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Climate change preparedness of enterprises in the Upper Rhine region from a business perspective—A multidisciplinary, transboundary analysis

Paul Aeverbeck¹ · Oliver Frör¹ · Nathalie Gartiser² · Nadja Lützel³ · Florence Rudolf⁴

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Abstract

Companies can be affected by climate change in many ways. Effective adaptation to climate change will only be possible if the associated risks and opportunities as well as their own strengths and weaknesses are sufficiently known. Following the conceptual framework of a SWOT analysis, this article outlines the self-perception of companies from the Upper Rhine region regarding their climate change vulnerability. Based on 26 qualitative semi-structured company interviews, managers' statements on climate change-related strengths, weaknesses, opportunities and threats are divided into three categories based on the business function concerned. The resulting 4 × 3 matrix is used to analyse which aspects companies do not pay much attention to. We also highlight typical, frequently cited strengths, weaknesses, opportunities and threats. It appears that the majority of companies perceive climate change as an external threat but see themselves in a position to counter this threat with the help of internal qualities.

Klimawandel-Anpassungsbereitschaft von Unternehmen in der Oberrhein-Region aus Sicht der Unternehmen – Eine multidisziplinäre, grenzüberschreitende Analyse

Zusammenfassung

Unternehmen können auf vielfältige Weise vom Klimawandel betroffen sein. Nur wenn die damit verbundenen Risiken und Chancen sowie die eigenen Stärken und Schwächen hinreichend bekannt sind, ist eine effektive Anpassung an den Klimawandel möglich. Dieser Artikel skizziert in Anlehnung an den Konzeptrahmen einer SWOT-Analyse die Eigenwahrnehmung von Unternehmen aus der Oberrheinregion bezüglich ihrer Klimawandelvulnerabilität. Basierend auf 26 qualitativen semi-strukturierten Unternehmensinterviews werden Aussagen von Managern bezüglich klimawandelrelevanter Stärken, Schwächen, Chancen und Bedrohungen anhand der betroffenen Unternehmensfunktion in drei Kategorien aufgeteilt. Anhand der entstehenden 4 × 3 Matrix wird analysiert, welche Bereiche von den Unternehmen wenig beachtet werden. Außerdem zeigen wir auf, wie typische, häufig genannte Stärken, Schwächen, Chancen und Bedrohungen aussehen. Es zeigt sich, dass die Unternehmen den Klimawandel mehrheitlich als externe Bedrohung wahrnehmen, sich aber in der Lage sehen dieser Bedrohung mit Hilfe von internen Qualitäten zu begegnen.

✉ Paul Aeverbeck
 aeverbeck@uni-landau.de

Oliver Frör
 froer@uni-landau.de

Nathalie Gartiser
 nathalie.gartiser@insa-strasbourg.fr

Nadja Lützel
 nadja.luetzel@unibas.ch

Florence Rudolf
 florence.rudolf@insa-strasbourg.fr

¹ iES Landau, Institute for Environmental Sciences, University of Koblenz-Landau, Fortstraße 7, 76829 Landau, Germany

² ICube—INSA Strasbourg, 24 Boulevard de la Victoire, 67084 Strasbourg Cedex, France

³ Department of Social Science, University of Bâle, Petersgraben 27, 4051 Basel, Switzerland

⁴ Insa de Strasbourg, 24 bd. de la Victoire, 67084 Strasbourg Cedex, France

1 Introduction

When hearing about climate change and associated problems, images of devastating impacts of floods and droughts in the Global South come to mind. However, the Upper Rhine region will not be spared from climate change-related impacts. Brasseur et al. (2017) predict that within Germany most climate parameters will experience particularly important changes in the south-western part of the country. Glaser (2013) identifies the Upper Rhine valley as one of five climate change hotspots in Germany with heat stress, river flooding and diseases being the main stressors expected for the region. The various changes forecast for the physical environment and emerging hazards will also impact on the enterprises operating in this region. For instance, more frequent and more severe storm events may damage corporate buildings and production sites. Beside these direct impacts of climate change, companies are already affected by indirect climate change impacts. These indirect impacts result from climate change triggered changes to the socio-economic environment of enterprises (Stecher and Fichter 2011). For example, the political will to decarbonise our society may lead to new laws that limit companies' scope for action (Hoffmann and Busch 2008). Furthermore, the market situation in which companies operate may change to create threats and opportunities. The demand for harmful products may for instance decrease, whereas climate change may create new opportunities for innovative products. Companies thus need to adapt in order to assert themselves in this new environment modified by climate change.

