Fragility: concept and related notions
Fragilità: concetto e nozioni affini

Daniele Chiffi
DAStU, Politecnico di Milano, daniele.chiffi@polimi.it

Francesco Curci
DAStU, Politecnico di Milano, francesco.curci@polimi.it

Article accepted by *TERRITORIO* (Peer Reviewed Journal: ISSN 1825-8689 , ISSNe 2239-6330)
Not yet published (forthcoming 2020)

Abstract [eng]: Fragility is perhaps the concept that best represents the many uncertainties of our time related to different issues such as political and economic instability, energy and ecological transition, climate change, demographic and migratory dynamics. The article aims at conceptually clarifying the notion of fragility so as to try to differentiate it from other related notions such as that of vulnerability. It is pointed out that vulnerability is a notion that, unlike fragility, can be understood (in line of principle) entirely by means of risk analysis tools; and secondly, although both fragility and vulnerability can be regarded as 'dispositions', they belong to two different types.

Abstract [it]: La fragilità è forse il concetto che meglio rappresenta le molte incertezze del nostro tempo legate a diverse questioni come l'instabilità politica ed economica, la transizione energetica e ecologica, il cambiamento climatico, le dinamiche demografiche e migratorie. L'articolo ha lo scopo di proporre una chiarificazione concettuale intorno alla nozione di fragilità in modo da differenziarla da altre nozioni affini come, ad esempio, quella di vulnerabilità. Si proverà a dimostrare che la vulnerabilità, a differenza della fragilità, è una nozione che può essere intesa appieno (almeno in linea di principio) attraverso gli strumenti dell'analisi del rischio e, in secondo luogo, che sebbene fragilità e vulnerabilità possano essere considerate come 'disposizioni', esse appartengono a due tipologie differenti.

Keywords: fragility, vulnerability, uncertainty / *fragilità, vulnerabilità, incertezza*

1. Introduction

Fragility is perhaps the concept that best represents the many uncertainties of our time related to different issues, from political and economic instability to energy and ecological transition, from the climate change to the complex relationship between demographic and migratory dynamics. This may serve to explain how the use of both the term and its adjective (fragile) has permeated an ever-growing number of fields. Fragile can in fact refer to objects, people, economic and social systems, territories, ecosystems, and so forth. Such a broad spectrum of applications, at least in abstract and metaphorical terms, helps to further explain the global popularity enjoyed by the concept of fragility. But up to what extent is this concept appropriate to understand and explain some of the most salient phenomena of our time?
Our contribution aims at conceptually clarifying the notion of fragility so as to try to differentiate it from other related notions such as that of vulnerability, for example. We tackle issues that deal with probabilistic risk assessment in order to show their methodological and theoretical limitations in grasping the very notion of fragility. In fact, we show how issues of fragility can rarely be reduced to or explained through the traditional methodologies of risk analysis. On the contrary, the notion of fragility shows a certain degree of familiarity

with that of uncertainty, which does not necessarily imply any quantitative (i.e. usually probabilistic) assessment of risk. Next, we suggest how to investigate, from a foundational point of view, the notion of fragility by means of the theory of dispositions. The use of dispositions will allow us to fine-tune our definition of fragility and differentiate it more appropriately from other related notions. Section 2 clarifies the distinction between risk conditions and the condition of (fundamental) uncertainty. Section 3 presents a conceptual clarification of the notion of fragility by comparing it with the concepts of vulnerability, resilience, resistance, robustness, tenacity and ductility. Section 4 focusses on the relationship between fragility and uncertainty by touching upon different ways of 'averting' fragility to lastly explain – also by means of some examples – why fragility should not be confused with vulnerability. Section 5 entails the conclusions of our contribution.

2. Risk and uncertainty

When referring to risk, many different definitions are implied, some informal, some more technical. A classic (and technical) definition is the one given by the Royal Society, according to which risk is the product of the probability of an event, the magnitude of its effect and the severity of the consequences in a stated period of time (Royal Society, 1983). This is a probabilistic definition of risk, often used in *probabilistic risk assessment*. However, other definitions are also to be found in the literature. For instance, risk can be understood as:

(i) an unexpected event that may or may not occur;
(ii) the cause of an unexpected event that may or may not occur;
(iii) the probability of an unexpected event that may or may not occur;
(iv) the expected statistical value (i.e. the product of the probability and a severity measure) of an event that may or may not occur; this is essentially the definition given by the Royal Society;
(v) the fact that a decision was made under known conditions of probability (*known unknowns*) (Hansson, 2018; Roeser *et al.*, 2012).

