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Adapting to climate change: Exploring the specific challenges for SMEs

Anpassung an den Klimawandel: Spezifische Herausforderungen für KMU

Susanne Schlepphorst, Markus Rieger-Fels, Christian Dienes, Michael Holz, Hans-Jürgen Wolter

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Abstract

We investigate whether and how businesses perceive and adapt to climate change. Our survey results suggest that most German enterprises are aware of climate change and its consequences. The perception of climate risks is less driven by business size than by experience. There is a wider gap between SMEs and large enterprises regarding implementing adaptation measures. Lacking financial resources and the prioritization of other current challenges constitute hurdles to further adaptation.

JEL: D22, D83, Q54

Keywords: *climate risks, risk perception, adaptation to climate change, risk management*

Zusammenfassung

Wir untersuchen, ob und wie Unternehmerinnen und Unternehmer den Klimawandel wahrnehmen und sich an diesen anpassen. Unsere Umfrageergebnisse legen nahe, dass die überwiegende Mehrheit der Unternehmerinnen und Unternehmer in Deutschland den Klimawandel und dessen Folgen im Blick hat. Entscheidend für die Wahrnehmung von Klimarisiken ist weniger die Größe der Unternehmen, sondern die bisherigen Erfahrungen mit den Folgen des Klimawandels. Eine größere Lücke zwischen KMU und Großunternehmen zeigt sich hingegen in der Umsetzung von Anpassungsmaßnahmen. Fehlende finanzielle Mittel wie auch die Priorisierung anderer betrieblicher Herausforderungen stehen Investitionen in weitere Anpassungsmaßnahmen entgegen.

Schlagwörter: *Klimarisiken, Risikowahrnehmung, Anpassung an den Klimawandel, Risikomanagement*

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Executive Summary

Adapting to the consequences of climate change – be they physical or transitory – is challenging for entrepreneurs. At the same time, the necessary adaptation to the changing framework conditions can open new market opportunities and potential innovation. However, adaptation requires that entrepreneurs recognise the need for action. This study examines how entrepreneurs of small and medium-sized enterprises (SMEs) perceive and deal with climate risks.

Both experiences and expectations have an impact on how climate risks are dealt with

The perception of and dealing with climate risks depends less on the size of the enterprise than on previous experience with and expectations of future exposure. Following this, we identified three attitude types: 44 % of the enterprises belong to the experienced type. One in three enterprises belongs to the concerned type, with no experience to date but expecting future impacts of climate change on their business activities. Every fifth enterprise belongs to the unaffected attitude type, which has not made any experience so far and does not expect any effects in the future.

Attention focuses on energy transition and bureaucratic burden

Entrepreneurs sometimes differ greatly in assessing the opportunities and risks associated with climate change. SMEs are more pessimistic about opportunities than large enterprises. Among the risks, rising energy prices during the energy transition and an increasing burden of bureaucracy are among the dominant issues.

Regarding physical climate risks, SMEs see themselves as either very little or very much affected, depending on their previous experience. Above all, enterprises worry about the risk of a supply chain disruption resulting from extreme weather events.

Enterprises rely on digitisation to reduce climate risks

Most entrepreneurs have already taken measures to adapt their businesses to the impacts of climate change. However, these primarily address transitory risks. Protection against physical risks, on the other hand, still plays a subordinate role in SMEs. Primarily, various digital solutions are used to facilitate the handling of transitory climate risks (e.g., visualising energy consumption) or to mitigate the consequences of extreme weather events (e.g., securing knowledge through digital backup).

Prioritisation of other business challenges opposes protection against climate risks

Many entrepreneurs do not yet feel sufficiently protected against physical climate risks. The reasons for not taking further adaptation measures are complex. They include a lack of financial resources, prioritising other business challenges, and a lack of perception of being affected by certain risks. Also, the benefits of many adaptation measures seem unclear to entrepreneurs.

The benefits of further awareness-raising measures are questionable

Given that SMEs are already largely aware of climate risks, it is to be expected that further information campaigns will have little effect. Because of the barrier of a lack of financial resources, expanding existing support programmes may seem justified at first glance. The increase in demand resulting thereof, however, could primarily lead to price increases rather than to further adaptation measures if the supply cannot be expanded accordingly. Concerning prioritising other business challenges, the possibilities of government intervention are limited. Since these business challenges include handling bureaucratic obligations, relief in this area could create scope for dealing with other business risks, including climate risks.