How managers perceive climate change and its impacts is crucial for the adaptation process (Bremer and Linnenluecke 2016; Pinkse and Gasbarro 2016). Indeed, only if managers are aware of specific threats and opportunities they can adapt accordingly. Knowing one's strengths and weaknesses is therefore essential to choose appropriate adaptation measures. Thus, a SWOT analysis, which examines a company's strengths, weaknesses, opportunities and threats is a useful tool for climate change adaptation. In addition, SWOT is a tool that is quite well known by business people and therefore it gives the ability to communicate about new issues like climate change adaptation in a language that is understood by business people. Indeed, when speaking with enterprises it often becomes visible that they do not feel very concerned until challenges linked to climate change are translated into business issues. There are some studies using SWOT-analysis in the context of climate change in order to evaluate mitigation or adaptation strategies of regions (Hill et al. 2010; Krysanova et al. 2010; Balbi et al. 2011; Li et al. 2017), within the sector of agriculture and forestry (Nzunda and Mahuve 2011; Nair 2012; Bloch et al. 2016; Riguelle et al. 2016) or to improve SWOT (Koponen and Pesonen 2012; Metzger et al.

2012; Pesonen and Horn 2014), but to date, only Mahammadzadeh (2012) conducted a SWOT analysis to analyse companies' perceptions of climate change. His analysis is based on two questions integrated in a larger online survey (cf. Mahammadzadeh et al. 2013 for details). However, in the frame of climate change research, online surveys have the disadvantage that managers must have a clear idea how climate change influences their business operations in order to give relevant answers. Starting from this recognition we expand on the findings from Mahammadzadeh (2012) and assess climate change preparedness of businesses in the Upper Rhine region using in-depth face-to-face interviews. Such an approach is open to unforeseen aspects and offers a deeper understanding of the issue at hand. We explore how companies perceive climate change related risks and opportunities and in how far they see themselves as capable to manage these risks and to grasp opportunities. We first address the link between climate change adaptation and vulnerability, which allows us to understand how enterprises can react to climate change. We then briefly explain the SWOT analysis to lay the foundations for understanding the subsequent explanation of our survey methodology and results.

2 Adaptation and strategic planning in businesses

Since at least the publication of the Stern report it has been known that it is important to react rapidly in order to mitigate climate change and its impacts even if this needs huge financial efforts. Indeed, a non-reaction to climate change will induce much bigger economic losses (Stern 2011). There are two fundamental strategies to tackle climate change. Namely mitigation (i.e. the endeavour to reduce the emission of greenhouse gases and thereby limit climate change to an acceptable extent) and adaptation (i.e. the attempt to react to climate change in a way that avoids or reduces the negative impacts of the changes). In the past, mitigation was by far the predominant approach in terms of practical implementation and research (Füssel and Klein 2006; Füssel 2007; Bremer and Linnenluecke 2016). Consequently, the importance to mitigate climate change seems to be already well embedded in the minds and strategies of public and business decision makers (Freimann and Mauritz 2010; Rudolf 2012). However, despite the efforts to mitigate climate change it is clear that humankind already experiences climate change and is not able anymore to completely prevent climate change and its impacts (IPCC 2014). It is thus important to take into consideration adaptation options as well, which in contrast to mitigation are quite recent and unknown. In this paper, we therefore focus on adaptation processes in companies. This does not mean

that companies should abandon climate change mitigation. On the contrary, climate change mitigation and adaptation must be considered simultaneously thereby reaping potential synergies. Companies may for instance decrease their fossil fuel consumption in order to mitigate climate change, which in fact is also an adaptation measure because companies make themselves less vulnerable to new regulations and other indirect climate change impacts. Hence, climate change mitigation and climate change adaptation are interlinked and it is sometimes difficult to differentiate the two approaches on the ground (Rudolf 2012).

In order to assess the climate change vulnerability of an enterprise, it is crucial to know its exposure (i.e. the degree to which a system is exposed to climate change effects), its sensitivity (i.e. in how far a system is affected by climate change effects) and its adaptive capacity (IPCC 2007). Adaptive capacity can be defined as:

The ability of a system to adjust to *climate change* (including *climate variability* and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC 2007, p. 21).

The adaptive capacity, thus, considers the potential impacts of climate change that can be diminished by taking appropriated measures. Factors that determine the adaptive capacity include knowledge about climate change, availability of technological options, structure and attitude of the corporate governance and economic possibilities (Fritzsche et al. 2014). Adaptation measures can be implemented in order to (1) decrease sensitivity (Füssel and Klein 2006; Fritzsche et al. 2014) for example by shading a building in order to be less sensitive to insolation, (2) to decrease exposure (Füssel and Klein 2006) for example by relocating to non-flood prone areas, (3) by increasing adaptive capacity (Fritzsche et al. 2014), for example by analysing adaptation possibilities, or (4) by reducing impacts (Füssel and Klein 2006) for example by temporally protecting buildings with sand bags during a flood event.

