Towards a Framework for Antifragile Organizations

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***Abstract*—Organizations operate in a socio-economic context, and alignment with this context is key for business success. The rate of change and impact of these changes on the operating model of the organization appears to be increasing. Major trends are the aftermath of the financial crisis of 2008, the "VUCA" aspects (volatility, uncertainty, complexity, ambiguity), and the COVID-19 pandemic. The challenge for organizations is to become resilient or even antifragile to survive (unexpected) external stressors.**

Antifragility refers to a class of systems that do not *deteriorate* (fragile) or withstand (robust) stressors, but actually *improve* as a result of stressors. Our objective is to design a framework that will help organizations achieve antifragile properties. We dub this framework *the Extended Antifragile Attribute List* (EAAL).

The EAAL is based on an extensive survey of available literature, and is validated with experts and leaders of various organizations. Considering the current economic and social impact on organizations and people of COVID-19, the EAAL is a relevant as well a timely framework, which is setting the scene of the domain of Antifragility that turned out to be extensive and holistic.

We suspect that the EAAL framework might also be applied to generic system design including technology infrastructure and software systems. This exploration is part of future research.

I. Introduction

The goal of organizations, operating in a socio-economic context, is to remain significant for its stakeholders. Stakeholders are owners, employees and consumers [1]. In order to do so, the organization has to stay aligned with its environment. As such, there is a constant 'dance' in which the organization adapts to changing conditions in the market place, and at the same time also influences this environment - all in the name of avoiding *strategic drift* (see e.g. [2]).

It is often said that the rate at which organizations have to change increases rapidly and that therefore we live in uncertain times [3] characterized by high volatility, uncertainty, complexity, and ambiguity (*VUCA*) [3]–[6]. For example, Anthony et al. state that "We're entering a period of heightened volatility for leading companies across a range of industries, with the next ten years shaping up to be the most potentially turbulent in modern history" [7]. We use the term *stressor* to denote an event in the environment of the organization that increases the need to adapt/ re-align in organizations. Typical stressors that organizations are facing are the COVID-19 pandemic, ever changing customer demands, and the effects of digital transformation (e.g. [8]–[10]).

In order to stay relevant/ stay aligned with its environment, it was long thought that organizations should strive to be *robust* with respect to external stressors. A more recent insight is that *robustness* is the middle ground between *fragility* (the organization deteriorates as a result of stressors) and *antifragility* (the organization improves as a result of stressors) [11], [12]. Therefore, a more ambitious goal is to become antifragile.

This brings us to the articulation of the objective for organizations that we hope to tackle in this paper: organizations have to find a way to stay relevant in the current VUCA world and be able to survive disruptive black swan stressors events. Our hypothesis is that this can be achieved if the organization has *antifragile* properties. This hypothesis is supported by literature from the field of risk management, complexity theory/ complex adaptive systems as well as enterprise governance (e.g. [3], [9], [12]–[16]).

This leads to the following research question: *What attributes make an organization antifragile?*

The main contribution of this study is that we provide insight in the characteristics of resilient and antifragile organizations. For scientists, our framework extends theories of organizational design. For practitioners, the framework provides attributes which are useful in designing organizations or parts of it.

To answer the research question, we will first frame our research in more detail by clarifying key terms and our way of looking at organizations (Section II). In Section III, we then present our research methodology which roughly follows the lines of *design science* and relies on literature reviews, and interviews with experts and practitioners as input for the design of our framework. In the remainder of the article, we present our results (Section IV) and conclusions (Section V), including a critical discussion of the results and future research.

The main result of our research is the EAAL Framework, which is validated by experts and practitioners. The EAAL framework is a synthesis of the attributes found in the selected literature, and is constructed from the concepts found in that same literature.

II. Framing our research

In this section, we will clarify how we frame our research. We start by clarifying the motivation for the term *organiza-*

tion (compared to similar terms such as *enterprise* that are sometimes used). We will also motivate why we consider organizations through the lens of *systems theory*, similar to the work by Morgan [17], while recognizing that there are different schools of thought in this area (see e.g. [18]–[20]).

A. Organization

The first concept that we will consider is *organization*. Myriad definitions exist – some colloquial, others more formal (e.g. from the realm of organization theory). In our view, there are two key aspects that should be considered:

- The first interpretation of the term *organization* is: that which results from the act of organizing. To clarify: suppose we have a collection of Lego bricks. These can be organized in different ways: by randomly tossing them on the table top or, for example, by neatly sorting them by size and color. The fact that our subjective assessment may be that the former process leads to something that is rather 'disorganized' is besides the point here. The same is true for the way people 'get organized': there are different methods for organizing people, processes, data, and other resources to achieve a certain objective.
- The second interpretation of the term *organization* refers to organization*s* (plural), recognizing them as a legal entity (see e.g. the introductory chapters of [16]). In the Dutch language, the category of *Person* (Dutch: *Persoon*) is specialized in two subcategories: *Natural person* (*Natuurlijk persoon*) and *Legal person* (*Rechtspersoon*). This further emphasizes the fact that organizations-as-legal-entities can be studied as independent entities.

