Journal of
Social and Administrative Sciences
www.kspjournals.org
Volume 8 March 2021 Issue 1

Critical decisions for crisis management: An introduction

By Mario COCCIA †

Abstract. In the presence of crisis, such as global COVID-19 pandemic crisis, governments have more and more take critical decisions to cope with consequential environmental threats in the presence of highly restricted time. This chapter provides a simple description of techniques of decision making in different environments/conditionsof crisis management and how that process is influenced by manifold social, economic and/or technical factors; ultimately it is presented how the approach of improvisation can support the process of decision-makingto cope with unforeseen and new events, rapid changes, turbulent environment and/or specific situations of emergency.
Keywords. Critical decision, Decision making, Decision support, Uncertainty, COVID-19, Crisis management, Problem solving, Bounded rationality, Improvisation.
JEL. F21, F68, O53, K23.

1. Introduction

The markets and environment have, more and more, a growing dynamism that generates uncertainty and turbulence (Johnson & Scholes, 1988; Emery & Trist, 1965). In uncertain and unstable environment, organizations/nations are open systems having activities in interaction with external factors (McDermott & Taylor, 1982; Gioia & Chittipeddi, 1991). Organizations/nations and leaders can confront crises and problematic situations that they do not face on a daily basis—for example, in the presence of hurricane, earthquake, political instability, pandemic, terroristic attacks, financial crisis, etc. (cf., Farazmand, 2001, 2007). Critical decisions are hard calls, which involve tough value trade-offs and also major changes, such as stop the production, lockdown, quarantine of population, social restrictions, staff cuts and/or move the location of firms in other geoeconomic regions, etc.In short, organization/nation and management in emergency situations have to take critical decisions to cope with consequential environmental threats in the presence of highly restricted time, endeavoringto minimize possible losses for a worst case scenario. A critical and effective decision requires interagency and inter-organizational coordination. Moreover, the effective implementation of critical decisions requires that personnel of different departments work

† CNR, National research Council of Italy & Yale University School of Medicine, 310 Cedar Street, Lauder Hall, Suite 118, New Haven, CT 06520, USA.
☎. + 85287-4804 ✉. mario.coccia@cnr.it

together. In this context, public organizations are originally designed to conduct routine business in accordance with values of fairness, lawfulness, and efficiency. However, critical decisions in the presence of a crisis require flexibility, improvisation, and the breaking of rules in a very short time[1].

2. Type of crisis and risks for applying critical decisions

A critical decision occurs in the presence of a crisis given by an unexpected complex problem that threats organizations, countriesor societies at risk (Farazmand, 2001). A general definition of risk for organizations/nations is a performance variance or environmental threat that negatively impacts the organization/nation/society (cf., Bouchet *et al.*, 2003, p.10). The sources of crises can either originate internally or externally to organizations/nations. If organizations/nations do not decide timely a solution, and sources of risk are left unaddressed, they can permanently damage the business, public service, organization, population and society with consequent socioeconomic problems. The identification of a crisis needs the evaluation of vital elements, such as: a) the problem must pose an imminent threat to the organization/nation; b) the situation must involve an element of surprise or shock; c) unexpected and uncertain nature of a complex problem will place pressure on organizations to make timely and effective critical decisions. Crisis can be due to manifold factors: rapid evolution of technology (Coccia, 2005a, 2006, 2014, 2017, 2017a, 2019; Coccia & Watts, 2020); natural disasters, such as earthquake, hurricane, flood, etc., as well as pandemic diseases that generate socioeconomic shock and severe health damages (cf., Coccia, 2017d); economic crisis generated by hyperinflation, high public debt, energy shortages etc. (cf., Coccia, 2005, 2007, 2010, 2016; Coccia, 2017b);political risk and revolutions (cf., Coccia, 2017c, 2019, 2019a, 2019b, 2019c; Farazmand, 2001; Miller, 1992); terrorism of some group organized that has technical skills to carry out a terrorist action directed to challenge a nation's authority and induce fear and anxiety into civilian population (cf., Crenshaw, 1981, Coccia, 2018, 2018a, 2018b, 2018c; Krueger, 2007; Newman, 2006). The effect of crises can be worsened by weak infrastructure and inefficiencies of local and national institutions; social crisis that increases violence in society.

[1] In this context, for studies about the interaction in different environments/conditions between decision systems, science, technology and innovation, their sources, evolution, diffusion and impact on socioeconomic systems, see: Cavallo et al., 2014; Coccia, 1999, 2001, 2004, 2005, 2005a, b, c, 2006, 2007, 2008, 2009, 2009a,b,c; 2010, 2010a,b; 2012, 2012a,b; 2013; 2014, 2014a, b, c,d; 2015, 2015a, b; 2016, 2016a; 2017, 2017a, b, c, d, e, f, g, 2018, 2018a, b, c, d, e, f, g, h, i; 2019, 2019a, b, c, d, e, f, g, h, i, l, m; Coccia, 2020a, b, c, d, e, f, g, h, i, l, m, n, o, p, q; Coccia and Bellitto, 2018, Coccia and Cadario, 2018; Coccia et al., 2015; Coccia and Finardi, 2012, 2013; Coccia et al., 2012; Coccia and Rolfo, 2008, 2009, 2010, 2013, Coccia and Watts, 2020.