3 SWOT Analysis

SWOT analysis, which stands for strengths (S), weaknesses (W), opportunities (O) and threats (T), is a popular tool to support strategic planning processes in businesses. The basic idea is to get a clear idea of all internal and external factors that may influence a company's performance in order to orientate the company's development accordingly (Pickton and Wright 1998). Internal factors are all factors describing the situation of the business itself. They can be strengths, such as a good financial situation, loyal customers and well-trained employees or weaknesses as for instance a bad reputation, or quality problems. Strengths

and weaknesses always have to be assessed in comparison with competitors. External factors describe the company's environment; therefore, they cannot be directly influenced by the company. Depending on the situation they can be threatening in the sense of having the potential for negative consequences for the company or represent opportunities for future gains. Typical examples for external factors are changing markets, technological development or new governmental or market regulations. The first step of a SWOT analysis consists of elaborating a list with all relevant internal and external factors. In a second step the internal factors are usually crossed with the external factors in order to obtain a 2×2 matrix from which it is possible to derive different business strategies (Helms and Nixon 2010). These strategies usually try to (1) use strengths in order to take opportunities, (2) overcome weaknesses and thereby take opportunities, (3) rely on strengths to avoid threats, or to (4) reduce weaknesses to prevent risks.

The major strength of the SWOT methodology is its simplicity, cost-effectiveness and the fact that it is one of the best known and most commonly used tools for strategic planning (Piercy and Giles 1989; Helms and Nixon 2010). This makes a SWOT analysis a suitable approach to communicate with businesses about strategy and adaptation possibilities. Another important benefit is that a SWOT analysis allows taking into account those effects that are not directly related to climate change, but that are relevant to business success, e.g. the general market situation (Hill et al. 2010). This is important because adaptation always takes place in a broader socioeconomic context (Smit and Wandel 2006) which could hamper the adaptation process if not taken into account.

Despite the immense popularity of SWOT analysis, the method has several shortcomings: Data is usually based on interviews without independent verification (Hill and Westbrook 1997; Clardy 2013), its assessment can be arbitrary because the identification of strengths and weaknesses can be inconsistent (Stevenson 1976), SWOT produces only lists without any weighting of factors (Hill and Westbrook 1997; Pickton and Wright 1998; Helms and Nixon 2010). Another important criticism is that SWOT is often used incorrectly, especially concerning the understanding of opportunities. Strategies, as for instance the launch of a new product, are often incorrectly defined as opportunities even though strategies are clearly internal (Everett 2014). The most important shortcoming is probably its simplicity, some even criticise the SWOT concept as being overly simplistic (Pickton and Wright 1998; Helms and Nixon 2010). We agree that for many purposes SWOT analysis might be too simplistic, especially if used as a stand-alone decision-making tool. Therefore, in most cases it is insufficient to base one's adaptation planning solely on a SWOT analysis. However, its ability to break down a complex set of factors into

simple and clearly defined categories is one of the strengths of SWOT analysis, (Pickton and Wright 1998) which might be one reason for its popularity. Despite the known weaknesses, we deliberately chose SWOT analysis because of its simplicity and popularity. Given that most companies are at best at the beginning of the planning phase of their climate adaptation programme and in many cases have never even thought about climate change impacts, it seems important to address the issue in a way that reflects their usual business thinking and that addresses business-relevant threats or opportunities without being too complex. In these circumstances SWOT analysis can be a very useful tool to bring companies in touch with climate change adaptation and to motivate them to start a more complex adaptation process. Indeed, even the most severe SWOT critics agree that SWOT analysis is an appropriate tool to help companies starting a discussion process (Hill and Westbrook 1997).

4 Methods

The purpose of this paper is to complement and to concretise the findings presented by Mahammadzadeh (2012) which were based upon a short online survey with a large number of participants. Therefore, we chose an alternative approach and used a small number of personal open-ended narrative and semi-structured face-to face interviews. The guiding questions relate to risks and opportunities associated with climate change and ways to react to climate change. Interviews were conducted from June 2016 to March 2017 in the upper Rhine region (cf. Gobert et al. 2017). Regarding the sample of interviewed companies, the basic idea was to represent the entire corporate landscape in the Upper Rhine, however without having the aspiration to use a representative sample. On the contrary, considering the fact that most enterprises have little concern about adaptation to climate change, we have focused from the outset on energy supply, water supply, logistics and tourism, as we believe that these sectors are particularly vulnerable to climate change (Zerbisch et al. 2005) and thus represent the avant-garde of companies dealing with this issue. Though in addition, we also wanted to include a small number of less vulnerable sectors and their views. The highly vulnerable primary sectors agriculture and forestry (Zerbisch et al. 2005; Fichter and Stecher 2011) were deliberately not taken into account because of the poor comparability of influencing factors with companies from the secondary and tertiary sectors. The single companies were randomly selected from the company database “Kompass”. The final sample included the sectors energy and water supply (7 companies), manufacturing (6), logistics (5), engineering and testing (2), winter tourism (2), construction (1), whole-

sale (1), waste collection (1) and service activities (1). Of the 26 interviews, 18 were conducted in Germany, 5 in France, and 3 in Switzerland. Three quarters of the sample is comprised of small and medium sized enterprises with less than 250 employees of which more than 50% are small enterprises with less than 50 employees. The selection criterion of interviewees within the company was that they hold an active organizational role within a sustainability-relevant position. Occupational titles of interviewees included Managing Director, Plant Manager, Site Manager and HSE Officer. Interviews, which lasted on average one hour, were conducted either in French or German and were fully transcribed in the respective language.

