

A Maturity Model to Assess and Foster the Resilience of Organizations

Joachim Stocker¹, Nils Herda¹, Maximilian Wolf¹ & Stefan Ruf¹

¹ Albstadt-Sigmaringen University

Correspondence: Maximilian Wolf, Albstadt-Sigmaringen University.

doi:10.56397/AS.2022.12.01

Abstract

Adverse events like energy supply shortages seem to be ubiquitous nowadays. They can negatively affect organizations to varying degrees. In case organizations are negatively affected by adverse events, they need to deal with such circumstances. The concept of resilience is a promising approach supporting organizations if adverse circumstances occur. Against this background, a novel maturity model to analyze and assess resilience capabilities of organizations or units thereof is proposed that aim to deal with adverse circumstances. The maturity model consists of three dimensions, twelve attributes and six stages that together form its structural design. For validation purposes a workshop with professionals working for different departments of a private-sector company has been conducted. The workshop generally reveals the suitability of the maturity model to assess the resilience of organizational units. Workshop participants especially value the maturity model with regard to transparency, comprehensiveness, comparability and the ability to provide indications for resilience improvements.

Keywords: organizational resilience, maturity models, assessments

1. Introduction

Many organizations currently face quite uncertain times. They are increasingly confronted with adverse events that may have negative impacts on business operations. Examples of such events are pandemics like the coronavirus disease (COVID-19) or military conflicts like the Russia-Ukraine war. The impacts of such adverse events can be manifold like material bottlenecks, disruptions of supply chains or the absence of employees. They may also have the potential to threaten the existence of organizations.

Against this background, it is important for organizations to deal with events and impacts that may adversely affect business operations. The concept of resilience can be a suitable approach to be used in this endeavor. It encompasses the ability to prepare, prevent, protect, respond, and recover from adversity (Thoma et al., 2016). In this respect, the concept of resilience holds the promise to support organizations in case adverse circumstances occur.

If adverse circumstances occur, organizations can be vulnerable in many ways. For example, employees with abilities not to be replaceable at present are unavailable or power systems supplying energy for critical business operations are irreversibly damaged. Knowing this, organizations need to consider various organizational aspects to assess how resilient they are if adverse circumstances occur. In view of the above, the following research questions are addressed:

- How can the resilience of organizations be assessed?
- Which aspects need to be considered to holistically assess the resilience of organizations?
- How valuable are assessments considering the resilience of organizations?

To answer the first and second question, a maturity model considering different aspects related to the resilience of organizations has been developed. The maturity model aims to holistically assess the current state of resilience organizations or units thereof possess. It can furthermore be used as guidance to strengthen the resilience of organizations.

To answer the third question, the maturity model developed has been validated by conducting a workshop with experienced professionals working for two organizational units of a private-sector company. The experienced professionals generally confirm the suitability of the maturity model to assess the resilience of organizations. The workshop reveals some varying resilience levels for the organizational units assessed.

The remainder of this paper is structured as follows. Section 2 outlines the basics for all subsequent sections. Section 3 describes the maturity model developed. Section 4 covers the validation of the maturity model. Section 5 states related work. Section 6 provides a summary of the work proposed.

2. Basics

In this section essential basics related to the research work proposed in this paper are briefly outlined. Firstly, organizations as main subjects of interest are described. Afterwards, the concept of resilience related to organizations is presented. Finally, maturity models as methods to assess the resilience of organizations are introduced.

2.1 Organizations

Organizations can be considered as complex sociotechnical systems (Carvalho et al. 2008). They are sometimes also described as business systems (Ferstl and Sinz 1998) or work systems (Alter 2013). Organizations can in this respect be generally considered as systems with humans and machines performing tasks by use of information, technology and other resources to produce products and services for specific customers (Alter 2014).

Organizations are typically part of different environments like business, political, social or natural environments. They can be influenced by environments they are part of. For example, non-availabilities of materials needed to produce products can lead to production downtimes. In case organizations are adversely influenced by some environmental factors their capacity to withstand adverse circumstances is demanded. Therefore, resilience as a capacity to withstand adverse circumstances can be considered as imperative for organizations, especially if they are part of complex and turbulent environments.

2.2 Organizational Resilience

Resilience in the context of organizations is discussed using different definitions (Birkie et al. 2013) and terms like business resilience (Zaerens 2015), enterprise resilience (Fiksel et al. 2015) or organizational resilience (Lengnick-Hall et al. 2011). Despite different definitions used, many authors consider organizational resilience to be a holistic concept (Erol et al. 2010, Thoma et al. 2016). Following this, resilience can be holistically defined as “ability to repel, prepare for, take into account, absorb, recover from and adapt ever more successfully to actual or potential adverse events” (Scharte et al. 2014).

From a holistic point of view, organizational resilience has to take into account preventive as well as reactive measures (Duchek 2020). Preventive measures are activities to be applied before adverse events or negative impacts thereof occur. They basically aim to prepare for and prevent against adverse circumstances happening (Demichela et al. 2015). Reactive measures are activities to be applied at the time or after organizations are affected by impacts of adverse events. They try to avoid or reduce negative impacts caused by adverse events in order to return to normal business operations (Ruiz-Martin et al. 2018) or even prosper to an advanced business operations state (Fiksel et al. 2015).