3. Crisis management and types of critical decisions

Organization can design a crisis management team for managing strenuous situations and complex problems and making critical decisions to resolve, as far as possible, them. Crisis management team should deal with threats before, during, and after they have occurred (cf., Groh, 2014). Successful crisis management teams understand the different types of crisis and are thoroughly prepared for all situations. Moreover, in a crisis, leaders are expected to reduce uncertainty and provide an authoritative account of problems, solutions and difficulties. When leaders have to formulate a strategy and critical decision for complex problems, they also must get others to accept the proposed solution. In fact, the critical decisions of leaders can coincide and compete with those of other parties, who hold other positions and interests and who are likely to suggest various alternative solutions and actions (Venette, 2003). Vital factors for a critical decision in aversive environment are:

(a) a threat to the organization

(b) the element of surprise

(c) a short decision time

Different types of critical decisionsare (cf., Seeger *et al.*, 1998; Shrivastava *et al.*, 1988; Bundy *et al.*, 2017):

Responsive critical decision

When a problem hits organizations/nations, it is important to have a plan of action ready that matches the situation at hand. Crisis management executes the plan of critical decisionand handles any unexpected roadblocks that may pop up.

Proactive critical decision

Proactive critical decision anticipates a potential problem and works to prevent it, or prepare for it. For example, building an earthquake-resistant factory and sharing an evacuation plan with employees/populationare methods to prepare for natural disasters. While not all crises can be prevented or planned for, actively monitoring for threats to organizations/nationscan reduce the impact of problematic situations in society.

Recovery critical decision

Sometimes, itis not possible to see the complex problem coming (e.g., earthquake, pandemic diffusion, etc.), or it is too late to prevent the damage it caused. In these cases, organizations/nations may not be able to lessen the impact, but it can begin to salvage what is left of the situation.

4. Structure of decision making and strategies for critical decisions

The process of critical decisions is based on strategic operations and steps, such as (Linstone, 1999):

- the definition of a complex problem *Pr* from volatile environment, and the implicit assumption that the problem can be solved.After that, it is important to gather information for possible solutions of the problem *Pr*
- *Reductionism*, the study of complex problems in terms of a very limited number of variables and the critical interaction among them
- Identification of the purpose of critical decision about the complex problem *Pr*under study
- Suggestion and evaluation of different alternative solutions to complex problem *Pr*under study
- Ignoring or avoiding the individual interests
- Selection of the optimal solution, or the search whenever possible, for a best solution in a short time
- Implementation of the critical decision and evaluation of results

In short, the starting point of critical decision is a complex problem that we assume a possible solution exists. A complex problem has several solution concepts (*Sl*), each of which leads to several consequential problems (*Pr*) and solutions (*Sl*). A critical decision can be schematically summarizedby a tree structure of decision makingwith consequential levels of *Pr* and *Sl*(Fig. 1).

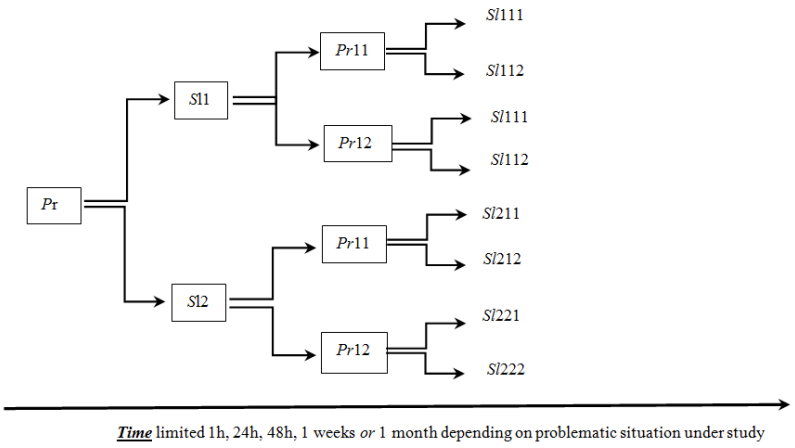

Figure 1. *The problem-solution tree for critical decisions.*
Note. *Pr*=problem; *Sl*=Solution.
Note: the increasing number from left to right indicates the sequence of decisions to cope with consequential problems

Different strategies for critical decisionsin the presence of turbulent scenario are schematically summarized in Figure 2.

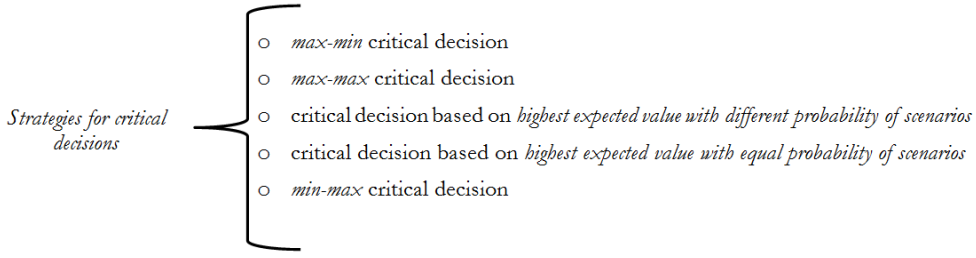

Figure 2. *Strategies for critical decisions*

A simple example can clarify these different strategies for critical decisions (cf., Lloyd & Dicken, 1977).

