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Crisis and Complexity of Economic and Social Systems: From Synergy to Exposition*

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Abstract

This paper analyses the crises that can effect a general economic and social system from an interdisciplinary point of view, focusing on the economic theories concerning the crisis of capitalist systems. Medical, epidemiological, psychological, sociological and political approaches are also considered.

Any entity, from a single person or company to wider and more structured realities of modern capitalism (i.e. national economies, productive areas, financial systems, etc.) regarding their respective level of complexity, can be involved in different kinds of crises.

The principal aims of the contribution are to understand how the systemic complexity affects both the development and the clearing of the crisis and to explore whether and in which way complex thought may influence a better investigation of crises in a general socioeconomic system.

Keywords: complexity, socioeconomic system, crisis, capitalism, exposition, vulnerability, propensity.

JEL code: M14

1. Purpose and structure of the contribution

The nexus between "crisis" and the level of complexity of over-individual socioeconomic institutions (i.e. enterprises, public administrations, governments, social groups and movements, inter-organizational nets, etc.) is the survey element of this treatise. This analysis considers both the systemic and the complex perspective. Each institution is qualified as a more or less dynamic, adaptive, complex and non-coherent system, the existence of which is influenced by the combined action between its single individuals and their "coalitions" or groups and the wider and more structured systems of which it is part.[1] The whole modern society constitutes a homogeneous and more complex social system, which results from the dynamic interaction between different levels of analysis.

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[1] On the conception of an enterprise as a system and, specifically, on the vital systemic approach (ASV), compare Golinelli (2005; 2008).

Through a critical and interdisciplinary literature review, we investigated the role of individualities and inter-systemic relationships in determining the start-up and the spread of a crisis from one system to another. More specifically, the concept of "systemic crisis"[2] (*rectius* inter-systemic), or rather of "systemic risk", is deduced from the distance between "horizontal" dynamics (i.e. systems of the same nature) and "vertical dynamics" (i.e. the top-down and bottom-up approaches between diverse systems). The reasons and dynamics of change are examined from the "synergy" within a system and between systems (through combinational, accumulative and/or multiplicative effects) to systemic "vulnerability" and "expositions" (i.e. the diffusive effect of dissipating pathologies[3]).

Considerations are then focused on the interpretation of the meaning of "crisis", a term widely used in economics and management studies as well as in common language. The aim is to underline whether and how the approach based on the complex systems may actually foster a better understanding of the "systemic crisis".[4] Authors are not willing to adopt a unique definition of crisis, instead preferring a hybrid and contingent approach. In the same way, the common nexus between crisis and recovery, in which a large part of economic studies is interested, is deliberately not going to be explained in depth.

A further objective of the following contribution concerns the relationship between "systemic complexity" and "crisis", or rather, whether and in which way the complexity of a socioeconomic institution may prime, prevent or smooth over the breaking out of crises. In fact, the possibility exists that the boosting and strengthening of socioeconomic systems with fast-growing complexity could foster more or less frequent, intense and sustained crises. It is easy to refer to "capitalistic market crises".

In addition, the most recent dynamics of capitalistic enterprises and markets has been interpreted as the expression of a crisis of the system itself[5] (i.e. the crisis breaks out from the inside and outside individualities of the system). Authors avoid giving a limited answer, which connects the

[2] When using the concept of "systemic crisis", authors refer to the crisis of any (more or less) complex system, while considering "inter-systemic crisis" or wide-range crisis (Golinelli, Gatti, Vagnani and Proietti, 2008, p. 294, note 67).

[3] An example of a dissipative effect, linked to the collapse of a building, can be found in Rullani (1989, p. 57).

[4] Referring to crises in a business and economic way and to the approaches to the management and clearing of enterprise crises, see Zito (1999), Danovi (2003), Guatri (2005) and Quagli and Danovi (2008). For any application consistent with the ASV, see Piciocchi (2003; 2005, pp. 53–66).

[5] In other words, authors want to understand whether malfunctions of the complex system are induced/fostered by the system constituent logics, i.e. by specific inner or outer aspects, making a distinction between "structural" and "economic" or "occasional" crisis factors.

crisis of socioeconomic systems to specific, but superficial factors or to a sole cause; moreover, they try not to refer excessively to relativism, which can be useless in the decision-making process.

The last research question concerns whether a systemic crisis can find its solution in a change of the system complexity, which itself originates and boosts downturn and at the same time justifies the social legitimacy of the system. The proposed methodology should be consistent with the theory of complexity and useful for explaining crises of complex systems in a socioeconomic field.

2. Individuals and systemic crises

The main epistemological principle of complexity assumes the existence of a sole, large and universal system, which is fed and composed by countless particular systems, classified as natural in reality, regardless of the observer.[6] Such a system is affected by many events, the classification of which as physiological or pathological cannot always be defined *ex ante*.[7] In fact, the judgement on a wasting event cannot be always negative if it is physiological and for some hypotheses it could regulate a selection. Even the physiological or pathological taxonomic attribution occurs only *ex post*, as socioeconomic systems are not predictable for long periods and probabilistic assessments are necessary. Moreover, the history of crises does not help in preventing *ex ante* the crises that periodically afflict the world's economic systems; however, history certainly contributes to the understanding of the evolution of downturns, because it offers important support to the clearing.[8]

The economic systems seem to contain a gene that leads both to success and to crisis. The main reason is that they include the individual, who always has "systemic" needs and is at the same time rational and irrational. From this thesis emerges the necessity of rules and regulations in order to control the economic and social needs of both individuals and communities. Hence, some approaches to governing systems in general and crises in particular appear. Is very pressing

[6] Systemic epistemology is part of epistemology, which studies complex systems and is sometimes called the "science of complexity" or "complex thought". Compare also Bocchi and Cerruti (2007) and Magrassi (2009).