1 Introduction

The consequences of climate change are no longer just a challenge for other regions. Because of rising global temperatures, extreme weather events are occurring more frequently and intensively in Germany, too (Kahlenborn et al. 2021). Since the beginning of systematic weather records, 2011 to 2020 was the warmest decade (Imbery et al. 2021).

Therefore, there is an enormous need for action by society, politics, and the economy to slow down global warming. It can particularly be achieved by reducing greenhouse gas emissions (mitigation). Against this background, the German Bundestag passed a new Federal Climate Protection Act in June 2021, setting the goal of greenhouse gas neutrality by 2045. Likewise, the Federal Government has adopted the 2022 Climate Protection Emergency Programme (Bundesministerium für Wirtschaft und Klimaschutz 2022), which, among other things, provides funding for all industries that can contribute significantly to the reduction target.

Since it is already clear that global warming can only be halted to a limited extent, it is also essential to take measures to adapt to the consequences of climate change. These measures include measures to protect against weather extremes, adapting to changing climatic conditions and changes in society and markets, for example, with regard to society's increasing expectations of a sustainable economy.

In the implementation of adaptation and mitigation measures, entrepreneurs are among the central actors. On the one hand, they have to implement laws and regulations on climate protection, environmental protection, and occupational safety. At the same time, it is in their own interest to prevent or reduce risks of damage to their enterprise and to take advantage of the opportunities arising in the market from the changing framework conditions. This can be challenging given the multitude of possible impacts of climate change, whose extent and impact also depend on location and industry. In the first place, entrepreneurs must recognise the impacts of climate change that affect them.

Due to the complexity of climate change and its possible consequences for individual enterprises, it can be assumed that adaptation is a particular challenge for entrepreneurs of small and medium-sized enterprises (SMEs). After all, their business models are often based on specialised products and services, target groups, and/or regions and are embedded in closely networked supply and

value chains. If loss events occur, the lower diversification can have a business-threatening effect. Therefore, it is particularly relevant for entrepreneurs of SMEs to consider climate risks and their direct and indirect impacts on the enterprise. At the same time, however, they have fewer human, financial, time and material resources than large enterprises, which makes it more difficult for them to address potential climate risks adequately.

Against this background, the present study explores how entrepreneurs of SMEs perceive climate risks and how they deal with them. This question is answered in several steps. In Chapter 2, we first summarise the existing literature on the topic and present a conceptual framework for perceiving and dealing with climate risks. Chapter 3 sets out the methodological approach and the databases, and Chapter 4 the empirical results. The study ends with a conclusion and recommendations for policy action.

2 Impacts of climate change on businesses and SMEs in particular

2.1 The consequences for the enterprises

Climate change has a wide range of effects on entrepreneurial activity in Germany: it poses new risks but also opens new (market) opportunities. On the risk side, a distinction must be made between physical and transitory risks.

Physical risks involve impacts that result directly from changes in climatic and weather conditions in Germany. These include acute risks such as increased extreme weather events (Deutscher Wetterdienst/Extremwetterkongress 2022). As a result, damage can be caused to people, buildings, or production facilities. An enterprise can also be indirectly affected if extreme weather events lead to disruptions in the supply chain, for example. In addition to acute risks, longer-term changes in the climate and their consequences can also be relevant for enterprises. Examples include the continuous rise in average annual temperatures, sea level rise, or precipitation level changes.

Transitory risks involve climate change consequences accompanying the transformation to a more sustainable economy. They include economic, political, legal, and regulatory changes, such as the expansion of emissions trading, the introduction of a CO_2 tax or stricter environmental regulations. Likewise, transitory risks can arise from adapting to changes in consumer behaviour, such as rejecting non-sustainably produced products.

In addition to location factors and industry affiliation, it is to be expected that the extent to which an enterprise is affected by climate risks also depends on its size. It is often stated that SMEs are particularly affected (Halkos et al. 2018; Skouloudis et al. 2020). Smaller enterprises have fewer production sites and fewer suppliers and customers. Thus, a loss resulting from, for example, an individual extreme weather event will have a (relatively) greater impact on the value creation process of a smaller enterprise than a similarly large loss at a large enterprise. In contrast, however, the probability of being affected by a local extreme event – e.g., a flooding event – decreases with decreasing production sites and partners in the value chain. While it is thus not clear whether SMEs are fundamentally more affected by physical climate risks, it can be stated that their risk structure differs from that of large enterprises.