Definition (i) only stresses the unexpected nature of a risky event, while (ii) makes the cause of an event coincide with the risk itself. Of course, it is one thing to talk about risk factors, but quite another to be able to distinguish between risk and cause, which can oftentimes become extremely misleading. Definition (iii) highlights the random character of the risky event, regardless of the potential impact of the consequences of such event. Quite the contrary, (iv) includes, in the definition of risk, the assessment of possible consequences. The last definition (v) stresses how decisions taken under risk conditions fall within the scope of *known unknowns*, that is, of those events that may or may not occur and of whose potential occurrence we have at least a probabilistic assessment. In the field of *disaster risk assessment*, in particular, the following are identified as risk components: the potential danger (or hazard), the exposed value (or exposure), and the vulnerability, which can be defined as the susceptibility of the exposed elements (people, manufactured products, economic activities, etc.) to suffer damage caused by a specific potentially harmful event (UNISDR, 2015).

Hence, we can technically speak of risk when we are able to both estimate the expected value of a possible event from a probabilistic point of view – since elements such as its statistical distribution are known – and to evaluate its possible consequences in a stated period of time. A well-known example of a decision taken under conditions of risk is betting at a casino roulette; here, all the probabilities of an event are computable *ex ante*. When this is not possible, we generically speak of uncertainty, which in the most severe forms is called *fundamental uncertainty* (*unknown unknowns*) or even ignorance (Carrara *et al.*, 2019). Fundamental uncertainty (also known as 'severe', 'genuine', 'deep', or 'great' uncertainty) has a non-probabilistic nature and represents the most common form of uncertainty that we experience in everyday life. Keynes makes this concept clear by stating that

> By 'uncertain' knowledge I do not mean merely to distinguish what is known for certain from what is only probable. The game of roulette is not subject, in this sense, to uncertainty [. . .] The sense in which I am using the term is that in which the prospect of a European war is uncertain, or the price of copper and the rate of interest

> twenty years [. . .] About these matters there is no scientific basis on which to form any calculable probability whatever. We simply do not know (Keynes, 1973: 213-214)[1].

According to Keynes' perspective it can be difficult to give a probabilistic risk assessment of deeply uncertain events that we have (almost) never even considered. It is exactly in these cases that we speak of uncertainty. In the following paragraph we will clarify the reasons why we believe that fragility adheres more to notions related to forms of uncertainty rather than to risk.

3. Notion of fragility and similar concepts

In this section, we will try to better explain the notion of fragility and show how it differs from similar notions. In a broad sense, by *fragility* we refer to the quality of an object or system (but metaphorically also of a person, a social group, a territory, etc.) to be easily 'broken' (from the Latin *frangĕre* = to break) even by a minor, ordinary, or non-violent force. Fragility may in fact increase or decrease over time, and can even appear in the absence of disruptive events or interventions, due to the gradual effect of passing time or to the mere exposure to environmental agents. Strictly speaking, however, fragility is an *intrinsic characteristic associated with a specific fracture modality (whether short, sudden, or abrupt) that is independent from the specific type of shock*[2].

Interestingly enough, something fragile is not necessarily vulnerable if it is protected from certain external events or agents able to potentially trigger or accelerate its breaking process. In fact, when we talk about the *vulnerability* of an object or system, we refer to the condition of insufficiency or inadequacy of its protective means with respect to a specific potential danger. Vulnerability therefore involves those characteristics that influence the ability to anticipate, cope with and oppose a hazardous event (Wiesner, 2016; Coburn *et al.*, 1991; Eriksson, 2012). In this sense, vulnerability is an 'adaptive' kind of notion, since it concerns the possible adaptation of an object or system to certain threats (tab. 1). Such concept regards a *condition prior to a specific shock*; thus, it can also refer to individuals and objects as well as to communities, systems, organizations and territories.

Resilience, on the other hand, can be defined as the ability to absorb or withstand the traumatic effects of a shock and to regroup, reactivate and, in the best cases, return to the state prior to the adverse event (Resilience Alliance, 2010). In fact, the notion of resilience also has a genuinely adaptive nature, being a *capacity that can be recognised and measured after a specific shock*. Similar to vulnerability, it can refer to both individual entities and complex communities and systems.