[7] Following such logic, we can use an example: a wood fire may be considered physiological when it totally or partially eliminates the wood, contributing to giving life to another one; anyway, if the flames destroy the ultimate wood present on a certain territory, they create an obstacle to the recovery of a specific wood and the existence of such a system would be menaced: in this case, the crisis would be pathological and not physiological.

[8] Structuralism, which is also at the base of economic anthropology, biology, Freudian psychology and psycho-analysis, theorizes that the human brain operates a continuous restructuration of reality. Therefore, people perceive a reality that is not true and absolute, but rather constructed or even distorted by the known conceptual categories. The biological and physical demonstration of the reality abstraction was explained by the 1981 Nobel Prize winners Hubel and Wiesel. Compare Levi Montalcini (2004, pp. 82–86) and Lehrer (2009). In such logic, the dynamic processes, as the crisis of an economic system, are seen as inescapable and above all the human being is an infinitely small part of the whole general system. In particular, the systems detected by people are subjective representations of reality without certainty about its existence as it is observed and represented.

government of systems that may also use compulsory rules better than free interaction between systems, based on trust and supported by soft regulations? This question will be further analysed later.[9]

One frequent cause of all crises are "excesses" (i.e. the managers' remuneration, the estimation of properties, the use of leverage, the evaluation of companies, etc.), which create an extreme gap between "effective" and "expected", making every prediction less reliable.

If we want to delve into the roots of the current financial crisis, we can note that they should not be ascribed only to the excessive use of leverage or to the uncontrolled action of big merchant banks, but rather to the widespread need for greater outputs or to the necessity of endlessly spurring the demand for goods and services. In this sense, finance has only supported major outputs requested by risk-averse individuals and industries with overproduction (i.e. industries' widespread culture that people can consume more than they are able to produce), without considering the related risks. In brief, what is lacking is the "precaution principle", especially during the expansion phases of the system.[10]

2.1. Systemic crisis: from synergy to exposition

The trigger cause of crises of economic systems lies in the identification qualities of the crises themselves: a centre of government that detects the interactions between objects and subjects, composing the system. In such systemic contexts, contraction can lead from synergy to exposition. This is the reason why the more there is an interrelation with other systems, the higher is the risk of a systemic crisis. Paradoxically, in the apical moments of the last crisis, the bank institutions with fewer relationships (for example Italian local cooperative credit banks) seemed to be less exposed to systemic risk.

Anyway, the central themes of our reasoning are the comprehension of the diffusion mechanism of a crisis and, in a complementary way, its end time. Actually, the diffusion mechanism can be induced by:

- the decisions of international centres of government or those of their operative structures (i.e.

[9] Von Hayek (2000, par. 3.6) states that human action is guided both by "rules" and by "regulations".

[10] Compare Galbraith (1958, pp. 52–56; 1972), Gandolfi (1999, pp. 52 ff.), Battaglia (2001) and Trouwborst (2002, pp. 8 ff.). Not causally, the more a complex system is resistant to outer upheavals, the more it is redundant. For example, in their spasmodic search for efficiency, banks have reduced their proprietary requirements, that is to say redundancy.

central banks, governments, stock exchange markets, anti-trust authorities, consumers' movements), which are able to influence through mechanisms of exposition and/or systemic dependence on the actions of other systems;

- the interactions between subjects and objects (for example, bankers' or manufacturers' communities, information, financial transactions, purchase options, etc.).

The previous mechanisms almost always operate contextually, although the "government" decisions are more evident to the observer, while the "interaction" ones are more latent. Nevertheless, the "interaction" decisions are no less responsible for systemic crises, because all individuals and all systems are potentially exposed, even if they are not directly connected to a centre of government.

2.2. The exposition of crisis: the diffusion processes

To illustrate the phenomenon of exposition among systems, it is important to make an initial distinction on three levels of analysis: individuals, communities (groups) and systems (also systems of systems). Actually, it is possible to detect the "diffusion processes", when a feature or a *status* is spread from a limited number to a multiplicity, or even to the totality, of the observed systems.

The activity of combination systems develops from a joint action "by chance" or "by necessity", because they operate rules of necessity and recombination and are opposed to organized systems, which are normally based on the principle of "cause–effect". From the micro-macro feedback comes the necessity effect, which characterizes the behaviour of the combination systems. The case by itself is never enough to start a macro-behaviour and the action of necessity rules is also needed, as they force the birth of micro-behaviors in the single elements of the system through a necessity factor. In other words, the case must be joined by necessity. The necessity rules often come from the obligation, the convenience, the will and the usefulness that may or may not be perceived by the single individual in conforming the micro- to the macro-behavior. As the recombination factor characterizes the macro-rules, the necessity factor characterizes the micro-rules. The more the micro-behaviour is perceived as necessary, useful and convenient, the more the macro-behaviour is devastating.

An economic example of the diffusion processes can contribute to explaining the phenomenon.