Besides the risks, the social and political reactions to climate change can also open up new business opportunities. Shifts in demand behaviour due to climate

change offer entrepreneurs the opportunity to develop new business models or expand existing ones. For example, the increased demand for technologies to use renewable energies or structural adaptation measures to protect against physical risks such as heat or extreme precipitation positively affects the business development of corresponding providers. In addition to these industry-specific aspects, however, sustainable production processes can also gain importance because sustainability aspects are increasingly considered in lending. The same applies to participation in value chains: enterprises with sustainable production techniques can become more attractive as suppliers because reporting sustainability obligations within supply chains are becoming more important (Löher et al. 2022).

2.2 Adaptation to climate change

In their entrepreneurial activities, entrepreneurs are generally required to adapt their business activities to the changing environment (Chakravarthy 1982). These activities include the adaptation to climate change, which is currently among the major challenges for many entrepreneurs (Howard-Grenville et al. 2014).

The subject of how entrepreneurs deal with climate change has gained importance in recent years, leading to increased scientific contributions (Sietsma et al. 2021). In essence, the results of the empirical studies support each other: the topic of climate change is perceived by most entrepreneurs (Bardt et al. 2012; European Investment Bank 2021; Fichter et al. 2011). However, a uniform picture of dealing with the consequences does not emerge. The spectrum of responses to physical climate risks ranges from proactive and innovative measures to reluctance and inaction (de Brito 2022; Gasbarro et al. 2016; Linnenluecke et al. 2012). A similar situation applies to the response to transitory climate risks. In parts, the focus is more on dealing with them than on dealing with physical climate risks (Bardt et al. 2012; Chrischilles/Mahammadzadeh 2011). In parts, however, entrepreneurs attach secondary importance to transitory risks (European Investment Bank 2021).

Several factors influence whether and to what extent enterprises take measures to adapt to climate change. Enterprises must perceive the corresponding risks as relevant to them (Linnenluecke et al. 2012; Linnenluecke et al. 2015). Enterprises also need human and financial resources to identify and implement suitable measures.

Although the perception of climate risks is a decisive aspect of whether and to what extent entrepreneurs adapt their business activities to the changing climatic conditions, little is known about what these assessments of entrepreneurs are based on (Pinkse/Gasbarro 2019). The Attention Based View (Ocasio 1997) offers an explanatory approach. Based on three principles, it explains why decision-makers pay great attention to some issues and – possibly – consider them relevant for taking action while paying little or no attention to other issues. According to these principles, (a) decision-makers focus their attention on a limited number of stimuli ("Focus of Attention"), which (b) are significant in their specific context or situation ("Situated Attention"). How decision-makers perceive and deal with situations and contexts depends, in turn, on (c) the organisational structures in the enterprise ("Structural Distribution of Attention").

From (c), it can now be deduced that attention to climate risks is fundamentally influenced by corporate structures – i.e., by the rules, resources, and actors that decide how information is procured, passed on to decision-makers and processed, and how solutions are found. Enterprises with structures for obtaining and interpreting climate-relevant information are more likely to perceive and interpret climate risks and develop specific adaptation measures (Ocasio 1997; Pinkse/Gasbarro 2019).

In this respect, there are striking differences between large enterprises and SMEs: Large enterprises have more comprehensive resources at their disposal, which enable the (internal) division of labour as well as technical specialisation and professionalisation in the identification of and dealing with climate risks. In SMEs, many of these tasks are the responsibility of the entrepreneurs. This is due to their size, but it also stems from the fact that the owners themselves manage most SMEs and are, therefore, “Mittelstand” (Pahnke et al. 2023). In the absence of special structures to perceive and interpret such events, SMEs could easily neglect particularly rare climate events (Lampel et al. 2009). Furthermore, many adaptation measures require high investments or fundamental strategic decisions.

Consequently, in most SMEs, the relevant decisions regarding climate risks are made at the management level. However, this, in turn, means that in SMEs, climate risks compete with other – not only strategic – decisions for the limited attention of the management. Accordingly, dealing with climate risks in SMEs is easily pushed into the background by the current challenges of day-to-day business.

