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Research Article

Interrelationships of climate adaptation and organizational learning: Development of a measurement model

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Climate adaptation and learning support organizations in dealing with the current and projected consequences of climate change by recognizing challenges as opportunities, ensuring business continuity and increasing their economic efficiency. Beside material resources, climate adaptation requires knowledge, technical expertise, and learning capacity. Our contribution examines the interrelationship between climate adaptation and organizational learning, as the consideration of climate adaptation in the long term and with respect to organizational learning or realignment is still represented very little in research. Thus, we conduct a regional study to analyze to what extent the companies already have climate-related structures conducive to learning, to what extent they take responsibility in terms of the learning object (climate change), and which elements prove to be limiting here. The survey of 288 companies and handicraft companies illustrate that intangible resources such as a sense of responsibility, executives' positive attitude and common values have a significant influence on the way companies deal with climate change. Executives characterize key actors for organizational goal setting, strategic development, and functional process monitoring. The study shows that the number of climate-related measures taken increases due to higher resource capacities. As we draw conclusions about changing learning requirements, conditions, and mediums in the face of climate change, findings can provide relevant inspiration for scholars or practitioners to perceive climate adaptation as a valuable and strategic challenge to enhance the organization's resilience per se.

Keywords: Climate adaptation; Organizational learning; Corporate social responsibility; Organizational development; Organizational education

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1. Introduction

The report of the Intergovernmental Panel on Climate Change [IPCC] published in March 2022 indicates how climate change is progressing and the 1.5° Celsius target as defined at the Paris Agreement is becoming more and more distant (Pörtner et al., 2022). The associated consequences, such as increased average global temperatures and extreme weather events, are mounting and pose numerous and interrelated risks (IPCC, 2022; Bundesministerium für Umwelt [BMU], 2020).

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Since economic actors utilize energy and other resources and contribute to higher amounts of greenhouse gas emissions (BMU, 2020; Gütschow et al., 2016; Umweltbundesamt, 2022), they are required to deal responsibly and effectively with climate-related uncertainties and risks (Schönbein et al., 2020; Statista, 2020). To cope with negative impacts of climate change, there are two approaches that have a reciprocal effect: climate mitigation and climate adaptation. Climate mitigation counteracts global warming by reducing carbon dioxide emissions. Reactive and anticipatory climate adaptation works locally and includes individual measures or strategies to deal with existing and future impacts.

As climate adaptation refers to the ability and volition to cope with external changes in a constructive manner, to anticipate future developments, and to continuously adapt internal processes to these changes, there are further interrelations with organizational learning. Organizational learning supports organizations to recognize related challenges as opportunities, ensuring business continuity and increasing their economic efficiency (see Argyris, 1976; Souza et al., 2020; Orsato et al., 2017). Related to organizational learning, leadership emerges as a relevant and significant determinant of employees' behavior, commitment to changes and strategic objectives in an organization (Nerdinger, 2014). Thus, studies of climate adaptation in organizational research frequently focus on the management level, as it is crucial for resources and the implementation of strategies or organizational realignment (Daddi et al., 2018; Mahammadzadeh et al., 2013; Meinel & Höferl, 2017; Meinel & Schüle, 2018).

Studies that consider organizational learning processes related to climate adaptation usually focus on individual units, like internal publications, lifecycle management, and management level (Bianchi et al., 2021; Nicolletti et al., 2019) or examine how climate adaptation is influenced by organizational learning capacities (Orsato et al., 2017). Based on this rather specific perspective regarding service instructions or environment declarations, studies deduce to what extent the organizations surveyed, for instance, deal with the issue of climate adaptation and which approaches have been chosen so far and how.

In particular, the consideration of climate adaptation in the long term (i.e., anticipatory adaptation) and with respect to organizational learning or realignment is still represented very little in research (Orsato et al., 2017). Our contribution examines the interrelationship between climate adaptation and organizational learning. We also refer to the question of which circumstances prompt organizations to learn (Gnyawali & Stewart, 2003) or even 'force' them to learn, and which factors are conducive and inhibiting in this process. Here, it is first crucial to identify previous adaptation efforts and their organizational design, as well as the corresponding promoters and barriers. For this purpose, a regional study is suitable to accumulate concrete findings. The study maps the extent and the processes, structures and individual steps taken by companies in the investigated region to initiate or implement adaptation measures and to identify (future) needs. The following research question will be answered: *How is climate adaptation related to organizational learning processes among the investigated companies?*

In the following, we provide an overview of the theoretical background on climate adaptation and organizational learning in order to explain our methodological approach. Subsequently, Section 3 includes the research design and Section 4 and 5 describe and discuss the results related to learning as well as to inhibiting and promoting elements. In the conclusion, the results are summarized and implications for further research are identified.

2. Theoretical Background

Climate adaptation is defined as an intervention to avoid economic damages while increasing economic effectiveness (Stocker, 2014). Related strategies include both short-term interventions and strategic ones that effect comprehensive changes in organizational practices and may also support organizational resilience in general (Berkes, 2007; Bowyer et al., 2014). Therefore, climate adaptation measures take effect at different points in time: reactive measures are designed to respond to a specific challenge or event, such as offering employees free drinks and appropriate

breaks on hot days. In contrast, anticipatory measures are implemented early on, for instance by planning and constructing energy-saving buildings, including technical protective devices (e.g., installation of snow guards on roofs). Researchers worldwide record climate adaptation efforts of companies, especially manufacturing companies (see Meinel & Schüle, 2018; Linnenluecke et al., 2013; Kanyama et al. 2018; Nicoletti et al., 2019).

2.1. Key Actors within Climate Adaptation

As already mentioned, the considered studies strongly focus on the management level as it is decisive for the development and implementation of adaptation strategies (see Eggers & Kaplan, 2009). Meinel and Schüle (2018) investigated the inhibitors of anticipatory climate adaptation on the management level based on supply chains in the manufacturing sector. From a theoretical perspective, they compare their assumptions with adaptive inaction and challenges for managers. Similar to Sump and Yi (2021) and Zollo et al. (2013), they identify the barriers for anticipatory climate adaptation. Orsato et al. (2017) differentiate between utility maximizing, behavioural and institutionalist climate adaptation. The first is about maximizing benefits by alternative raw materials, services, etc. The behavioural approach is about perception and attitude in relation to adaptation and organizational realignment. The institutionalist approach, which is often taken up in research projects, is systemically oriented, i.e., adaptation dependent on social, political and economic conditions (Orsato et al., 2017). Similar to Orsato et al. (2017), we emphasize with our results the need for a systemic approach which refers to an adaptation that is consistent with direct (physical, human), and indirect (economic, regulatory) climate impacts. Profound climate adaptation is characterized by the fact that it is a continuous process and that it takes place in a systemic way, which means involving the organization and its internal and external environment. However, this strategic idea also requires the capacities for it, i.e., awareness for innovation, resources to carry out technological and structural changes and, in particular, fostering internal and external transfers of experience and knowledge. It is also a matter of the extent to which the organizations in general have capacities for learning and how existing processes, knowledge and structures can be changed. These properties can be transferred to organizational learning, as explained in the next paragraph.