2.3 Maturity Models

Maturity models can be defined as methods “to assess the maturity (i.e., competency, capability, level of sophistication) of a selected domain based on a more or less comprehensive set of criteria” (de Bruin et al. 2005). Therefore, they can also be considered as appropriate means to assess resilience-related aspects of organizations in a holistic manner. Maturity models can in this respect serve for different purposes. They can be used to assess the current state of a subject like an organization considering different aspects of a topic (descriptive purpose). Maturity models can also be used to provide indications for desirable subject developments in the future (prescriptive purpose). They furthermore allow to compare different subjects like organizational units (comparative purpose) (Röglinger 2012).

To serve the different purposes mentioned, maturity models typically consist of maturity stages. Maturity stages represent the different levels of maturity to be used for assessment. They form, as a whole, a desired evolution path where the bottom stage usually represents an initial state that characterizes no or little capabilities with regard to the criterion assessed (Becker et al. 2009). On the opposite, the highest stage can be considered as the

most sophisticated one (Rosemann and de Bruin 2005) to be achieved and may also be described as best practice (Maier et al. 2012).

3. Maturity Model for Organizational Resilience

In this section the maturity model developed to assess organizational resilience is introduced. The maturity model mainly aims to assess the current state of resilience capabilities organizations or units thereof possess by considering different elements. The design, dimensions, attributes and stages of the maturity model are described in sections 3.1, 3.2, 3.3 and 3.4. Furthermore, the maturity model is explained in its entirety in section 3.5.

3.1 Design

The design of the maturity model shows its structural setup. It consists of three elements: dimensions, attributes and stages. The design elements of the maturity model are depicted in figure 1. They are described below.

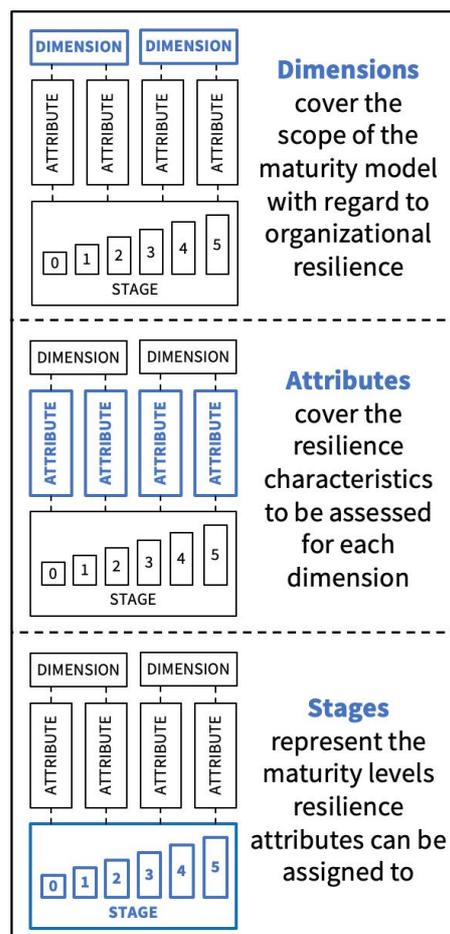


Figure 1. Design elements of the maturity model

Dimensions cover the scope of the maturity model with regard to organizational resilience to be considered as starting point for organizational resilience analysis. The maturity model consists of three dimensions: adverse events, coping strategies as well as case handlers. The dimensions of the maturity model are described in section 3.2.

Attributes cover the resilience characteristics to be assessed for each dimension. The maturity model consists of twelve attributes. Each attribute relates to one dimension of the maturity model, whereas a dimension comprises several attributes. The attributes of the maturity model are described in section 3.3.

Stages represent the maturity levels resilience attributes can be assigned to. The maturity model consists of six maturity stages. Each attribute can be assigned to one maturity stage at a particular time. The stages of the maturity model are described in section 3.4.

3.2 Dimensions

The dimensions of the maturity model are depicted in figure 2 and are described below.

Adverse events can be considered as starting points for organizational resilience analysis. They can negatively affect business operations to some extent like delays or failures of processes. Adverse events can either originate internally or externally and be, for example, natural disasters, diseases or power outages.

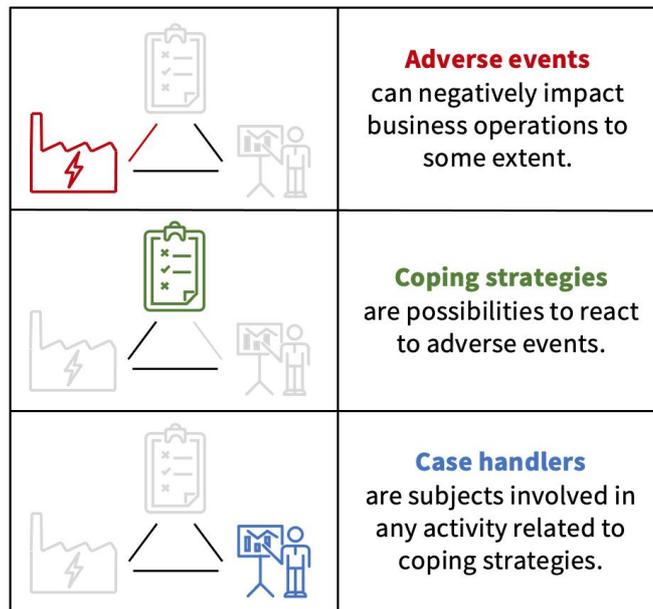


Figure 2. Dimensions of the maturity model

Coping strategies are possibilities to react to adverse events. They aim to prevent or reduce negative effects resulting from adverse events. Coping strategies can, for example, be redundancy, shifting or outsourcing. For instance, redundancy means that a resource like an employee can be replaced by another resource in case of failure.