It should also be noted that what is fragile does not necessarily have little resistance if it can withstand large 'loads' or stresses. By *resistance*, in fact, we mean the ability of an object or system to withstand large and/or repeated efforts before its rupture occurs. This means that resistance is an *ability that can be recognised and measured during one or more specific shocks*. Unlike resilience, resistance does not include the ability to reorganize and is not an adaptive notion (Aven, 2010; Scholz *et al.*, 2012). The same applies to the notion of *robustness*, referring to the ability of opposing impactful events without suffering damage that is disproportionate to the amount of stress received.

In the study of materials (and, by way of analogy, in other areas) it is also common to distinguish plastic deformations, which indicate the permanent modification of a material following a stress, from elastic deformations, which instead disappear when the stress stops. *Ductility* is a material's ability to plastically deform before breaking, while *tenacity* is its ability to plastically absorb energy before breaking. These two last properties are thus also to be set apart from fragility, which does not imply elasto-plastic reactions but rather abides by an abrupt and rapid type of rupture.

[1] On the notion of fundamental uncertainty see also Hansson (1996) and Chiffi, Pietarinen (2017).
[2] By specific shock we mean the event that can trigger the occurrence of a potential danger (*hazard*).

Concept	Peculiarity	Adaptability
Fragility	Abrupt rupture	NO
Vulnerability	Insufficient protection (from threats)	YES
Resilience	Elastic shock absorption (recovery/reactivation)	YES
Resistance	Endurance (load or fatigue)	NO
Robustness	Proportion between stress and damage	NO
Tenacity	Plastic absorption	YES
Ductility	Plastic deformation	YES

Table 1. Related concepts and their peculiarities

4. Fragility and uncertainty

Fragility shows to be a multidimensional concept; for this reason, we have at our disposal diverse solutions in order to 'avert' fragility, some based on prevention measures (when fragility exists but is prevented from manifesting itself), others on out-and-out alternatives to it. We recognize at least four ways of averting fragility: (i) an adaptive way based on reducing *vulnerability*, that is by providing a set of protection and modification measures or mechanisms able to reduce the risk of rupture so as to avoid the very occurrence of fragility (which, as we know, often remains latent); (ii) a non-adaptive approach based on *resistance* and *robustness*, i.e. the intrinsic ability of an object or system not to be seriously damaged, thus avoiding any type of rupture; (iii) an adaptive approach based on *resilience*, as the ability of recovering from a shock without remaining permanently broken or deformed; (iv) an adaptive approach based on *tenacity* and *ductility*, i.e. the ability to have a plastic absorption or deformation prior to the inevitable rupture.
Averting fragility therefore may lead us down different paths, some of which deal with the issue of *predisposition*. Strictly speaking, predisposition precedes a shock, thus without directly affecting the adaptability of a system in the subsequent phase. From a philosophical standpoint, such predisposition (to break) can be read as a *disposition* (Borghini, Williams, 2008). Dispositions in fact represent the ability of an object or system to trigger a certain situation (i.e. its 'manifestation') as the result of a set of stimuli that are, in turn, linked to the dispositions of other objects involved in the shock; such other objects also have their own dispositions: and it is thanks to the complementary dispositions of the involved objects that mutual manifestations are produced. For example, a glass bottle – a fragile material *par excellence* – can be destroyed by the blow (i.e. an appropriate stimulus that causes shock) of a hammer (an object with a disposition to break fragile objects). Dispositions are characterised by the manifestations they produce and are thus specific to certain manifestations. As previously mentioned, the disposition to fragility has its manifestation in an abrupt and rapid rupture, reason why fragility can be seen as the disposition of an object or a system to break abruptly. However, in order for a disposition to possess any possible behaviour, it is not necessary for its manifestation to occur: a fragile object in fact expresses in itself the possibility, and above all, the typology of its own breaking. This also implies that a family of different stimuli can lead to the same type of shock. In the case of the glass bottle, we know it can break in various ways, meaning that the manifestations of the disposition to

be fragile are multiple and diverse: the bottle can break in two or three parts, but also shatter, crumble, and so on. Common dispositions (such as the disposition to fragility) for which there is a plurality of manifestations and appropriate stimuli (i.e. proper to create shock) are called *conventional dispositions*. *Canonical dispositions*, on the other hand, are characterised by an explicit and specific set of stimulus conditions and manifestations (Choi, 2008).