2.2. Brief overview of Guiding Concepts of Organizational Learning

In the face of disruptive external change, the interest in learning in, by, and among organizations (Göhlich et al., 2018) within the scientific discourse is growing (Weber et al., 2011; Easterby-Smith & Lyles, 2003) as learning in organizations serves their continued existence, development, performance, and competitiveness (Cömlek et al., 2012; Feld & Seitter, 2018; Kim, 2021; Marsick & Watkins, 2003; Nicolletti et al., 2019; Souza et al., 2020). Especially, the German Organizational Education focus on organizational learning is increasing with interdisciplinary research (e.g., business studies, social sciences, psychology) and works by March and Olsen (1975), Argyris and Schön (1997), Nonaka and Takeuchi (1995) and Senge (1990) at the beginning of the 1990s, as Göhlich (2018) states. The initial position here is the consideration of organizations as complex social entities (Weber et al., 2019) which are confronted with highly dynamic changes of external environments. Organizations have to face unpredictable challenges and risks to maintain their efficiency and to ensure their economic existence.

According to Luhmann's system Theory (1994) an organization represents a closed system that operates independently and follows its own logics and models of meaning which constantly recreate themselves. In this system-theoretical approach, 'system' and 'environment' are differentiated and the analysis of organizations is carried out holistically corresponding to the habitus, the actions, the members, and the environment, which are all in a reciprocal relationship to each other. Consequently, the conglomerate of these interrelationships, decisions, communication, values, rules, and other determinants of impact constitutes organizations. Such a perspective also makes it difficult to develop a unified concept of organizational learning, as the

implicit and explicit learning processes cover the entire set of impact relationships and are difficult to reduce to single 'factors' or 'impulses'.

With a behaviourist understanding of learning, i.e., a behavioural change as a result of external stimuli (Göhlich et al., 2018), March and Olsen define organizational learning as an adaptation process. Organizations learn from experiences which they observe, reflect and modify for subsequent actions (Göhlich et al., 2018). Further, Senge's 'Fifth discipline' guides many modern management theories and it is more applicable than other learning theories (Göhlich et al., 2018). Referring to systems thinking, Senge defines learning as a rethinking process. Here, he indicates the five core disciplines of personal mastery, mental models, shared vision, and team learning (Schlüter, 2018; Senge, 1990; Souza et al., 2020). His assumption is that organizational learning is initially a theoretical construct or vision which is driven by organizational members in a processual manner by evolving successively to achieve their goals (Schlüter, 2018).

In the organizational learning process, specific changes in mental models - in which processes, structures, and actions are processed reflexively and mimetically - are more appropriate (Göhlich & Zirfas, 2007). However, the measurability of such initially incidental changes and knowledge (see Marsick & Watkins, 2003; Nonaka & Takeuchi, 1995) is complex and may be deficient.

2.3. Measurability of Organizational Learning

There is a variety of questionnaires in the literature to operationalize organizational learning, but there is no measurement model based on indicators of organizational learning with regard to climate-relevant measures. In general, due to the multitude of interactions and influencing factors, organizational learning is difficult to measure and to consider in absolute terms. One validated model is the 'Dimensions of Learning Organization Questionnaire' [DLOQ] by Marsick and Watkins (2003) in order to measure learning organizations and derive strategies to develop the organizational learning culture. The model relates to several indicators defined by Marsick and Gephart (2003) that an organization needs to adapt in an integrative and effective way to dynamic organizational environments (Delios & Beamish, 2001). Beside the underlying organizational conditions, Marsick and Gephart (2003) list internal and external communication, innovativeness, collective learning, and the accumulation of knowledge and expertise as core elements.

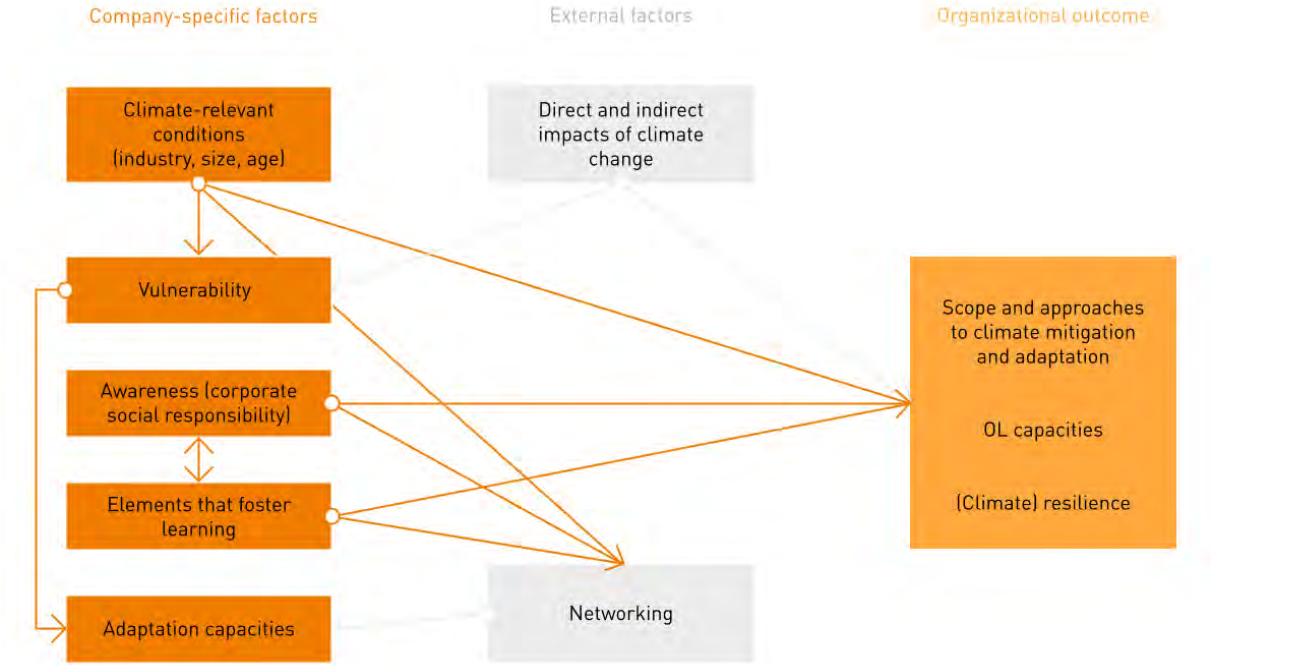
According to the DLOQ (Marsick & Watkins, 2003), we operationalized seven guiding latent indicators of organizational learning related to climate adaptation in our developed measurement model (see Section 3.2, Table 2): innovation, error management culture, corporate culture, leadership, collaborative learning, external support, and responsibility. Here, the dimension 'Innovation' refers to the requirement to analyse external change with market-regular changes and product and service demands,that and to adapt dynamically. Dealing with errors is of major relevance for organizational development processes and their individual innovativeness (Fischer et al., 2018). Internally, for example, a constructive error culture should be cultivated along with flat communication systems that can be used to share needs, requirements for change, and error-and-learning experiences with executives and employees. The scale 'Learning through others' is designed to show the extent to which the companies are oriented toward similar or foreign companies and have already introduced external impulses from third parties such as authorities and experts. In addition, it should be assessed how important the basic exchange with other companies is with regard to the company. The scale 'Shared vision', adopted from Lloria and Moreno-Luzon (2014) deals with a shared point of view within the company and a common understanding on climate-related goals and actions. As mentioned above, executives are responsible for setting corporate goals, developing strategies, and monitoring functional processes, as they play a key role in deciding how to use resources. The scale 'Knowledge accumulation', modified from Moreno-Luzon (Lloria & Moreno-Luzon, 2014), should map the extent to which companies have (personnel, technical, organizational) structures in place to exchange knowledge and experience interdisciplinarily. Here, it is also necessary that learning experiences are documented and made available to all employees to increase organizational learning. Further,

knowledge sharing can be one of the key elements to identify in-house barriers and address divergent perceptions and weighting of climate change. Organizational learning implies the integration of individual knowledge and experience (Gherardi, 2013). 'Participation' implies involving concrete knowledge, experiences, and needs of employees in application-oriented strategies rather than just following the top-down approach.

