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Crisis management as a learning system: Understanding the dynamics of adaptation and transformation in-between crises

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ABSTRACT

In a world of ever-changing threats and vulnerabilities, the actors involved in crisis management need to learn continuously in order to adapt and transform their capabilities, also in-between crisis. The crisis management actors can be regarded as a heterogeneous system-of-systems, where each sub-system, i.e., actor, has its specific role, culture, and procedures but where there exists little of any common theory-in-use. Achieving a conscious and coordinated change in such a system-of-systems represents a considerable challenge. This challenge is further underlined by the duality of the crisis management system, being a planning system in-between crises and a response system during crises. In this article, the theories of organisational learning are combined with general systems theory to develop a model for how systems learn in order to adapt and transform. Equating the system configuration with the concept of theory-in-use allows for a discussion on single-loop and double-loop learning as changes in single system elements and their relationships, and in the overall system configuration, respectively. This model is used to enhance the understanding of the dynamics of learning and change in crisis management systems. Further, the concept efficacy is proposed as the measurement of performance when assessing the crisis management system and its sub-systems.

1. Introduction

Crises are events that affect modern societies in the most fundamental ways, threatening human lives, economies, and societal values. They are characterised by extensive uncertainties and high stakes, as well as by severe constraints in the time available for analysis and response (Boin et al., 2016). Crises can be distinguished from emergencies in that they generally result in challenges that fall outside the normal frameworks of the organisations affected by, or managing, them (Boin, 2009; Borodzicz and van Haperen, 2002; Wybo, 2004). Thereby, crises are difficult to handle by using normal routines and procedures (Lagadec, 2009; OECD, 2015).

In the complex societies of today, management of large-scale crises involves a vast number of sectors, organisations, and individuals, which all have their own cultures, characteristics, roles, and objectives (Boin et al., 2016; Doyle et al., 2015; Eriksson et al., 2017). *During crises*, the agility and adaptability of these crisis management actors are crucial to accomplish an effective and efficient response (Ansell et al., 2010; Comfort, 1999).

Evolutions, as well as revolutions, in societal structures, technologies, and globally interdependent economies result in changes in threats and vulnerabilities (Boin, 2009; Eriksson et al., 2017; OECD, 2015). Research and lessons from response operations and exercises offer knowledge on these threats and vulnerabilities, as well as on how to manage future crises.

Hence, there is a need for crisis management actors to learn from this knowledge continuously in order to adapt and transform their capabilities in a coordinated manner *in-between* crises. Today, there exists no established process for this, although joint training and joint exercises have been suggested as important tools (Boin et al., 2016). Furthermore, it is not obvious how to delimitate the group of actors that need to take part in this process, nor how this group can be described. The crisis management actors are disparate organisations, with varying experience from managing crisis as well as from working together. Although some actors are active in most crisis management responses, it is impossible to predict the exact composition of actors in the next one. Finally, the heterogeneity of the actors in the crisis management system means that they differ in knowledge, and in how their knowledge directs their actions. This lack of a common *theory-in-use* (Argyris and Schön, 1996) also complicates any concerted and coherent development of the crisis

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management system.

The objective of this article is to contribute to the conceptual understanding of the dynamics for learning and change, especially in-between crises, in the heterogeneous group of crisis management actors. This is done by exploring if and how general systems theory and the theories of organisational learning can be combined. *Systems theory* offers an understanding of the traits and dynamics of a group of actors that interact, while the theories of *organisational learning* offer insights into the mechanisms of different types of learning. The following research questions are addressed:.

- What is a learning system and how can the dynamics between learning and the system change be understood? How can the crisis management capabilities be described as a system?
- How can the process for learning in order to achieve concerted system change be described in the case of a system of crisis management capabilities?

2. Background

This section discusses fundamentals of organisational learning and systems theory. In the following section, these fundamentals are used to develop a model for describing how learning and changes can be understood in a system.

2.1. Organisational learning

Organisational learning gained momentum in the 1970s. It mainly deals with questions such as *if*, *why*, and *how* organisations learn, and what obstacles and potential risks lie in such learning (Levinthal and March 1993; Schulz, 2002). Although this research has had a major impact on organisational theories, the examples of it being applied in the area of crisis management, especially as a basis for the development of a strategy for systematic and continuous development of crisis management capabilities, represent few albeit noticeable exceptions (Andersson and Eriksson, 2015; Boin et al., 2016; van Laere and Lindblom, 2019; Metallinou, 2017).

There exists no universally accepted definition of *organisational learning*. However, by combining characterisations offered by Argyris and Schön (1996) and Levitt and March (1988), while regarding learning as a process for change and development, the following definition of organisational learning is proposed:.