Let us take into account one of the most acclaimed factors of the recent financial crisis, that is, the spread of the subprime loans. The heuristic model that explains this specific exposition is the following:

- individual level: the need to take out a loan to purchase the main residence (micro-rule or necessity factor);
- collective level: families' (i.e. a community's) wish to buy a house (a feature with an increasing utility because of the community desire to own such an object) and, consequently, the value of the "house" meant as a "good" (macro-rule or recombination factor);
- systemic level: the single takeover (i.e. the underwriting of loans) makes such a phenomenon (i.e. the demands and granting of loans) more widespread and less "cautious" (macro-behaviour) in the international financial system (micro-macro feedback).[11]

The example applies to the diffusion of systemic needs. In fact, behaviours spread throughout the whole ecology of systems and overcome a fundamental barrier: the "precaution principle" of decisions, which protects both the individual and the system from possible excesses. Through an "offer of protection" to the individual (micro-system), the system very often suppresses its capacity for criticism as well as its independence. In this way, behaviours become "standard", almost consonant. However, such consonance reduces the borders of systems and tends to combine them, so one component of a crisis can gradually lessen the resistance of the overall systems' population.

2.3. The interdisciplinary debate about the concept of crisis, between physiology and pathology: some notes

The social sciences consider change as a moment of continuity or discontinuity and it is on this meaning that the not merely negative and worst vision of crisis is based.[12] Even in the mentioned "theory of change", there is still the need to distinguish among different "qualities" of crises. A partially satisfactory solution seems to be the differentiation of crises on the basis of the

[11] In other words, the necessity factor (the purchase of the house) linked to the recombination one (the increase in the value of properties) triggered the diffusion of the real estate loans at a systemic level. Particularly, that diffusion, together with the increase in loans' value, brought the system to grant credit even to single individuals who lacked substantial reimbursement capacity. Indeed, *feedback* created a situation in which a single "entity" was not able to reimburse *ex ante* the credit received, because of the progressive rise in the properties' cost; moreover, the guarantee granted by the bank (the real estate value) was not suitable with regard to the granted loan.

[12] See Huntington (1975) for an essential reference to political sciences.

intensity/seriousness of effects and the survival ability of the interested system.[13] That is why the cited studies prefer to talk about "traumatic crises" and "normative or transition crises", depending on the existence of a meaningful nexus of causalty with one or more forces.[14]

With reference to the mathematical logic explained by Russell, the "theory of change" combines a general and polyvalent vision of crisis with a more particular and discriminating idea, which is stated for politics and actions of crisis, contingency or change management. Therefore, two levels (i.e. change orders) exist:

- physiological crisis: an evolutionary or continuous change, which entails an internal change in a certain system or "group";
- pathological crisis: a discontinuous and more radical change based on the "logic kinds" and with a shift of the base schemes, because they are intrinsically contradictory and outdated.

Please note that the same remarks are valid for the concept of recovery. In the first case, we can talk about a permanent recovery that is linked to the enterprise's necessity of evolving towards more desirable states without continuity. In the second case, the recovery is seen as a necessary moment of discontinuity during the transition towards a new state.

Complex thought bears out such assumptions, because the crisis can be easily compared with the concepts of punctuation balances, co-evolutionary dynamics, edge of chaos, landscapes with an exponential reduction of the adequate available variations, self-organized criticality, emerging features of self-organization, sensitivity to the initial conditions, path dependence, bifurcations, etc. Moreover, the promoters of complex thought clearly qualify the idea of "crisis" as "detector" and "effector" of a different process reality, which cannot be otherwise attainable or made aware.[15] In other words, a crisis is an extraordinary event, which reveals the latent, the virtual, the invisible, the possible and the unconscious, contrasting them beside the manifest, the real, the visible, the current and the aware. A crisis transforms the society and becomes a deciding fulcrum of it.

Nonetheless, some remarks focus on the growing environmental uncertainty and on the precariousness of every competitive advantage position. A fundamental step was taken by the famous speech of Peters and Waterman, who stated that continuous innovation is the only way to

[13] This is because the *ex post* knowledge of the final outcome of the change is necessary and it is assumed to observe the course of a crisis in a passive and detached manner, almost "isolating" (as in a laboratory experiment) from every strength and conditioning, which is clearly unrealistic. See Guatri (1992, p. 507) regarding crisis levels.
[14] The distinction is in Erikson (1968).
[15] See Morin (1985, pp. 191–203, specifically p. 191).

achieve corporate success. Such an assumption was followed by the echo of the well-known saying by Mintzberg (1987) about the rise and fall of the formalist illusion of "strategic planning" in such a turbulence context. According to him, the corporate strategy may only arise from the crossbreeding between the management's plans and the empirical results, also known as "calculated strategy" and "emerging strategy". Even Normann and Ramirez remarked on the fact that every enterprise (not only the less worthy, but also the apparently successful) has to consider itself as perpetually "on a crisis". In other words, it is important for the enterprise never to stop the research and reformulation of its competitive strategy by restarting the life cycle of its offer. The main focuses of this new paradigm are: frequent interventions in the configuration of the value chain, involving directly and with innovative methods clients, business partners and other key figures of the "value constellation"; actions on the distributive and differentiation politics of the offer; inauguration at the sector level of new relational paradigms (i.e. cooperative ones) with key stakeholders, also including other competitors and political interlocutors (Kotler, 1987, pp. 8–16). According to such an approach, the crisis sometimes does not consider the real corporate criticalities; in addition, at worst it may be frightened or even artificially "created" by the management (Grinyer *et al.*, 1988; Grinyer, 1990, pp. 131–146) in order to spur the organization to follow new competitive paths. This kind of definition dampens the borders between crisis and recovery so much that the distinction between a critical state and a balanced one is not necessary. Even if they have different levels of urgency, in both cases the enterprise has to wonder how to set up a new recovery plan. Hence, a paradox exists that acquires a general application: the life cycle of an enterprise can be graphically represented with a parabola, whereby there is a chronological coincidence between the apex of success and the beginning of decline.