An example of a canonical disposition is the disposition to vulnerability. Vulnerability is usually expressed with statements such as «5% of buildings in this city would collapse following a storm with the wind at 150 km/h and an inclination of 45 degrees». In this case, both the stimulus condition (wind speed and inclination) and the manifestation (the collapse of 5% of buildings) are well specified. It is worth noting that vulnerability can be linked to the (probabilistic) notion of risk of a specific shock, following a precise and unambiguous description of the appropriate stimulus for determining it; fragility, instead, involves deeper forms of (fundamental) uncertainty. In fact, fragility is difficult to express by means of probabilistic measures since the appropriate shocks and stimuli for it are not (or cannot) always or completely be explicit. As we have seen, the existence of several stimuli and different possible manifestations of the shock also depends on the dispositions of the other objects able to cause the rupture.

Research conducted as part of the 'Excellence' project of the Department of Architecture and Urban Studies at Politecnico di Milano (DAStU) has shown that «fragility consists in the predisposition of an object or situation to radically change its state as a result of unexpected accidental events»[3]. Contrary to what happens with vulnerability, such events do not need to be specified from time to time. The concept of fragility, in fact, involves forms of uncertainty that result from the complexity of the object or system it refers to. This is why one must consider the possibility of unexpected scenarios coming to the fore, which is evident not just in the case of simple objects, but even more in complex systems such as cities, territories, or ecosystems. On the contrary, the notion of vulnerability is linked to assessing the severity of the consequences of a potential hazard in a specific and well-defined scenario.

All in all, notions such as probability, expected utility, damage and consequences assessment can be very problematic when applied to the concept of fragility. This does not mean that probabilistic risk estimates are always useless for an analysis of fragility; yet, they are clearly not the only tool available nor do they represent the most appropriate method to follow. Fragility-related issues appear to be closer to fundamental uncertainty and to have some affinities with the so-called *wicked problems* (Rittel, Webber, 1973; Hajer *et al.*, 1993), which are often dealt with in planning theories. The term 'wicked' points to complex and 'malicious' dilemmas that can only be fully expressed and understood after the formulation of their solution; in turn, a solution will be difficult to formulate due to the problem's uniqueness and the poorly-defined aspects involved. In other terms, in order to anticipate any questions arising from wicked problems, it is necessary to have knowledge of all possible solutions. And fragility-related issues – with their multifaceted structure and their way of interacting with other complex and scarcely defined systems – seem to belong even more to this family of problems.

In this section we presented 'negative' ways of reflecting upon the notion of fragility; yet, it should be pointed out that no English word can be actually used as its opposite, as Nassim Taleb recently observed. Taleb therefore proposes to introduce the term *antifragile* – both as a noun and an adjective – with a focus on the core concept of randomness and uncertainty. An antifragile object or system should be able to also relate with what is unknown. Following his definition, antifragility – unlike fragility – should be endowed with an adaptive character because it would be associated with self-organization mechanisms that go beyond the concepts of resistance, robustness and resilience, bringing the object or system to even improve its own characteristics and capabilities. According to Taleb, in sum, antifragility would ultimately provide the conceptual means to better understand the same notion of fragility (Taleb, 2012).

5. Conclusion

Fragility expresses a broad and articulated concept that cannot be fully captured with the existing tools of risk analysis. Such difficulty stems from the complex nature of the concept of fragility, which shows relevant

[3] The presentation of the Excellence project is online at http://www.eccellenza.dastu.polimi.it/. The text about 'territorial fragility' has been partially extrapolated from an early version of the article by F. Infussi, in this issue (pp. XX-XX).

affinities with issues and methods of fundamental uncertainty. We started out by demonstrating how the peculiar characteristics of fragility differ from those belonging to related notions. In particular, we showed how fragility should not be confused with vulnerability for at least two reasons: vulnerability is a notion that, unlike fragility, can be understood (in line of principle) entirely by means of risk analysis tools; and secondly, although both fragility and vulnerability can be regarded as dispositions, they belong to two different types. Fragility is in fact a *conventional* disposition in which the manifestations and stimuli required for rupture are not specified, whereas vulnerability is a *canonical* disposition in which both the manifestation and the stimuli must be well-specified and calculated. And, even though it would be perfectly possible to investigate the conventional disposition to fragility through the canonical disposition of vulnerability in a specific scenario, the result would be a highly simplified, incomplete and contextual notion of fragility.