> *Organisational learning is the process through which an organisation evolves and transforms by acquiring knowledge in the form of understandings, know-how, techniques, and practices and encoding this new knowledge into routines that guide its behaviour.*

Organisations store knowledge in a wide variety of artefacts and forms such as documents, standards, social and physical geography, culture, organisational stories, and in the perception of *how things are done here* (Levitt and March 1988); individuals, maps (descriptions of work flows, organisational charts, etc.), memories (files, records, accounts, and physical objects such as tools), and programs (work plans, protocols, etc.) (Argyris and Schön, 1996); procedures, norms, rules, and forms (March 1991). Furthermore, the physical design of the organisation may in itself represent knowledge, as it defines how specific tasks and objectives should and could be accomplished (Argyris and Schön, 1996).

The representation of knowledge directing the actions in a specific organisation is known as the *theory-in-use* (Argyris and Schön, 1996). All individuals in an organisation have different, and incomplete, interpretations of the organisation's theory-in-use. These interpretations are not static, but adjust as conditions change. Furthermore, the organisation's theory-in-use is built on the individual interpretations. According to Argyris and Schön (1996), the conclusion is that organisational learning changes the organisation itself. March (1991) introduced the term *mutual learning* to explain the relationship between the learning of the organisation and the learning of the individuals in the organisation: As the individuals are socialised into the organisation, learning from the established theory-in-use, the organisation as a whole learns from the individuals.

Argyris and Schön (1996) introduced the concepts of single-loop and double-loop learning. Existing frameworks not delivering the results expected may trigger one of these learning processes, in both cases through an *organisational inquiry* to find new knowledge (Argyris and Schön, 1996). *Single-loop learning* means learning about imperfect strategies and procedures within the existing theory-in-use. There is a functioning theory-in-use that defines what the system should do and what it should achieve. Learning focuses on improving performance within the limitations of these values (Argyris and Schön, 1996). This may include doing the same things slightly better, increasing effectivity and efficiency, as well as slowly adapting the way things are done in order to meet changes in the environment.

Double-loop learning is more complex, as it involves changes in the underlying values of the organisation's theory-in-use (Argyris and Schön, 1996). Such changes require decisions on what the system should be and how this should be achieved. As it involves looking beyond the prevailing paradigm, double-loop learning is often a more cumbersome process (Boin et al., 2016).

An organisational inquiry can be either in the form of exploration or in the form of exploitation (Levinthal and March, 1993). *Exploration* is the pursuit of things that might come to be known. It may provide high returns, but these results are generally uncertain and possibly distant in time. Still, exploration could be necessary to ensure organisations' relevance over time. *Exploitation* is the use and development of things already known. This process is more certain to provide results than exploration, although usually with more moderate returns. These results may also be more immediate. Still, exploitation could be necessary for short-term competitiveness. There is a need to strike a balance between the resources invested in exploration and exploitation (Levinthal and March, 1993; March, 1991). Insights based on exploration as well as exploitation may contribute to both single-loop and double-loop learning.

2.2. Systems theory

Systems theory began to develop during the first half of the 20th century (von Bertalanffy, 1972). With its holistic perspective, studying the system as a whole rather than trying to understand it by analysing its parts and as an integrator of different scientific disciplines, systems theory was able to answer questions that reductionist determinism could not (von Bertalanffy, 1972; Boulding, 1956; Ingelstam, 2012). Skyttner (2005) regarded systems thinking as "a response to the failure of mechanistic thinking in the attempt to explain social and biological phenomena".

As with organisational learning, *systems theory* lacks a universally accepted definition (Adams et al., 2014). However, Boulding (1956) offered a description of systems theory as being a:.

> *[T]heoretical model-building that lies somewhere between the highly generalized constructions of pure mathematics and the specific theories of specialized disciplines.*

A system is a set of interacting elements (von Bertalanffy, 1968). A well-defined system is a meaningful and unified entity of elements, clearly delimitated from the surrounding context with which it still interacts (Skyttner, 2005). However, all systems are constructions, defined and delimited to enable observation and understanding of specific phenomena. Hence, what is defined as the system and what is defined as its context depends on the character of the phenomena that are to be studied (Ingelstam, 2012; Skyttner, 2005).

Goal seeking, or system purposefulness, regulation of the system elements, and the hierarchy of systems and sub-systems are important system properties (Skyttner, 2005). In this article, *purposefulness* is regarded as the goals, roles, and mandates that the system strives to fulfil. Furthermore, the interrelated system elements must be regulated so that the system fulfil its purpose, for instance through feedback loops that identify and correct deviations (Skyttner, 2005). Regulation can be achieved through both tangible mechanisms, such as procedures, rules and organisation, and abstract ones, such as culture. Hierarchy means that an element in a system can be studied as an indivisible object, but in many cases also as a sub-system, having its own purpose, regulations, and elements (Hallberg et al., 2018; Skyttner, 2005).