Additionally, in order to take up the expert interviews published in the pre-study (see Fischer et al., 2020; Appendix 2) and to verify conducted statements deductively, we developed the following conceptual model. The model maps that climate-related changed economic framework conditions lead to a necessity of adaptation and increased demands for learning capacities to sustain an organizational development. Furthermore, it illustrates the internal and external impact factors related to organizational adaptation. As we aim to map the interrelationships of climate adaptation and organizational learning, we only analyze elements of organizational learning within the dynamics of climate adaptation. Based on the literature, and the expert interviews analysed according to the Grounded Theory methodology (published in Fischer et al., 2022, we developed a conceptual model to illustrate internal and external factors influencing organizations in the face of climate change (see Figure 1).

Figure 1

Conceptual model of the relationship between internal and external drivers in dealing with climate change



Note. Own figure based on expert interviews (Fischer et al., 2022) and literature (Ameling et al., 2012; Bianchi et al., 2021; Hurrelmann et al., 2018; Kind et al., 2015; Mahammadzadeh et al., 2013; Orsato et al., 2017).

Primarily, the model in Figure 1 illustrates that although organizations are initially confronted with different framework conditions, they increasingly have to deal with direct and indirect effects of climate change. The framework conditions such as the number of employees and turnover, but also intangible influencing factors such as organizational awareness or the attitudes of executives are crucial for the strategic integration of the topic of climate change within an organization. The model includes elements such as capacity and vulnerability as well as enabling factors such as awareness, networking with third parties, and structures conducive to learning. The arrows illustrate the individual interactions that lead to the hypotheses listed below which are related to the derived dimensions and scales of the measure model (see section 3.2). The hypotheses include intangible aspects of climate adaptation which, according to the literature and the expert interviews, have an increased influence on dealing with climate change of organizations. Primarily, the focus is on the extent to which the companies and handicraft companies studied

have structures that foster learning, i.e., the extent to which the derived scales are pronounced (see Section 4, Table 3).

H1: A positive climate-related attitude of executives corresponds with climate-related structures conducive to organizational learning.

H2: Structures conducive to organizational learning correspond with the adaptation capacities of companies and handicraft companies.

H3: Executives and structures conducive to learning have a positive influence on the adaptation capacities of companies and handicraft companies.

Our brief theoretical outline serves as a starting point for our subsequent analyses and development of a measurement model to identify climate-relevant indicators of organizational learning. We aim to map the interrelationships of elements of organizational learning and climate adaptation strategies and awareness with a quantitative survey. The results should provide an overview of relevant organizational units and approaches to change thinking and behaviors among economic actors. Furthermore, theorists and practitioners could use the identified fields of actions in order to deal with opportunities related to increasing the organization's resilience towards external crises.

3. Method

Since climate adaptation has to take place on a local level and in each organization separately, our analysis considers companies and handicraft companies in a strongly industrialized Bavarian region where the average warming rates are already above the national average (Rauh & Paeth, 2011). Thus, we analyze to what extent the companies in the examined region already have climate-related structures conducive to learning, to what extent they take responsibility in terms of the learning object (climate change), and which elements prove to be limiting here. Moreover, we examine how far the issue of climate change is being incorporated in a strategic manner and which inhibitions and limitations affect this kind of organizational change process.

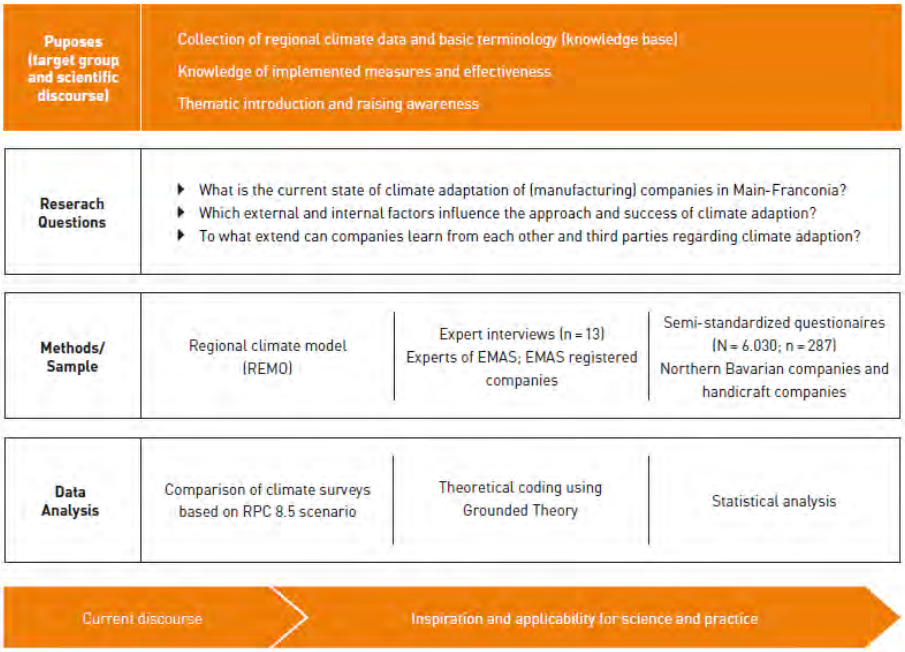
3.1. Research Design of the Regional Study

To answer our research question, we conduct a regional study which is nourished by triangulating methods through results from regional climate data, expert interviews, and semi-standardized questionnaires, see Figure 2. The expert interviews and the questionnaires were collected from June 2021 to January 2022. Since the results of climate models and expert interviews were published within a pre-study (Fischer et al., 2022), we exclude the climate data and only briefly refer to the findings of the expert interviews.

3.2 Measurement Model and Analysis

After pretesting, the data of 288 manufacturing/non-manufacturing companies and handicraft companies (see Table 2) were analyzed using the mean value of a scale together with a reliability analysis (Cronbach's alpha) to determine how reliably a scale (Risher & Hair Jr, 2017) represents a variable, see Table 1. According to Taber (2018), it was considered that Cronbach's alpha (α) must be above 0.7 to have a reliable value (Table 1). Afterwards, we recoded each scale into a binary variable (agree and disagree) to obtain a concise tendency. Further, we used selected significance tests such as Pearson's R and multiple regression to test individual hypotheses. The interpretation of the Pearson coefficient states that -1.0 indicates a strong inverse relationship, 0 no relationship and +1.0 a strong direct relationship between the variables (Merthler et al., 2021). Due to a target group-specific design (in terms of length and items), fewer scales were asked for the handicraft companies. For the manufacturing and non-manufacturing companies, a questionnaire with 39 items, including three filter questions, was constructed (see Appendix 1). The version for the handicraft companies contains 22 questions with two filter questions. The questionnaire for the handicraft companies included the same questions and structure in compact form.