Case handlers are subjects involved in any activity related to coping strategies. They can, for example, be involved in the planning, execution or coordination of coping strategies. Case handlers may be performers, coordinators or decision-makers. Activities of case handlers contribute to prevent or reduce impacts of adverse events on organizations in a preventive or reactive manner.

3.3 Attributes

The attributes and related dimensions of the maturity model are depicted in figure 3. Each attribute relates to one dimension. For example, the attribute *systematization* relates to the dimension *adverse events*. The attributes of the maturity model are described below.

Adverse events	Coping strategies	Case handlers
<p>Systematization</p> <p>Detection</p> <p>Analysis and assessment</p> <p>Reporting system</p>	<p>Counter measures</p> <p>Documentation</p> <p>Simulations and exercises</p> <p>Effectiveness checks</p>	<p>Responsibility and accountability</p> <p>Knowledge</p> <p>Abilities</p> <p>Organizational authorities</p>

Figure 3. Attributes and related dimensions of the maturity model

(1) *Systematization*

Systematization relates to the question of how adverse events are categorized. Adverse events can, for example, be systematized based on their origins (internal versus external), probabilities (unlikely versus most likely) or impacts (low versus high) of occurrence.

(2) *Detection*

Detection relates to the question of how adverse events are detected. Adverse events can either be detected before, at the time or after occurrence. They can be detected using one or more sources such as weather or supply chain data. Furthermore, technologies like real-time monitoring systems can be used to detect adverse events with the aim to uncover anomalies.

(3) *Analysis and assessment*

Analysis and assessment relate to the question of how adverse events are analyzed and evaluated. Adverse events can be analyzed and evaluated at one or more predefined dates or situation-specific in an ad-hoc manner. Thereby, the methods used to analyze and evaluate adverse events are also of importance. The scope ranges from scientifically grounded to organization-specific methods which can also be modifications of the first one mentioned.

(4) *Reporting system*

Reporting relates to the question of how adverse events are reported. The reporting system with reporting lines, subjects to be involved as well as means used to report adverse events are aspects to be considered in this regard. The reporting system must ensure that information regarding adverse events needs to be available by responsible subjects in a timely manner. Especially adverse events with possibly severe negative impacts are time-critical to report.

(5) *Counter measures*

Counter measures relate to the question of which measures can be used to react to negative impacts caused by adverse events. They can be considered as possible solution approaches to be used to handle adverse circumstances. Counter measures can, for example, be redundancy, substitution, shifting or outsourcing. They aim to prevent or at least reduce negative impacts that may affect business operations.

(6) *Documentation*

Documentation relate to the question of how coping strategies should be documented. Coping strategies can generally be part of different organizational documentations like instructions or process descriptions. They should be documented in a way that all members of organizations immediately know what to do in case they are needed.

(7) *Simulations and exercises*

Simulation and exercises relate to the question of how coping strategies are simulated and exercised. Computer-based simulations can be an essential contribution towards knowing the impact of different scenarios with and without applying coping strategies. Exercises are another way for employees of organizations to familiarize themselves with executing coping strategies for different emergency situations.

(8) *Effectiveness checks*

Effectiveness checks relate to the question of how effective coping strategies are. Coping strategies can be not or to a certain extent effective depending on the specific circumstances organizations face. If the same or similar circumstances as in the past arise proven coping strategies should be the first choice to react to them. Applying coping strategies should in this respect be done on the comparison of current with past circumstances.

(9) *Responsibility and accountability*

Responsibility and accountability relate to the question of which case handlers are responsible and accountable for coping strategies. Responsible case handlers are subjects that, for example, plan, execute or coordinate activities relating to coping strategies. Accountable case handlers are subjects that are needed to make decisions with regard to coping strategies.

(10) *Knowledge*

Knowledge relates to the question of how knowledge of case handlers is integrated into the organizational knowledge base. Knowledge with regard to coping strategies can basically be gained in different ways. It can, for example, be gained through exercises, practical experiences or in the aftermath of carrying out coping strategies. Against this background, knowledge need to be continually captured and managed in order to be available for case handlers if needs arise.

(11) *Abilities*

Abilities relate to the question of which abilities case handlers need to possess in order to perform activities related to coping strategies. In this regard, case handlers may be equipped with different abilities depending on the duties to be performed by them. Abilities of case handlers need to be known, continually managed and may be subject to change in case coping strategies are advanced in any kind.