In this article, the *configuration* of a specific system is defined as its goals, roles, mandates, culture, procedures, rules, and organisation, together with the system elements and their relationships. While the system elements, regardless of whether they are single objects or sub-systems, bring a number of inherent competencies, technologies, and capacities to the system, the characteristics of their mutual relationships are defined by the culture, procedures, rules, and organisational structures of the overall system.

A specific system configuration has a specific set of system properties and system capabilities that decide its performance in a specific context at a specific moment in time, the *state of the system* (Ackoff, 1971). A system of solar panels may be able to keep one house heated during autumn, but not another, less insulated, one during winter. Furthermore, the quality of single system elements, as well as of the relationships between these elements, affect the variance in the system output. This variance is also be context dependent. If a system element malfunctions more frequently in a cold environment, the variance will increase with sinking temperatures.

If the output of a system can be measured, the current configuration's performance can be evaluated in relation to the objectives and the specific context. Skyttner (2005) discerned three measurements of system performance: effectiveness, efficiency, and efficacy. He defined them as follows:.

- Effectiveness: the extent to which a system achieves its intended transformation (i.e. achieves its objectives).
- Efficiency: the extent to which the system achieves its intended transformation with the minimum use of resources.
- Efficacy: the extent to which the system contributes to the purposes of a higher-level system of which it may be a subsystem.

Sub-standard performance can be identified in one or several of these measurements of performance. However, they are not necessarily independent of each other. If effectiveness is low, this often results in low efficacy.

A *system-of-systems* (SoS) is a system that includes elements that are themselves systems. These sub-systems have some degree of operational as well as managerial independence. Maier (1998) developed a SoS taxonomy, that includes *directed*, *collaborative* and *virtual* SoS. This taxonomy was further developed by Dahmann and Baldwin (2008), adding the *acknowledged* SoS. In the acknowledged SoS, there is a central, authoritative node and at least some generally acknowledged overall purposes, possibly provided by an outside party. However, the sub-systems are still independent in their objectives, funding, resources, etc.

3. A model for understanding how systems adapt and transform through learning

This section describes a model for understanding how socio-technical system-of-systems adapt and transform through learning. In the next section, this model is applied to crisis management.

3.1. Why systems underperform

Systems underperform for a number of reasons. Firstly, the system configuration may not be well suited to the task as it is designed for other types of tasks, misconfigured, or simply obsolete. This could be due to, for instance, irrelevant elements, inadequate mandates, or outdated technologies. A system with a less suitable configuration may still be able to handle the task, by chance or as a result of a conscious effort to create a flexible and adaptive system. The latter could be achieved through the recruitment of adaptable and capable personnel and the development of an adaptive organisational culture (Costanza et al., 2016). The resulting output would still often be of a lower quality and produced in a less efficient manner.

Secondly, even if the system is properly configured for the task, single elements or relationships may fail due to human errors, deficient equipment, or misinterpreted rules. A system that is ill-prepared may still be able to handle the task, although the resulting output would in most cases be of a lower quality and associated with an increased variance.

Hence, to be able to perform optimally at a given time and in a given context, a system must not only do the right things but also do these things right. This (upper right in Fig. 1) in turn requires that the system is both properly configured for the tasks at hand, alternatively highly adaptive, and well-prepared.

An organisation is a type of system. Ackoff (1971) defined an organisation as:.

> *a purposeful system that contains at least two purposeful elements which have a common purpose relative to which the system has a functional division of labor; its functionally distinct subsets can respond to each other's behaviour through observation or communication; and at least one subset has a system-control function.*

When an organisation fails to deliver according to expectation, this can result in an *organisational inquiry* for new knowledge (Argyris and Schön, 1996). This organisational inquiry may take the form of exploitation of things already known, exploration to find things not yet known, or a mix of the two. The aim is to identify the reasons for disappointing results and find adequate solutions, which may include single-loop as well as double-loop learning in order to achieve change.

3.2. Systems that adapt and transform

By equating the system configuration with the concept of *theory-in-use,* it becomes possible to relate the configuration of the system, as well as the quality of its elements and their relationships, to the need for

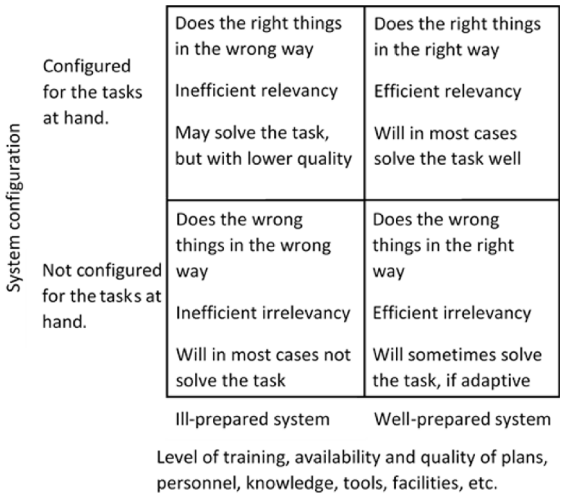

Fig. 1. Configuration and level of preparation of a system.

different types of organisational learning. This, as will be discussed in this section, facilitates the understanding of how learning can be used to adapt or transform the system.