3. A second reading through a systemic perspective of the economic theories on capitalistic crises

Economic studies have offered a good contribution to the comprehension of economic crises. Paradoxically, such a debate was so heated and influenced by ideological profiles that the most advanced and inspiring assumptions were rejected by the prevailing theoretic *corpus*, namely bent to political needs alien to the scientific field. Therefore, the complex thought enables the reviewing

of such a debate in an epistemological way and detects the progressive affirmation that capitalism is seen as an extremely complex system subject to crises; in particular, even if these specific crises have an intrinsic root that is difficult to defeat, this does not mean that the market economy is easily negotiable (Chart 1).

Chart 1: Fundamental theoretical strands on capitalism as a system and on its crises

Denomination	Description
An orthodox, conventional or middle-class economy, inclusive of conceptual "reforms" introduced by the *business cycle theory* and by the economic theory of Keynes	Capitalism is (originally) intended as a "rational process", a self-expansive and self-balancing system, in which crises are totally ignored, insignificant or anyway negotiable
Marxist and non-Marxist, underconsumerist theories "of the fall"	Capitalism is a complex system necessarily inclined towards imbalances and crises, which determine the final disintegration of the system itself
Theories on the tendential fall of the profit test, with different reasons from chronic underconsumption	Capitalism is a complex system with self-limited growth, structurally subject to crises, but not doomed to self-disintegration

Source: Authors' elaboration

The first strand includes some theories that are very different from each other but that are pooled by considering the capitalistic system as extremely harmonic, balanced, stable and obviously autopoietic. In fact, this system is spontaneously inclined towards expansion, regeneration and self-balancing. Consequently, such a system should not have historical limits, because it can survive by itself, thanks to the principle of "*laissez faire*" and the "offer's politics" (i.e. the sole, very limited, public intervention perspective in an economy[16]). In this pattern, soaked with mechanism and "will optimism" (or voluntarism), capitalism is a rather simple and mechanic system, which practically excludes crises (Chart 2).[17]

[16] De Gregori (1974, pp. 759 ff.), talking about criticism of Veblen and Ayres's "conventional" economy, referred to the "obsession of the market" and almost mystic trust in its automatic rebalances.

[17] Weber (1930; 1977) explained capitalism as a "rationale process" based on ideological (Protestantism and Calvinism), institutional (secret societies and corporations) and economic conditions.

Chart 2: Original explanations of crises in the classical and neoclassical economy

Refusal	Unacceptability of crisis for incompatibility with the static balance.[18]
Underproduction crisis	As in the *pre*-capitalistic economies, exceptional events caused by natural or anthropical phenomena (cataclysms, capitulation of lands and seas, wars, civilian fights, moments of incomprehensible general optimism, etc.); they are exogenous with regard to the functioning of enterprises and markets, but in any case negotiable.
Business cycle theory[19]	Attempt to work out the frequency and regularity of instabilities by replacing the static balance with the "economic cycles". These cycles are oscillations and endogenous fluctuations with regard to the system, but also rhythmical and soft fluxes, which make the balances dynamic without altering the self-reproductive capacity of the system itself. Anyway, serious crises are not explainable.
Tendential fall of the profit test	A more worrying hypothesis that was already foreshadowed by the classical economists and later disparaged because of its inability to offer a logical explanation and an empirical observation.
Smith's mistake	Smith's "makeshift" hypothesis first about a sectorial crisis and then about a general one because of excessive price competition between enterprises.[20] It was soon overcome by Ricardo and Marx.
Ricardo's mistake	Ricardo's "makeshift" hypothesis about the fall of the profitability of the tendential fall of the working productivity. It was soon overcome by Marx.[21]

Source: Authors' elaboration

Nevertheless, with the 1929 crisis, there was a failure of the above directions and the dominant paradigm was reviewed intensively, primarily by the Keynesian theory.[22] Such a rethinking line does not change the self-reproduction and self-balancing capability of the system; it mainly identifies the crisis's determinants as "errors" of public regulation, which are in most cases "related" and not "at the root".[23]

In total contrast to the previous trend, there is a praxis that considers the market free of mechanisms and self-expansion capability. Despite its need for growth, the market economy feeds

[18] Gailbraith (1988) noted with irony that "it could not to be a remedy for depression, if depression was excluded by the theory. Doctors, even those best known, haven't got a cure for a sickness that does not exist".

[19] Schumpeter (1939) identified a classical cycle of 7–11 years, discovered by Juglar in 1862, when he measured the intervals between the major commercial crises. He differentiated them into 2 cycles: the former (called *inventory cycleo*, cycle of supplies) is 3–4 years and it was observed by Kitchin in 1930; the latter (i.e. macro-cycle) is 50–60 years and was discovered by Kondratiev in 1925, but already realized by Hyde Clark in 1847. In addition, in 1923, Kuznets (1925) added a cycle of 15–25 years with reference to homes and industrial buildings. For more details, see Rostow (1971), Kalecki (1972), Mandel (1975) and Van Dujn (1983).