Note that organizations in this second interpretation are the result of the act or organizing, i.e. the first interpretation. In [16], the leading term is *enterprise*, which is defined as "Entities of purposeful human endeavor". It is also stated that:

> In the case of enterprises, the sensible opposite of doing nothing and the inevitable development of disorder is organizing: the harmonious ordering and arrangement of activities and means in view of the enterprise' purpose(s). (ibid)

We concur with this view. Yet, making a formal distinction between *enterprise* and *organization* makes this paper needlessly complex. We will only use the term *Organization* to signify organizations as a legal entity which is 'organized' to achieve goals of its associated stakeholders. Our point of view is that organizations do not 'have' goals but stakeholders involved in the organization do. More formally, when it is stated that the 'organization x has goal y' then our interpretation is: stakeholders with regard to organization x agree (to some extent, at least) on the goal y.

B. System

The term *system* is notoriously difficult to define. A full review of the literature on systems theory is beyond the scope of this article. We base our discussion here on [18]–[22]. In order to limit the scope of our discussion here further, i.e. to avoid giving a full overview of systems theory, we pose that we are mainly interested in using systems theory as a lens on/ to study organizations – as defined in the previous section. As such, we are not claiming that organizations *are* a system, merely that considering them through this lens provides useful insights in light of our research goal: when looking through this lense we can identify (systemic) properties of organizations as systems, and study whether these properties contribute to the fragility/ robustness/ antifragility of the organization.

In Ashby's view, a *system* is considered to have a clear boundary, and transforms inputs to outputs [21]. One of the key results of Ashby's work is the idea that systems are considered as a *black box* and correlate inputs with outputs without understanding the inner construction/ functioning of the system that is studied. This perspective is too limited for our purposes.

In the FRISCO framework [22], a system is defined as

> A system is a special model, whereby all the things contained in that model (all the system components) are transitively coherent, i.e. all of them are directly or indirectly related to each other from a coherent whole. A system is conceived as having assigned to it, as a whole, a specific characterization (the so-called "systemic properties").

whereas a model is defined to be "A model is a purposely abstracted, clear, precise, and unambiguous conception." In other words, a system is considered to be a mental construct and it is at least suggested that a system consists of interconnected *parts*. This fits well with our notion of organizing parts into a whole.

The authors of the FRISCO framework remark that (ibid) "The decision where to draw the boundary of the system depends on the system viewer", which further reinforces the subjective nature of what constitutes a system. We also subscribe to this view. Particularly when systems become more complex, it is harder to precisely and objectively determine its boundaries when more than one stakeholder is involved. In this light, it is useful to consider the work by Boulding (See a discussion about [23] in [19]) describing a hierarchy for considering systems on different levels: (1) static structures and frameworks, (2) clockworks, (3) closed-loop control mechanisms, (4) open systems with structural self-maintenance, (5) lower organisms with functional parts and blueprint growth, (6) animals with a brain to guide behavior, capable of learning, (7) people with self-consciousness, (8) socio-cultural systems with roles, communication, and the transmission of values, and (9) transcendental systems, the home of the 'inescapable unknowables'.

From this, we learn that *organizations* have a high level of complexity; they are high-up in the hierarchy. This aligns with the study by Morgan [17] who presents different *images* on *organization* as systems (e.g. the organization as a clockwork/ mechanism, as an organism, etc.).

C. Complexity

One aspect that underlies the above mentioned hierarchy of Boulding is the fact that higher levels are more *complex* than lower levels. This begs the question: what is meant by this complexity? In our view, the Cynefin framework by Snowden provides a useful perspective [24]–[27]. This framework is a *sense-making framework*, means that it offers guidance on how to respond in certain situations based on the subjective assessment of the nature of a specific situation by an actor/ decision maker. Cynefin distinguishes the following modes:

- In the *simple domain*, causal effects between variables are apparent, so the proper response is to recognize the situation and act according to the best practice at hand.
- In the *complicated domain*, causal effects are *knowable*: it may take a lot of time and effort but through analysis they can be found. The proper response is to analyze the situation and then act according to the findings of the analysis.
- In the *complex domain*, causal effects are too complex for analysis and can only be determined in hindsight. The response mode is: hypothesize what might work, act according to the hypothesis and study the effect of the intervention. If the effect is desirable, the hypothesis was correct. If not, then the effects should be dampened by corrective action.
- The *chaotic domain* is an unordered domain with no constraints, and apparently random/ unpredictable, threatening behavior. It is often seen as the area where immediate action is required in order to return from utter chaos (and potentially threatening situations) to one of the other domains.
- The *disorder domain* is the 'catchall' domain, representing situations where an actor/decision maker has not yet come to a conclusion in which of the 'other' domains s/he is.