Transforming a system from "not properly configured" to "properly configured" would represent double-loop learning, as it involves changes in the basic structures and values of the system. This is not only about changing the system; first, it must be determined what the system should change into. Such deliberations are often both intricate and associated with uncertainties as well as sensitivities. Furthermore, if the system's environment continuously changes, the learning and influx of new perspectives must reflect this or the system will stagnate and the stored organisational knowledge will become obsolete (March, 1991).

Adapting systems from "ill-prepared" to "well-prepared" represent single-loop learning as it is about improving the system within the limitations of the current *theory-in-use*. The process of adaptation could include improvements of the system preparedness (for instance, through training or maintenance), as well as improvements of specific aspects of the system configuration. The latter could be a clarification of rules or the replacement of a system element for a new one that does the same thing albeit more efficiently or in a more reliable manner.

The balance between adaptation and transformation shares some features with the previously discussed balance between exploitation and exploration (Levinthal and March, 1993). One such common feature is the choice between short- and long-term relevance. A system may need both incremental improvement, adaptation, through single-loop learning to function well in the short term, and radical transformation of the theory-in-use itself through double-loop learning in order to remain relevant in the long term. Another shared feature is the choice between either reasonably safe, but small, returns or uncertain, but potentially high, ones.

While the choice between exploitation and exploration concerns prioritisation of the resources available for identifying and creating knowledge, the choice between single- and double-loop learning concerns a much more fundamental aspect: whether or not to change the system's (organisation's) overall strategy and *raison d'être*.

Fig. 2 illustrates how this model can be used to understand the differences between adaptation through single-loop learning and transformation through double-loop learning, as well as the importance of context. The configuration of the elliptically shaped system, if it had been well-prepared (black), would be highly capable in the context that exists at a specific moment in time (A). However, if it due to, for instance, untrained personnel is ill-prepared (white) it will only reach a limited capability relative to the context. Although the system may strive to become better prepared through adaptation, for example, by training the personnel, this will not always help the situation. The system may become better prepared to handle the context at (A), but the environment may also change, leaving the system obsolete or at least less capable to handle the context at the new moment in time (B). In fact, improving the system could in itself lead to changes in the environment, for instance, in the form of a shift in expectations.

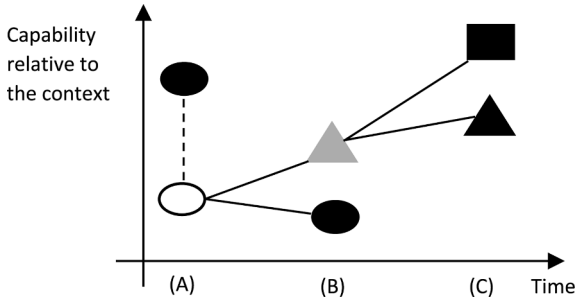

Fig. 2. The greyscale illustrates how well prepared the system is. A black system has reached the full potential of its current configuration and a white system has reached only a fraction of this potential. Grey is in-between. The different shapes represent different system configurations. The Y-axis is the capability relative to set capability aims and relative to the context at a specific moment in time (X).

Hence, the model shows that it may not be enough to adapt single system elements or system features in a single-loop process. Instead, it may be necessary to redesign the system configuration, for instance by bringing in completely new categories of personnel ready to perform new types of tasks. In such a case, the system is no longer adapting, it is transforming into a new shape (triangle in Fig. 2) as it redefines its theory-in-use and configuration using double-loop learning. This new system (triangular shaped) will possibly be better suited to handle the context at this specific moment in time (B) than the elliptical system. However, in a future moment in time (C), a further transformation (rectangular shaped) may be an even better alternative.

4. Crisis management capabilities as a learning system-of-systems

In the previous section, a model for understanding how systems, and thus organisations, adapt and transform through learning was discussed. In this section, this model is applied to crisis management. First, crisis management as a system-of-systems and how this system learns, particularly in-between crises, is discussed. Thereafter, some of the challenges to such learning are considered.