Figure 2
Conceptual research design of the underlying regional study



Note. The results of the expert interviews are available in Fischer et al. (2022) and the descriptive results of the regional study are published in Fischer & Schmitt (2022).

The main approach with regard to the conceptual model (see Section 2, Figure 1) was to adopt the dimensions of Marsick and Watkins (2003) that relate to organizational learning. Based on this, we selected existing scales from the literature that focus on climate-relevant topics and modified them according to the dimensions of Marsick and Watkins (2003). The questionnaire developed in this way aims to investigate the extent to which the companies surveyed have aspects that foster learning and whether these aspects that foster learning are also perceived and used in relation to climate-relevant issues (see Table 1). The collected questionnaires were first analyzed descriptively by means of the software for statistical analysis SPSS (see Fischer & Schmitt, 2022). For this purpose, the data sets were first exported and cleaned. Invalid answers were marked and the free text answers were sorted. Variables that are supposed to represent latent characteristics such as climate awareness were combined into a scale using the averaging procedure. The reliability analysis (Cronbach's alpha) was used to check how reliably this scale represents a variable, this way individual questions (items) could be omitted if necessary. After all the question and answer formats were available in accordance with the required data level, the descriptive data were first evaluated. Subsequently, the hypotheses were tested by using the correlation according to Pearson and the multiple regression.

3.3 Data Collection and Sample

We selected a probabilistic sample with companies and handicraft companies located in the northern Bavarian region, see Table 2. Here, small companies are classified as having up to 49 employees and a revenue of up to 10 million euros. Medium-sized companies have up to 249 employees and revenues of up to 50 million euros (see Günterberg & Wolter, 2002). In cooperation with leading professional associations, we could access a total of 6,030 member companies and handicraft companies from all economic sectors represented in the region. After a six-week data

Table 1
Construct and scales of organizational learning related to climate change

Construct/Scale	*Adopted and modified from / Items*	*Reliability*
Innovation	Çömlek et al. (2012)	
Openness to technology	6.1.a) We explore relevant technological trends regularly 6.1 b) We are open to new technologies / business practices 6.1.c) We have concrete functional units / processes to analyze technological trends 6.1.d) We start to implement new technologies measures immediately after the evaluation	alpha = 0.8 (very good)
Error management culture	Lloria and Moreno-Luzon (2014); Iqbal and Ahmad (2021)	
Coping with failures	7.2.a) Errors will be analyzed and communicated to all employees 7.2.b) Errors are considered as constructive learning experiences 7.2.c) We foster a positive error culture 7.2.d) Our management admits and communicates its own mistakes	alpha = 0.9 (excellent)
Collaborative support	Lloria and Moreno-Luzon (2014)	
Learning through experiences	7.2.e) We derive our own need for action from crises experienced by other companies 7.2.f) We use our experience from past crises in dealing with climate change	alpha = 0.72 (acceptable)
Corporate culture, Leadership	Lloria and Moreno-Luzon (2014)	
Shared vision	8.1.a) We consider a common point of view as important 8.1.c) We have a common understanding of climate-related objectives across the entire company	alpha = 0.83 (very good)
Attitudes	8.1.d) Our leadership/management level addresses and communicates the need for climate-related action internally	
Collaborative learning	Lloria & Moreno-Luzon (2014) 8.1 b) We regularly exchange knowledge and experience (e.g. within working groups)	alpha = 0.7 (acceptable)
Knowledge acquisition	Nicoletti et al., (2019); Marsick and Watkins (2003) 8.1.e) We have specific contact persons / functional email addresses etc. to whom employees can communicate their ideas	
Incentive systems	8.1.f) We have concrete incentive systems (e.g. prizes) to motivate employees to communicate their ideas	alpha = 0.83 (very good)
Information and knowledge management	8.1.g) We document knowledge / learning experiences Information and knowledge management and make it available internally to all (e.g. in newsletters, annual report) 8.1.h) We have concrete processes / databases to make collected knowledge accessible internally	

Table 1 continued

Construct/Scale	*Adopted and modified from / Items*	*Reliability*
External support	Lloria & Moreno-Luzon (2014)	
Learning through others	9.1.a) We orient ourselves in climate adaptation to companies from the same sector	
	9.1.b) We orientate ourselves in climate adaptation to companies from other sectors.	
	9.1.c) We are networked with other companies and / or exchange information regarding climate change	alpha = 0.84 (very good)
	9.1.d) We have / plan cooperations with institutions (e.g. research field) to learn more about the issue	
	9.1.e) We integrate external impulses into the development of processes / products / services.	
Responsibility	Montada et al. (2014)	
Corporate social responsibility	10.2.a) Our company is open to obtain information about environmental problems (e.g. air pollution)	
	10.2.b) Our company is open to actively seek new scientific knowledge about the extent of and solutions to environmental problems.	alpha = 0.93 (excellent)
	10.2.c) Our company is open to invest in the installation of environmentally friendly equipment (e.g. photovoltaics)	
	10.2.d) Our company is open to spend more money on products / raw materials / services if they are produced in a more sustainable way than comparable products / raw materials / services.	

Note. The table derived from the expert interviews and reference literature (Cömlek et al., 2012; Lloria & Moreno-Luzon, 2014; Montada et al., 2014; Nicolletti et al., 2019). After pretesting, item reliability (Cronbach's alpha) was tested and optimized. Own table, conceptual idea adopted from (Teo et al., 2006)

288 valid questionnaires were evaluated. The response rate of our study is 4.8 %. According to the studies considered (see Tuten et al., 2002; Theobald, 2017), the response rate of online surveys ranges around 33% and is determined by several variables. However, we used several approaches to achieve the highest possible response rate, including advance announcements, reminder e-mails, simple design of the questionnaires and short processing time (12 minutes). Nevertheless, empirical access depends on the motivation of the sample and the questionnaires probably did not reach as many companies as originally assumed.

Table 2
Demographic data on companies ($n = 133$) and handicraft companies ($n = 155$)

	Companies	*Valid*	*Handicraft companies*	*Valid*
	Number	%	Number	%
Category				
Non-manufacturing	80	59.7	-	-
Manufacturing	52	38.8	-	-
Company age				
≤ 5 years	6	5.9	-	-
> 5 years	94	93.0	-	-
Size				
Microenterprise	19	18.8	81	64.3
Small company	19	18.8	-	-
Midsize company	24	24.0	32	25.4
Large company	37	37.0	8	6.4
Up to 100,000	-	-	14	11,1
100,000 to 250,000	-	-	25	19.8
250,000 to 500,000	23	22.7	15	11.9
< 2 million			-	-
2 to 10 million	17	17.0	33	26.2
10 to 50 million	18	18.0	-	-
> 50 million	33	33.0	-	-
Owner	49	49.0	118	76.0
Third-party	46	46.0	25	16.0

Note. The percentages refer to the number of responses in each case and vary in the range between n = 111 and n = 126, own table. The estimated total number of companies and handicraft companies requested indicates a response rate of 4.8%. As shown in Table 1, 80 non-manufacturing companies, 52 manufacturing companies and 155 handicraft companies were questioned.

4. Results

The examined companies and handicraft companies increasingly have to deal with direct and indirect effects of climate change. In both groups, heat, heavy rain, floods, and high tides were the most frequently cited impacts. Analysis of the regional climate model REMO also shows that the average temperatures will increase further (Fischer et al., 2022). Apart from the direct impacts, the increase in the cost of raw materials and other resources or entire failures within the supply chain are recorded most frequently across the entire sample. However, it cannot be clearly determined whether these impacts are caused by climate change or other crises or shortages. Regulatory requirements imposed by politicians are also perceived and concern larger companies on a slightly larger scale. Generally, there are also considerable market-regulatory fluctuations and changes in market demand.