First of all, we create a matrix of outcome associated with strategies and environmental situations (or *payoffs*)as in Table 1.

Table 1. *Matrix of payoffs for a critical decision process*

	Environmental Situation		
	I	II	III
Strategy 1	200	155	145
Strategy 2	130	220	130
Strategy 3	118	118	225

Critical decision depends on manifold endogenous and exogenous factors, also considering the behavior of management towards risk and uncertainty. Results of critical decision listed in Figure 1 are as follows.

- *Pessimistic critical decision* is based on a rule of *max-min*, selecting the max of the worst result in each strategy:

145 for strategy 1	Critical decision with *max-min*
130 for strategy 2	
118 for strategy 3	

- *Optimistic critical decision* is based on a rule of *max-max*, selecting the max of the best result in each strategy:

200 for strategy 1	
220for strategy 2	
225 for strategy 3	Critical decision with *max-max*

- *Rational critical decision*considers relative probabilities of each environmental situation.

If the probability of different environmental situations in table 1 is assumed to be:

	Probability
Environmental Situation I	0.2
Environmental Situation II	0.5
Environmental Situation III	0.3
Total (certain event in probability)	1.0

then, critical decision here is based on selecting the strategy with the *highest expected value,* given by:

Strategies		*Expected value*
strategy 1	0.2(200)+0.5(155)+0.3(145)	*=161*
strategy 2	0.2(130)+0.5(220)+0.3(130)	*=175* Critical decision
strategy 3	0.2(118)+0.5(118)+0.3(225)	*=150.1*

- *Approximate critical decision* assumes that the probability of different environmental situations is equal. Table 1 has three environmental situations and the equal probability is 0.333 (i.e., 1/3=0.333….):

	Probability
Environmental Situation I	0.333…
Environmental Situation II	0.333…
Environmental Situation III	0.333…
Total (certain event in probability)	1.000

This critical decision is also based on selecting the strategy with *the highest expected value:*

Strategies		*Expected value*
strategy 1	0.33(200)+ 0.33 (155)+ 0.33 (145)	*=165* Critical decision
strategy 2	0.33 (130)+ 0.33 (220)+ 0.33 (130)	*=158.4*
strategy 3	0.33 (118)+ 0.33 (118)+ 0.33 (225)	*=152.5*

- *Critical decision with Min-Max strategy*

If the critical decision, *a priori*, is strategy 3 and the environmental situation, *a posteriori*, is I in table 1, the best critical decision *ex-post*would be strategy 1, rather than strategy 3; the regret ex-post for the wrong choice done *a priori*is 83 (i.e., 200-118). The calculation of this value for each cell is the base for *Min-Max* rule of critical decision, given by minimizing the max value of strategies, i.e.,

80 for strategy 1	
95 for strategy 2	
82 for strategy 3	Critical decision with *Min-Max*

5. Improvisation for critical decisions

Planning can reduce uncertainty, but even the most carefully devised plans may have to be abandoned or modified in the face of unanticipated changes or challenges. Improvisation is one of approaches that stands outside of rational models of decision making mentioned above. Improvisation is a combined behavioral and cognitive activity that requires consequential creativity under tight time constraint in order to meet performance objectives (Mendonça & Fiedrich, 2006, p. 350). Improvisation carries an immediate answer for a need in the presence of environment threats (Lee, 1995). Improvisation is also a way of take advantage of important and unexpected opportunities without formal plans or systematic procedure (Sharkansky & Zalmanovitch, 2000). While rational planning aims to control a situation by reducing the uncertainty, improvisation is a reaction to a novel situation and a way of working within uncertainty. While rational planning is directed at optimal solutions, improvisation aims at dealing with problems rather than solving them in an optimal manner. In short, improvisation may be employed to overcome the limitations of rational planning. Understanding of cognition in highly non-routine situations can lead to improvements for decision-making in these situations (Klein, 1993). A two-stage process for improvisation may be: 1) the organizationrecognizes either that no plan applies to the current situation or that plan cannot be executed; 2) the responding organizationhas to develop and deploy one or more new procedures. Mendonça & Fiedrich (2006, p. 350) argue that:

The improvisation may range from substitution (e.g., using a close substitute resource for one that is unavailable) to the construction of new procedures (e.g., developing an entirely new procedure). In the case of substitution, the responding organization 'mixes and matches' existing procedures and/or the materiel used in them. At the other end of the spectrum, the organization must develop new procedures and possibly find new material for use in those procedures. More radically, it may also entail changing the goals of the response (e.g., deciding in the field that the

real problem to be solved is providing shelter in place rather than evacuating).