4.1. Crisis management capabilities as a system-of-systems

The organisations, structures, and resources tasked with the prevention and management of crises can be regarded as a constantly changing system-of-systems (SoS), consisting of a large number of subsystems (the police, rescue services, volunteer organisations, etc.). Such a system perspective has been used in previous research, particularly for discussing how crisis management systems emerge and adapt *during* crises, and in some cases for defining generic requirements for the crisis management systems (Abrahamsson et al., 2010; Ansell et al., 2010; Comfort, 1999; Uhr et al., 2008). The crisis management system could be labelled an *acknowledged system-of-systems* (Dahmann and Baldwin, 2008) as there usually is some type of controlling element while the system elements are largely independent when it comes to objectives, funding, and resources.

As an acknowledged SoS, the crisis management system is heterogeneous. How the crisis management system and its sub-systems adapt and transform in a coordinated manner *during* crises is a crucial issue. *Centralised hierarchies* and *decentralised networks* are two potential strategies for achieving this (Ansell et al., 2010; Boulding, 1956; Christensen et al., 2016; Kettl, 2003). In practice, both strategies co-exist in most crisis management systems during a crisis and even the most hierarchal systems generally depend on independent organisations coming together (Ansell et al., 2010; Brattberg, 2012; Christensen et al., 2016).

However, the crisis management system must also reinvent itself to fit a specific crisis (Boin et al., 2010). Although some basic abilities are required in most responses, such as logistics, coordination, and communications, the exact configuration will vary from crisis to crisis. Furthermore, as threats change and vulnerabilities transform, the crisis management system should also adapt and transform *in-between* crises to remain relevant.

This means that there are two different crisis management system-of-systems. In-between crises there is a *planning system,* which consists of a number of organisations trying to foresee and prepare for different types of crises. During crises, another system-of-systems, a *response system*, emerges to handle the specific situation.

Although the response system is largely based on the actors in the planning system, it is not exactly the same. It may include system elements from actors that are not part of the planning system, such as private companies or volunteer organisations, and not all actors in the planning system might take part in a specific response. The relationships

between system elements may also look different in the response system compared to the planning system. For example, the importance of a specific element or actor in the response system varies with the type of crisis. The fire brigade has a lesser role during a pandemic than a forest fire.

There is a body of research on how crisis response systems adapt and transform during crises (Ansell et al., 2010; Comfort, 1999). The way single organisations learn and change after having been engaged in a crisis response has also been studied (Broekema et al., 2017; Deverell, 2010). However, research on how crisis management planning systems learn and change on an inter-organisational level in-between crises is less abundant.

4.2. Understanding the dualistic crisis management system

The heterogeneity of the crisis management system is likely to affect the functionality of the system, as well as the way the system learns and develops. The above mentioned duality of this system, adds to this complexity. Instances of underperformance, as well as other types of experiences, are generally observed by the response system during crises or in exercises, while the long-term analysis, learning, and change leading to adaptation or transformation *in-between* crisis generally need to take place in the planning system.

Hence, understanding the relationship between the planning and response systems is key for understanding the process through which crisis management systems may learn and develop. Lawson (2010) offered a model for describing the interaction between two non-static systems, where one alters the state of the other (Fig. 3).

The model contains a respondent system that is created through the combination of resources available in a pool of system assets. The respondent system is configured to meet and change the state of the situation system.

Lawson's model can be modified to describe the interactions between the planning system and a respondent system in the design of a response. In the case of crisis management, the respondent system is built on assets from several different pools of assets. Each of these pools represent an actor or a group of actors that contributes assets to a subsystem in the crisis management response system (Fig. 4). When the crisis response operation (or exercise) has ended, these assets usually return to the pools they came from, taking with them experiences, lessons and assessments of performance.

This acquired knowledge may result in local change – adaptation or transformation – in the organisations from which the assets originate. However, to achieve coordinated adaptation or transformation in the overall crisis management system, a joint process of the actors in the various pools of assets would be required.

Furthermore, while a specific crisis response system in a specific crisis could be defined by observing its actors, it is far less straightforward to define and delimitate the crisis management planning system. Dynes (1970) offered a typology of four main groups of crisis management actors. *Established actors* use their regular organisation to carry out

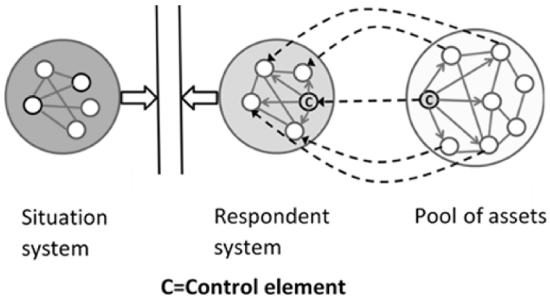

Fig. 3. Lawson's (2010) model of the interaction between two non-static systems as adapted in Hallberg et al (2018).

