate has requested about 5000 years! This contraction in the time of about a hundred times is a measure certain of the forcing action, which leads from stability to climatic instability.

The forcing action, able to dramatically change the climate, lies in the growth of the concentration in the atmosphere of CO_2, the main "greenhouse" gas. The switch from stability to climate instability is the transition that we are already living, countless the tests experimentally verified, some of which were mentioned at the beginning. Inevitable surprises, as the subtitle of the NRC report says.

About the 'simplicity' of the model. Really, it represents climate, physical-mathematically speaking, like it were a pendulum under the influence both the gravity and a "forcing action". The evolution of this system can be drawn, as for any other two-dimensional dynamical system, in a proper two-dimensional space called "phase space". In this plane, it is possible to draw a *phase diagram* characteristic of each system, a "phase portrait"; that is, a geometrization of the dynamics, which allows us to see "with the eyes" what is the evolution of the system and its quality properties like stability, instability, attractivity and other.

This way of representing dynamics, preferring the qualitative aspects of an evolution—the stability properties—than the quantitative results such as an analytical calculus could provide, is due to the theory of stability, that was proposed, separately, by Poincaré (1890) and Lyapunov (1907) at the round of Nineteenth century. It is a useful tool to obtain a lot of information about a dynamical system without solving the problem of the differential equations associated to the system, often impervious because the nonlinearity of the equations.

Born in the context of Mechanics, this method can be applied and has been very largely applied to almost any system—physical, chemical, biological, demographic, economic—to describe its evolution in time. The stability theory does not explicit, in general, the dependence on time of the evolution, as analytical calculus could do, when performable, but in many interesting cases the time law can be easily derived by the kind of trajectories followed by the system; e.g., to the closed orbits in the "phase portrait" correspond periodic motions.

In our case, the phase portrait exhibits areas of stability and areas of instability and the arising of a chaotic dynamics, determined the latter by the assumption of some threshold value by the parameter that rules the intensity of the forcing action. The complexity of the dynamics of the "simple" model is well represented in the figures below (Figs. 3, 4, 5), by the behavior of the so-called "separating curves"—the stable "manifold" (green) and the unstable "manifold" (red) in the phase portrait; and by the subdivision of the phase space in stability "islands" and chaotic regions (Fig. 6).

Figures 3, 4, 5, 6 have been drawn from the National Research Council's Report (2002). They refer to the so-called "standard" map of pendulum, and in Fig. 6 the same phase portrait suggests which are the "islands" of stability, the ellipses closed around a fixed point, and the chaotic regions, around the hyperbolic points.

It is worth to note that a portrait analogous to that of Fig. 4 had been forecasted by Henry Poincaré in the study of the "three body" problem in Celestial Mechanics: "… one will be hit by how much this figure is complex, so much that I do not try to draw it (AT)" (ibidem, p. 389). Surely, the "three body" problem shows difficulties major than our one, but a kind of "universality" of the chaos, arising from the dynamics of non-integrable systems, legitimates the comparison between the phase portrait of the two problems which we are talking about. Among many other issues scientifically important, Poincaré has "invented" the chaos, that only in more recent times, starting from the Sixties, has raised research interest; famous, under this regard, the Lorenz model (Lorenz 1963) and the very lucky quip about the wing beat of a butterfly, that is overflowing out of the banks of science to cross movie screenplays.[1]

This digression tries, on one hand, to prove that if a "simple" model can make us meeting chaos, all the more reason it can be supposed that this will be the case when more realistic and more sophisticated models are used, like it is true on the basis of the more recent researches. Thus, it is more understandable the clear-cut assertion about the earth's climate as a chaotic system, given in the NRC report: "… in a chaotic system, such as the earth's climate, an abrupt climate change always could occur. However, existence of a forcing greatly increases the number of possible mechanisms".

[1] "Does the flap of butterfly's wings in Brazil set off a tornado in Texas?", this question is successfully aimed to emphasize the strong sensitivity of the Lorenz model to small perturbations on the initial state. Really, the model deals with meteorology (high-frequency phenomena, i.e., few days), not with climate (low-frequency phenomena, more than seven days), but it is able to exhibit a complex dynamic—a chaotic one with its "strange attractor", well known to the scholars—despite that the sensitivity to small perturbations is only one of the requests for setting up chaos, whose rigorous characterization goes beyond this note.