(12) *Organizational authorities*

Organizational authorities relate to the question of which hierarchy levels need to be involved in case adverse events requiring any coping strategy occur. In general, case handlers belonging to different hierarchy levels may be involved in one case. Therefore, case handlers belonging to different hierarchy levels need to be connected to ensure exchange and collaboration in order to appropriately react to organizational threats.

3.4 *Stages*

The maturity model consists of six stages ranging from *non-existent* to *optimized* where the first one represents the lowest and the last one the highest maturity level with regard to resilience. The stages are used to assess the current maturity level of each resilience attribute belonging to the maturity model. They are depicted in figure 4 and are described in general terms below.

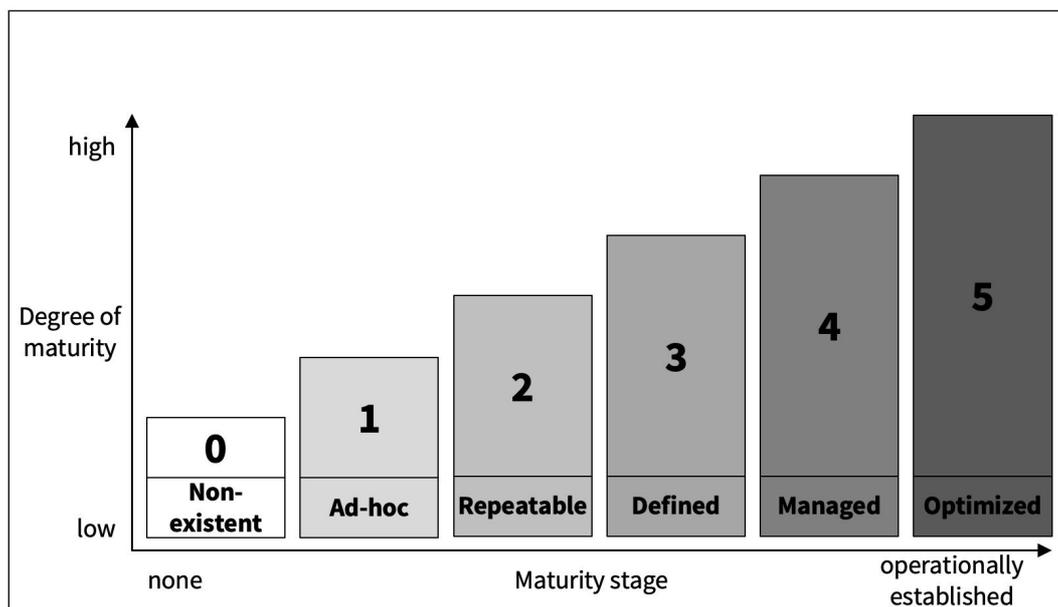


Figure 4. Stages of the maturity model

(1) *Non-existent*

The maturity stage *non-existent* means that the respective resilience attribute is not known or there is no awareness of it. The attribute has so far not been used in any case with regard to resilience matters by the organizational unit assessed.

(2) *Ad-hoc*

The maturity stage *ad-hoc* means that the respective resilience attribute is known. However, awareness related to the attribute exists only barely. The attribute is not institutionalized in any way. It has been considered or used in the past, but only in case of need. The attribute is not part of day-to-day business. Dealing with the attribute has only been done on an exceptional basis so far.

(3) *Repeatable*

The maturity stage *repeatable* means that the respective resilience attribute is institutionalized based on individual experiences of employees. Therefore, some attention has occasionally been devoted to the attribute in the past. Employees dealing with the attribute are to some extent aware that it contributes towards achieving a resilient organization.

(4) *Defined*

The maturity stage *defined* means that the respective resilience attribute is institutionalized based on

organizational procedures. Employees are mostly aware of the attribute and its contribution towards achieving a resilient organization. The attribute is part of day-to-day operations and can also be found in some work instructions.

(5) *Managed*

The maturity stage *managed* means that the respective resilience attribute is part of ongoing management activities and may also be part of organizational objectives. Employees are largely aware and actively manage the attribute. They have intensively been dealt with the attribute to continually ensure a certain level of resilience. Deviations related to the attribute jeopardizing the level of resilience are timely communicated to responsible employees.

(6) *Optimized*

The maturity stage *optimized* means that the respective resilience attribute is in addition continually checked for improvements. Employees are aware that improvements of attributes can foster the resilience capabilities of organizations. Responsible executives support employees in their efforts to continually optimize and increase the level of resilience. The attribute is deeply embedded into entrepreneurial thoughts and actions.

3.5 Maturity Model Overview

The maturity model with its different components is depicted in figure 5. Dimensions of the maturity model are shown at the top of the figure. Attributes are depicted below the dimension they relate to. Stages are shown on the left side of the figure indicating their mapping to each resilience attribute.

Overall, the maturity model consists of 72 possible assessment values (6 stages for each of the 12 attributes). If an assessment is conducted, 12 assessment values for each organizational unit to be assessed result (for each attribute one stage needs to be determined). Therefore, the maturity model can be considered as a profound assessment method to capture the maturity of different aspects related to the resilience of organizations.