[20] A thesis also considered by Brenner (1998, pp. 29, 100–103, 136–138) to explain the U.S. crisis in the period 1965–73, starting from manufacturing. *Contra* Shaikh (1999). The sectorial focus, which is typical of the traditional industrial organization, has been overcome with the intense business diversification and convergences coming from collaborations between companies (Dezi, 1996).

[21] See Shaikh (1999, pp. 104–105, 125, 133–135 and 136; 1978, p. 235) for Smith and Ricardo's theories.

[22] See Shaikh (1978, p. 219) for literature on crises in classical, neoclassical and Keynesian school thought.

[23] Shaikh (1989, p. 21) explained that public action transformed the huge unemployment and deflation of the 1930s into a more durable, but graduated stagflation; however, he also observed that the public intervention in the economy is the cause neither of the postwar boom nor of the successive crisis (Shaikh, 1989, p. 19).

itself with external "sources", which are consequently incorporated and approved. Hence, there is a need for new "sources".[24]

The so-called theories of underconsumption are incorporated here. According to them, crises arise from external limitations (sell-out of other growth limits), which are inevitable and can trigger imbalances between supply and demand.[25]

The last school of thought believes that the market economy is capable of creating self-expansion that is unbalanced and unlimited in time. The accumulation process itself induces the system to amplify the external contradictions and tensions. Marxist theories have been linked to this topic even though they are not so close to Marx's arguments. According to these theories, entrepreneurs tend to accumulate capital as quickly as possible. Consequently, only the growth (not the stagnation or the crisis) is the normal tendency of the system, which is, however, unable to grow in a definite, gradual and harmonious way. Among such theories, the strongest is the one that considers a crisis as a consequence of a structural fall in profitability. The latter is not the effect/symptom of other causes (i.e. lack of demand, wage claims, less productive effort of the workforce, excess competition, technological changes, etc.), but the failure is in itself and is linked to the increasing production mechanization and to the autonomization of capital.[26]

Here comes the financial crisis issue. These crises are primarily related to business and financial transactions. They stem from increasing investment in "fictitious" capital (i.e. investments in unsure future wealth), which are typical of the most expansive phases of the economy. When such expectations are not verified or lose credibility, financial collapses occur; however, such collapses have more restricted impacts if the industrial disorientation and disinvestment are not so strong.

4. From systemic complexity to an interpretive scheme of crisis of the complex system

Now that the meaning and the importance of a crisis within the social sciences have been clarified and the theoretical debate on economic crisis has been analysed, the authors provide a generalized reading of the logical link between crisis and systemic complexity. It is important to

[24] Emblematic examples of "external sources" are pre-capitalist economies and generally poor countries.

[25] Underconsumerism had already found a great deal of support before Marxism, even in the liberal thought. The principal impulses and developments came after Marx, even though he confuted underconsumerism at its basis, demonstrating that the market economy could pursue durable growth and the lack of demand is just an effect/symptom of crisis; in fact, the falling profitability triggers underconsumerism and not the opposite. The hypothesis of durable growth of the economy is called by Marx "balanced growth" or "expansive reproduction" of capital (Shaikh, 1978, p. 227); it is considered an extraordinary event and causal in the auto-organization of capitalism (Tugan-Baraowsky, 1966).

[26] This layout is the most loyal to the original thesis, which explains that the real limit of capitalism is intrinsic to the system (Marx, 1967, vol. III, p. 250).

avoid a discussion of the several definitions of a complex system, characterized by different doctrinal points of view. The authors assume that a complex system is the result of different actors' behaviours, who act according to each other's expectations and reactions. In addition, the complex system can be considered a common, distributed and decentralized structure of command/control.[27]

Such a configuration fosters high synergy, emergency, flexibility and resilience.[28] The delicate mix of conditions and factors, through which the complex system operates, passing from one state to another, on one hand allows the system to carry out a wide range of actions and possibilities and on the other hand exposes the system to different chances of failure.[29] The system is vulnerable to relatively rare, but highly catastrophic problems, which cannot be solved by the system itself, since the complexity achieved as "protection" from more or less widely "known" failures (i.e. considered) can expose the system itself to other possible critical difficulties.[30]

In this sense, it is important to reflect on the abnormal events, called "black swans", that periodically occur in the economic scenario.[31]

As an interpretative scheme, we can summarize that:

- the logical category of the crisis seems to be the quintessence of systemic complexity;
- a systemic crisis has an intrinsic or structural origin, caused by its vulnerability or latent tendencies, which are sometimes accentuated by different pressures or external events;[32] taking into account the capitalistic crisis before the years 2007–2008, this assumption is supported by several studies and it implies that crises, although primarily financial, usually have a real root;