The question of when to improvise for a critical decision may be conceptualized as a choice problem, in which the ability or likelihood of a decision-maker to categorize correctly is influenced by a number of factors, such as penalties associated with making an incorrect choice and the likelihood that the response will succeed. The question of how to improvise may be conceptualized as a search and assembly problem, which may be influenced by factors, such as time available for planning, risk in the environment and the results of prior decisions. In short, learn how to develop and deploy new procedures and critical decisions in a consequential manner under time constraint; after that, inform multiple decision-makers and make inferences about the present and likely future states of complex systems (Weick, 1993, 1998). Indeed, training has proven capable of improving human ability to recognize salient similarities and differences between current and past situations for critical decisions– even at a very fine-grained level (Klein, 1993). Hence, improvisation involves the ability to act in real time, when the need arises, and to find an action when none of the established alternatives appear to be practical. It is useful when there is uncertainty, few precedents, or few reliable facts and suitable routines; and when there is pressure to act in a short time or with resources that appear to be insufficient. Stressful environments may foster improvisation more than less fraught ones. Thus, unpredictable and rapidly changing environments are probably more likely to promote improvisation than more stable environments. Improvisation may be more likely when there is not enough time, information, knowledge, or material resources to plan, measure, weigh, consider, and document an optimal response, or when opposing demands are so intense that calculated compromise appears unproductive. Thus, critical decision with improvisation is likely to occur in emergencies, crises, and novel situations, and when the problem it comes to address is perceived to be intractable. Improvisation has inherent drawbacks. It may generate instability and consequential improvisations to cope with the effects of previous improvisations. Improvisation tends to be judged by its results that can lead to success or fail.

6. Conclusions

The decision rule and mechanism for critical decisions, of course, change according to the situation that can be affected by manifoldorganizational and environmental variables. In this context, it is important to consider the *ecological rationality* that claims *how* the rationality of a decision depends on circumstances in which it takes place, so as to achieve one's goals in a specific context. What is considered rational under the theory of rational choice account, it might not always be considered rational under the ecological rationality account. In particular, rational choice theory puts a premium on internal logical consistency, whereas ecological rationality also

targets external performance in the world (cf., Allais, 1953; Kahneman *et al.*, 1982; Gigerenzer & Todd, 1999; Simon, 1955). However, within process of critical decisions, it is also important to consider bounded rationalityof decision makers, i.e., rationality is limited when individuals make decisions by the tractability of the decision problem, the cognitive limitations of the mind, manifold environmental variables and the time available to make the decision. Organizations/nations, in a context of *bounded rationality*, aim to a behavior of *satisficing* rather than maximizing critical decisions to cope with consequential environmental threats in the presence of highly restricted time (Simon, 1947; 1957; Gigerenzer & Selten, 2002). In general, acritical decisions provide vital material and information for a process of learning for turbulent and problematic situations in future. In fact, critical decisions are part of collective memory within and between organizations/nations and a vital source for historical analogies useful to leaders and organizations/nations in future complex situations (cf., Seeger *et al.*, 1998; Shrivastava *et al.*, 1988; Bundy *et al.*, 2017). Overall, then, critical decisions deal with problems that are choicesituations in which what is done makes a significant difference to those who make the choice (Ackoff & Rovin, 2003, p.9). These problems can be treated in different ways as follows (Ackoff & Rovin, 2003, pp.9-10):

- *Resolution* is when management employs behavior previously used in similar situations, adapted if necessary, so to obtain an outcome that is good enough. This approach for critical decisions is based on past experience, trial and error, and a common sense.
- *Solution* means to discover or create a behavior that yields the best, or approximately the best possible outcome, one that optimizes. However, change in environment and new information can cause solutions to deteriorate. In general, solutions do not exist in isolation from other problems and environment.
- *Dissolution* means to redesign either the organization that has the problems or the environment in such way as to eliminate the problem or the conditions that caused it, thus enabling the organization to do better in the future than the best it can do today. Moreover, stakeholders might seize upon the lessons of crises to advocate measures and policy and organizational reforms to improve overall efficiency of organization/nation (cf., Bundy *et al.*, 2017).

The critical decision of consequential problems can be based on a mix of these ways in the presence of more and more, turbulent markets, uncertain and volatile environments.

References

Ackoff, R.L., & Rovin, S. (2003). *Redesigning Society*, Stanford University Press, Stanford, CA.

Allais, M. (1953). Le Comportement de l'homme rationnel devant le risque: Critique des postulats et axiomes de l'ecole Americaine. *Econometrica*. 21(4), 503–546. doi. 10.2307/1907921

Bouchet, M.H., Fishkin, C.A., & Goguel A. (2018). *Managing Country Risk in an Age of Globalization. A Practical Guide to Overcoming Challenges in a Complex World*, Palgrave Macmillan.

Bundy, J., Pfarrer, M.D., Short, C.E., & Coombs, W.T. (2017). Crises and crisis management: Integration, interpretation, and research development. *Journal of Management*, 43(6), 1661–1692. doi. 10.1177/0149206316680030

Cavallo, E., Ferrari E., Bollani, L., & Coccia M. (2014). Strategic management implications for the adoption of technological innovations in agricultural tractor: the role of scale factors and environmental attitude, *Technology Analysis & Strategic Management*, 26(7), 765-779. doi. 10.1080/09537325.2014.890706

Coccia, M. (2001). Satisfaction, work involvement and R&D performance. *International Journal of Human Resources Development and Management*, 1(2-3-4), 268-282. doi. 10.1504/IJHRDM.2001.001010

Coccia, M. (2003). Metrics of R&D performance and management of public research institute. *Proceedings of IEEE- IEMC 03*, Piscataway, pp.231-236.