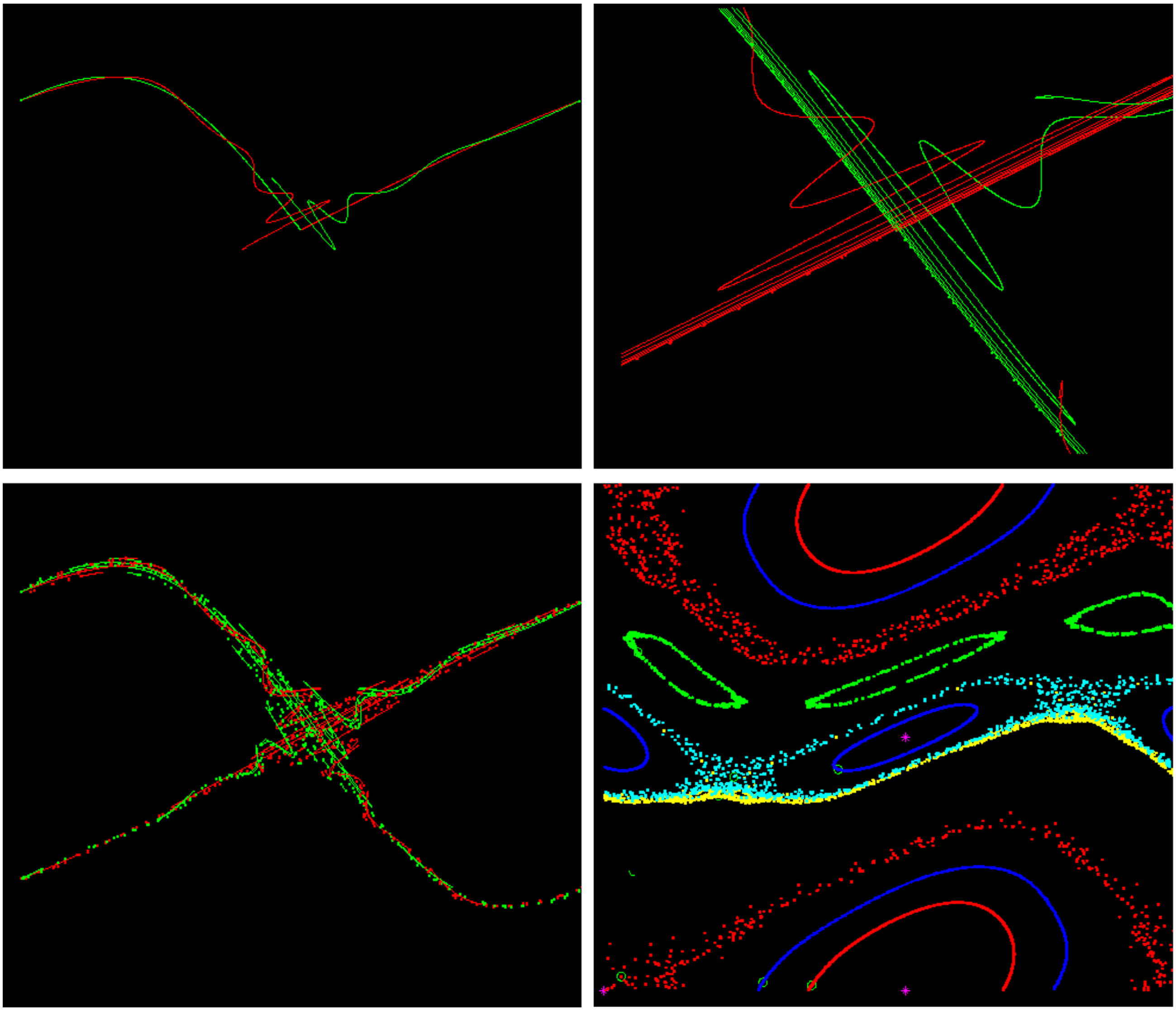

Fig. 3–6 The emergence of a chaotic dynamic: the "standard" map of pendulum. *Source*: Milani Comparetti A (2002)

An example of the sustainability triple helix dynamics facing the challenge of climate change

Our application of an AIG model demonstrates how sustainability can be reached when the actors represented in the triple helix model and integrated into the triple bottom line model interact in a virtuous dynamic. An example, in this sense, is provided by the evolution in terms of policies and actions about sustainability, climate change and more conscious industry policies (see Scalia et al. 2016).

In the years 2005–2006, the world's major Academies urged major world governments—the G8s of, respectively, Gleneagles an S. Petersburg—about the problems arising from the current development model and its effects in terms of global warming, mainly caused by human activity on Earth. The Academies' solicitations had been substantiated in two statements (Scalia et al. 2016), in which they denounced the harmful effects of the industrial model adopted worldwide in terms of sustainability, and called for a "prompt action" against global warming and its effects on Earth in general. The action of Academies stands as driving force that incepts the movement of the other two elements (governments and industry).