Based on the relevant dimensions derived from literature and the expert interviews (see Fischer et al., 2022), the aim was to draw implications for existing learning and adaptation capacities. As shown in Table 3, we map the results using the mean (M) and standard deviation (SD).

Table 3
Mean values, standard deviation and number of cases (n) for the scales queried for manufacturing (M), non-manufacturing (NM), and handicraft companies (H)

	Companies	*Valid cases*	*SD*
Innovation			
Technology openness	M/NM	3.0 (n = 113)	1.0
	H	3.0 (n = 113)	1.2
Error management culture			
Coping with failures	M/NM	2.5 (n = 106)	1.0
	H	2.4 (n = 114)	1.0
Collaborative support			
Learning through experience	M/NM	2.9 (n = 105)	1.0
Shared vision	M/NM	2.7 (n = 86)	1.2
Participation	H	3.0 (n = 112)	1.4
Executives			
Attitudes	M/NM	2.8 (n = 96)	1.3
	H	2.9 (n = 106)	1.4
Collaborative learning			
Knowledge accumulation	M/NM	3.0 (n = 100)	1.3
Incentive systems	M/NM	3.2 (n = 99)	1.7
Information and knowledge management	M/NM	3.0 (n = 88)	1.2
External support			
Learning through others	M/NM	3.1 (n = 102)	1.2
	H	2.1 (n = 127)	1.0
Awareness			
Corporate social	M/NM	2.5 (n = 133)	1.0
responsibility	H	3.1 (n = 112)	1.3

Note. A six-point Likert scale (1 = strongly agree to 6 = totally disagree) was provided and supports mean averaging through the symmetrical response format, own table.

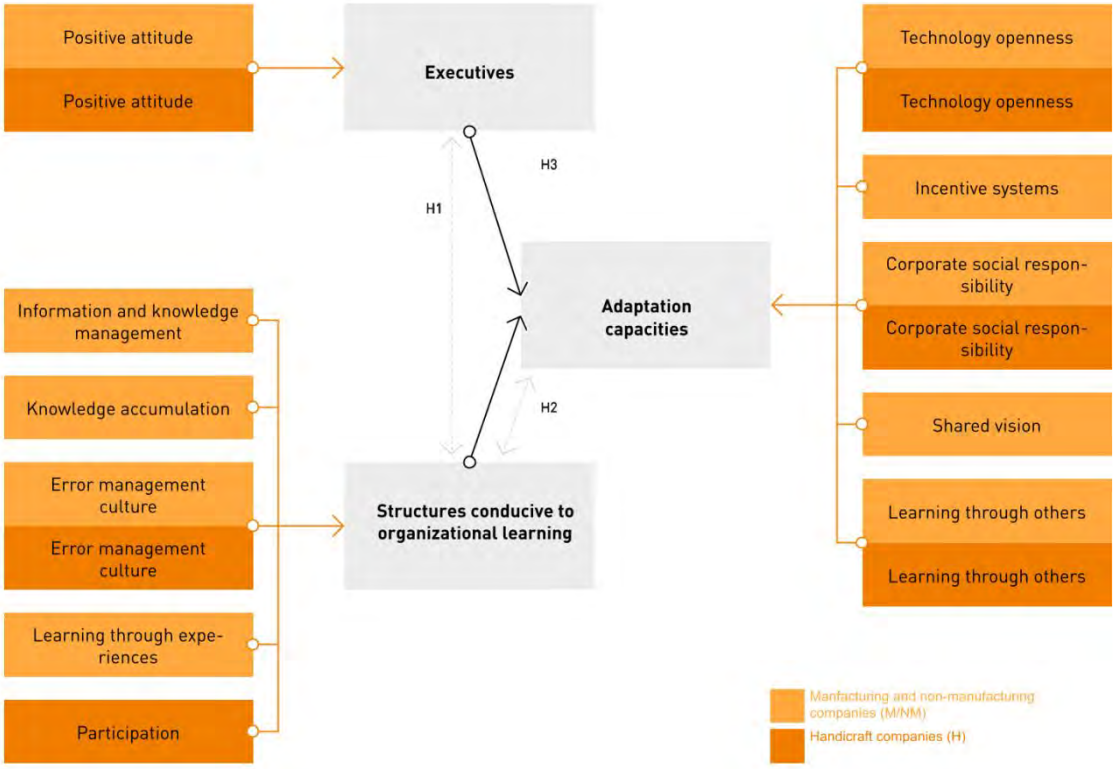
Our findings indicate that adaptation can occur in individual areas or behaviors. An example of this are executives who serve as role models or inspire restructuring of processes. Climate adaptation constituted as an organizational learning process requires the involvement of executives and management, individuals and teams, internal and external networks, work resources and processes, and organizational culture. As presented in Table 3, the mean values of learning-enabling elements in terms of climate adaptation are similar between companies and handicraft companies, except for minor differences in 'Coping with failures' and 'Corporate social responsibility', where the handicraft enterprises are weaker. The results show that the companies and handicraft companies surveyed already have climate-relevant structures in terms of learning, knowledge transfer, motivation, and participation. However, the values around 3.0 show that these structures are only moderate and that there is still potential for further improvement.

Besides analyzing the maturity of climate adaptation and the available capacities, we tested hypotheses for companies and handicraft companies to investigate the correlations between indicators that support organisations to deal with climate change (see Figure 3). Here, the variables 'Executives' and 'Structures conducive to organizational learning' among the manufacturing and non-manufacturing companies show a significantly strong positive correlation ($r = 0.716$; $p \leq 0.001$). Thus, the alternative hypothesis H1 is accepted which states that there is a positive relationship between executives attitudes and structures conductive to organizational learning. Furthermore, a significant and positive correlation of the two variables can be noted among the handicraft companies ($r = 0.594$; $p < 0.001$). Accordingly, H1 supports the assumptions from the expert interviews and the literature that executives have an important influence when it comes to providing appropriate work environments and structures conducive to learning in organizations. Here, these structures have to be designed comprehensively to enable learning at both the

individual level and the organizational level. Beside their function as role models and their functional responsibility, executives contribute to the employees' ability to participate in the work process in accordance with their abilities and potentials. In particular with regard to climate adaptation, the integration of all the existing information, knowledge and experience is advantageous in order to develop specific and practice-oriented concepts.

Figure 3

Visualization of the independent (Executives; Structures conducive to organizational learning) and dependent variables (Adaptation capacities) and the related hypotheses 1-3



Note. All results and variables for the companies (M/NM) and handicraft companies (H) are differentiated by colour.

Further, the second alternative hypothesis (H2) also points to a significant strong positive correlation between the variables 'Structures conducive to organizational learning' and 'Adaptation capacities' ($r = 0.828$; $p < 0.001$, see Figure 3). Accordingly, it is assumed that structures conducive to organizational learning correspond to structures that contribute to climate adaptation and basically should be considered for any change management processes collectively rather than individually. For this reason, an organization should analyze and adapt structures that serve the learning, development and change of an organisation as an entire unit holistically rather than only with regard to a single occurrence that could present itself, for example, as a result of climate change. Among the handicraft companies, we find a very weak positive correlation that is not significant; this means that the alternative hypothesis is rejected. It is unclear to what extent the result is due to statistical irregularities and it is important to consider that correlation analyses do not provide information about the causality of interrelationships.