Coccia, M. (2004). Spatial metrics of the technological transfer: analysis and strategic management. *Technology Analysis & Strategic Management*, 16(1), 31-52. doi. 10.1080/0953732032000175490

Coccia, M. (2005). Countrymetrics: valutazione della performance economica e tecnologica dei paesi e posizionamento dell'Italia, *Rivista Internazionale di Scienze Sociali*, CXIII(3), 377-412.

Coccia, M. (2005a). Metrics to measure the technology transfer absorption: analysis of the relationship between institutes and adopters in northern Italy. *International Journal of Technology Transfer and Commercialization*, 4(4), 462-486. doi. 10.1504/IJTTC.2005.006699

Coccia, M. (2005b). Technometrics: Origins, historical evolution and new direction, *Technological Forecasting & Social Change*, 72(8), 944-979. doi. 10.1016/j.techfore.2005.05.011

Coccia, M. (2005c). Economics of scientific research: origins, nature and structure, *Proceedings of Economic Society of Australia*.

Coccia, M. (2006). Classifications of innovations: survey and future directions. *Working Paper Ceris del Consiglio Nazionale delle Ricerche*, 8(2), 1-19. [Retrieved from].

Coccia, M. (2006a). Analysis and classification of public research institutes. *World Review of Science, Technology and Sustainable Development*, 3(1), 1-16.

Coccia, M. (2007). A new taxonomy of country performance and risk based on economic and technological indicators, *Journal of Applied Economics*, 10(1), 29-42.

Coccia, M. (2008). Science, funding and economic growth: analysis and science policy implications. *World Review of Science, Technology and Sustainable Development*, 5(1), 1-27. doi. 10.1504/WRSTSD.2008.01781

Coccia, M. (2008a). Spatial mobility of knowledge transfer and absorptive capacity: analysis and measurement of the impact within the geoeconomic space. *The Journal of Technology Transfer*, 33(1), 105-122. doi. 10.1007/s10961-007-9032-4

Coccia, M. (2008b). New organizational behaviour of public research institutions: Lessons learned from Italian case study. *International Journal of Business Innovation and Research*, 2(4), 402–419. doi. 10.1504/IJBIR.2008.018589

Coccia, M. (2009). A new approach for measuring and analyzing patterns of regional economic growth: empirical analysis in Italy. *Italian Journal of Regional Science- Scienze Regionali*, 8(2), 71-95. doi. 10.3280/SCRE2009-002004

Coccia, M. (2009a). Measuring the impact of sustainable technological innovation, *International Journal of Technology Intelligence and Planning*, 5(3), 276-288. doi. 10.1504/IJTIP.2009.026749

Coccia, M. (2010). Public and private R&D investments as complementary inputs for productivity growth. *International Journal of Technology, Policy and Management*, 10(1/2), 73-91. doi. 10.1504/IJTPM.2010.032855

Coccia, M. (2010a). Foresight of technological determinants and primary energy resources of future economic long waves, *International Journal of Foresight and Innovation Policy*, 6(4), 225–232. doi. 10.1504/IJFIP.2010.037468

Coccia, M. (2010b). Energy metrics for driving competitiveness of countries: Energy weakness magnitude, GDP per barrel and barrels per capita. *Energy Policy*, 38(3), 1330-1339. doi. 10.1016/j.enpol.2009.11.011

Coccia, M. (2010c). Spatial patterns of technology transfer and measurement of its friction in the geo-economic space. *International Journal of Technology Transfer and Commercialisation*, 9(3), 255-267. doi. 10.1504/IJTTC.2010.030214

Coccia, M. (2010d). The asymmetric path of economic long waves, *Technological Forecasting & Social Change*, 77(5), 730-738. doi. 10.1016/j.techfore.2010.02.003

Coccia, M. (2010e). Democratization is the driving force for technological and economic change, *Technological Forecasting & Social Change*, 77(2), 248-264. doi. 10.1016/j.techfore.2009.06.007

Coccia, M. (2011). The interaction between public and private R&D expenditure and national productivity. *Prometheus-Critical Studies in Innovation*, 29(2), 121-130. doi. 10.1080/08109028.2011.601079

Coccia, M. (2012). Political economy of R&D to support the modern competitiveness of nations and determinants of economic optimization and inertia, *Technovation*, 32(6), 370–379. doi. 10.1016/j.technovation.2012.03.005

Coccia, M. (2012a). Evolutionary trajectories of the nanotechnology research across worldwide economic players. *Technology Analysis & Strategic Management*, 24(10), 1029-1050. doi. 10.1080/09537325.2012.705117

Coccia, M. (2012b). Evolutionary growth of knowledge in path-breaking targeted therapies for lung cancer: radical innovations and structure of the new technological paradigm. *International Journal of Behavioural and Healthcare Research*, 3(3-4), 273-290. doi. 10.1504/IJBHR.2012.051406

Coccia, M. (2012c). Converging genetics, genomics and nanotechnologies for groundbreaking pathways in biomedicine and nanomedicine. *International Journal of Healthcare Technology and Management*, 13(4), 184-197. doi. 10.1504/IJHTM.2012.050616