Here, we are not making any claims about the level of complexity of organizations - even though the Boulding hierarchy suggests that *organizations* as defined in this article are likely to be in the complex domain. In our view, the level of complexity depends on how much is known about a given domain and the perspective may be perceived differently from one person to the next, and it may shift over time: what was considered to be *complex* in the early days of the industrial age, is likely to be *complicated* or perhaps even *simple* with our current understanding of organizations and society. In light of our objective to understand the antifragility of organizations, this means that we have to take into account how much stakeholders (can) know about the organizations that we are studying.

D. (Anti)fragile, variety, and the learning organization

The term *stressor* is used for an event from outside the system that causes stress in the system. For this study we use the following definition of a stressor: "When systems are performing effectively, they are in a predetermined condition and conversely when they are not functioning correctly, they are in an unintended state. An unintended condition can be known or unknown. Stressors are forces that threaten to transfer a system from an intended to an unintended condition" [28], [29]. Three relevant theories for dealing with stressors are the notion of (anti)fragile, variety, and the learning organization.

1) (Anti)fragile: Fragile is the concept of losing value from exposure to stressors. Antifragile is the antithesis of fragile: it is the concept of gaining value from exposure to stressors. The concept of stressors having no effect on the value is called robust [12]. Fragile, robust and antifragile form together a triad [12], [30]–[33]. Figure 1 illustrates the differences in the way the three main categories deal with stress.

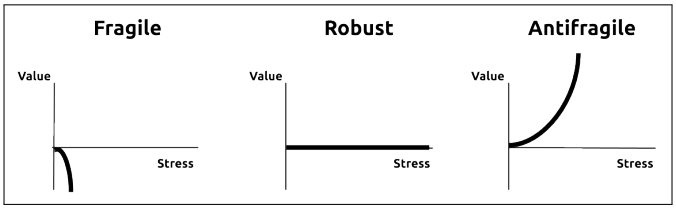

Fig. 1. Triad of fragile, robust and antifragile

Resilience is a concept that is often mentioned related to (anti)fragile. Resilience is the ability to recover from or adjust easily to misfortune or change [13].

Figure 2 illustrates the generic concept of resilience.

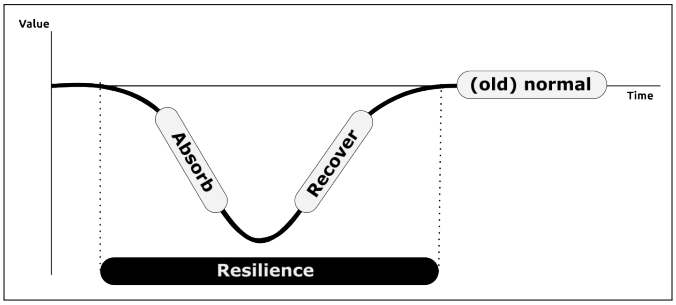

Fig. 2. Generic concept of resilience

Resilience falls into three subtypes: (1) engineering resilience, (2) systems resilience, and (3) complex adaptive systems (CAS) resilience, as identified by [13], [14]. The goal of engineering resilience is to prevent disruption and changes and to bounce back to the fixed function/basis [13], [14], [34]. Engineering resilience can be measured by the following three characteristics: resistance, elasticity and stability [13]. The function and construction of the system stay the same over time. In case of systems resilience, the system has the capacity to absorb disturbance and reorganize while undergoing changes. While doing this, the system retains essentially the same function, structure, identity, and feedback, where 'essential' is defined as "something functional and not identical" [13], [35]. In this situation, the system is able to withstand the impact of any interruption and recuperate while resuming its operations [36], the function of the system stays the same over

time, and the construction of the system may change. With CAS resilience, the system is able to become more resilient and to generate new system relationships by reorganization [13], [14]. In this case, the function is maintained, but system structure may change [13]. This results in the system to being as dynamic as the world around them, thus a system that is constantly evolving [14]. The function of the system may change over time, and the construction of the system may change over time.

Figure 3 illustrates the differences in the way the three subtypes of resilience deal with stress.

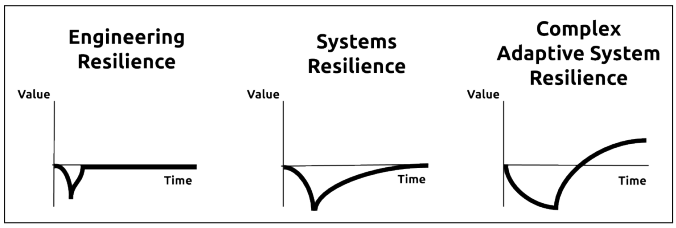

Fig. 3. Three subtypes of resilience by Martin-Breen 2011

2) Variety: A different way to study complex adaptive systems is via the concept of variety. Based on the work of Ashby and Beer there are two types of variety manipulations: (1) to attenuate variety and (2) to amplify variety [21], [37]. To attenuate variety is reducing the variety in a system. The absorption of change in the context of systems reduces variety. To amplify variety is increasing the variety in a system. To amplify internal variety is about increasing the chance of a higher entropy and therefore being more capable to absorb increasing external variety caused by change. Emergence leads to variety amplification. Engineering and systems resilience are considered to result from attenuating variety. CAS resilience and antifragile are considered to result from amplifying variety.