The last hypothesis (H3) was tested by multiple regression using SPSS, with interpretation of the constant, the Anova and the coefficients (coef), see Table 4. For the companies, the model shows significant explanatory quality and the regression of $R^2 = 0.887$ can explain 88.7% of the dispersion of the dependent variable 'Executives' H3 ($R^2 = 0.887$; $p < 0.001$; $coef_1 = 0.187$; $coef_2 = 0.680$). The assumed alternative hypothesis indicates that leadership and organisational structures conducive to learning positively influence the assessment of the companies' adaptation capacities. For the handicraft companies, too, the model has a significant quality and indicates that managers have a significantly positive influence on the dependent variable, whereas 'Structures

conducive to organizational learning' have a non-significant negative influence on the dependent variable (see Table 4). Accordingly, the third alternative hypothesis is also accepted for the handicraft companies.

Table 4
Results of the regression analysis differentiated in manufacturing / non-manufacturing companies and handicraft companies

	N	*β*	*SD*	*p*	*R*
Manufacturing/Non-manufacturing companies	106			<0.001	0.887
Executives		0.187	0.050		
Structures conducive to organizational learning		0.680	0.068		
Handicraft companies	118			<0.001	0.262
Executives		0.137	0.054		
Structures conducive to organizational learning		−0.42	0.064		

Consequently, the hypothesis tests indicate that, in general terms, there is a strong correlation between learning and adaptation and that the two concepts cannot be considered separately. Rather, it is important to focus on the enabling and inhibiting elements in learning and adaptation processes, these will be discussed further in Section 5. First of all, relevant indicators are compared with the scope of measures implemented by companies and handicraft companies.

Furthermore, the questionnaire for companies contained parts with questions on general, constructional and technological climate-relevant measures (multiple-choice answer). Generally, companies applied an average of M = 5.8 (n = 111) measures. Those companies that already experienced damage costs due to climate change (n = 23) implemented a mean of M = 7.5 of those listed. Small and medium-sized companies implemented an average of M = 2.2 and M = 2.6 of the nine measures listed, while large companies implemented an average of four measures. Finally, the binary variables formed in each case for the indicators conducive to learning should be compared with the total number of specified measures for climate mitigation and adaptation among the companies and handicraft companies (see Table 5).

Table 5
Derived indicators conducive to learning, which were recoded into binary variables, versus mean measure volume of companies (total of 25 measures) and handicraft companies (total of 9 measures) by cross-tabulation, own table

		Measures taken (mean value)	
Dimension	*Type*	*Agreement*	*Disagreement*
Technology openness	N/NM	6.1	3.1
	H	2.5	2.5
Error management culture	N/NM	5.8	4.0
	H	2.5	2.5
Shared vision	N/NM	6.7	5.1
Participation	H	2.5	2.5
Knowledge accumulation	N/NM	7.1	4.6
Learning through others	N/NM	6.9	5.2
	H	2.5	2.0
Corporate social responsibility	N/NM	6.7	1.6
	H	2.5	2.5

The ratios show concisely that companies that agree to possess the questioned structures conducive to learning realize more of the measures than companies that reject the issue. This result underlines the link between structures conducive to learning and the extent of climate mitigation

and adaptation measures. The average measures taken by handicraft companies in terms of agreement and disagreement with OL indicators are nearly identical. Here, it is necessary to discuss how far this result corresponds to reality or indicates irregularities in the data. These and other considerations of the results are discussed below in combination with answering our research question.

5. Discussion

Organizational learning is based on learning and knowledge from members who know more than the organization itself. This is due to the fact that most actions and decisions are driven by the implicit knowledge of the members (Argyris & Schön, 1997; Nonaka & Takeuchi, 1995). It becomes apparent that organizational learning occurs through an interplay of learning objects, learning agents and various modes. Focusing solely on learning from a cognitivist perspective leaves out content-related aspects such as ability learning, life learning, and learning to teach (Göhlich et al., 2018). Even the initially simple adaptations of behaviors (see single-loop learning) are not sufficient to promote strategic learning constitutions. However, the measurability of such initially incidental changes and knowledge (Nonaka et al., 1995; Marsick & Watkins, 2003) is complex and may be deficient as there are many factors influencing organizational learning, different learning agents, and changing learning objects. Furthermore, learning agents are not often aware of which point they learn and to what extent they assume responsibility for the learning object. Hence, we identify influencing factors that affect scope, decisions and climate-related attitudes based on our conceptual model derived from literature. By means of different dimensions, the regional study maps to what extent and by means of which processes, structures, and projects the investigated companies and handicraft companies anchor the issues of climate mitigation and climate adaptation in a strategic manner.

5.1 Community and Practice

By considering the interdependence between adaptive capacities and structures conducive to learning, it becomes apparent how important it is to establish a workplace environment where all the employees can participate with their decisions and experience as well as integrate their individual skills and needs into the operating processes, as also identified by Marsick and Watkins (2003) or Lloria and Moreno-Luzon (2014). Similarly, the networks and friendships between organizational members and stakeholders in the process are relevant to organizational learning (Rupic, 2018). Generally, the establishment of a positive error management culture is crucial (Fischer et al., 2018). This kind of culture promotes the discussion of misguided measures (maladaptations) or deficiencies in the implementation of new measures and the overall communication about collected learning experiences between employees. This is essential to make good use of employees' skills, as they are often confronted with concrete, climate-related challenges during their daily work. When a sustainable error management culture considers errors as constructive learning experiences, employees stay motivated to contribute ideas and make suggestions for strategies in their work areas. Besides, specific incentive systems could encourage employees and convince them of the relevance of the topic. Dedicated members of an organization develop a common framework in which they mutually influence their decisions and actions, benefit from their collective experience, and cooperatively address challenges.

5.2 Importance of Executives and Corporate Social Responsibility

As the findings indicate, executives characterize key drivers for organizational goal setting, strategic development and functional process monitoring. Climate-conscious companies or handicraft companies usually named executives, their own employees and social demands as drivers of their adaptation measures which were implemented accordingly on a larger scale. It must also be considered that, in addition to their more developed awareness, these types of companies usually also utilized scientific sources and links with third parties (companies and experts) in their strategies and target development. According to the Institute for Ecological Economic Research (2012), the general climate-related availability of knowledge and data through extensive communication media is very good. Despite this, there are gaps between the companies surveyed in terms of their ability to draw on this information and involve it in strategy development. Here, knowledge sharing can be one of the key elements in identifying internal

barriers and addressing the divergent awareness and importance of issues related to climate change.

The consideration of executives for fostering organizational learning processes is important insofar as executives are instructed to activate and motivate employees to participate in change processes and to actively integrate their climate-relevant knowledge and experience into those change processes. Furthermore, executives are responsible for the individual encouragement of employees (see Michel et al., 2014), whether it be further training or the implementation of focus groups where employees can learn from each other and benefit from each other's experience.