A first immediate response from politics was the "Stern's Report" delivered to the customer, Tony Blair, in November 2006 (Stern Review on the Economics of Climate Change 2006). The review, a voluminous account of forecasted trends through computer simulations realized by a hundred of researchers, shows what will happen in a BAU (Business as Usual) scenario: "Using the results from formal economic models, the Review estimates that if we do not act, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year, now and forever… The investment that takes place in the next 10–20 years will have a profound effect on the climate in the second half of this century and in the next. Our actions now and over the coming decades could create risks of major disruption to economic and social activity, on a scale similar to those associated with the great wars and the economic depression of the first half of the twentieth century. And it will be difficult or impossible to reverse these changes". An unprecedented alert in the "Anthropocene", that perfectly mixes environmental crisis with the capitalistic one.

As a matter of fact, the "Stern's Report" was another academic contribution, even though issued by an UK Government require. The urgency highlighted by the scientific studies made pressure on policy makers involving, in particular, the European governments that, in 2007, within the Council of Europe, pledged to increase their commitment towards sustainable development, and established the "20–20–20" targets to be achieved by 2020. These targets concerned: 20% cut in greenhouse gas emissions (from 1990 levels), 20% reduction of energy consumptions via energy efficiency and 20% of EU energy from renewable energies. These targets were enacted in legislation in 2009. Accordingly, the legislation went to impact also on the Industry, which was required to use more sustainable energy systems and production, increasing investment in renewables, which were supported by the action of the Government. The response of the market to this kind of solicitation has been amazing: while traditional manufacturing sectors, like car and building, overwhelmed by the bursting of the financial bubble of 2008 were living a deep crisis with falls of two-digit percentage, the investments in renewables were rising from 40 billion of dollars (2004) (Global Status Report-REN 21 2015) to 330 billion of dollars in 2015 (Clean Energy Investment 2016).

Central to this process was the substantial and effective interaction between industry and governments on a global and local level, as well as the translation of macroeconomic policies in policies that were adopted by companies.

These positive results, derived from the virtuous interaction between the three key actors (Academy, Government, Industry), ended up in the Paris Agreement that was reached in December 2015, at the CoP 21. This agreement, which has entered into force on the 4th of November 2016, set out a global action plan for what concerns global warming and climate change by limiting global warming to well below 2 °C. Moreover, Governments agreed to reduce emissions, to be more transparent for what concerns the implementation and reporting of their actions, to strengthen societies' ability to deal with the impacts of climate change, to support local authorities in this path towards sustainability. In this sense, society as well plays a fundamental role in the reception of guidelines and policies defined at central level for what concerns climate change and to embed sustainability targets in major behaviours at environmental, social and economic level.

As said, the main relevant element of the triple helix model, integrated with the dimension of the triple bottom line model and re-read through a systems perspective, implies that sustainability can be reached only when virtuous interactions among those dimensions occur. The way towards the definition of shared policies against climate change is a good example in this sense: starting from the solicitations of the world's most relevant Academies, global decision makers started to define policies that could be more consistent with a shared definition and vision of development, translating this orientation into effective rules and practices that have to be adopted by companies, as well as by society in general. What emerges is that only the participation of all the actors can 'activate' the helix dynamics, thus making effective a positive process of development oriented towards sustainability.

Final remarks and conclusion

In conclusion of this short explanation of the model, we focus on some additional issues that arise in the systems perspective, and on which it is useful to draw the attention of the players already involved.

- The model suggests a helical motion; then, something that is recursive. This means that it draws a variety of levels, variously linked through the components and together with the elements of other areas/perspectives.
- The three areas of sustainability are read in an anthropocentric perspective, since it is always necessary to choose a perspective of analysis of phenomena. So, assuming the point of view of an individual, we can read how this scheme functions: within the environment, an individual with a particular perspective extracts the information necessary to define a specific context (environment-society intersection). Then, from there, he/she redefines the intersection between society and economy.
- The interaction well simulates a dynamics that changes the initial variety, both in terms of quantity and in terms of quality. From this "evolutionary" dynamics, processes changes occur that affect the states of the environment, economy, and society, and that can promote or compromise the equilibrium conditions.

The interpretive proposal outlined in this contribution, in conclusion, it is the harbinger of many developments that affect the actors of the policy making, scientific and economic communities, as well as all the other numerous non-governmental actors and the wider civil society engaged in the challenge for the transition towards sustainability.

Many practical implications, then, are woven with the theoretical and research perspective, due to the underlying message that we intend to propose with this work. The challenge of sustainability requires a major mobilization of resources; above all, it requires intelligences, sharing a common vision that emerges from a system of shared values.