3) Learning organization: A final way to deal with stressors is to adapt concepts from the learning organization as described by Senge [38] and Garvin [39]. The learning organization is a way to create resilient organizations which let them cope with unknown and unpredictable events. "Continuous improvement requires commitment to learning." [39].

Garvin provides an actionable approach to creating the learning organization where Senge provides an holistic view on which disciplines are needed to create a learning organization. Therefore we select Senge to provide a framework to capture the attributes relevant in creating a learning organization.

Senge identifies five disciplines that together form the learning organization: (1) Personal mastery, which is a discipline of continually clarifying and deepening our personal vision, of focusing our energies, of developing patience, and of seeing reality objectively, (2) Shared mental models. Mental models are deeply ingrained assumptions, generalizations, or even pictures of images that influence how we understand the world and how we take action, (3) Building shared vision, which is a practice of unearthing shared pictures of the future that foster genuine commitment and enrollment rather than compliance, (4) Team learning, that starts with 'dialogue', the capacity of members of a team to suspend assumptions and enter into genuine 'thinking together', and (5) Systems thinking. This is the fifth discipline that integrates the other four. Systems thinking needs the disciplines of building shared vision, mental models, team learning, and personal mastery to realize its potential.

Building shared vision fosters a commitment to the long term. Mental models focus on the openness needed to unearth shortcomings in our present ways of seeing the world. Team learning develops the skills of groups of people to look for the larger picture beyond individual perspectives, and personal mastery fosters the personal motivation to continually learn how our actions affect our world [38].

III. Methodology

In order to answer our research question, we need two things: first, we need to understand which characteristics influence the antifragility of organizations, when studied through the lens of organizations as complex systems. Then, we need to arrange these characteristics in a structured framework.

The key input for these two steps is a survey of the available literature that is validated by experts and professionals. This leads to a research approach with the following steps:

1) Search and select literature (search + snowball).
2) Categorize and summarize the literature.
3) Select most relevant literature.
4) Identify system attributes described in the relevant literature.
5) Create a framework to categorize system attributes and use this to design a sorting algorithm (decision tree) to apply to the selected attributes.
6) Sort the identified system attributes by applying the decision tree.
7) Validate the results so far with experts and professionals.
8) Design the final framework by mapping the sorted attributes back on the framework that was designed in step 5.
9) Validate the final framework with experts and professionals.

Section III-A describes the characteristics of our literature survey in more detail. Section III-B explains how we used triangulation to safeguard the quality of our results. The combination of research methods applied in this research can best be described as a post-positivist exploratory qualitative naturalistic field-study research [15], [40]–[45].

A. Characteristics of validated literature survey

The literature review is used to identify system attributes, and also to design the framework in which these attributes are ordered.

An initial scan of the available literature on antifragility suggests that the body of *scientific* literature (i.e. peer-reviewed) is relatively small, and that there are few case reports that describe how lessons learned have been applied in practice.

Similarly, the 'practical' body of knowledge on antifragility is relatively small which is unsurprising for such a novel topic. This impacts our methodology in the sense that a critical literature survey will likely yield few results. For other (related) topics (e.g. systems theory, complexity theory), the body of research is more mature. To counter the risks of an unbalanced critical literature survey, we have adopted an approach that is exploratory in nature: we focus on the *knowledge question* of which attributes impact the antifragility of the organization, rather than the *design question* of how such attributes can be impacted through interventions [42], [46].

In order to validate the results of the literature, reviews are conducted with both experts and practitioners. The objective of this validation is to evaluate and improve the outcome of the literature survey [47]. Since the topic of complexity theory and complex adaptive systems is mostly unknown to the various experts and c-level managers, the naturalistic research approach is the most logical research method for the validation of the EAAL model. Naturalistic research is described as: "The researcher seeks to make the research experience as much a part of the subjects' everyday environment as possible" [44], and as "A research method to be set in a natural setting in an attempt to explain or interpret a certain phenomenon" [15], [45].

B. Triangulation

The combination of literature review, expert review, and practitioners review is a form of triangulation. Triangulation is defined as the use of multiple methods mainly qualitative and quantitative methods in studying the same phenomenon [48], [49]. Triangulation, as in shown in figure 4, is applied for the validation of the created framework, consisting of the list of attributes found in the literature survey [48], [49].

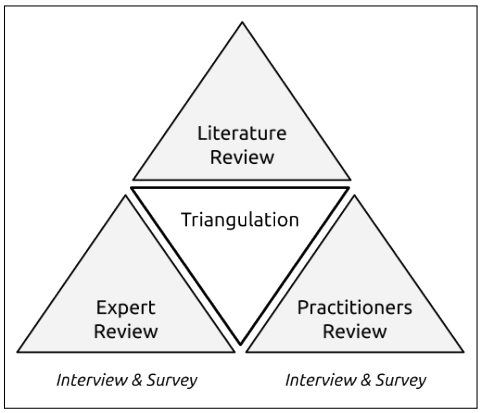

Fig. 4. Main research methods [50].