[27] For any notion about complex systems and drivers of systemic complexity, see Chapter I and II in Johnson (2006, p. 16).
[28] For the cited properties, see Comfort, Sungu, Johnson and Dunn (2001, pp. 144 ff.).
[29] That affirmation, which appears paradoxical, is coherent with the uncertainty theoreticians as "incommensurable risk", *in primis* Knight and Keynes. For a synthesis, see Proietti (2008).
[30] That is Johnson (2006, p. 16). Perrow (1999) supports that systemic complexity causes inevitable malfunctions and failures.
[31] The fallibility of a complex system is summarized metaphorically by the *Swiss cheese theory* or *vulnerable system syndrome*, which represents the system as a set of slices of Swiss cheese, in which holes are active mistakes (intentional and otherwise) and latent mistakes/conditions. The former are several individual mistakes and are identified by very "mobile" holes, which open and close quickly in many zones of the slice; the latter are less "mobile" and more stable holes, because they are bound to the organizational planning and working rules. Reason (1990) refined the conceptualization in health companies: human mistakes come from mechanic individual vision and enter a system-organizational perspective, which integrates all the implied elements of the system into a unique picture.
[32] Emblematic is what Gilbert stated (2007, p. 925): "new trends of analysis develop, related less to a specific, critical situation than to changes and destabilizations in systems of actors. From this point of view, crisis has a strongly endogenous character and crises analysis tends to converge with the analysis of risks as public problems and with the analysis of 'normal' situations". Elster explained capitalism as a "micro-foundation" (1989, pp. 216–217), while Ferrer-Pacces stated that (1970, p. 34): "the system […] has created and fed for centuries germs of its own destruction". *Contra*, Hirschman (1980, p. 116) talked about the "ideology trap" and "structuralism (or fundamentalist) fallacy" to disapprove of research into intrinsic and deep causes. Fortune and Peters (1995) defined vulnerability as "a system's susceptibility to the adverse consequences of a trigger event", while Turner (1976; 1978) and Reason (1997) used metaphors respectively of "incubation" and "resident pathogen".

- the complexity is on one hand a possible way of overcoming difficulties and on the other hand a feeding modality for eventual future "disasters" thanks to the integration, the coordination, the communication and the sharing occurring among the different systemic members;
- the persistence of "negative self-organization" or "dysergia" can generate reactions at a contextual level that can be ruinous for the system in crisis.

In brief, we can here talk about a "dark evil" of the complex system, because of its tendency to fail due to causes that are usually intrinsic, deep and connected to its complexity.[33] The sentence "the enterprise and beyond the enterprise" has two meanings: the former is that the systemic crisis can affect the single enterprise as well as the more complex systemic reality (up to the market economy and the global financial system); the latter is that the inability to face the crisis *ex ante* and *ex post* can lead to more or less non-legitimization of the firm and of its connected complex capitalistic system.

The existence of really complex realities, such as the SOS can help us to ponder their tendency to generate crises. The available studies have tried to outline a shared methodology to qualify such potential *failures*.[34] The studies have also underlined that the interdependencies are the "relational leverage" of systemic services, both in positive situations and in those deteriorated by propagating, diffusive, homologous and emulative processes.[35]

However, "the private incentives", which arise in these circumstances, cause excessive interdependencies compared with what is needed by the complex system.[36] As a consequence, on one hand, the only relatedness cannot be the base of a systemic crisis, especially for the SOS (i.e. global finance); on the other hand, the individual intentionality has a main role within the system frame (*institution*). Obviously, the intentionality is sometimes exposed to the approving pressure of hegemonic cultures at the base of the system.[37]

[33] The expression "obscure evil", which is intentionally suggestive and provocative, can be found in De Cecco (2008), but it is nevertheless a different explanation of the last financial crisis. However, as noted by Berto (1964), it is a well-known "literary case" on depression (i.e. individual, not of markets) apparently of difficult explanation.

[34] Significant contributions are: Beer (1981, 1994); Kickert (1980); Van Gigch (1986, pp. 131 ss.), who distinguished between *failures of* (i) *technology*, (ii) *behaviour*, (iii) *structure*, (iv) *regulation*, (v) *rationality* and (vi) *evolution*; Jackson (2003), who operated an interesting correlation between systemic approaches and SOS; and Nakamura and Kijima (2009, pp. 34 ff.).

[35] See Maccoun, Cook, Muschkin and Vigdor (2008, pp. 695 ff.) for details on *social norm effects*, contagion effects, informative "waterfalls" and *peer effects* (*peer* means closer subject, with a similar grade, so imitated). Conte and Paolucci (2001) focused on processes of *social learning* based on *learning by interacting* and distinguish between *facilitation* and *imitation*.

[36] See Gallegati, Greenwald, Richiardi and Stiglitz (2008).

[37] Supportive elements can be taken from criticism of the theory of centralized mega-capitalism, which discredits itself.

4.1 A diagram of systemic crises based on a trigger event and bifurcations

The above-mentioned considerations set up the prologue to the reasoning about the crises of economic systems and their consequences from the smallest system (i.e. a single person or family) to the complex socio-economic system, considered as a "system of systems".[38]

First of all, it is important to stress that the crisis phenomenology is inherent in the evolution of systems. Crises are often linked to the growth of systems and are part of organizations and institutions and also of the development of the economy. That is why the idea of crisis should not be considered as totally negative, but also as a transition in its physiological manifestation.[39]

Furthermore, it is also relevant to understand the factors that trigger a crisis, the consequences that such a "trigger event" can determinate in a larger economic system and whether such consequences can be foreseen.

Not all the events can be considered relevant: some are more important and a single event can have more significant consequences depending on the vulnerability of the system.[40] An experience is important if it produces a bifurcation in the system's dynamics.