Coccia, M. (2012d). Driving forces of technological change in medicine: Radical innovations induced by side effects and their impact on society and healthcare. *Technology in Society*, 34(4), 271-283. doi. 10.1016/j.techsoc.2012.06.002

Coccia, M. (2013). What are the likely interactions among innovation, government debt, and employment? Innovation: *The European Journal of Social Science Research*, 26(4), 456–471. doi. 10.1080/13511610.2013.863704

Coccia, M. (2013a). The effect of country wealth on incidence of breast cancer. *Breast Cancer Research and Treatment*, 141(2), 225-229. doi. 10.1007/s10549-013-2683-y

Coccia, M. (2014). Path-breaking target therapies for lung cancer and a far-sighted health policy to support clinical and cost effectiveness. *Health Policy and Technology*, 1(3), 74-82. doi. 10.1016/j.hlpt.2013.09.007

Coccia, M. (2014a). Emerging technological trajectories of tissue engineering and the critical directions in cartilage regenerative medicine. *Int. J. Healthcare Technology and Management*, 14(3), 194-208. doi. 10.1504/IJHTM.2014.064247

Coccia, M. (2014b). Converging scientific fields and new technological paradigms as main drivers of the division of scientific labour in drug discovery process: the effects on strategic management of the R&D corporate change. *Technology Analysis & Strategic Management*, 26(7), 733-749, doi. 10.1080/09537325.2014.882501

Coccia, M. (2014c). Driving forces of technological change: The relation between population growth and technological innovation-Analysis of the optimal interaction across countries, *Technological Forecasting & Social Change*, 82(2), 52-65. doi. 10.1016/j.techfore.2013.06.001

Coccia, M. (2014). Socio-cultural origins of the patterns of technological innovation: What is the likely interaction among religious culture, religious plurality and innovation? Towards a theory of socio-cultural drivers of the patterns of technological innovation, *Technology in Society*, 36(1), 13-25. doi. 10.23760/2421-7158.2017.004

Coccia, M. (2014e). Religious culture, democratisation and patterns of technological innovation. *International Journal of Sustainable Society*, 6(4), 397-418. doi. 10.1504/IJSSOC.2014.066771

Coccia, M. (2014f). Structure and organisational behaviour of public research institutions under unstable growth of human resources, *Int. J. Services Technology and Management*, 20(4/5/6), 251–266. doi. 10.1504/IJSTM.2014.068857

Coccia, M. (2014g). Steel market and global trends of leading geo-economic players. International *Journal of Trade and Global Markets*, 7(1), 36-52, doi. 10.1504/IJTGM.2014.058714

Coccia, M. (2015). The Nexus between technological performances of countries and incidence of cancers in society. *Technology in Society*, 42, 61-70. doi. 10.1016/j.techsoc.2015.02.003

Coccia, M. (2015a). Patterns of innovative outputs across climate zones: the geography of innovation, *Prometheus. Critical Studies in Innovation*, 33(2), 165-186. doi. 10.1080/08109028.2015.1095979

Coccia, M. (2015b). General sources of general purpose technologies in complex societies: Theory of global leadership-driven innovation, warfare and human development, *Technology in Society*, 42, 199-226. doi. 10.1016/j.techsoc.2015.05.008

Coccia, M. (2015c). Spatial relation between geo-climate zones and technological outputs to explain the evolution of technology. *Int. J. Transitions and Innovation Systems*, 4(1-2), 5-21. doi. 10.1504/IJTIS.2015.074642

Coccia, M. (2015d). Technological paradigms and trajectories as determinants of the R&D corporate change in drug discovery industry. *International Journal Knowledge and Learning*, 10(1), 29-43. doi. 10.1504/IJKL.2015.071052

Coccia, M. (2016). Asymmetric paths of public debts and of general government deficits across countries within and outside the European monetary unification and economic policy of debt dissolution. *The Journal of Economic Asymmetries*, 15, 17-31. doi. 10.1016/j.jeca.2016.10.003

Coccia, M. (2016a). Radical innovations as drivers of breakthroughs: characteristics and properties of the management of technology leading to superior organizational performance in the discovery process of R&D labs. *Technology Analysis & Strategic Management*, 28(4), 381-395. doi. 10.1080/09537325.2015.1095287

Coccia, M. (2016). Problem-driven innovations in drug discovery: co-evolution of radical innovation with the evolution of problems, *Health Policy and Technology*, 5(2), 143-155. doi. 10.1016/j.hlpt.2016.02.003

Coccia, M. (2016c). The relation between price setting in markets and asymmetries of systems of measurement of goods. *The Journal of Economic Asymmetries*, 14(B), 168-178. doi. 10.1016/j.jeca.2016.06.001

Coccia, M. (2017). The source and nature of general purpose technologies for supporting next K-waves: Global leadership and the case study of the U.S. Navy's Mobile User Objective System, *Technological Forecasting and Social Change*, 116, 331-339. doi. 10.1016/j.techfore.2016.05.019

Coccia, M. (2017a). Optimization in R&D intensity and tax on corporate profits for supporting labor productivity of nations. *The Journal of Technology Transfer*, doi. 10.1007/s10961-017-9572-1

Coccia, M. (2017b). Varieties of capitalism's theory of innovation and a conceptual integration with leadership-oriented executives: the relation between typologies of executive, technological and socioeconomic performances. *Int. J. Public Sector Performance Management*, 3(2), 148–168. doi. 10.1504/IJPSPM.2017.084672

Coccia, M. (2017c). Sources of disruptive technologies for industrial change. *L'industria – rivista di Economia e Politicaindustriale*, 38(1), 97-120.