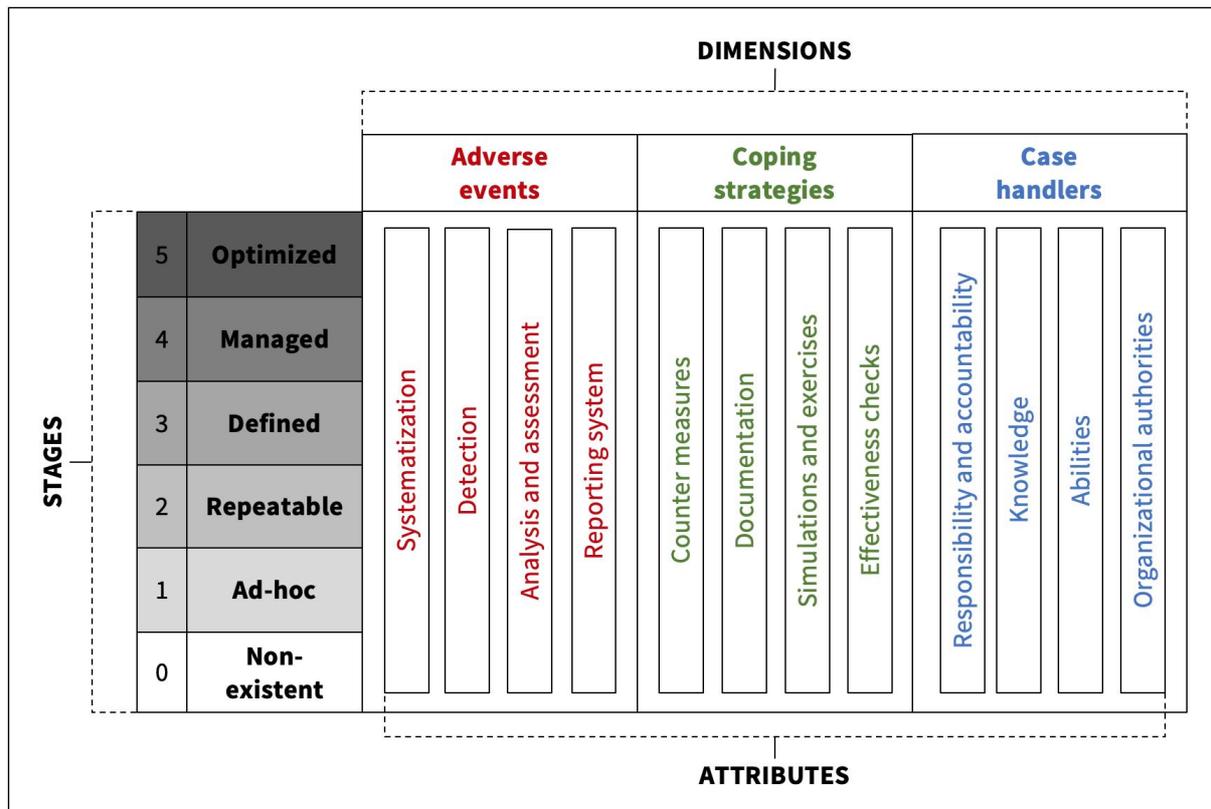


Figure 5. Components of the maturity model

4. Validation

In this section the validation of the maturity model is described. The maturity model has been validated by conducting a workshop with professionals from two different organizational units of a private-sector company. The company operates internationally, has several business locations across Europe and provides high-quality

products to private and commercial customers. Further information related to the company cannot be disclosed due to reasons of confidentiality.

Section 4.1 provides general information with regard to the workshop conducted. Section 4.2 outlines the findings obtained during the course of the workshop. Section 4.3 discusses limitations of the validation conducted.

4.1 Workshop

The workshop was conducted with five professionals working for the information technology (IT) department and another five professionals working for the manufacturing department of a private-sector company. The workshop participants with the department they belong to, years of working experience, experience level as well as managerial responsibility are listed in table 1. They can be considered as sufficiently experienced with on average more than eleven years working in their profession. The majority of participants hold a senior position and also take on responsibility for some managerial duties.

Table 1. Overview of workshop participants

Participant	Department	Years of working experience	Experience level	Managerial responsibility
1	Information technology	12	Senior	yes
2	Information technology	9	Intermediate	no
3	Information technology	10	Senior	no
4	Information technology	13	Senior	yes
5	Information technology	11	Senior	yes
6	Manufacturing	8	Intermediate	no
7	Manufacturing	15	Senior	yes
8	Manufacturing	11	Senior	yes
9	Manufacturing	12	Senior	yes
10	Manufacturing	10	Senior	yes

The following steps have been performed during the course of the workshop: (i) introduction to the goals of the workshop (ii) general explanation of maturity models and the concept of resilience (iii) explanation of the maturity model developed with regard to its design, content and application (iv) Application of the maturity model developed to respective organizational units (v) Discussion about the suitability of the maturity model and possible changes (additions, deletions, amendments) to be addressable for improvements.

4.2 Findings

The maturity model has been used to assess the maturity level of each resilience attribute for both the IT department as well as the manufacturing department. The professionals listed in table 1 have been part of the assessment. The assessment results obtained are depicted in figure 6. Essential findings are described below.