IV. Results

A. Step 1: search and select literature

The search for literature starts with the following three types of sources. The literature list in these sources functioned as the start of the snowballs [51], [52]. As primary sources we use the references from the book Antifragile by Taleb [12] and the references from the Wikipedia pages on 'Antifragile' and 'Antifragility'. For the secondary sources, several academic search engines are used, namely: (1) Google Scholar, (2) Bing Academic, (3) Semantic Scholar, (4) ReseachGate, (5) Citationsy, and the (6) Library of Antwerp Management School. These are further extended by additional searches in: (7) Amazon.de, (8) Goodreads, (9) Google Books, (10) Diva (Sweden), (11) Scripties Online (the Netherlands), (12) Narcis (the Netherlands), (13) OpenThesis.org (USA), and (14) OATD (Global).

The following keywords initially where used for the search queries: *antifragile*, *anti-fragile*, *antifragility*, *anti-fragility*, *Taleb*, *Nassim Taleb*, *antifragile organisations*, *antifragile organizations*, *anti-fragile organisations*, *anti-fragile organizations*. The literature search was conducted between October 2018 and June 2019. This step resulted in 358 sources[1], of which in total 87 sources[2] where categorized in the following research steps.

B. Step 2: categorization and summarize the literature

The 87 sources are labeled according to one or more of the following six categories: (1) *Antifragile*, (2) *Antifragile & IT*, (3) *Organization*, (4) *Risk and Resilience*, (5) *Complexity Science*, and (6) *Science*. These categories emerged during the creative process of labeling and were validated with experts and practitioners in the triangulation as described in Section III-B.

C. Step 3: select relevant literature

A first reading of the 87 categorized sources suggested that several sources were not as relevant as initially hoped and expected. To narrow down the set, we used a filter with the following criteria: *must contain listings of attributes that are linked to antifragile behavior, comprehensiveness, and relevance* . This narrowed the list of sources to nine: [33], [53], [31], [54], [15], [14], [30], [32], [55].

D. Step 4: select system attributes

The following attributes where provided in the individual sources.

- Ghasemi and Alizadeh [33]: Absorption, Redundancy, Introduction of low level stress, Eliminating stress, Non-monotonicity, Requisite variety, Emergence, Uncoupling.
- Johnson and Gheorghe [53]: Entropy, Emergence, Efficiency vs. risk, Balancing constraints vs. freedom, Coupling (loose/tight), Requisite variety, Stress starvation, Redundancy, Non-monotonicity, Absorption.
- Kennon et al. [31]: Emergence, Efficiency and risk, Requisite variety, Stress starvation, Redundancy, Absorption, Induced small stressors, Non-monotonicity.

[1]https://gitlab.com/edzob/antifragile-research/-/wikis/EAAL-literature-thesis

[2]https://gitlab.com/edzob/antifragile-research/-/wikis/EAAL-literature-selection

- Markey-Towler [54]: High in openness, High in conscientiousness, Fair degree of extraversion, Moderate degree of agreeableness, Low in neuroticism.
- Henriksson et al. [15]: Strategy - Design versus emergence, Strategy - Seneca's barbell strategy, Opportunities - networks, Opportunities - innovation, Opportunities - resources, Motivation - mind-set, Motivation - employee motivation, Motivation - communication
- Kastner [14]: Self-organization, Ownership (result based system /'skin in the game'), Diversity of cells and organizational learning, DNA-shared purpose, values and culture.
- Gorgeon [30]: Simplicity, Skin in the game, Reduce naive interventions, Optionality, Inject randomness into the system, Decentralize / develop layered systems.
- Hole [32]: Modularity, Weak links, Redundancy, Diversity, Fail fast, Systemic failure without failed modules, The need for models.
- O'Reilly [55]: Modularity, Weak links, Redundancy, Diversity.

E. Step 5: create sorting algorithm for organizations

In order to transform the list of attributes into a framework, we needed to develop a sorting algorithm that helps us to determine which categories we should use, and which attributes belong in a specific category. The sorting algorithm was developed in several iterations, and is based on a second study of the available literature. As before, we used triangulation to validate the sorting algorithm as discussed in Section III-B.

Figure 5 comprises the framework that we we designed to categorize system attributes, which is mainly based on the discussion of (anti)fragile, variety, and the learning organization in Section II-D.

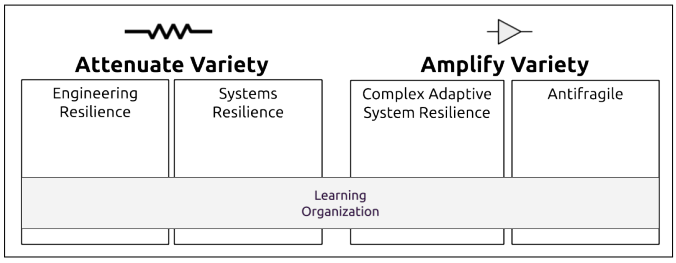

Fig. 5. Framework to categorize system attributes

Using this framework, we ended up with the decision tree that is visualized in Figure 6.