On the other hand, Mittelstand entrepreneurs generally attach greater importance to meta-economic goals such as environmental and climate protection than managers in (large) non-Mittelstand enterprises (Pahnke et al. 2023). At the same time, due to the overlap of ownership and management, Mittelstand enterprises can implement measures to protect against climate risks more quickly and flexibly than non-Mittelstand enterprises. The more pronounced long-term orientation of Mittelstand enterprises also enables them to take longer payback periods as a basis for implementing measures. This long-term orientation tends to favour the adoption of mitigation and adaptation measures. To protect their businesses in the long term and secure their long-term income stream, Mittelstand entrepreneurs are more inclined to consider longer-term aspects – including climate risks – and to respond appropriately to them. Also, due to their strong local ties, local Mittelstand enterprises have a longer historical memory and better knowledge of climate-related local conditions. They can thus more easily identify manifesting climate risks. The strong social "closeness" of Mittelstand enterprises also facilitates the exchange of information and joint protective measures with other entrepreneurs and stakeholders in the region (Schlepphorst et al. 2022).

In both Mittelstand and non-Mittelstand enterprises, managers have to filter and select information because the ability and resources to absorb information are limited (Davidsson 1991; Ocasio 1997). What they focus their attention on depends, among other things, on the entrepreneurs' personal background, experiences, values, and emotions. For example, entrepreneurs informed about climate change are more likely to be aware of their enterprise’s vulnerability to climate risks and correspondingly see a greater need to take adaptation measures (Linnenluecke et al. 2015; Ngo et al. 2020). Experience with climate risks is of particular importance. In this regard, previous studies illustrate that one's experience of climate events is closely related to risk perception (Bardt et al. 2012; Chrischilles/Mahammadzadeh 2011; Linnenluecke et al. 2012).[1]

In addition to the personal experiences and attitudes of decision-makers, the Attention Based View focuses on the specific context of an enterprise: the respective situation in which entrepreneurs find themselves influences the relevance and, thus, the attention they pay to certain issues (Ocasio 1997). This means that the factual affectedness of climate risks should influence how much

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1 This is also known from bureaucracy research: Experiential experiences in dealing with bureaucracy sustainably affect how entrepreneurs perceive bureaucracy (Holz et al. 2019).

attention entrepreneurs pay to these risks. Thus, the subject should receive greater attention in enterprises in certain industries, such as agriculture and tourism, or certain locations in exposed areas, such as coastal areas, near rivers or forests. Similarly, enterprises whose value chain process heavily depends on certain suppliers or customers should be more aware of risks that lead to a disruption of their value chain. Value chains controlled by large enterprises are usually more complex and internationally oriented – and thus more susceptible to climate risks than those controlled by SMEs. On the other hand, large enterprises usually have a much larger number of suppliers. They are thus less dependent on individual ones. SMEs that are integrated into global value chains as suppliers are, in turn, often restricted in their autonomy of action and often cannot make independent decisions about their suppliers (and the associated climate risks).

Since the impact of a climate event can bring considerable economic damage to SMEs, it is reasonable to assume that they will consider these risks more intensively. On the other hand, the type and scope of measures taken in SMEs may be affected by the lower availability of resources compared to large enterprises. Moreover, not least due to the multiple crises of recent years and the increased investment, innovation and transformation requirements, SMEs generally have fewer financial reserves available than large enterprises. Consequently, it is to be expected that SMEs are currently postponing part of the planned measures to protect against climate risks to a later point in time – when the financial situation improved.

In summary, it can be concluded that the perception of climate risks is not only related to objective risk criteria such as industry affiliation, local conditions, or dependence on certain market partners. Experiences, but also the individual convictions of the relevant decision-makers, are equally important. Contrary to the common view in the literature that SMEs generally underestimate or neglect climate risks, an analysis based on the Attention Based View shows that a priori, it is not possible to unambiguously predict how SMEs and large enterprises differ in terms of risk perception. On the one hand, the lack of specialised structures means that climate risk assessment and management compete for limited management attention and thus tend to be neglected. On the other hand, the higher vulnerability of SMEs in the event of a natural hazard should draw greater attention to these risks. Whether one and, if so, which of these effects outweighs the other cannot be determined a priori.