Basically, it can be stated that the results obtained from using the maturity model to assess the IT department as well as the manufacturing department for resilience purposes vary to some extent. No resilience attribute assessed in either of the two departments has been assigned to the highest maturity level. This indicates that improvements to be addressable in the future are possible. Furthermore, only the resilience attributes *simulations and exercises* as well as *effectiveness checks* have yet not been existed in the IT department. Consequently, the departments already achieved some higher maturity degrees considering all other resilience attributes.

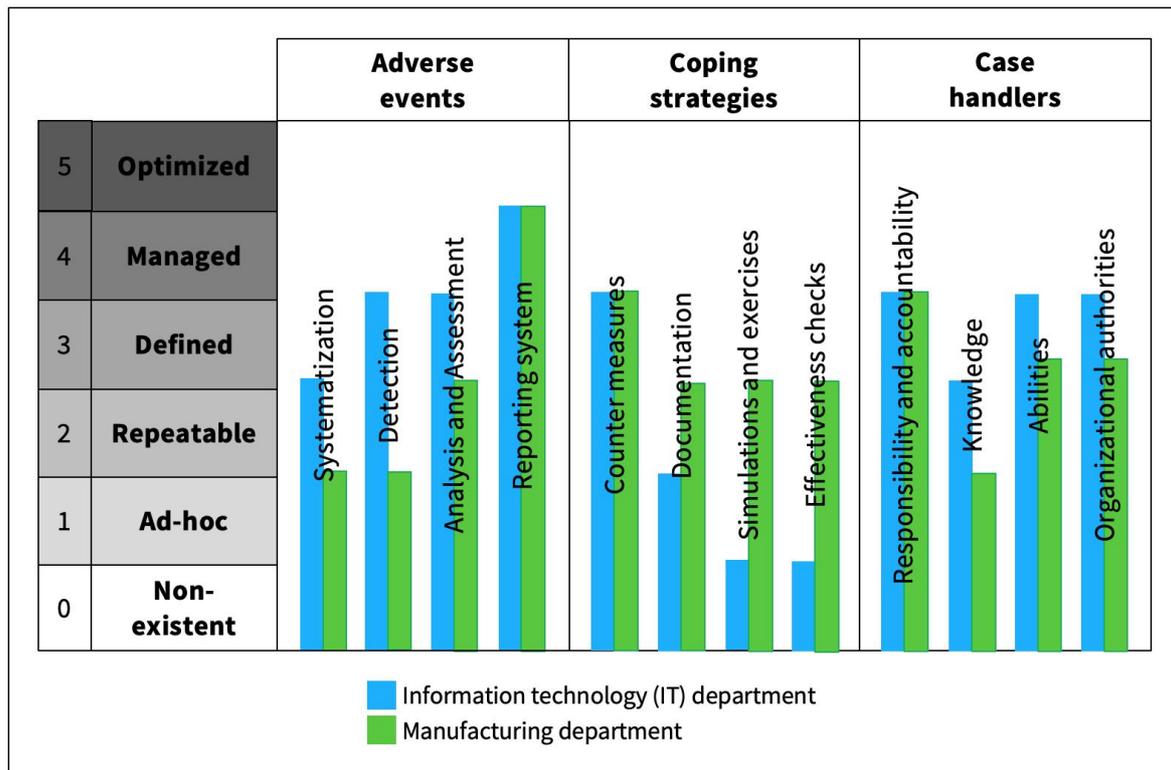


Figure 6. Results obtained by assessing the maturity levels of each resilience attribute for the information technology department and the manufacturing department

The IT department has in comparison with the manufacturing department achieved the same or higher maturity levels if the attributes related to the dimension *adverse events* are considered. This may be an indication that the IT department has in comparison dealt with adverse events quite intensively, possibly due to the various kinds of cyber threats and their severe consequences they may have on business operations. By contrast, the manufacturing department has in comparison with the IT department achieved the same or higher maturity levels if the attributes related to the dimension *coping strategies* are considered. This may indicate that the manufacturing department has in comparison more dealt with coping strategies, possibly because it operates in a rather predictable environment with common coping strategies to be applied repeatedly.

The highest maturity stage has been assigned to the attribute *reporting system*, followed by *counter measures* as well as *responsibility and accountability* if assessment results of both departments are jointly considered. This may be interpreted as reporting of adverse events to responsible persons which are able to initiate counter measure activities have been key tasks for both departments in the past. The departments may have rather been dealt intensively with these resilience-related duties in comparison with others and are thus possibly more familiar with them if they are demanded in the future.

Overall, the workshop participants have valued the maturity model proposed in this paper as suitable to holistically assess the resilience of organizations. They valued the maturity model especially with regard to the following advantages:

(1) *Transparency*

The maturity model has been valued for the possibility to systematically assess the maturity levels of different resilience-related characteristics in organizations. In this respect, the structure and different components of the maturity model have been regarded as strongly supportive for organizational resilience analysis purposes.

(2) *Comprehensiveness*

The maturity model has further been valued for the scope to cover the diverse topic of resilience considering the context of organizations in a holistic manner. The ability of the maturity model to capture a holistic picture with regard to resilience matters of organizations has thus been regarded as especially advantageous.