The analysis combines quantitative and qualitative content analyses; the latter within the meaning of a structuring content analysis (Mayring 2016). The quantitative content analysis investigates the number of mentions as a proxy of concern. The qualitative analysis intends to overcome the weaknesses of quantitative content analysis, in particular the lack of contextualization and prioritization. For this purpose it is helpful to build categories on the basis of which the text can be examined in a structured manner (Mayring 2016). In our case, the category formation consisted of two coding steps. In a first top-down step, the categories given by the SWOT analysis framework were used. Thus, all interview transcripts were coded with regard to mentioned strengths, weaknesses, opportunities or threats.

The second analytical step consisted of an inductive bottom-up analysis of relevant codes in order to isolate the dimensionality within and between the SWOT categories. In other words, we took the codes obtained from the top-down analysis and clustered them around emerging topics without having a pre-existing framework in mind in order to identify which SWOT categories typically relate to which business functions. By clustering the different statements from the top down analysis, we found that it is possible to subdivide strengths, weaknesses, opportunities and threats into three business functions or organizational categories that we named “Production and Operation”, “Market Integration” and “Planning and Adaptation”. In some cases, codes can belong to several categories simultaneously.

- “Production and Operation” relate to the day to day business of companies and includes specifically, but not exclusively, statements relating to means of production, production facilities, technological issues related to production, work processes, staff, buildings, sensitivity, and exposure of the location and infrastructure.
- “Market integration” refers to statements related to indirect and long-term impacts through markets, such as sales, procurement, profit, public perception, reputation, competitive advantage/disadvantage, competition and market developments.

- “Planning and Adaptation” refers to statements relating to knowledge, information, partnerships, networks, prevention, (non-)existence of alternatives, flexibility, (in)dependencies, and (financial) resources.

Different coders were involved in coding and, therefore, their coding was systematically cross-checked to ensure inter-coder reliability. For this purpose, two interviews were coded by all coders in parallel and the coding was examined for differences. Subsequently, the reasons for the differences were discussed with the result that the differences were primarily due to a different view of the above categories. In order to standardize the coding, the categories were discussed with all coders and different text passages were then coded together until a uniform understanding of categories was determined and thereby a consistent coding was achieved.

5 Results and Discussion

When merging the top-down and the bottom-up step of the analysis outlined above we obtained a 4×3 matrix as illustrated in Fig. 1 showing the distribution of all statements that can be attributed to the different categories. This table shows where companies feel threatened by climate change, where they see opportunities and where they see themselves to be strong or weak. The table gives an indication of frequency; however, quantitative comparisons should be done with caution. Due to the survey design, threats may be over-represented, as we directly asked for impacts of different weather conditions in the interviews. Instead of looking at the absolute values it should therefore be mainly focused on the frequency classes represented by the different shades of grey.

In the following section we will highlight some characteristics of the distribution, interpret the distribution, explain the most important strengths, weaknesses, opportunities and threats and illustrate them with examples.

	Production & Operation	Market integration	Planning & Adaptation
Strengths	120	84	221
Weaknesses	97	51	111
Opportunities	31	102	70
Threats	356	126	138

Fig. 1 Distribution of statements in the analysis matrix

5.1 Threats

When analysing the external business conditions i.e. threats and opportunities, the high number of statements on threats is striking. A part of this dominance could be due to the survey design as outlined previously, but nevertheless it is obvious that managers are concerned that climate change might degrade the environment in which they operate. It also appears that by far the most concern relates to threats to “Production and Operation”. Thus, we can conclude that when talking about climate change threats, managers mainly think of immediate threats to production processes and operations. Our interviews show that these threats often concern direct damages to buildings and other installations caused by weather events like storms, heavy rainfall and flooding. Production processes are also relatively often seen to be threatened by weather events. In particular, high temperatures with heat waves impairing working conditions were mentioned frequently; they seem to be a serious problem for many enterprises. Threats that have been experienced recently by the companies are quite present in interviewees’ perceptions, while others are often only realized during the conversation about possible climate change effects. Long-term, structural problems as expressed in the categories “Planning and Adaptation” as well as “Market integration” are mentioned significantly less often. They seem to be less important, more difficult to grasp, or difficult to trace back to climate change.