Even the moment (i.e. status) in which the "economically relevant" event takes place is important. Economic systems can react differently under diverse degrees of resistance (i.e. the vulnerability or sensitivity of the system). The *turnaround situation* is defined by theory as the "initial conditions". According to the chaos theory, or rather the theory of non-linear dynamical systems, the behaviours of the majority of economic phenomena do not follow regular rhythms, but show a "bifurcation". Such a bifurcation multiplies and generates turbulence (i.e. a crisis), which consequently generates entropy. However, the involved systems do not disperse, but remain close following their own rules.[41] This is due to the so-called "attractors", which are points of mutual influence among systems that allow the observer to identify a bound "scenario" (i.e. probable), in which the systems affected by turbulence will move.[42]

One of the most important features of non-linear dynamic systems is useful for gaining a better understanding of systemic crisis (i.e. the spontaneous organization emerging from the interaction between different components of the system). Unexpected cooperation between the single

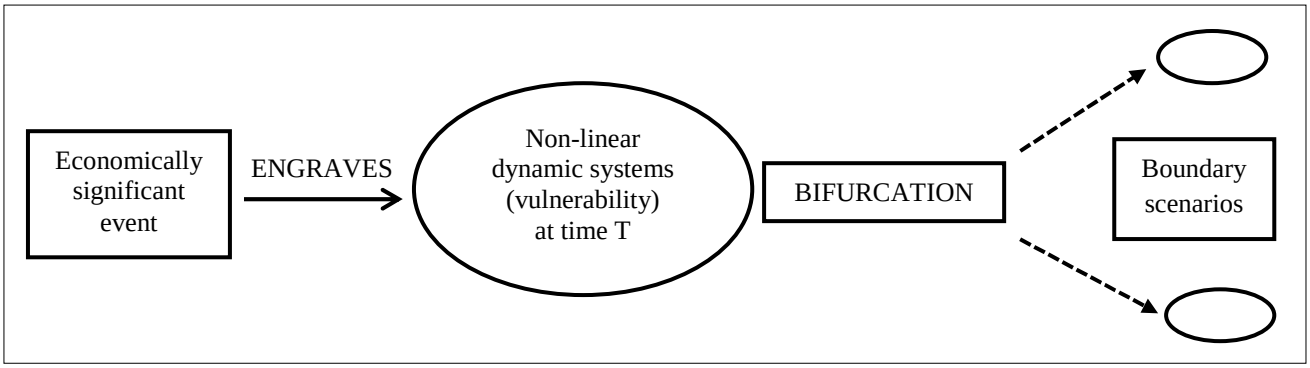
[38] See paragraph 4.1 about systems and *supra*.
[39] On cycles of economy, see Schumpeter (1939) and note 21.
[40] As an example, an influence can be of little significance in a healthy individual, while it can be fatal in an already ill subject.
[41] The concept of bifurcation is known in the theory of complex systems and it is graphically represented by Feingenbaum (diagram of bifurcations). For more details, see Bertuglia and Vaio (2003).
[42] Economic systems, like enterprises, are complex, but not linear systems. On the properties of those systems, see ch. I.

components of the external environment is established, because they reorganize themselves in order to bring out ignored, but innovative properties.

The above considerations provide a key to interpret the crisis, if they are rigorously followed and the principles of the non-linear dynamic systems theory are changed:

- economically significant events, which branch off from the evolution of the system (both for a single system and for a system of systems);
- possible scenarios (as a direct result of economically significant events) identify a "group" of oscillations in which the system will evolve;
- resilience (i.e. resistance or vulnerability) of the systems to interactions with other systems emerging from the previous bifurcation;
- the point of departure, namely the status in which the system is located at time T;
- the point of likely arrival, which does not coincide with any given point, but with a "round" point for non-linear dynamic systems.

Figure 1: The crisis in the case of "bifurcations", according to the complexity theory



Source: Authors' elaboration

Figure 1 shows the probable relationship between cause (economically significant event) and effect (scenario) from a unidirectional perspective. Therefore, it has a double limit: in the case of non-linear systems (like a firm), the bifurcation is bidirectional (i.e. the scenarios can affect both the bifurcations and the economically significant events[43]) and the influence of the single observer on the system behaviour (scenario) is not considered.

[43] It is not a direct cause–effect nexus, as in the case of deterministic systems, but a simplified situation of complexity.

5. Which is the right approach to overcome a crisis? A question that should be solved step by step

The above-discussed remarks cannot be ignored in the decision-making process when facing a crisis. That is why a *crisis management* methodology coherent with the complex school of thought is needed.

The release of a complex social system from the *impasse* may depend primarily on several agents' trust and expectations, because confidence is a key element of the system.[44] However, referring to confidence, it cannot solve the problem, as it is a "volatile" systemic result characterized by paradoxes.

Moreover, it is useful to make a distinction between the different logistic responses to the crisis, which are directly inspired by the theory of complexity (Chart 3). Such logics are designed from a "conservative" point of view. They consider the entire observed complex system, without taking into consideration the possible hypothesis of totally overcoming the system or its functions' degradation.

[44] When we talk about trust, it is important to distinguish the generic "to trust", which implies complete reliance on a third party, from "to be confident", which assumes a sort of knowledge and *ex ante* evaluation.

Chart 3: Different logistic answers to a crisis of the socio-economical complex systems

Name	Description	Strengths and weaknesses	Applicability conditions
Complication of the system	Increasing in number and variety of the constraints under which the system and its agents rely. The dispersion within the system of "control points" can increase, together with the distinction between regulators and operators.	Action viable in the medium term too. It can result in ineffectiveness as well as inefficiency. It can also provide unintended incentives for replication.	Preferably utilized in the case of prolonged crisis (L crisis).
Complexity of the system	Introduction of rules and technologies leading (and not imposing) to processes and behaviours of self-control and self-management of the system.	Action viable in the medium term; however, it does not have reliable results (i.e. efficient but not necessarily effective).	Preferably utilized in the case of brief, but intense crisis (V crisis).
Simplification of the system (complexity reduction)	Direct intervention inside the culture of the system and contextual installation of the different attitudes and beliefs, in order to stop the crisis and to avoid it in the future.	Usually effective action, but very slow and expensive (i.e. not very efficient and timely). It can totally change the system, altering the observers' perspective.	Preferably utilized in the case of a convulsive crisis affected by rapid and repeated changes (W crisis).