Following the simulated dynamics, we have above proposed, one could say that the real driver is complexity, and the model can be analysed with reference to the theoretical evolutionary path of sustainability. The three perspectives of sustainability have been traditionally analysed separately (Saviano 2016; Barile and Saviano 2017). This derived from the idea of those who had attention to resources that the environment sphere would not affect the economy sphere; this idea was supported by the fact that the economic and social paths were, in a certain way, easily predictable.

This consideration led scholars belonging to one of the three areas to believe that each area could evolve on the basis of certain and determinable paths, according to a reductionist/deterministic view that was valid as long as it was thought that each of the three areas had definite routes. The first signal came with changes in the environment, due to deforestation, ozone depletion, etc., that originally was thought to be solvable by making reference to old solutions, i.e., taking the areas separate. This became no more possible when the defined rules and constraints were seen to be not effective anymore, as they were linked to the old cause-effect mechanism.

Some consequences can be underlined:

1. There are no certainties. In fact, the functioning of the evolution via helices is affected by the action of complexity drivers thus obliging to refer the model to the social complexity, i.e., something not objective or objectively determinable.
2. The lack of a real dynamic, as that of a dynamical systems, implies that the order between the three spheres has to be redefined, with reference to the new conditions that occur in the environment, the possible developments that can arise in society and the resulting effectiveness that arises in the economy.
3. Also if you correct the conceptual error of defining the three areas as if they were single and separate from each other, instead of treating all of them together as a whole, it seems a very arduous problem to equip the model with a "true" dynamics, such as the one that, e.g., refers to Goodwin's type models (Goodwin 1967), from which one can derive an explicitly time-dependent "trajectory" towards sustainability and that takes in account all the "spheres": environment, society, economics in a sustainability model. A mere attempt in this direction has been recently done (Scalia et al. 2016).

Thus, one could hope that can be rigorously defined some kind of "field forces" able to generate a systemic dynamics and a synergy of great importance in the transition towards sustainability; but we must also learn to know and to manage the possible implications, and how to manoeuvre the 'helix of a boat' to allow navigation, between the eddies and currents encountered during its journey.

Compliance with ethical standards

Conflict of interest The authors declare no conflicts of interest.

References

Angelini A, Farioli F, Mattioli G, Scalia M (2015) Le due crisi: crisi del capitalismo e crisi ambientale. Una soluzione sostenibile? Parte I. Culture della sostenibilità, p 16

Angelini A, Farioli F, Mattioli G, Scalia M (2016) Le due crisi: crisi del capitalismo e crisi ambientale. Una soluzione sostenibile? Parte II. Culture della sostenibilità, p 17

Barile S, Saviano M (2013) An introduction to a value co-creation model, viability, syntropy and resonance in dyadic interaction. Syntropy 2:69–89

Barile S, Saviano M (2017) Complexity and sustainability in management: insights from a systems perspective. In: Barile S, Pellicano M, Polese F (eds) Social dynamics in a systems perspective, New Economic Windows Book Series. Springer, pp 39–63

Barile S, Saviano M, Iandolo F, Calabrese M (2014) The viable systems approach and its contribution to the analysis of sustainable business behavior. Syst Res Behav Sci 31(6):683–695

Barile S, Saviano M, Polese F, Caputo F (2015) T-shaped people for addressing the global challenge of sustainability. In: Gummesson E, Mele C, Polese F (eds) Service dominant logic, network and systems theory and service science: integrating three perspectives for a new service agenda, Giannini

Barile S, Lusch R, Reynoso J, Saviano M, Spohrer J (2016) Systems, Networks, and Eco-systems in ServiceResearch. J Serv Manage 27(4):652–674

Barile S, Saviano M, Iandolo F, Caputo F (2017). La dinamica della sostenibilità tra vortici e correnti: un modello a Tripla Elica In: Borgonovi E, Aiello G, Fellegara AM (eds) Sviluppo, sostenibilità e competitività delle aziende. Il contributo degli economisti aziendali. Collana AIDEA, Il Mulino, pp 61–82

Carayannis EG, Barth TD, Campbell DF (2012) The Quintuple Helix innovation model: global warming as a challenge and driver for innovation. J Innov Entrep 1(1):1–12

Clayton AMH, Radcliff NJ (1996) Sustainability. A systems approach. Earthscan, London

Clean Energy Investment (2016) http://www.bloomberg.com/company/clean-energy-investment/. Accessed 14 Jan 2016

Elkington J (1997) Cannibals with forks: the triple bottom line of 21st century business, Capstone

Elkington J (2008) The triple bottom line. In: Russo VM (ed) Environmental management: readings and cases. SAGE, London