Mentioned threats related to “Market integration” are clearly less frequent than those related to “Production and Operation” and mostly concern the behaviour of customers. Water suppliers, for example, are confronted with high peak consumption during hot periods and the tourism sector in the Rhine Valley suffers from excessive heat in summer and from a lack of snow in winter at higher altitudes. Problematically, companies that have already adapted their products to climate change complain that customers are not willing to pay for climate-friendly products. Many companies see little understanding on the part of their customers regarding climate change and weather-related problems. In contrast to sales, where many companies do see problems caused by climate change, purchasing is perceived as rather unproblematic. Here, companies appear to be confident that relevant markets will largely be spared from climate change or that they will manage to adapt in time. One notable exception is energy supply, which is considered by several companies as an increasing risk factor in the wake of climate change. Also, for the energy sector itself, threats linked to “Market integration” are more important than for the other sectors. This seems to be mainly due to a difficult market situation, which is closely linked to the ongoing energy transition as well as problems of acceptance in connection with the energy transition and associated costs.

Concerning threats related to “Planning and Adaptation” there are two major issues. Firstly, there is great uncertainty regarding both physical climate change and legislative changes. This makes it difficult for many companies to pursue proactive adaptation strategies to minimize threats. A manufacturing company confirms: “But it’s quite clear. The industry works for a long time and when the legal regulations fluctuate it is difficult to plan. For many companies, safety comes first. If they are not sure to have the same legal situation in 10 years, they will not invest. That’ll slow things down” (Company 2). Secondly, always seeing the well-known storm in a teapot can lead to wasting resources due to unnecessary adaptation. Thus, within a context of uncertainty, companies need to balance their adaptation measures in-between not doing enough and doing too much. In this context, companies often mention a qualitatively or temporarily insufficient quality of weather forecasts, which, however, only influences coping capacity and not long-term adaptation. The other major problem area concerns existing adaptation measures. Companies perceive it as threatening, if they face problems for which there are no suitable adaptation measures or for which the existing adaptation measures represent a high financial burden. A crucial question at this point is whether companies correctly assess financial consequences of adjustment measures in the sense of a cost-benefit analysis and whether the implementation of adjustment measures is uneconomical, or whether the benefits of the adjustment are not sufficiently known. The latter would be particularly critical because it leads to potentially avoidable losses. In addition, some companies experience conflicts between adaptation measures on the one hand and existing requirements, e.g. in the area of hygiene or fire protection, on the other. The example of air conditioning also shows existing conflicts between adaptation and mitigation strategies which are difficult to solve.

5.2 Opportunities

Some companies also see opportunities, but for most of them, the threats clearly predominate. This is contradictory to the results from Mahammadzadeh (2012) stating that for most enterprises opportunities prevail. A reason for this may be that respondents in Mahammadzadeh’s study possibly misunderstood the definition of opportunity and therefore overestimated opportunities. As outlined in the section about SWOT analysis this misinterpretation of opportunities (counting strengths as opportunities) is a common problem we avoided through an external classification. Also, the fact that the responses in Mahammadzadeh’s study are somehow incoherent (inasmuch as his respondents mainly expect negative impacts of climate change but simultaneously see more opportunities than risks for nearly

all business functions), suggests that concerning opportunities, Mahammadzadeh’s results may be biased.

Opportunities are seen for all categories but opportunities regarding “Market integration” slightly prevail. Typical market related opportunities that managers consider are possibilities to develop new markets or increase sales. Especially, higher sales are often linked to damage, experienced by third parties because of extreme weather events or changing climate conditions. Consequently, some managers are somehow embarrassed when admitting that some climate change effects that are harmful for others are in fact business opportunities for them. But not all market opportunities are linked to damages. Interviewees confirm that climate change effects lead to political and social rethinking and at the same time to a higher demand for climate friendly products. Indeed, noticeable climate change effects like less snow, more heat and droughts as well as the necessity of climate change mitigation force companies and consumers to shift their purchase behaviour to adapted products which creates new markets for these items. In other words, climate change effects induce market changes and market changes offer opportunities.

Managers rarely mention opportunities that relate to “Planning and Adaptation”. The most abundant aspect within this category is that possibilities for improvement and adaptation do exist. It is for example possible to increase a company’s resilience through redundancies in order to mitigate utility outfalls caused by climate change effects. Another aspect in this sense is the widespread belief that climate change will take very long and that there is still enough time for adaptation. For example, an energy supplier mentions: “At the speed at which climate change is happening business can keep pace with it” (Company 21). Even if there are rather few managers who directly mention this aspect, implicitly it appears to be a main reason for the relatively low importance many managers attach to climate change. Indeed, when asking managers about the time range that they consider for investments and strategic planning, they usually mention periods of 3–10 years. In such a short time period, long-term changes like climate change are hardly noticeable. Therefore, it is not surprising that managers are confident that they will be able to react and adapt to climate change and its effects. Companies that are more confident about climate change are those that are used to constantly adapting, for instance by changing their portfolio of products in order to adapt to changing markets. In addition, some companies see possible synergies between climate change adaptation and other adaptation necessities. One company mentioned for example that they have some problems with working conditions on hot days which usually coincides with periods with a poor order situation. This allows them to adapt working times without impacting the production.