5.3 Innovation and Technologies

Our analyzes also indicate correlations between the openness to technologies and the measures implemented. Openness to technologies, technological trends and innovative business methods, as well as the ability to try out new methods and measures, are considered as criteria for organizational learning (Castro et al., 2013; Lopez-Cabrales, Real, & Valle, 2011; Marsick & Watkins, 2003; Nicolletti et al., 2019). Within the companies and handicraft companies, this kind of innovativeness is only moderately developed. An open mind regarding these issues generally might support the organizations' adaptability in terms of the rapidly growing market for green tech, the increasing need for self-sufficient energy supply, and the requirement to increase energy and resource efficiency in economic processes. Further, the respondents are aware that corporate strategies can still be optimized in terms of climate mitigation and corporate sustainability (Fischer et al., 2022). In addition, the general awareness regarding their role of responsibility is certainly more pronounced. This awareness represents an essential point of departure for scientific and political institutions to bridge the mentioned gaps among economic actors with targeted offers and to increase the motivation to take action. In this context, climate-related and reliable corporate communication structures are significant factors for addressing climate-related issues in a more comprehensive, 'institutionalized' manner (Mahammadzadeh et al., 2013).

5.4 Corporate Culture

The corporate culture with historically grown values and jointly developed visions also plays an important role in the adaptation process (related to a behavioral approach, see Orsato et al. (2017)) together with learning and adaptation capacities (Mbah et al., 2021). A corporate culture constitutes an organizational reference system which contains values, guiding principles, behaviors, patterns of thinking, and rules and orders of a company (Hentze et al., 2005). It is also changed by leadership and at the same time shapes the extent to which values, mission statements, and convictions are reflected (see Park & Kim, 2018) and involved into leadership behavior. In this respect, the present study does not provide more precise ratios, an aspect that must be supplemented by subsequent projects.

5.5 Immaterial Learn and Adaptation Capacities

The study shows that the number of climate-related measures taken increases in proportion to the company's size, which is likely due to higher resource capacities. Further, although the difference between manufacturing and non-manufacturing companies in terms of measures taken is not significant, it is evident that some measures are carried out primarily by larger companies. This applies, for example, to the restructuring of working conditions such as modified work schedules, areas of responsibility, and further training opportunities and can be justified by a greater capacity to finance such measures as well as by an existing scope for testing and adapting measures for their effectiveness. It seems obvious that companies with corresponding functional positions that deal solely with climate-related issues have an advantage.

We assume that climate change is an ongoing challenge for organizations and that reactive adaptation will be less effective than anticipatory adaptation, this requires a shift in attitudes and awareness (Iturriza et al., 2020) and profound changes in economic activities. In this process of climate adaptation, all members of the organization are required to contribute their experience, knowledge, and motivation to cooperatively strengthen the organization in the face of climate change, i.e., to increase its resilience. Thus, the goal for the companies studied in climate adaptation must be to increase their ability and capacity to learn to be competitive and to ensure long-term viability despite all the challenges outlined above. Increased adaptive capacity can be used to develop the organizational resilience necessary to meet these challenges. Here, climate adaptation can begin in individual areas of an organization, for example with initially simple

measures such as establishing a climate-relevant function. Beyond that, concrete structures must first be created to enable internal and external exchange, management must act as a role model and assume responsibility, employees must be motivated to transparently communicate their knowledge and experience, and mistakes must be shared. Climate adaptation needs to be carried out in a systemic way to foster an organizational learning process that strengthens organizations to deal constructively with other uncertainties and challenges.

With respect to the research question, the results illustrate that the entire sample already deals with climate change and that intangible factors such as a sense of responsibility, leadership's positive attitude and common values (see Orsato et al., 2017) have a significant influence on the way companies deal with climate change. One limiting factor here is that it cannot be clearly distinguished whether the structures conducive to learning, such as a positive error culture, innovation openness, and an external network, are merely attributable to the issue of climate adaptation or are part of the fundamental 'organizational set-up'. Thus, companies examined do have structures and processes in place for deriving climate-relevant topics, tasks and goals, assigning them to specific functions and modifying them for specific purposes, although these values are merely mid-range. A comparison with the relevant literature shows that climate change is a difficult topic to differentiate and that it is more important to examine companies in terms of their resilience to a highly dynamic economic environment.

6. Conclusion

With increasing regulatory requirements regarding emission levels and the use of renewable energies, public pressure on companies to strategically integrate issues such as sustainability and climate mitigation into their processes is growing immensely. According to the derived measuring model and the hypotheses outlined, the extent to which adaptation to climate change takes place within an organizational learning process was surveyed. A limiting condition is that no terminological differentiation was made between climate mitigation and climate adaptation since it cannot be assumed that all respondents are aware of the two concepts. Thus, our research focuses on the question to what extent companies and handicraft companies prepare themselves to strengthen their resilience in the face of climate change and the forecasted uncertainties. Here, it is equally applicable that only tendencies and elements of organizational learning can be examined. As the systemic analysis of organizational learning or even learning organizations is highly complex due to the many influencing factors, levels and implicit learning mechanisms or knowledge contents, it requires mixed-methods and rather ethnographical accesses. Hence, our study is limited to indicators of organizational learning related to climate adaptation.

Climate adaptation refers to local climatic conditions that diverge from those in other regions and countries. Thus, standardized guidelines, such as global adaptation strategies, are not suitable. Especially the indirect effects of climate change represent a challenge for companies. The results of our study can be applied to various organizations, regardless of how far climate change has already progressed in their respective environment. Undeniably, organizations around the world will have to adapt to the global climate change, starting by analyzing their conducive and inhibiting conditions. After all, as our contribution underscores, organizational learning supports organizations in sustaining their existence and operating effectively. Like the coronavirus pandemic or the war of aggression against Ukraine, climate adaptation can constitute an externally incisive event that 'forces' organizations to restructure and strengthens them to be sustainable in the long run. However, an organization can only be effective long-term if it establishes structures that foster learning processes and is not just reacting to an occurrence.

Our findings show that executives can be decisive in determining which material and immaterial resources can be used to support organizational learning processes. Further, empirical research therefore should examine individual attitudes, framework conditions and learning requirements of executives and highlight how executive development can be used to enable executives to think and act in a more climate-conscious way. In our subsequent research, we are developing a business game specifically for this purpose. Using this constructivist approach in game development, the experiences and educational needs of the target group (functional leaders of organizations) will be integrated.

As economic conditions and certain uncertainties of climatic trends and the emergence of natural disasters or extreme events illustrate, dealing with climate change will be obligatory for all actors within economic and ecological systems in the future. In this context, those actors who address their preconditions, opportunities and risks at an early stage and possess structures and

capacities for strategic learning processes will enhance their climate resilience by reducing their vulnerability to uncertainties.