Source: Authors' elaboration

If the complication of the system was supported by the different proponents of the "regulated capitalism" in 1929 and the simplification leads to changes in the cultural background, the complexity of the system requires a mix of regulations and new technologies, which trigger possible rebalances.[45]

This is not a simplification based on cultural changes, because there is no direct action on the fundamental shared values and no internalization of the principles of common interest within the single operator. This last operator will moderately lead a management non-adherent to general principles, but according to expediency.

[45] An example of this last option relies on recent modifications in the discipline of the Italian traffic circulation: many intersections have registered the abandonment of traffic lights (a typical complex system) in favour of roundabouts. This change is a mix of over-ordinamental laws, technology and self-organization (between car drivers); in fact, a car cannot enter the roundabout without moderating its speed, because of the excessive centrifugal power and the difficulty of controlling the entry of other cars from the different entrances. A more rigid, formalized and hierarchical system (i.e. with the separation between moments of "decision" and "execution") is replaced with a more flexible one, which is based on different actors' self-control. The traffic example is not causal and anomalous, as it has already been used by Keynes (1936).

6. Final conclusion: implications and limits of the study

This paper is based on rather recent events and revises different doctrines of various disciplinary matrices. It underlines the deep and meaningful relationship between the complexity and the crisis of a system. The theme of crisis takes priority while thinking about the economy. The economy has, in fact, long ignored or trivialized complexity, because it is anchored on a one-economical-financial dimensionality (typical of growth) and on contractual and firm relationships.

The keep-going entreaties, which come from the complexity school of thought, foster the interpretation of socio-economical systems' crises and contribute to the reasonable and flexible "scientification" process, considered important by the social sciences.[46] Different conceptions of the crisis have been studied and those proven to be most consistent with the complexity theory look at the crisis in a multivalent sense (combination "threat/opportunity"). They maintain the demarcation between physiology and pathology and give priority to few endogenous, structural and latent factors, even if there is an interaction between exogenous and endogenous factors and a number of causes always exist. As a consequence, in order to analyse and understand a crisis, it is important not to stop at the identification of superficial or "future" determinants (i.e. space, time, logical links). Caution should be exercised and confusion between the determinants and the effects or symptoms should not be made. However, at the same time, the possibility of a self-combination of circularity between causes and effects should be considered.[47]

Another result of this work is the answer to possible turbulences, instabilities and failures in social systems, caused by the internal logic of the system itself (i.e. by means of two particular "cells" operating externally and internally). Such a long-standing *querelle* can be overcome or at least freed by excessive simplification if:

- the contradictions and critical trends at the institutional level (i.e. intrinsic to the system) do not imply the cancellation of individualities and their intentionality;[48]

[46] See Golinelli (2008, pp. XIX ff. and pp. 3–6 and note 5) for "responsible rationality" and scientification in the socio-economic area. On complexity as a triumph of the "quality" difference in dry, distorting and standardizing "quantity", see Gummesson (2006, pp. 167 ff.); there are also references to Morin's thought on the abandonment of universal explanations and formal and polished modelizations.

[47] Myrdal theorized the general idea of circularity in the economic area (Streeten, 1998, pp. 539 ff.).

[48] See Giddens (1981, pp. 23 and 91).

- assuming that the intent of single individuals is always the concrete force that drives a social action, the systemic logic can shape personal behaviours through the common culture, as it is more consolidated and institutionalized.

In the case of crisis, the "responsibility" of the system and its components should always be recognized, showing the existence of endogenous exposure or real contradiction factors. This is not a way to deny the existence and the importance of contingent and contextual factors, such as pressure from other systems, because they only have a role as accelerators or even as trigger elements. However, defining the last global financial crisis as a lack of regulation/supervision is reductive, because it has been undistorted by a range of innovative financial products and/or inconsistent savers' requests for return. In addition, the financial system seems to be increasingly affected by a search for accumulation, which is not easily maintainable for an indefinite period of time.

Another examination undertaken in this study concerns the logical link between the significant/increasing systemic complexity (primarily measured in terms of self-organization level and abundance/diffusion of governance/system control "nodes") and the tendency towards crisis. Increasingly complex socio-economical systems do not necessarily imply a higher propensity for crisis, but rather underline greater social evidence of the crisis itself. An automatic increase in social delegitimization and of radical change should not derive from it.

Finally, the contribution identifies a taxonomy of some logics, useful for facing crises of social–economical systems and determining a distinction between "simplification" (i.e. a lack of awareness in understanding the complexity of reality), "complication" (i.e. an attempt to reduce complexity through a more or less computability effort) and "complexity".

The main limit of this study stems from its bibliographical methodology.[49] Hence, there is a possibility for further investigations, for example through macro- and/or micro-empirical surveys, including research on involved "witnesses" or economic agents in order to support/refute the hereby outlined theory.

[49] See Fillis for limits of that structuring (2006, pp. 198 ff.).

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