Opportunities related to “Production and Operation” are mentioned very rarely. Most of them are linked to better working conditions and less complication linked to ice and snow in wintertime. For some companies the increase of mild winters also offers the opportunity of an extended working season. For instance, a construction company states: “A pure increase of the average temperature, if we do not consider any climatic side effects that clearly will occur, but purely increasing the average temperature would be positive for us. Because that means less frost means we can work for longer” (Company 6). Some managers also mention positive factors of their location that they perceive as beneficial with regard to climate change as for instance, the proximity to a railway or the accessibility to a reliable power supply. Another mentioned opportunity concerns the possibility to produce their own renewable energy and thereby diminish the dependency on energy prices. This is at the same time considered as an adaptation strategy to climate change effects.

5.3 Strengths

Internally, managers focus on strengths rather than on weaknesses. This shows that generally they are confident regarding their ability to counter negative climate change impacts. This confirms the finding from Mahammadzadeh (2012) that for all business functions except for investment and logistics, companies are optimistic concerning their own strengths.

Strengths are mostly related to “Planning and Adaptation”. When talking about how to counter the effects of climate change, managers focus on foresight and flexibility, which allows them to align and adapt their businesses to given circumstances in the short as well as the long term. One of the most important strengths that companies mention in the context of climate change is their own flexibility. This feeling of being flexible is often based upon the structure of the enterprise, especially managers of small companies often mention the simple decision-making structure and that if they want to change something this can be implemented much quicker than in big enterprises. Another way that companies explained their flexibility is that they are used to adapting to new situations. For example, a manufacturing company predicts “As I said, we will have to adapt our products, but that is our daily business” (Company 2). Though this argumentation is valid in most cases, some companies overstretch this idea and reason “we managed it last time, why would we not do so in future?” which is an attitude that hampers risk management and proactive adaptation. Also, planned or implemented adaptation measures are often mentioned. In almost all cases, however, mentioned adaptation measures are not implemented in the course of a long-term climate adaptation strategy but as

a short-term reaction on damages or as a side product of other strategies that seek to decrease costs or to improve the company’s image. In addition, some of the mentioned measures have in fact nothing to do with climate change but are rather general environmental protection measures.

Another strength that companies see in terms of “Planning and Adaptation” is a good level of information concerning climate change which is often based on some cooperation with other companies or research institutions. Also, companies that complain about an insufficient range of information concerning climate change in most cases do not want more information, but instead information that is more specific for their business case. Small companies in particular do not have the time and capacity to inform themselves in detail about climate change and to deduce potential risks for their business. For instance, the various types of uncertainties linked to different climate change scenarios, which are quite central to the scientific climate change debate, are often overwhelming. Companies generally want clear and specific information like they are used to having for weather forecasts, ideally with concrete recommendations for adaptation. The scientific community and weather services therefore, need to find the right balance between correctly informing about uncertainties and delivering operationalized information and recommendations. Concerning cooperation with other companies regarding climate change adaptation, two different strategies are observable. On the one hand companies, especially large companies that are part of a business group, try to make themselves independent of other enterprises in order to be able to manage difficult situations without any external help; on the other hand, companies rely on networks and cooperation with other firms in order to stay informed and increase resources for innovation. Some companies however declare to be satisfied concerning their integration into such networks, even if it appears that they hardly ever exchange about climate change. This somehow reflects the low importance that this issue has in the everyday business operation.

Also, strengths related to “Production and Operation” are mentioned relatively often. Typically, they focus on buildings and equipment, which are seen as up to date and capable of countering negative effects of climate change. For instance, a logistic company explains: “The rooms are air-conditioned, the trucks are air-conditioned, so the employees like to be here when it is hot” (Company 1). A large number of these statements are related to the use of renewable energies. Though the use of renewable energies can effectively be seen as an adaptation to climate change in some single cases, this confirms the initially stated assertion that climate change mitigation is much more embedded in companies’ reflections than adaptation. In fact, many companies have the feeling that they are not really affected by climate change, either because they feel that their location

is not exposed to relevant climate change effects, or because their production is not sensitive. The latter can be due to processes that are not really affected by climate change or to the very low extent of impacts. One company confirms: “yes, production decreases a little but that does not kill us” (Company 9).

The fewest strengths fall within the category of “Market integration”. The most frequent strength within this category is that companies have the impression to sell climate friendly products or generally speaking to be an environmentally friendly company. Here again it appears that some companies mix up climate issues and environmental issues in general. Reasoning like “we are climate friendly, we do not use a lot of water and we have a nice green area on our site” is not rare.

5.4 Weaknesses

Managers speak less about weaknesses than about strengths which confirms the findings of Mahammadzadeh (2012) concerning the predominance of strengths. But nevertheless, most managers identify weaknesses especially concerning “Production and Operation” and “Planning and Adaptation”. In particular, manufacturing enterprises seem to be aware of their weaknesses concerning “Production and Operation”. Typical weaknesses within this category concern old or obsolete buildings or equipment, which are vulnerable to weather events or changing climate. Also, sensitive processes e.g. regarding temperature variations are very central for some companies. In this sense a company explains “Warming is also a big issue. Of course, we have extreme costs for air conditioning. Here we have 1200m² of laboratories in which we process the drugs, and we must have completely constant temperature conditions” (Company 3). From a phenomenological viewpoint the by far most commonly mentioned weakness relating to “Production and Operation” is the difficulty to manage heat-waves and negative consequences on working conditions or processes. Missing or insufficient air conditioning and bad insulation sometimes in combination with exothermal processes are at the source of this weakness.