(3) *Improvements*

The maturity model has also been valued as a method to improve resilience-related characteristics in organizations. It can, for example, be used as guidance towards fostering the resilience of organizations and may be used as a starting point to initiate projects to pursue this aim.

(4) *Comparability*

The possibility to compare organizational units at certain points in time with regard to resilience maturities has been regarded as another advantage. The maturity model reveals strengths, deficiencies and may also be used for benchmarking purposes across different organizational units.

4.3 *Limitations*

The following limitations with regard to the assessment conducted need to be considered.

Firstly, the workshop participants are only a subset of the employees working within the respective departments. If other employees with different levels of knowledge would have been part of the workshop, the results may be different. To counter this limitation, participants that are predominantly senior professionals were part of the workshop as they most likely cover an extensive scope of knowledge available.

Secondly, the validation was conducted with support of a private-sector company. In case the maturity model would have been used to assess organizational units of other private-sector or public organizations the findings may also change. This limitation could partially be overcome by conducting interviews with employees from other organizations and compare the responses received with the findings stated in this paper.

5. **Related Research**

In this section research work that relate to some extent to the maturity model described in this paper is introduced. Furthermore, the related research work stated is delimited to the research work proposed in this paper.

In general, many authors proposed maturity models for different domains like software engineering or process management (Wendler 2012). However, to the best of the authors knowledge, a maturity model that holistically deals with resilience aspects considering the context of organizations as presented in this paper has not been found at the date of submitting this paper.

To get an overview of existing maturity model research the research work of Wendler (2012) can be used as a first reference point. Wendler (2012) conducted a mapping study including publications from more than twenty domains and stated some research gaps to be addressable in the future. Another more specific literature review focusing on enterprise maturity models was provided by Santos-Neto and Costa (2019). The authors also included an extensive number of publications and presented possible improvements regarding future developments of maturity models. Both publications have been used as a starting point to develop the maturity model proposed in this paper.

Gilly et al. (2014) developed a conception of resilience based on an organizational and territorial dimension. The organizational dimension covers capacities of organizations to deal with environmental disturbances. The territorial dimension comprises capacities of actors that contribute to facilitate developments of responses to external disturbances. This research work addresses meta-level considerations on organizational and territorial resilience, whereas the work proposed in this paper concretizes organizational resilience by providing a maturity model with different aspects to be assessed for this purpose.

Stachowiak and Pawłyszyn (2012) propose a methodology for self-assessments of organizations. The diagnosis methodology has been based on maturity models as well as resilience concepts. It was validated by experts' opinions as well as a case study. The methodology can further be used for benchmarking purposes and designing improvements strategies. The authors state that they developed the assessment methodology based on holistic definitions. However, they did not address resilience as an ability of organizations with different characteristics to be considered as the research work in this paper is based on.

Caralli et al. (2010) describes the development and foundations of a CERT® Resilience Management Model. The model contributes a path for integrating resilience as repeatable, predictable, manageable, and improvable steps over which organizations have control. It includes an extensive range of aspects and assets to be used for resilience considerations by organizations. However, the model does not provide an assessment method to evaluate them. By contrast, the maturity model presented in this paper can be used as an assessment method for resilience-related organizational aspects.

Sanchis et al. (2020) proposed a quantitative method to enhance enterprise resilience. The method allows to select preventive actions to be activated in order to reduce the impacts of adverse events on organizations. The authors also state that the method can be used to improve the capability to be prepared against disruptive events. The method mainly focuses on preventive actions and disruptive events. Specific preventive actions and

disruptive events are also used to calculate a numerical example using the method proposed. By contrast, the work in this paper covers a wider scope of organizational matters to be addressed by resilience considerations.

The work of Maier et al. (2012) reviewed maturity grids and developed a roadmap for their development. The roadmap consists of four phases: planning, development, evaluation, and maintenance. Each phase covers a number of decision points for development such as maturity levels. This research work mainly focuses on the question of how to develop appropriate maturity assessments whereas the research work proposed in this paper deals with the design and application of a maturity model to assess organizational resilience. Both research contributions have been validated in industrial practice.

6. Conclusion

The knowledge with regard to adverse events, their impacts on business operations as well as how to deal with them can be crucial for organizations, especially if they operate in dynamic and complex environments. Therefore, it is important to holistically approach these aspects in order to be prepared for such circumstances. The concept of resilience is a promising approach to be of use aiming to support this endeavor.

To know how resilient organizations are, assessment methods can be used. Maturity models can be regarded as appropriate assessment methods to be able to capture different characteristics related to the resilience of organizations. Thus, they are able to cover resilience characteristics of organizations in a holistic manner.

Against this background, a novel maturity model to holistically analyze and assess the resilience of organizations or units thereof has been developed and presented in this paper. The maturity model consists of three dimensions and twelve attributes to analyze the resilience of organizations. It also encompasses six stages to assess the maturity level for each resilience attribute.