3 Methodological approach

3.1 Empirical basis

So far, little is known about how entrepreneurs perceive and deal with climate risks. To fill this gap, we conducted a nationwide business survey in Germany between July and August 2022. Since some questions can only be addressed to a limited extent using a standardised questionnaire, we also interviewed entrepreneurs from SMEs at the beginning of 2023. The interview partners declared their willingness to be interviewed as part of the survey. These two research approaches complement each other in that the survey, due to a large number of survey participants, makes it possible to obtain generalisable statements on a solid empirical basis. The interviews, in turn, make it possible to gain a deeper understanding of the topic (Diekmann 2009).

We used the Markus database of the credit reporting agency Creditreform and Bureau van Dijk to obtain business survey addresses. When the addresses were drawn, this database contained around 2.2 million enterprises of all sizes, ownership, and management structures in Germany.[2] We draw a stratified random sample to obtain sufficient responses for all industries and size classes. We invited 55,369 enterprises by email to participate in the online survey. Of these, 2,760 enterprises took part, of which 1,331 fully answered each question, yielding a response rate of 2.4 %. Figure 1 shows the distribution of these enterprises by size and industry. The individual cells are provided with corresponding weighting factors to extrapolate the results to the totality of all enterprises located in Germany according to the business register (Business Register System 95, the reporting year 2019) and turnover tax statistics.[3]

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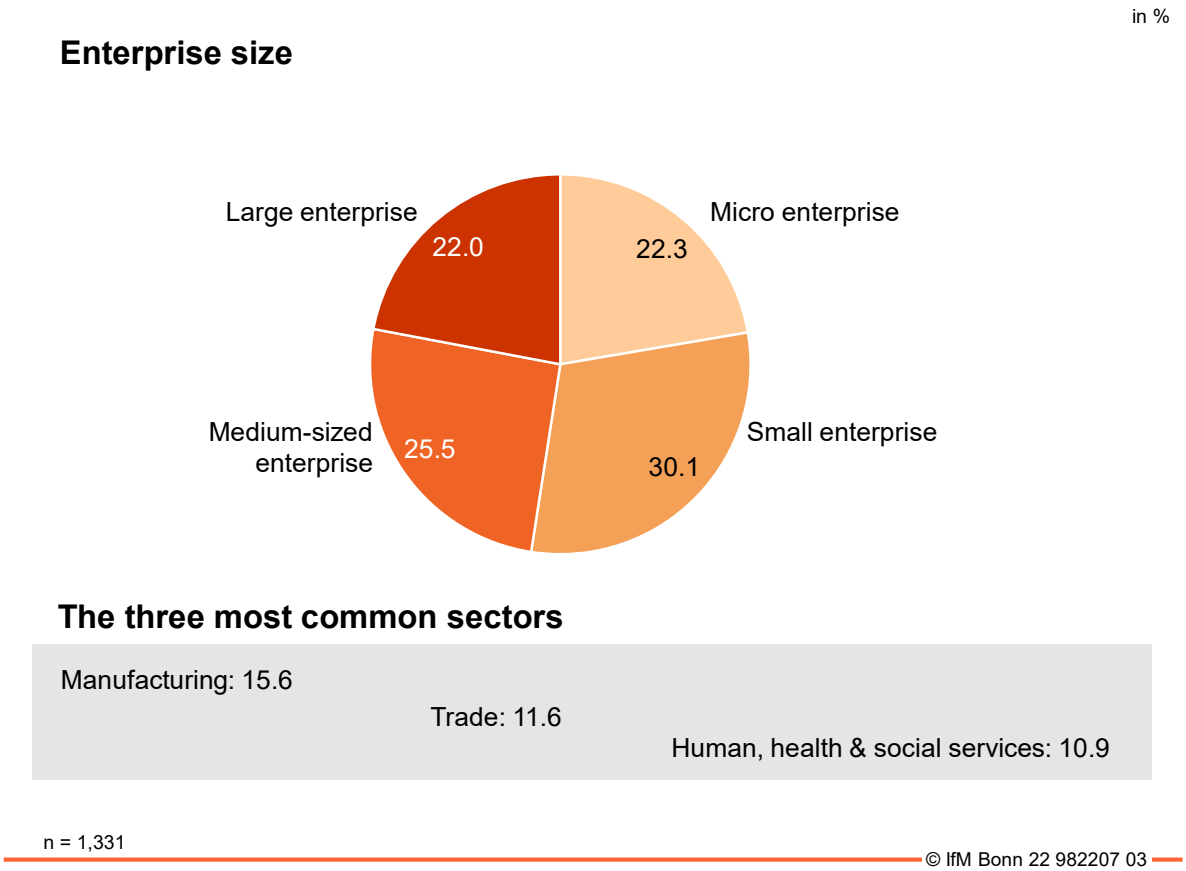
2 The criterion for admission is an entry of the respective enterprise in the business register. Enterprises not entered in the business register are only taken into account if a credit inquiry/information on these enterprises is available. Since small sole proprietorships are usually not listed in the business register (cf. Haunschild/Wolter 2010, p. 12), these are underrepresented in our survey.