Elkington J, Fennell S (1998) Can business leaders satisfy the triple bottom line? Vis Ethical Bus 1:34–36

Espejo R (2014) Organizational transparency, inclusion and sustainability. In: Refereed proceedings of the business systems

laboratory—2nd international symposium, January 23–24, 2014. Universitas Mercatorum, Rome
Espejo R (2015) Good social cybernetics is a must in policy processes. Kybernetes 44(6/7):874–890
Espinosa A (2015) Governance for sustainability: learning from VSM practice. Kybernetes 44(6/7):955–969
Etzkowitz H (1998) The triple helix as a model for innovation studies. Sci Public Policy 25(3):195–203
Etzkowitz H, Leyesdorff L (2000) The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. Res Policy 29(2):109–123
Farioli F, Barile S, Saviano M, Iandolo F (2018) Re-reading sustainability through the Triple Helix model in the frame of a systems perspective. In: Marsden T (ed) The SAGE Handbook of Nature. SAGE, London, pp 10–37
Golinelli GM, Barile S, Saviano M, Farioli F, Masaru Y (2015). Towards a common framework for knowledge co-creation: opportunities of collaboration between Service Science and Sustainability Science. In: Gummesson E, Mele C, Polese F (eds) Service dominant logic, network and systems theory and service science: integrating three perspectives for a new service agenda, Giannini
Goodwin RM (1967) A growth cycle. In: Feinstein CH (ed) Socialism, capitalism and economic growth. Cambridge University Press, Cambridge
Key World Energy Statistics (2015) International Energy Agency. http://www.iea.org
Komiyama H, Takeuchi K (2006) Sustainability science: building a new discipline. Springer, New York
Komiyama H, Takeuchi K, Shiroyama H, Mino T (2011) Sustainability science: a multidisciplinary approach. Sustainability Science Series, vol I. UNU Press, Tokyo
Lorenz EN (1963) Deterministic nonperiodic flow. J Atmos Sci 20(2):130–141
Leydesdorff L, Etzkowitz H (2003) Can 'the public' be considered as a fourth helix in university-industry-government relations? Report on the Fourth Triple Helix Conference, 2002. Sci Public Policy 30(1):55–61
Lombardi P (2012) An advanced triple-helix network model for smart cities performance. In: Ercoskun OY (eds) Green and ecological technologies for urban planning: creating smart cities. IGI Global
Lyapunov A (1907) Problème général de la stabilité du mouvement. Annales de la faculté des sciences de Toulouse 9:203–474
Milani Comparetti A Introduzione ai sistemi dinamici (2009). http://copernico.dm.unipi.it/~milani/dinsisno. Accessed Dec 2017
National Research Council (2002) Abrupt climate change: inevitable surprises. The National Academies Press, Washington, DC
Pearce DW, Atkinson GD, Dubourg WR (1994) The economics of sustainable development. Annu Rev Energy Environ 19:457–474
Poincaré H (1890) Sur le Problème des Trois Corps et les Équations de la Dynamique. Acta Math 13:1–271
Renewables (2015) Global Status Report-REN 21
Saviano M (2015) Multi-actor co-creation systems for progressing toward sustainability: criticalities and challenges. In: 5th International conference on sustainability science (ICSS), 22–23 January, Tokyo
Saviano M (2016) Il valore culturale del patrimonio naturale nella promozione dello sviluppo sostenibile. Sinergie Ital J Manag 34(99):167–194
Saviano M, Barile S, Spohrer J, Caputo F (2017a) A service research contribution to the global challenge of sustainability. J Serv Theory Pract 27(5):951–976. https://doi.org/10.1108/JSTP-10-2015-0228
Saviano M, Nenci L, Caputo F (2017b) The financial gap for women in the MENA region: a systemic perspective. Gender Manag 32(3). https://doi.org/10.1108/GM-07-2016-0138
Scalia M, Angelini A, Farioli F, Mattioli GF, Saviano M (2016) The chariots of Pharaoh at the red sea: the crises of capitalism and environment. A modest proposal towards sustainability. Culture della sostenibilità 1:3–63
Schwaninger M (2015) Organizing for sustainability: a cybernetic concept for sustainable renewal. Kybernetes 44(6/7):935–954
Stern Review on the Economics of Climate Change (2006) http://webarchive.nationalarchives.gov.uk/20100407172811/http://www.hm-treasury.gov.uk/stern _review_report.html. Accessed Dec 2017
Takeuchi K (2010) Rebuilding the relationship between people and nature: the Satoyama Initiative. Ecol Res 25(5):891–897
United Nations (2016) United Nations Treaty Collection