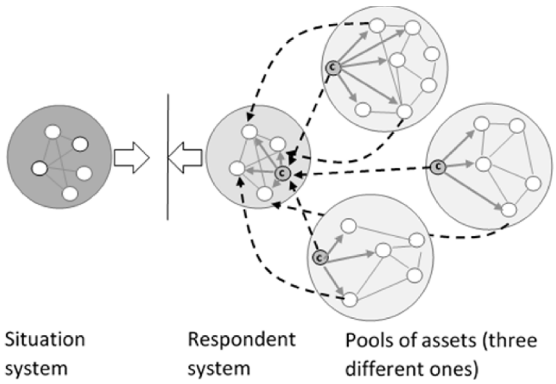

Fig. 4. A modified version of Lawson's (2010) model to reflect the response of a crisis management respondent system. C represents the system's control elements.

their regular tasks in a crisis. This group includes, for instance, emergency rooms in hospitals, rescue services, and companies repairing electric power distribution networks. *Extending actors* use their regular organisation to perform tasks that they would normally not carry out. This group includes, for instance, municipalities, food retailers, and local sports clubs. *Expanding actors* often only exist in the form of small cadre organizations in-between crises and are boosted with part-time personnel or volunteers during crises. These actors carry out their regular tasks, but with a de facto new organisation each time. This group includes volunteer organisations, such as Doctors without Borders and Save the Children, but may also include public organisations boosting their efforts with personnel from pools of volunteers. *Emergent actors*, finally, do not exist in-between crises, but are formed ad-hoc during a crisis. This group includes spontaneous volunteer groups, but also coordinating functions that evolve when organisations (public and private) that normally do not cooperate with each other need to work together.

The groups are less clear-cut than what they may seem. Different parts of an organisation may fit the description of different groups, where one part is more of an established actor and another is more of an extending actor (Boin and 't Hart, 2010; Dynes, 1970). Furthermore, not all parts of an organisation may be aware of, or prepared for, crisis management tasks. For many organisations, crisis management is a fringe task, sometimes considered as something stealing focus and resources from the main tasks (Eriksson et al., 2017).

The established actors are often regarded as the core of the crisis management system, possibly together with some of the expanding actors (Boin and 't Hart, 2010; Strandh, 2019). However, the extending actors are important as they include a number of other private and public actors with potential roles in crises, for example, as providers of vital resources, competences, and labour (Boin, 2009; Dynes, 1970; Horwitz, 2009). Some of the extending actors have crisis management roles and tasks defined in laws, regulations, or agreements, and are thus identifiable. This may include local municipalities, private and public actors in sectors such as telecom and electric power production, water and sewage services, and financial services. Others do not recognise themselves as part of the crisis management community, or do so only in very specific cases (Eriksson et al., 2017). This could include food retailers, sports clubs, and libraries. Many of the extending actors would probably have few objections to being excluded from the crisis management planning system, as they generally have little or no resources for participating in crisis management planning activities.

Defining and delimitating the crisis management planning system is an important step to be able to discuss how to achieve learning and change. Unfortunately, there is no simple answer to the question of what makes up the planning system. Depending on the context, including national laws, national crisis management structures, and prioritised

threats and risks, the planning system includes different actors, is governed by different regulations, and has different aims and mandates. However, the modified Lawson model, together with the Dynes (1970) typology, offers an analytical framework for discussing the planning system in different contexts.

4.3. The lack of a common theory-in-use

Each sub-system normally has its own theory-in-use in the sense that it has purposefulness, culture, a set of rules and procedures, and an organisational structure (Andersson et al., 2014; Stinchcomb and Ordaz, 2007). At the overall system level, the situation is quite different. The crisis management *planning* system do possess some level of common purposefulness, expressed in terms such as being able to prevent crises, respond to crises, and mitigate the consequences of crises. However, these aims are often political and difficult to operationalise. For instance, in Sweden the aim of the overall crisis management system is (1) to reduce the risk of accidents and crises that could threaten societal security and protect human health and lives as well as fundamental values such as democracy, rule of law, and human rights by maintaining essential services, and (2) to mitigate and limit the damage to property and environment during accidents and crises (Regeringen, 2019). These types of aims, although necessary, offer little help when it comes to the identification and prioritisation of measures for developing the crisis management system.

In most countries, there exist some regulations outlining the relationships between the actors in the planning system, in the form of laws, other types of normative regulations, or cultural norms. These regulations may include the appointment of lead organisations, the framework for the planning processes, and the identification of actors that are obliged to participate in crisis management exercises. In Sweden, this is done through a mixture of laws and non-codified norms and principles (van Laere and Lindblom, 2019; Olsén et al., 2020). However, such regulations mostly control the relationships between public actors and possibly a few private actors within specific sectors such as telecom or the electric power industry.