3 The extrapolation factor results from the number of enterprises in the population per cell divided by the number of enterprises in our sample per cell.

Figure 1: Composition of the sample by size and sector



Source: IfM Bonn: Climate Change Survey (2022).

The supplementary **interviews** were conducted using guidelines to give the interviews a concrete structure and to guide the interviewees to the topics central to answering the research questions. At the same time, the flexible interview format allowed us to take up and deepen issues that arose during the interview. In addition, this format gives the interviewees room to answer comprehensively (Bryman/Bell 2011). A total of seven interviews were conducted. We included different company sizes among SMEs and diverse industry affiliations in the selection process. Furthermore, care was taken to ensure that all attitude types (see Chapter 3.2) were represented in the interviews. An overview of the enterprise characteristics of the interview partners can be found in the Appendix (see Overview A1).

3.2 Derivation of attitude types

In addition to the size of an enterprise, we consider another aspect in the analyses that is important for the perception of and dealing with climate risks. As emerged in Chapter 2, one's own experience with climate events has a lasting

impact on the risk perception for potential events in the future. It can therefore be assumed that the experiences and expectations of entrepreneurs decisively influence how they deal with climate risks. To take this aspect into account, we derive four attitude types based on the following two survey questions:

a) Have events that occur more frequently due to climate change, such as extreme weather, heat, or flood/low water, affected the enterprise's operations in the past five years?
b) When do you expect climate change to have a concrete impact on your business?

We refer to the identified attitude types as the "experienced", the "concerned", the "unaffected", and the "optimist" (see Overview 1).

Overview 1: Formation of the attitude types

		Has experience with extreme events in the past	
		Yes	No
Expects climate change impacts now/in the future	Yes	**"Experienced"**	**"Concerned"**
	Probably never	**"Optimist"**	**"Unaffected"**

Source: IfM Bonn: Climate Change Survey (2022), own presentation.

The "experienced" make up the largest group with 44 %, followed by the "concerned" (36 %) and the "unaffected" (19 %). The fourth type, the "optimist", is of marginal importance with less than 1 %. Therefore, this type cannot be used in the following for more detailed evaluations and is only listed here for completeness.[4]

While the experienced have witnessed the suddenness and intensity of extreme weather events and are thus more sensitised to future climate risks, the unaffected are much more sceptical about the consequences of climate change and do not expect to be fundamentally affected themselves. This differentiated view

4 It is not astounding, that there is a strong correlation between experience and expectation. Virtually, there is no enterprise that ever has experienced an extreme event and rules out possible future climate change impacts. This is where the advantage of type formation becomes apparent. It allows to consider the "concerned" as a reference group, from which the "experienced" differ in terms of their experience and from which the "unaffected" differ in terms of their expectation.

of climate change was also evident in the interviews. Overview 2 contains quotations that we consider exemplary for the three types identified.

Overview 2: Perception of climate change

"The flood disaster (in our region) was a very impactful experience for us, even though we were not (directly) affected in our enterprise, only privately through colleagues. Of course, this influences how we look at things and realise how quickly things can change!" (U5)

"I've had (climate awareness) for maybe three or four years now. 2018 was a very bad drought. That's when I realised: gosh, there have always been dry years, but we haven't had anything like 2018. And then 2019, which was very similar, and then 2020, which was also bad. 2021 was relatively average, and 2022 was too dry, but it was still okay. And you notice (all) that when you connect with nature." (U4)

"We have never felt any particular consequences of climate change, either in our private lives or in the context of our work. ... There is even a certain scepticism as to whether this topic exists at all in how it is being politically discussed right now." (U2)

Source: IfM Bonn: Climate Change Survey (2022).