F. Step 6: sort the identified system attributes

While we initially hoped that classifying the attributes with our decision tree would be an almost mechanical process, this turned out to be not feasible. The overall context of the description of the attribute in the selected works and expert judgment were needed to come to a sort. Therefore, we ended up following a creative process in the sorting of the attributes. The following examples are illustrative for this process:

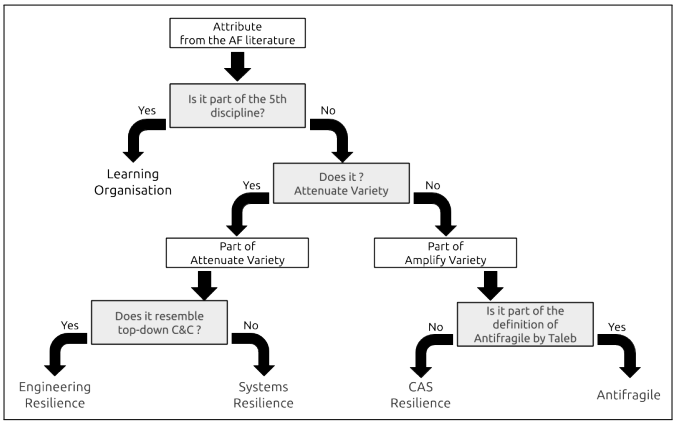

Fig. 6. Decision tree to order the attributes.

- Redundancy was identified in [31]–[33], [53], [55]. It does not describe an aspect of the learning organization and its main goal is to maintain the function of a system when a sub-system fails. This attenuates the variety. The use of sub-systems to maintain the functionality is described by Martin-Breen [13] as attribute of Systems Resilience.
- Another example is Efficiency vs. risk as discussed in [53]. This attribute does not fit the learning organization. Efficiency does attenuate variety and is described similar to engineering resilience by Martin-Breen [13], and risk is described in line with freedom of employees and fits more Martin-Breen's description of CAS Resilience than Taleb's description of Seneca's barbell.

The result of this step is the EAAL framework that will be explained later in this Section.

G. Step 7: reviews

1) Expert review: The EAAL framework was validated by 18 experts. Validation took place in one-by-one sessions (10 persons) and in two group sessions (10 and 3 persons). There was a small overlap designed in this setup.

The experts where very diverse. The expertise topic of the experts are 'at least' one of the following list: antifragility, enterprise architecture, enterprise engineering, organization design, organization change.

The two questions asked to the experts were: (1) Does it make sense what I am telling you?, and (2) Do you see any big mistakes, blind spots or contrary statements?.

The one-by-one sessions were semi-structured interviews with a duration of 30 minutes to 90 minutes per interview. The group sessions were in the form of a presentation concluded with an open discussion. The duration of these sessions was 120 minutes.

2) Practitioners review: To review the applicability and relevance of the EAAL framework, seven C-level managers (CFO, CIO, CTO, COO) of seven different organizations where interviewed. Table I contains the demographics of the

interviewees. The method applied was that of semi-structured interviews with a maximum duration of one hour.

The questions asked were: (1) Do you see or do you hear something that is not right?, (2) Do you see or do you hear anything that sounds too far-fetched and only theory based?, and (3) Does what I tell you resonate with you, and can you apply this in your work?

TABLE I
DEMOGRAPHICS PRACTITIONERS

Role	Type of organization	FTE
CIO	Aviation company	70.000 - 90.000
CIO	Aviation company	1.000 - 5.000
CIO	Governmental organization	10 - 200
COO	Non-profit organization	10 - 200
CIO	University	200 - 400
CFO	University	1.000 - 5.000
CTO	Retail	200 - 400

H. Step 8: EAAL framework

The EAAL framework is the result of synthesizing all previous results as discussed in this article. In essense, this meant that we had to plot the attributes that resulted from step 5 back on the main framework that was presented in Figure 5. Figure 7 shows the result of this analysis, and contains the EAAL framework. Table II defines the different attributes of the EAAL framework.

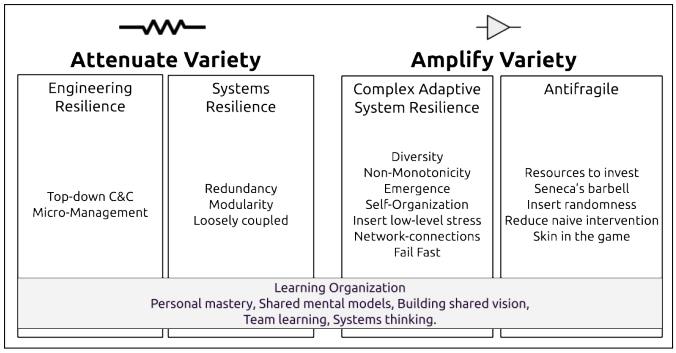

Fig. 7. EAAL Framework

I. Step 9: reviews

1) Expert review: The overall feedback from the one-on-one expert reviews was that the EAAL model sparked inspiration and was relevant to their individual expertise. The main feedback that resulted into (re)designing the EAAL model where the following feedback points: (1) All the aspects of a learning organization as described by Senge (1990) are always relevant [38], (2) It is impossible to find out based on observation why something is working. In this case, the expert was referring to the function and construction dilemma and to the issue of determining causal relations based on observation.