In a *response* system, the focus is on operational aims, which often are more tangible. This gives the response system a degree of purposefulness, expressed in terms such as protecting the population in a crisis-stricken area. However, although the participating actors (sub-systems) may agree on these overall aims, they may not agree on how to reach them and who is going to solve what tasks. Hence the need for agility and coordination during crises, as discussed above.

Regulations defining the relationships between sub-systems within the crisis management response system are in some cases vague and presented in the form of recommendations and general principles. In Sweden, for instance, the principle of responsibility is the main guiding regulation in a crisis and coordination is largely achieved through cooperation amongst equals (van Laere and Lindblom, 2019; Olsén et al., 2020). It has proven to function well in emergencies and smaller crises, but has been problematic in large-scale crises such as the covid-19 pandemic, where the lack of a controlling authority has resulted in difficulties, for instance regarding the prioritisation of resources (Eriksson, 2020). In other cases, these regulations are rule-bound and rigid, leaving little room for necessary agility and improvised coordination (Boin and 't Hart, 2010; Comfort, 2007).

This does not mean that there is a complete lack of a common theory-in-use in the crisis management planning and response systems, but any existing theory-in-use is weak and blurred at best. Hence, in a specific crisis response system, the goals, mandates, roles, and cultures of the individual sub-systems will most likely have a strong influence on cooperation and relationships as well as on how the goals should be interpreted for different actors. It is somewhat like solving a jigsaw puzzle using pieces from several different boxes.

Furthermore, there exists few *common* storages of experiences and other types of knowledge in the crisis management system. Only a limited amount of knowledge is truly shared among the sub-systems (Eriksson et al., 2017). Instead, knowledge, and sometimes contradicting knowledge, is stored locally in a distributed manner within each sub-system, i.e. actor, in the planning system. Even if there exists pieces of common knowledge, the interpretation remains the prerogative of each sub-system, resulting in different representations of this knowledge, i.e., different theories-in-use (Argyris and Schön, 1996). Therefore, it is unlikely that an adequate and common theory-in-use develops within crisis management systems. Instead, the theories-in-use continue to vary between sub-systems at the same level (e.g., between the rescue service and the police), and between the different layers in the system-of-systems (e.g., between a coordinating function and the rescue services and the police). This complicates any attempt to establish a joint process for the development of the overall system, while the lack of such a process will hamper the development of a common theory-in-use.

4.4. Efficacy as a key

The lack of a common theory-in-use in the heterogeneous crisis management planning and response systems is likely to affect negatively the combined system's ability to adapt and transform. Without a common theory-in-use, it is difficult to achieve a shared understanding of what constitutes sub-standard performance in a response system, of the assessment of actual performances, and of when to start an organisational inquiry for new knowledge in the planning system. While a sub-system, i.e. a crisis management actor, may be content with its own performance in a specific response based on its own specific goals, mandates and roles, another sub-system may find this performance completely inadequate, as it fails in supporting the overall effort.

However, Skyttner's (2005) three types of performance (effectivity, efficiency, and efficacy) represent a structure to discuss how to evaluate the performance of system elements in a crisis management response system with a weak and blurred theory-in-use. While the effectivity of the crisis management response system-of-systems could be measured post-crisis in terms of its perceived success or failure in mitigating consequences and saving lives, the effectivity of the sub-systems is less straightforward to assess. First, the performance of a specific sub-system is in most cases intertwined with, and dependent on, the performance of a number of other sub-systems, leaving it difficult to discern. Second, if there is no agreement on what a specific sub-system should contribute to the overall effort, any attempt to evaluate its performance risks being rejected by the sub-system if it regards the aspects evaluated as being beyond its mandate and tasks.

The efficiency of a system could be regarded as its internal effectiveness, assessing whether the system used its resources in a cost-effective manner. Although efficiency in a public organisation is a relevant measure, not least from a taxpayer perspective, it is of less interest to the overall crisis management system. If an actor uses too much resources to solve a task, this is not of much concern to the overall crisis management system, as long as the task is solved. It only becomes an issue if this non-efficient use of resources means that the actor is not able to handle the next crisis or if other actors are denied resources.

The efficacy of a system and its sub-system, i.e. the extent to which the sub-system reaches its objectives in such a way that it supports the purpose of the higher-level system, is a potentially more useful measure of system performance. Efficacy could be regarded as the link between the evaluable effectivity of the overall crisis management system in a specific situation and the performance of the different sub-systems, such

as the police or the rescue services. Using efficacy the focus is no longer on the potentially subjective aspect of whether the sub-system "did a good job", but on whether the sub-system contributed to the overall crisis management effort in an optimal manner. Efficacy may thus become a catalyst for a discussion on mutual expectations and on how the sub-system relates to the overall system and its configuration. Furthermore, efficacy could also help actors agree on underperformance and on the need for organisational inquiries for new knowledge. Such organisational inquiries, using exploitation or exploration, may result in either adaptation through single-loop learning or transformation through double-loop learning. Finally, these joint discussions on mutual expectations and performance may to some degree help the development of a common theory-in-use, which in turn would facilitate future assessment of performance. This would be a gradual and iterative process, although it is hardly likely that the heterogeneous crisis management system will ever have a fully developed theory-in-use that is internalised in all sub-systems.