Mentioned weaknesses related to “Planning and Adaptation” mostly concern negative experiences with own adaptation processes or a complete absence of adaptation. One company representative told us for example that during a storm event a huge window frontage was damaged by stones used as roof coverage. Instead of changing the roof coverage the stones were refilled without any thought about the next storm. In line with Mahammadzadeh (2012) limited resources are frequently put forward as a weakness resulting in non-adaptation. In certain cases, a limitation of information is mentioned.

Weaknesses related to markets are clearly mentioned less frequently than other weaknesses. Mostly they are not very specific but relate to the company’s market position, the difficulty of finding good employees or rising energy costs. Weaknesses expressing the interconnection and dependence between companies seem to be very rare or difficult to grasp. For instance, only one company mentions possible difficulties due to a dependence on climate sensitive resources. Another company which sells climate friendly logistics claims that it is very difficult to find companies that care about their scope 3 emissions¹. Thereby the company indirectly confirms that most companies do not think far beyond their company boundaries when it comes to climate change.

Overall, we found a higher level of concern among companies regarding climate change than Mahammadzadeh (2012). In fact, he found that most companies do not feel affected yet and many do not think to be affected in future whereas we did not find a single company that was not at least partly impacted by climate change. This is likely a result of the different study designs. Mahammadzadeh (2012) probably underestimates the overall concern because when speaking with companies we noticed that for companies it is almost impossible to be aware of all possible climate change impacts. Indeed, companies that first stated not to be affected, often stated a wide range of experienced impacts during the interview. Therefore, simply adding some questions to an online survey is not sufficient to grasp the full concern of companies. This finding clearly reveals the importance of in-depth face-to-face interviews for analysing in how far companies are impacted by climate change. Our study on the other hand probably overestimates the general level of concern because companies that do not feel concerned by climate change were probably less willing to spend time on the interview than companies that are concerned about the issue.

The most important strengths, weaknesses, opportunities and threats underpinned by some further quotes from interviewees are summarised in Table 1.

6 Conclusion and outlook

This study aimed at expanding on the findings from Mahammadzadeh (2012) and assesses climate change preparedness of businesses in the Upper Rhine region. In contrast to Mahammadzadeh (2012) we based our analysis on qualitative face-to-face interviews. Our interviews

¹ According to the influential Greenhouse Gas Protocol scope 3 emissions are emissions that are not directly emitted by the company but by contractors (except energy provision which is scope 2). It is optional to report scope 3 emissions (Smith 2004).

Table 1 Typical climate change related strengths, weaknesses, opportunities and threats for companies

	Production & operation	Market integration	Planning & adaptation
Strengths	Use of renewable energy sources	Climate friendly products/enterprise	Implemented/planned adaptation measures
	Location is not very exposed to climate risks	Good position in the market	Flexibility (e.g. range of products)
	Good equipment/buildings	Flexibility regarding markets and products	Well informed
	Modern processes	Not very dependent on low carbon prices	Good organisation allows quick response
	Production is not sensitive (due to low energy consumption, low temperature sensitivity)	No liability for potentially impacted items/processes	Good network and partnerships
	“We have no problems in the new building, the building is quite new, it’s two years old.” (Company 18)	“We are well positioned, we have very good access to customers. We just have to stay up to date technically. We try to position ourselves accordingly, to save energy, to optimise costs. Especially our environmental goals. We are also certified according to ISO. We are trying to get better and better.” (Company 5)	Clear vision/targets
	“For example, trucks have €5 or higher standard, 5 and usually 6. The modern engines are more efficient and CO2 emissions are also lower.” (Company 16)		“And this is our goal here to be independent from other service providers, that is why we also have our own trucks, everything from one source in the end. Also for the customer that he is not dependent on other service providers, that we can solve everything in the group.” (Company 1)
Weaknesses	Problems with processes or for workers due to heat	Weak market position	Lack of time (to stay informed, to build networks)
	High exposure (e.g. in flood prone area)	Difficulty to sell products	No clear vision or strategy
	Old or bad equipment (e.g. insulation, air condition ...)	Rising energy costs	Limited resources
	Sensitive/non optimal processes	Dependence on climate sensitive resources	Implemented adaptation measures have negative side effects
	“If we assemble something for industrial and commercial customers somewhere in a production facility, this is relatively independent of the weather, but otherwise most work takes place when the weather is good.” (Company 6)	“Our energy costs, they go like this [points upwards] and that’s logical. We have to cool a lot more in summer. And also the period during which we heat is longer. I just can’t grasp why, but it’s also longer.” (Company 4)	“But of course the cost-intensive investment is the problem we have as a medium-sized company.” (Company 3)
		“We work together with large customers who make very profit-oriented purchases in logistics and do not value our ecological, social approaches.” (Company 16)	“Of course I am thinking; what dangers might come? What is the most likely? But for a planning horizon of five years, maximum 10 years.” (Company 11)
Opportunities	Extended working season because of mild winters	Improved order situation due to heat or damages	Possibilities for adaptation do exist
	Fewer problems with ice and snow	Higher demand for climate friendly products	Long time scale of climate change allows sufficient time for adaptation
	Advantages of location allowing low sensitivity/exposure	Cost savings and climate friendliness can be combined	Adaptation has positive side effects
	“Yes the temperature of the materials can play a role. One day we asked ourselves if we are not going to heat this building, but as we have no more winter, it is a good thing, there is no need for heating anymore!” (Company 19)	New opportunities (products, markets)	Climate change related problems can be solved together with other issues
		Markets are not climate sensitive	“We have many options from the perspective of renewable energy or saving energy that we want to pursue in the future and which I do not see as a disadvantage but rather as a technological opportunity.” (Company 21)
		“The order situation is not actually affected by rain, unless we have heavy rain events with damages, then we also have a better order situation.” (Company 6)	