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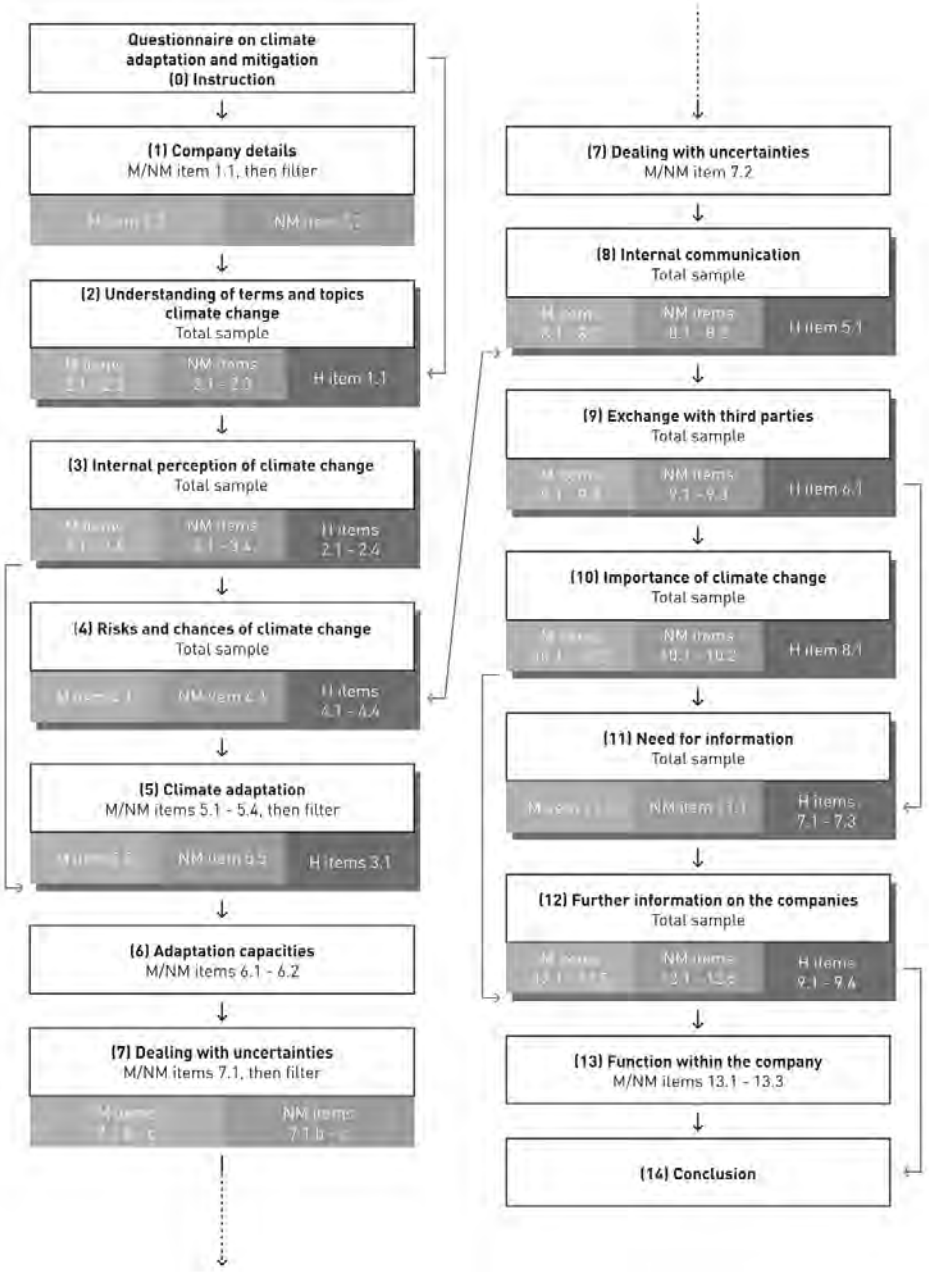
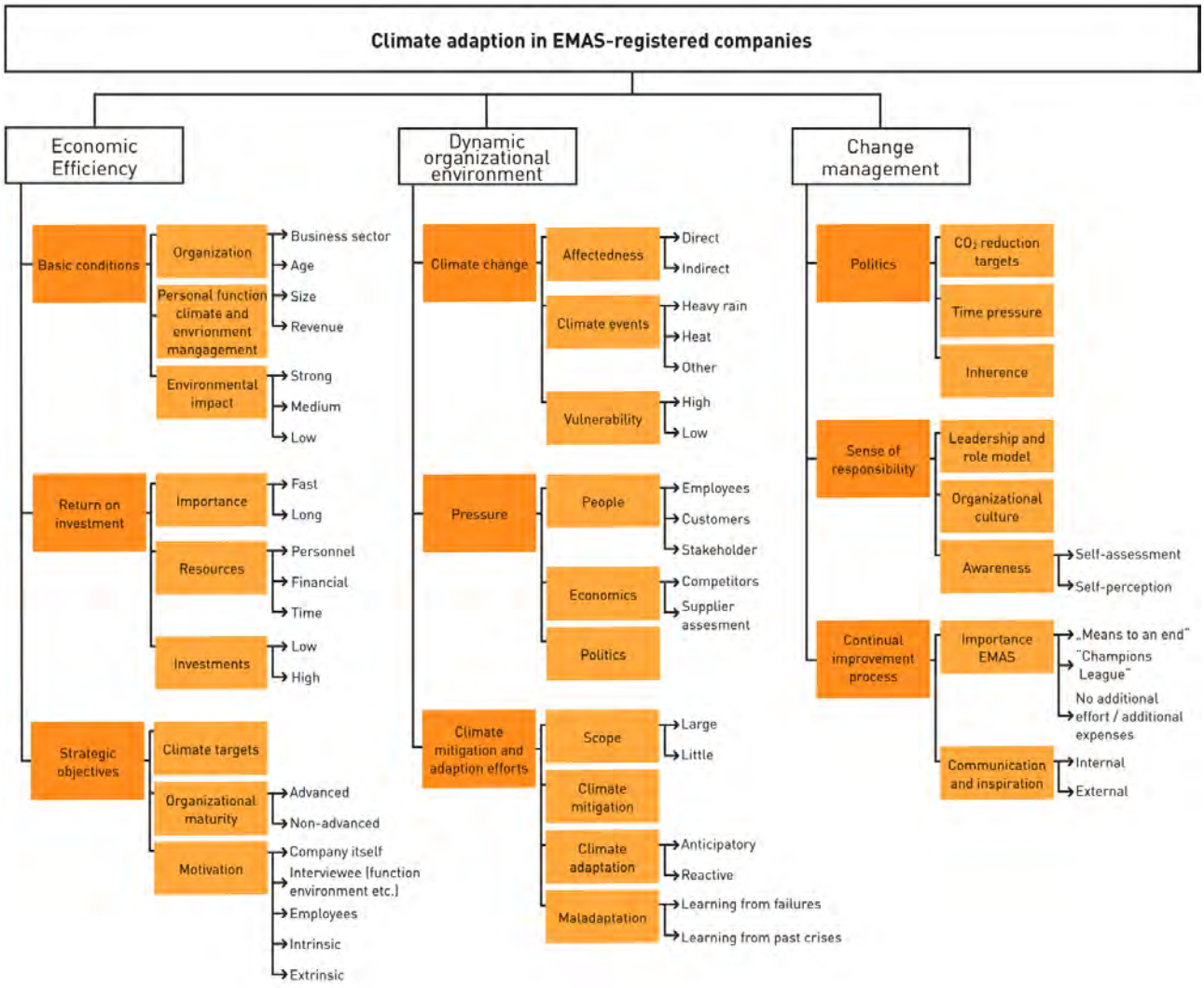
Appendix A. Structure and items for manufacturing companies (M), non-manufacturing companies (NM) and handicraft companies (H)



Appendix B. Results of the conducted expert interviews published in Fischer et al. (2022)



Note. Following the principles of Grounded Theory Methodology the expert interviews were analysed within an iterative coding process. During the selective coding, we identified three core categories, which interlink all interviews and base on three derived theories. The diagram shows the identified Core Categories, subcategories and related dimensions. Depending on the core categories and related subcategories, further levels open up, which are used to map the specific features and differences.