5. Discussion

In this article, systems theory and the theories of organisational learning are combined in order to increase the conceptual understanding of the mechanisms behind learning and change in a heterogeneous system-of-systems of crisis management capabilities. What remains to address are the potential practical consequences, including for the process of learning and change in-between crises.

A crisis management system needs to be able to handle a multitude of different contingencies, of which many are unknown or considered highly unlikely until they actually occur (Boin et al., 2016). While an emergency response system may have a number of prepared default combinations of assets and capabilities, applicable in different types of emergencies, this seems less useful for crisis response systems (Lagadec, 2009). Crises are by definition events that occur outside the normal framework of the involved organisations and, thereby, difficult to describe and prepare for in advance (Lagadec, 2009; OECD, 2015).

However, efforts to prepare the crisis management system to meet future crises are not futile. On the contrary, activities in the form of, for instance, joint planning, joint training, and joint exercises can be valuable for the system's ability to meet new or even unexpected crises (Boin et al., 2016). Using the perspective of this article, it is necessary to continuously develop the system configuration, including the purposefulness (what are the aims and mandates of the system), the regulations (what should the interaction between the different system element look like), and the composition of the system (what system elements should be included). Still, one fundamental question remains to be answered: If learning is to be used to achieve concerted change amongst actors, either in the form of adaptation or in the form of transformation, exactly where is this change expected to take place?

The answer to this question is less self-evident than it may first seem. The planning system as well as the response systems are largely defined by their sub-systems, meaning that little actual change will take place if the sub-systems do not change too. In a hierarchical system, this could possibly be achieved through a top-down process. However, in an acknowledged and heterogeneous system-of-systems such as the crisis management system this is probably not feasible. Instead, a joint development process is required.

Using the perspectives offered in this article, it is possible to outline a process for how crisis management systems, together with their sub-systems, can learn in order to adapt or transform. The first step is to agree on an assessment of the performance in recent exercises or operations. This in turn requires two things: First, an agreement on what constitutes acceptable performance for the system as a whole and for its sub-systems, and second, an ability to measure and analyse the actual performance of the system and its sub-systems during a crisis.

Agreeing on what constitutes acceptable performance is not straightforward due to the lack of a common theory-in-use. The relationships between the system elements, i.e. the sub-systems, are defined by the culture and mandates of the sub-systems, rather than by the rules and procedures of an overall system. This affects the ability to evaluate the performance of the system and its sub-systems. In order to be able have fruitful discussions on what constitutes acceptable performance, the main measurement of performance should be efficacy, i.e., the extent to which the performance of a system contributes to the overall aims of the higher-level system, rather than effectivity and efficiency.

If there is agreement that the overall system, or one or several sub-systems, have underperformed, the second step is to start an organisational inquiry for new knowledge (Argyris & Schön, 1996). These inquiries could be in the form of exploration or exploitation, using different methods including exercises, research, and analysis of lessons learned. If the inquiry reveals a need for change, the concepts of single-loop learning (adaptation) and double-loop learning (transformation) will facilitate an understanding of what these development processes constitute.

An important challenge, not addressed in this article, is to establish who should initiate and lead a joint development process and what mandate this actor, or group of actors, must have. Clearly, these are complex issues, touching on inter-organisational sensitivities, but still necessary to clarify to ensure the legitimacy and credibility of the process and, thereby, the gradual development towards an effective crisis management system.

6. Conclusions

Adequate crisis management capabilities are vital for modern societies. However, it is a challenge to develop and maintain these capabilities in a concerted and cost-effective manner, not least due to the heterogeneous character of the crisis management system. Combining general systems theory and the theories of organisational learning makes it is possible to better understand the dynamics of learning and change in the crisis management system, including how the duality of the crisis management system affects these dynamics. Furthermore, by using efficacy as the preferred measurement of performance, some of the difficulties associated with the lack of a common theory-in-use in the crisis management system are overcome. This facilitates a joint assessment of the performance of the system and its sub-systems, and a common process for achieving change. As exercises are important tools to develop and maintain crisis management capabilities, future research is encouraged to focus on how exercises can contribute to this type of structured and concerted system change.

CRediT authorship contribution statement

Pär Eriksson: Conceptualization, Methodology, Writing – original draft. **Niklas Hallberg:** Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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