Table 1 (Continued)

	Production & operation	Market integration	Planning & adaptation
Threats	(Potential) damage to buildings and other installations	Decline or greater variations in resource availability	It is difficult to foresee climate change risks
	Temporary shutdown (e.g. after a flood event or during a heatwave)	Customers are not climate sensitive enough to buy climate friendly products	Bad (late/imprecise) weather forecasts makes it difficult to prepare
	(Potential) restrictions of work and processes (e.g. because of heatwaves)	Customers have no comprehension for problems resulting from climate change effects (e.g. delayed delivery)	Options for adaptation are too expensive or do not exist
	“Lighter trucks in northern Germany are repeatedly hit by wind gusts and tipped over.” (Company 14) “In summer when temperature is high we already notice that our efficiency is not so high, because the people are not so efficient.” (Company 5)	“Our customers are used to certain products and expect us to be able to deliver them. If this is not the case, this can lead to problems.” (Company 15)	Existing alternatives are not sufficient or conflict with other requirements “When you have 3 or 4 weeks where the temperatures are relatively high each year, we switch to night shift for these people. But we have the whole night shift restrictions, so that are costs for us as well.” (Company 9)

suggest that managers mainly perceive climate change as merely a negative external force that must be managed through positive internal qualities. The effects of this force are immediate (Production & Operation), while the means to manage them are also strongly related to flexibility and foresight (Planning & Adaptation). Managers are confident that their company's strength will enable them to cope with climate change and that consequently their business as a whole will not be seriously affected by climate change. At the same time, most managers confirm that climate change will be a serious issue for society in general and for businesses in particular. This suggests that most managers consider their own businesses to be less vulnerable to climate change than the average company. It is of course not possible that everybody is less vulnerable than the average. Therefore, an interesting question, which can be derived from these findings is whether managers overestimate their own adaptive capacity or whether they overestimate the vulnerability of average companies and thus the importance of climate change for the business world. Overestimating one's own adaptation capacity is dangerous, because this may lead to a negligence of proactive adaptation measures aimed at improving adaptive capacity (Gasbarro and Pinkse 2016). Further research should clarify which sectors and which types of companies tend to overestimate their adaptive capacity, thus increasing their climate change vulnerability. Therefore, a sector specific analysis of companies' adaptive capacity is required. Apart from the sector, the specific location of an enterprise likely greatly influences its climate change vulnerability. In order to get a more precise picture of which factors contribute to the vulnerability of companies, it would certainly be helpful to investigate in detail factors related to the location such as

the topographical location, the proximity to a river and the type of transport connection.

Another interesting issue for further research arises from the finding that companies often mention high adaptation costs as an important hurdle for adaptation. Considering the high level of uncertainty that many companies perceive regarding climate change, the question needs to be asked whether the perceived hurdle of high costs is a reality on the ground compared to potential benefits. We may face a similar problem here to climate change mitigation, where at a first glance high mitigation costs seem to justify non-action but in the long run this non-action involves much higher costs. In contrast to the mitigation problem where those who have to pay for climate change mitigation and those who suffer from climate change are not necessarily the same entities, the case of adaptation is much simpler. If companies understand the impacts of climate change, it is in their own interest to invest into adaptation measures in order to benefit in the long-term. Therefore, further research investigating climate change impacts for companies and corresponding awareness rising is crucial.

From a methodological viewpoint, our results show that in order to analyse a complex problem such as climate change preparedness of businesses, in depth face-to-face interviews provide new knowledge that can help to complete and scrutinise findings based on standardized questionnaires.

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