In future contributions, we intend to extend the research scope of fragility and to develop both theoretical and empirical type of activities with a precise and circumstantiated look at different forms of fragility about territories. We will outline how the notion of fragility when applied in a specific field may diverge from its general meaning assuming metaphorical connotations calling for a pragmatist invitation to act and promote targeted policies.

Acknowledgments
Our research on these issues is supported by the Excellence Project *Fragilità Territoriali* (2018-2022; L. 232/2016) of the Department of Architecture and Urban Studies (DAStU) at Politecnico di Milano. We are especially grateful to all the colleagues at DAStU who, during informal meetings as well as in seminars organised within the Project, have enriched this first research phase by providing seminal suggestions and observations on the notion of fragility.

References

Aven T., 2010, «On some recent definitions and analysis frameworks for risk, vulnerability, and resilience». *Risk Analysis*, 31(4): 515-522. Doi: 10.1111/j.1539-6924.2010.01528.x

Borghini A., Williams N., 2008, «A dispositional theory of possibility». *Dialectica*, 62: 21-41. Doi: 10.1111/j.1746-8361.2007.01130.x

Carrara M., Chiffi D., De Florio C., Pietarinen A.-V., 2019, «We don't know we don't know: asserting ignorance». *Synthese*: 1-16. Doi: 10.1007/s11229-019-02300-y

Chiffi D., Pietarinen A.-V., 2017, «Fundamental uncertainty and values». *Philosophia*, 45(3): 1027-1037. Doi: 10.1007/s11406-017-9865-5

Choi S., 2008, «Dispositional properties and counterfactual conditionals». *Mind*, 117(468): 795-841. Doi: 10.1093/mind/fzn054

Coburn A.W., Spence R.J., Pomonis A., 1991, «Vulnerability and risk assessment», In: UNDP/UNDRO Training Module. UNDP/UNDRO Disaster Management Training Programme.

Eriksson J., Juhl A.K., 2012, eds., *Guide to risk and vulnerability analyses*, Swedish Civil Contingencies Agency (MSB).

Hajer M.A., Hoppe R., Jennings B., 1993, *The argumentative turn in policy analysis and planning*. Durham, NC: Duke University Press.

Hansson S.O., 1996, «Decision making under great uncertainty». *Philosophy of the Social Sciences*, 26(3): 369-386. Doi: 10.1177/004839319602600304

Hansson S.O., 2018, «Risk». In: Zalta E.N. (ed.), *Stanford Encyclopedia of Philosophy*. Online: https://plato.stanford.edu/entries/risk/ (ultimo accesso: 2020/01/26).

Keynes J.M., 1973, «The general theory and after. Part II. Defence and development». In: Johnson E., and Moggridge D. (eds.), *The Collected Writings of John Maynard Keynes*, vol. XIV, London: Macmillan, pp. 213-214.

Resilience Alliance, 2010, *Assessing resilience in social-ecological systems: Workbook for practitioners*. Online: http://www.resalliance.org/3871.php (ultimo accesso: 2020/01/26).

Rittel H.W., Webber M.M., 1973, «Dilemmas in a general theory of planning». *Policy Sciences*, 4(2), pp. 155-169. Doi: 10.1007/bf01405730

Roeser S., Hillerbrand R., Sandin P., Peterson M., 2012, (eds.), *Handbook of risk theory: Epistemology, decision theory, ethics, and social implications of risk,* Cham: Springer Science & Business Media.

Royal Society, 1983, *Risk assessment: report of a Royal Society study group*. London: Royal Society.

Scholz R.W., Blumer Y.B., Brand F.S., 2012, «Risk, vulnerability, robustness, and resilience from a decision-theoretic perspective». *Journal of Risk Research*, 15(3): 313-330. Doi: 10.1080/13669877.2011.634522

Taleb N.N., 2012, *Antifragile: How to live in a world that we do not understand*. London: Allen Lane.

UNISDR - United Nations Office for Desaster Risk Reduction, 2015, *UNISDR Annual Report 2015*: *2014-15 Biennium Work Programme Final* Report, Geneva. Online: https://www.unisdr.org/files/48588_unisdrannualreport2015evs.pdf (ultimo accesso: 2020/01/26).

Wiesner B., 2016, «Vulnerability as concept, model, metric, and tool». In: *Oxford Research Encyclopedia of Natural Hazard Science*. Oxford: Oxford University Press, pp. 1-52.