The overall feedback from the group validations was also that the EAAL model sparked inspiration and is relevant for the future. The group of 10 experts also provided feedback that the topic was pretty complex and would need examples on how to apply this in their day-to-day work.

Based on the feedback of the experts, the main adjustment in the EAAL model was that we positioned the learning organization across “attenuate variety and amplify variety”. In the first version of the EAAL model, the learning organization was positioned only across ”amplify variety”.

2) Practitioner review: The overall feedback from the practitioners was that the EAAL model sparked inspiration but it can not be used in the boardroom in this form. Instead, the EAAL model should be used in the department that advises the board during the analysis and design process. Based on the EAAL model, ‘smart’ questions can be created and asked in the boardroom.

Highlights of the feedback of the interviews are:

- “For the first time I see a holistic overview of the field of antifragility, resilience and agile”.
- “This is a powerful tool to think about the future design of the company”.
- “This does not resonate with me. I do not understand what you are trying to tell me”.
- “This all sounds very logical and clear to me. Great to have it in one image”.
- “After your talk with our CTO he is researching holacracy and the possibilities in the transformation of our organization”.

The feedback of the practitioners did not lead to adjustments of the EAAL model.

V. CONCLUSION

A. Conclusion

The literature search regarding antifragile and the subsequent expert and practitioner reviews led to the development of a framework, called Extended Antifragile Attribute List (EAAL). The objective of the EAAL is to help organizations achieve antifragile properties. The main contribution of this study is that we provide insight in the characteristics of resilient and antifragile organizations. For scientists, the EAAL extends theories of organizational design. For practitioners, the EAAL provides attributes which are useful in designing organizations or parts of it.

B. Discussion

The applicability of the EAAL needs further consideration. Looking from a traditional perspective on systems thinking towards an antifragile world leads to a non-productive discussion, because the mindset and paradigms seem to be completely opposites.

Although antifragile – and her thesis of making organizations stronger by absorption of external impacts – has advantages, we do not take the position that antifragile is the solution and replaces current methodologies for strategic management, governance and enterprise architecture.

EAAL, considering the current economic and social impact on organizations and people of the COVID-19 pandemic, is

a relevant as well a timely framework which offers a new perspective, next to traditional systems thinking and systems design [17]–[20].

We state the EAAL to be a promising framework providing a holistic view of the domain of antifragile. From this (holistic) perspective, the attributes grouped per behavior type of the organization, provided by the EAAL, can be utilized as a sharping tool during the (re-)design of strategy, governance, and enterprise architecture addressing the resilient and/ or antifragile behavior of the organization.

The EAAL turns out to be more extensive than the narrow focus of a book review starting with Taleb's [12].

C. Limitations

The selected literature for the synthesis into the EAAL, is mostly based on deduction, reasoning, and synthesis. The EAAL is validated through this lens. The EAAL and the underlying literature is not (yet) validated in its application.

D. Future research

The EAAL can be improved in rigor via replication of the literature research, and validation by an expert group. The literature research replication should apply an even more rigorous manner while including a more extensive explanation of arbitrary choices. The validation replication could be established by organizing a program of group support sessions, in which the same validation script is followed in a relay mode with c-level experts (such as CIO's or CFO's) and domain experts (such as IT domain) from different sectors (like Health Care, SME or Financial Institutions). The extended validation replication is needed to verify possible application in the generic system design field.

Another direction of further research is to focus on the humanities of complex and antifragile organizations. The statement by Markey-Towler [54] and Kastner [14] that the antifragile organization fits certain personality types better than others, leads to the following future research questions. Firstly, considering that an antifragile organization itself is a system-of-systems including less resilient sub-systems, diversity is an attribute of a CAS-resilience system and Seneca's barbell is an attribute of an antifragile system. This would result into the reasoning that a more heterogeneous representation of the various personality types in an organization is preferable over a more homogeneous. Secondly, the statement that the current view on an antifragile organization prefers a certain type of personality, raises the ethical question of the impact on the people in the organization when applying organizational change to improve resilience.

Further research is to identify and develop an antifragile mindset and tool-set based on human behavioral concepts, such as emotional maturity in agile teams. These concepts are not well represented in the domains of enterprise governance and architecture. Enterprise governance and architecture have their roots in the reductionist approach and are considered helpful in the Cynefin domains of complicated and simple/ clear.

Digital transformation, fueled by COVID-19, and the agile way of working have increased internal and external connections within and between organizations. This extra connectivity results in organizations being confronted with a complex and chaotic context. Human behavior plays a major role in countering this increased complexity [16], [19], [20], [27], [37].