Coccia, M. (2017d). Sources of technological innovation: Radical and incremental innovation problem-driven to support competitive advantage of firms. *Technology Analysis & Strategic Management*, 29(9), 1048-1061. doi. 10.1080/09537325.2016.1268682

Coccia, M. (2017e). A Theory of general causes of violent crime: Homicides, income inequality and deficiencies of the heat hypothesis and of the model of CLASH, *Aggression and Violent Behavior*, 37, 190-200. doi. 10.1016/j.avb.2017.10.005

Coccia, M. (2017f). New directions in measurement of economic growth, development and under development, *Journal of Economics and Political Economy*, 4(4), 382-395.

Coccia, M. (2017g). Disruptive firms and industrial change, *Journal of Economic and Social Thought*, 4(4), 437-450.

Coccia, M. (2017h). The Fishbone diagram to identify, systematize and analyze the sources of general purpose Technologies, *Journal of Social and Administrative Sciences*, 4(4), 291-303.

Coccia, M. (2018). A theory of the general causes of long waves: War, general purpose technologies, and economic change. *Technological Forecasting & Social Change*, 128, 287-295 10.1016/j.techfore.2017.11.013

Coccia, M. (2018a). The relation between terrorism and high population growth, *Journal of Economics and Political Economy*, 5(1), 84-104.

Coccia, M. (2018c). Violent crime driven by income Inequality between countries, *Turkish Economic Review*, 5(1), 33-55.

Coccia, M. (2018d). The origins of the economics of innovation, *Journal of Economic and Social Thought*, 5(1), 9-28.

Coccia, M. (2018e). Theorem of not independence of any technological innovation, *Journal of Economics Bibliography*, 5(1), 29-35.

Coccia, M. (2018e). Theorem of not independence of any technological innovation, *Journal of Social and Administrative Sciences*, 5(1), 15-33.

Coccia, M. (2018f). Competition between basic and applied research in the organizational behaviour of public research labs, *Journal of Economics Library*, 5(2), 118-133.

Coccia, M. (2018g). An introduction to the methods od inquiry in social sciences, *Journal of Social and Administrative Sciences*, 5(2), 116-126.

Coccia, M., & Bellitto, M. (2018). Human progress and its socioeconomic effects in society, *Journal of Economic and Social Thought*, 5(2), 160-178.

Coccia, M., & Igor, M. (2018). Rewards in public administration: a proposed classification, *Journal of Social and Administrative Sciences*, 5(2), 68-80.

Coccia, M., & Bozeman, B. (2016). Allometric models to measure and analyze the evolution of international research collaboration. *Scientometrics*, 108(3), 1065-1084. doi. 10.1007/s11192-016-2027-x

Coccia, M., Falavigna, G., & Manello, A. 2015. The impact of hybrid public and market-oriented financing mechanisms on scientific portfolio and performances of public research labs: a scientometric analysis. Scientometrics, 102(1), 151-168. doi. 10.1007/s11192-014-1427-z

Coccia, M., & Finardi, U. (2012). Emerging nanotechnological research for future pathway of biomedicine. *International Journal of Biomedical Nanoscience and Nanotechnology*, 2(3-4), 299-317. doi. 10.1504/IJBNN.2012.051223

Coccia, M., & Finardi, U. (2013). New technological trajectories of non-thermal plasma technology in medicine. *International Journal of Biomedical Engineering and Technology*, 11(4), 337-356. doi. 10.1504/IJBET.2013.055665

Coccia, M., Finardi, U., & Margon, D. (2012). Current trends in nanotechnology research across worldwide geo-economic players, *The Journal of Technology Transfer*, 37(5), 777-787. doi. 10.1007/s10961-011-9219-6

Coccia, M., & Rolfo, S. (2000). Ricerca pubblica e trasferimento tecnologico: il caso della regione Piemonte. *In* S. Rolfo (ed), *Innovazione e piccole imprese in Piemonte*, Franco Angeli Editore, Milano.

Coccia, M., & Rolfo, S. (2002). Technology transfer analysis in the Italian national research council, Technovation - *The International Journal of Technological Innovation and Entrepreneurship*, 22(5), 291-299. doi. 10.1016/S0166-4972(01)00018-9

Coccia, M., & Rolfo, S. (2007). How research policy changes can affect the organization and productivity of public research institutes, *Journal of Comparative Policy Analysis, Research and Practice*, 9(3) 215-233. doi. 10.1080/13876980701494624

Coccia, M., & Rolfo, S. (2010). New entrepreneurial behaviour of public research organizations: opportunities and threats of technological services supply, *International Journal of Services Technology and Management*, 13(1-2), 134-151. doi. 10.1504/IJSTM.2010.029674