The three types occur in all size classes (see Figure 2), although there are differences concerning the concrete distribution. As the size of the enterprise increases, the proportion of the unaffected decreases: While around one in five micro enterprises belongs to this group, only 7 % of large enterprises do. The opposite is true for the experienced, whose share rises with increasing company size.

Figure 2: Shares of the attitude types by size

Source: IfM Bonn: Climate Change Survey (2022), extrapolated results.

Our multivariate analyses also show (see Table A1 in the Appendix) that, in addition to size, industry affiliation and company location also play a role in which attitude type the enterprises belong to. The experienced are found more often and the unaffected less often in industries such as agriculture or construction or at locations close to rivers.

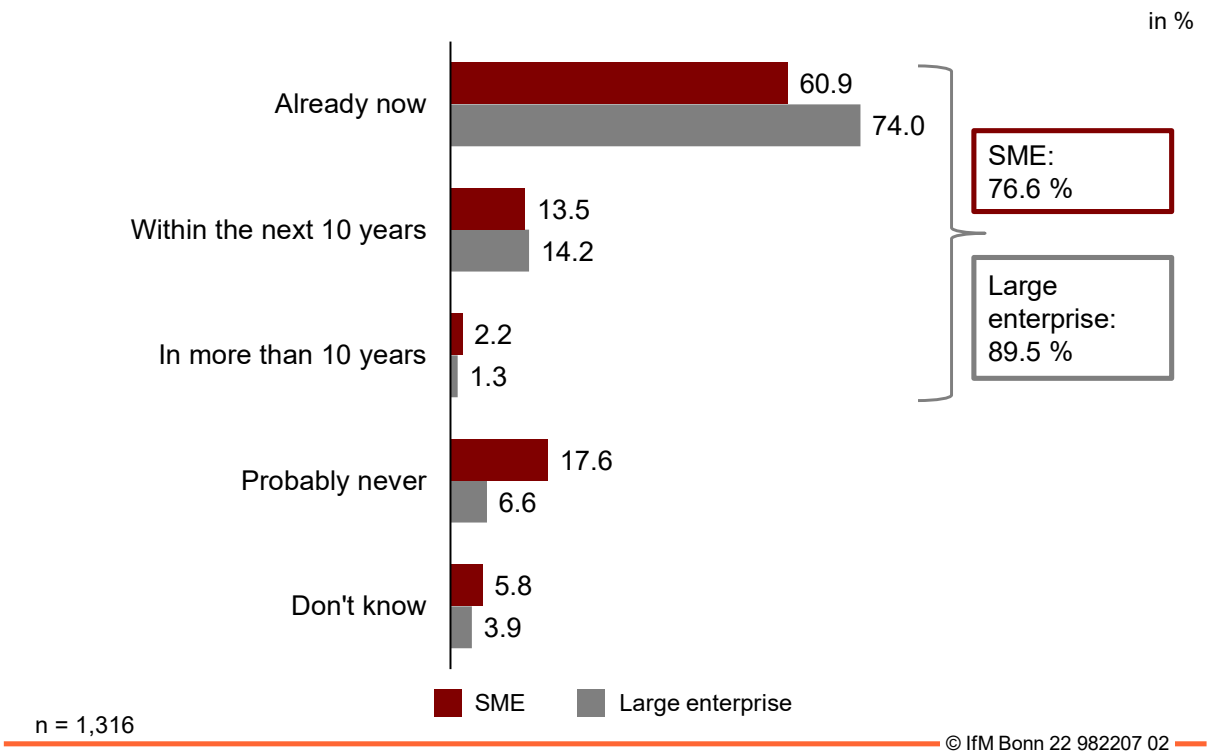
The following chapter presents the empirical investigations' results, broken down by company size and attitude type.

4 SMEs and their dealing with climate risks

4.1 Climate change in the perception of SMEs

41.4 % of SMEs have already had experience with climate change-related events in the past. At 50.3 %, the share is somewhat higher among large enterprises. It is, therefore, not surprising that more than three-quarters of SMEs assume that climate change is already impacting their enterprises or that this will be the case in the future (see Figure 3). Among large enterprises, there are hardly any enterprises that assume that climate change will not have an impact on their business.