For validation purposes, a workshop with experienced professionals working for two departments of a private-sector company has been conducted. The professionals have stated the suitability of the maturity model to holistically analyze resilience aspects of organizations. They valued the maturity model especially regarding transparency, comprehensiveness, comparability, and indications to improve the resilience of organizations. For future research, the validation results obtained could be compared with responses from interviews to be conducted in other private-sector or public organization

References

- Alter S. (2014). Theory of Workarounds. *Communications of the Association for Information Systems*, 34(55), 1041–1066.
- Alter S. (2013). Work System Theory: Overview of Core Concepts, Extensions, and Challenges for the Future. *Journal of the Association for Information Systems*, 14(2), 72–121.
- Becker J, Knackstedt R, Pöppelbuß J. (2009). Developing Maturity Models for IT Management—A Procedure Model and its Application. *Business & Information Systems Engineering*, 1(3), 213–222.
- Birkie S E, Trucco P, Kaulio M. (2013). State-of-the-Art Review on Operational Resilience: Concept, Scope and Gaps. *Advances in Production Management Systems. Competitive Manufacturing for Innovative Products and Services*, Emmanouilidis C, Taisch M, Kiritsis D (Ed.s), Springer, Berlin/Heidelberg (Germany), pp. 273–280.
- Caralli R A, Allen J H, Curtis P D, White D W, Young L R. (2010). Improving Operational Resilience Processes. 2nd International Conference on Social Computing, *IEEE*, pp. 1165–1170.
- Carvalho P V R, dos Santos I L, Gomes J O, Borges M R S. (2008). Micro incident analysis framework to assess safety and resilience in the operation of safe critical systems: A case study in a nuclear power plant. *Journal of Loss Prevention in the Process Industries*, 21(3), 277–286.
- De Bruin T, Freeze R, Kulkarni U, Rosemann M. (2005). Understanding the Main Phases of Developing a Maturity Assessment Model. Australasian Conference on Information Systems (ACIS), Bunker D, Campbell B, Underwood J, pp. 8–19.
- Demichela M, Gallo M, Salzano E. (2015). A review of the methodologies for the resilience assessment in the process industry. *Journal of Polish Safety and Reliability Association*, 6(3), 39–44.
- Duchek S. (2020). Organizational resilience: a capability-based conceptualization. *Business Research*, 13(1), 215–246.
- Erol O, Sauser B J, Mansouri M. (2010). A framework for investigation into extended enterprise resilience. *Enterprise Information Systems*, 4(2), 111–136.
- Ferstl O K, Sinz E. (1998). Modeling of Business Systems Using SOM. *Handbook on Architectures of Information Systems*, Bernus P, Mertins K, Schmidt G (Ed.s), Springer, Berlin/Heidelberg (Germany), pp.

347–367.

- Fiksel J, Polyviou M, Croxton K L, Pettit T J. (2015). From Risk to Resilience: Learning to Deal with Disruption. *MIT Sloan Management Review*, 56(2), 79–86.
- Gilly J-P, Kechidi M, Talbot D. (2014). Resilience of organisations and territories: The role of pivot firms. *European Management Journal*, 32(4), 596–602.
- Lengnick-Hall C A, Beck T E, Lengnick-Hall M L. (2011). Developing a capacity for organizational resilience through strategic human resource management. *Human Resource Management Review*, 21(3), 243–255.
- Maier A M, Moultrie J, Clarkson P J. (2011). Assessing Organizational Capabilities: Reviewing and Guiding the Development of Maturity Grids. *IEEE Transactions on Engineering Management*, 59(1), 138–159.
- Röglinger M. (2012). Maturity models in business process management. *Business Process Management Journal*, 18(2), 328–346.
- Rosemann M, de Bruin T. (2005). Towards a Business Process Management Maturity Model. ECIS 2005 Proceedings of the Thirteenth European Conference on Information Systems, Rajola F, Avison D, Winter R, Becker J, Ein-Dor P, Bartmann D (Ed.s), pp. 521–532.
- Ruiz-Martin C, López-Paredes A, Wainer G. (2018). What we know and do not know about organizational resilience. *International Journal of Production Management and Engineering*, 6(1), 11–28.
- Sanchis R, Canetta L, Poler R. (2020). A Conceptual Reference Framework for Enterprise Resilience Enhancement. *Sustainability*, 12(4), 1–27.
- Santos-Neto J B S D, Costa A P C S. (2019). Enterprise maturity models: a systematic literature review. *Enterprise Information Systems*, 13(5), 719–769.
- Scharte B, Hiller D, Leismann T, Thoma K. (2014). Introduction. *Resilien-Tech Resilience by Design: A strategy for the technology issues of the future* (acatech STUDY), Thoma K (Ed.), utzverlag, München (Germany), pp. 9–17.
- Stachowiak A, Pawlyszyn I. (2021). From Fragility through Agility to Resilience: The Role of Sustainable Improvement in Increasing Organizational Maturity. *Sustainability*, 13(9), 4991.
- Thoma K, Scharte B, Hiller D, Leismann T. (2016). Resilience Engineering as Part of Security Research: Definitions, Concepts and Science Approaches. *European Journal for Security Research*, 1(1), 3–19.
- Wendler R. (2012). The maturity of maturity model research: A systematic mapping study. *Information and Software Technology*, 54(12), 1317–1339.
- Zaerens, K. (2015). Business Resilient Vulnerability Analysis for Dynamic High Security Environment. 18th International Conference on Network-Based Information Systems, *IEEE*, pp. 242–249.

Copyrights

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).