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TABLE II
EAAL ATTRIBUTES

Attribute	Description	References
Top-down C&C	Top-down command and control applies when an employee does not have the freedom to decide their own action but has to follow instructions from the organizational hierarchy. The careful design of the features of an iPhone or a good pen are examples of limited freedom of movement in the product itself.	[13], [53], [15], [14], [55]
Micro-management	Micro-management entails the freedom in the use of the product. A detailed working instruction describing a business process, results in no freedom for the employee in the execution of their job. An example is a Lego building block. It is engineered and fabricated with the greatest detail resulting in a building block that is almost completely robust. Lego has a very small resilience behavior through engineering.	[13], [53], [31], [15], [33], [14]
Redundancy	Redundancy is about having not a single point of failure by making use of duplication. An example is a backup electricity generator. Another example is local government as backup system of the central government.	[13], [53], [31], [32], [33], [31], [55]
Modularity	Modularity is the degree that components may be separated and recombined, often with the benefit of flexibility. For example, a car with a standard chassis onto which different components can be connected creating a unique car.	[13], [30], [32], [55]
Loosely coupled	Loosely coupled is the degree of dependency on the exact working of another module. It is important to understand that there is always some degree of coupling. Loosely coupled is also known as 'weak links', 'uncoupling', 'loose/tight coupling', or 'a low level of interconnectedness between components'. For example, when there are new employees introduced at the finance department this should not impact the taste of the coffee at the same office.	[13], [53], [30], [32], [33], [55],
Diversity	Diversity is the ability to solve a problem in more than one way with different components. Optionality, the availability of options, is a specialisation of diversity. An example is that within a team you want diverse co-workers since other types of people come up with other types of solutions.	[13], [12], [30], [32], [15], [14], [55]
Non-monotonicity	Non-monotonicity is learning from bad experiences. Mistakes and failures can lead to new information. As new information becomes available it defeats previous thinking, which can result in new practices and approaches.	[53], [30], [31], [32], [33]
Emergence	When there is little or no traceable relation between micro and macro level output then emergence is there. This is the situation where random things (unintended states) appear more often and X-events (black swans) appear. The law or requisite variety applied in this reasoning, makes that internal emergence counters external emergence, and this subsequently leads to antifragility	[53], [31], [15], [14], [33]
Self-organization	Self-organization is a process where some form of overall order arises from local interactions between parts of an initially disordered system. For example, students sitting together in the school cafeteria.	[31], [15], [14]
Insert low-level stress	Continuous improvement is achieved by inserting low-level of stress continuously into a learning system. This will keep the system sharp all the time.	[12], [31], [30], [33]
Network-connections	A network is created by connections to other nodes. More connections increase the potential for optionality for new constructions and also new functionalities.	[53], [30], [15], [32], [14], [33], [54], [55]
Fail fast	The other combined attributes in this group enable the possibility to execute the strategy "fail fast".	[31], [30], [32], [33]
Resources to invest	Opportunities can only be seized when there are resources free to do so. Resources can be money but also time and labor. To survive, a black swan investment should be possible when required	[12], [30], [14], [15]
Seneca's barbell	To be antifragile a robust sub-system is needed to which 80-90% predictable value with low risk is situated. The remaining 10-20% should be used for high return on investment activities.	[12], [53], [31], [15]
Insert randomness	When insert-low-level stress and fail fast delivers no issues the next step is to insert randomness into the systems. A great example of this is chaos engineering by Netflix or the HackerOne bug-bounty system.	[12], [31], [30], [33]
Reduce naive intervention	Naive intervention is an intervention based on a model and reductionistic logic which ignores experience. An example is not listening to the experienced but not so articulate employee, or by ignoring the balance nature has found in an ecosystem.	[12], [30], [14]
Skin in the game	Make certain that the person making the decision and doing the work has a pain and gain relation with the outcome. This goes beyond having a feedback system in place. This goes beyond having KPI's in place. An example is that when working Agile scrum, the product owner should be a co-worker in the team for whom the solution is build.	[12], [15], [30], [14]
Personal mastery	Personal mastery is a discipline of continually clarifying and deepening our personal vision, of focusing our energies, of developing patience, and of seeing reality objectively.	[38], [30], [15], [33], [32], [54]
Shared mental models	Mental models are deeply ingrained assumptions, generalizations, or even pictures of images that influence how we understand the world and how we take action.	[38], [32]
Building shared vision	Building shared vision - a practice of unearthing shared pictures of the future that foster genuine commitment and enrollment rather than compliance.	[38], [15], [14]
Team learning	Team learning starts with 'dialogue', the capacity of members of a team to suspend assumptions and enter into genuine 'thinking together'.	[38], [53], [31], [15], [32], [30], [32], [14], [33]
Systems thinking	Systems thinking is the Fifth Discipline that integrates the other four. Systems thinking also needs the disciplines of building shared vision, mental models, team learning, and personal mastery to realize its potential.	[38], [53], [30], [31], [32], [33], [14], [54], [55]