Coccia, M., & Rolfo, S. (2013). Human resource management and organizational behavior of public research institutions, *International Journal of Public Administration*, 36(4), 256-268. doi. 10.1080/01900692.2012.756889

Coccia, M., & Rolfo, S. (2009). Project management in public research organization: Strategic change in complex scenarios. *International Journal of Project Organisation and Management*, 1(3), 235–252. doi. 10.1504/IJPOM.2009.027537

Coccia, M., & Wang, L. (2015). Path-breaking directions of nanotechnology-based chemotherapy and molecular cancer therapy, *Technological Forecasting and Social Change,* 94, 155–169. doi. 10.1016/j.techfore.2014.09.007

Coccia, M., & Wang, L. (2016). Evolution and convergence of the patterns of international scientific collaboration. *Proceedings of the National Academy of Sciences of the United States of America*, 113(8), 2057-2061. doi. 10.1073/pnas.1510820113

Crenshaw, M. (1981). The causes of terrorism. *Comparative Politics*, 13(4), 379-399. 10.2307/421717

Emery, F.E., & Trist, E.L. (1965). The causal texture of organizational environments. *Human Relations*, 18(1), 21–32. 10.1177/001872676501800103

Farazmand A. 2001. *Handbook of crisis and emergency management*, CRC Press

Farazmand A. 2007. Learning from the Katrina crisis: A global and international perspective with implications for future crisis management. Public Administration Review, vol. 67, pp. 149-159

Gigerenzer, G., & Selten, R. (2002). *Bounded Rationality*. MIT Press, Cambridge.

Gigerenzer, G., & Todd, P.M. (1999). Ecological rationality: the normative study of heuristics. *In* G. Gigerenzer, P.M. Todd (Eds.), *Ecological Rationality: Intelligence in the World,* (pp.487-497). New York: Oxford University Press.

Groh, M. (2014). Strategic management in times of crisis. *American Journal of Economics and Business Administration*. 6(2), 49–57. 10.3844/ajebasp.2014.49.57

Johnson, G., & Scholes, K. (1988). *Exploring Corporate Strategy, Hemel Hempstead, England*, Prentice Hall.

Kahneman, D., Slovic, P., & Tversky, A. (1982). *Judgment Under Uncertainty: Heuristics and Biases*. Cambridge University Press.

Klein, G.A. (1993). A Recognition-Primed Decision (RPD) model of rapid decision making, *in* G.A. Klein, J. Orasanu, R. Calderwood & C.E. Zsambok (Eds.) *Decision Making in Action: Models and Methods*, (pp.138-147), Norwood, NJ: Ablex Publishing Corp.

Krueger, A.B. (2007). *What Makes a Terrorist: Economics and the Roots of Terrorism*. Princeton and Oxford: Princeton University Press.

Lee, J.M. (1995). The Reorganization of the British Council: Management Improvisation and Policy Uncertainty. *Public Administration*, 75(3), 339–355. doi. 10.1111/j.1467-9299.1995.tb00832.x

Linstone, H.A. (1999). *Decision Making for Technology Executives. Using Multiple Perspectives to Improve Performance*. Artech House, Boston, USA.

Lloyd, P.E., & Dicken, P. (1977). *Location in Space: A Theoretical Approach to Economic Geography*. SAGE Publications Inc.

McDermott, R.I., & Taylor, M.J. (1982). *Industrial Organisation and Localization*, Cambridge University Press, Cambridge.

Mendonça D., & Fiedrich F. (2006). Training for improvisation in emergency management: opportunities and limits for information technology, *Int. J. Emergency Management*, 3(4), 348–363. doi. 10.1504/IJEM.2006.011301

Miller, K. (1992). A Framework for integrated risk management in international business. *Journal of International Business Studies*, 23(2), 311-331.

Newman, E. (2006). Exploring the root causes of terrorism. *Studies in Conflict & Terrorism*, 29(8), 749-772. 10.1080/10576100600704069

Seeger, M.W., Sellno, T.L., & Ulmer, R.R. (1998). Communication, organization and crisis. *Communication Yearbook*. 21, 231–275. 10.1080/23808985.1998.11678952

Shrivastava, P., Mitroff, I.I., Miller, D., & Miclani, A. (1988). Understanding industrial crises. *Journal of Management Studies*. 25(4), 285–303. doi. 10.1111/j.1467-6486.1988.tb00038.x

Simon, H.A. (1947). *Administrative Behavior: A Study of Decision-Making Processes in Administrative Organization*. The Free Press

Simon, H.A. (1955). A behavioral model of rational choice. *The Quarterly Journal of Economics*. 69(1), 99–118. doi. 10.2307/1884852

Simon, H.A. (1957). *Models of Man*. John Wiley.

Venette, S.J. (2003). *Risk Communication in a High Reliability Organization: APHIS PPQ's Inclusion of Risk in Decision Making*. Ann Arbor, MI: UMI Proquest Information and Learning.

Weick, K.E. (1993). The collapse of sensemaking in organizations: the Mann Gulch disaster, *Administrative Science Quarterly*, 38(4), 628–652. doi. 10.2307/2393339

Weick K.E. 1998. Improvisation as a mindset for organizational analysis, *Organization Science*, 9(5), 543–555.