Figure 3: Impact of climate change on the enterprise

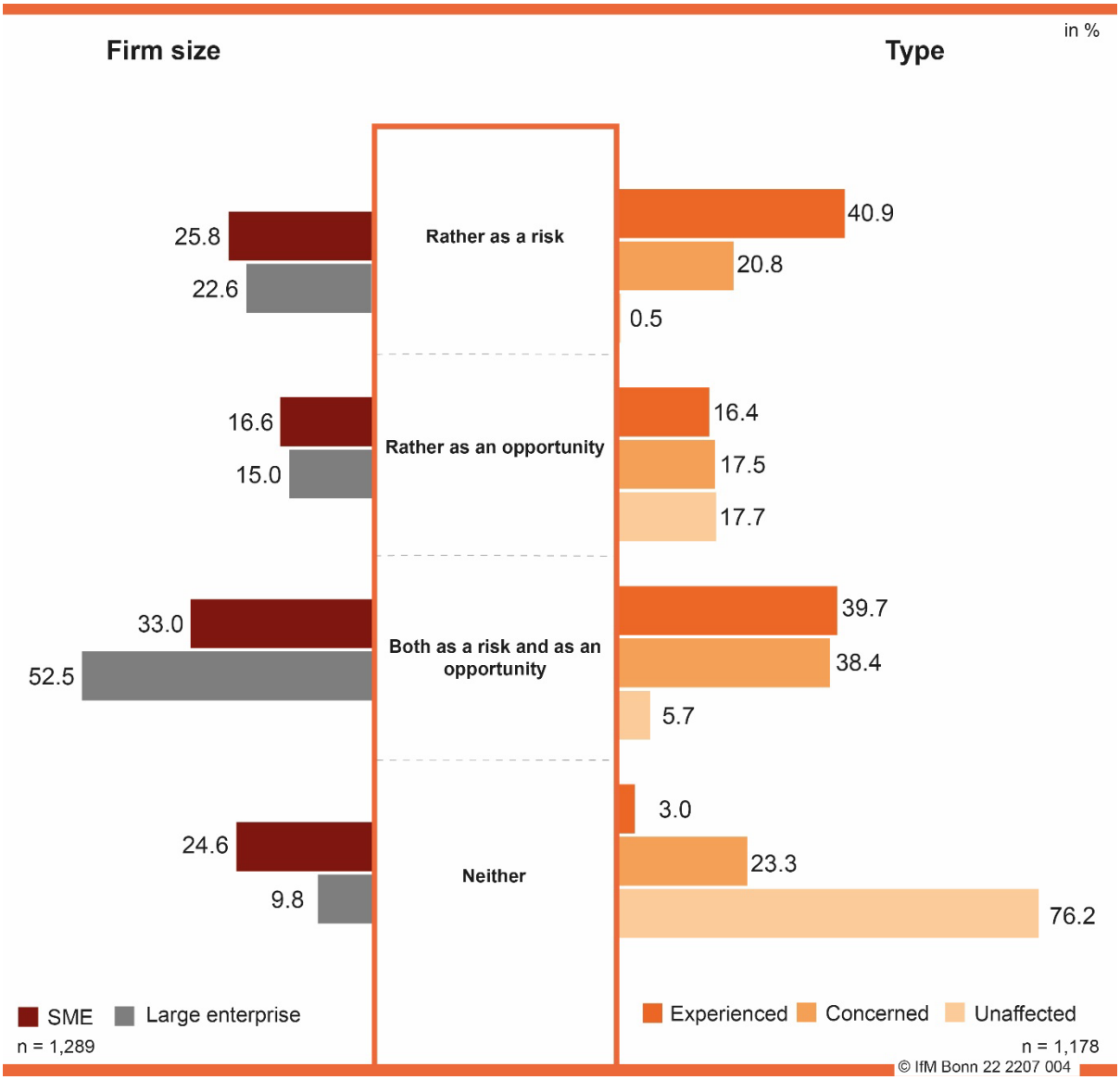


Source: IfM Bonn: Climate Change Survey (2022), extrapolated results.

Climate change is generally associated with risks. However, the consequences for enterprises do not have to be all negative. Rather, new opportunities for entrepreneurial activities can also arise. Therefore, in the following we examine whether the entrepreneurs see these opportunities or whether they put the risks associated with climate change to the fore. Doing so, a mixed picture emerges (see Figure 4). Entrepreneurs from large enterprises more often see climate change and its consequences as a mixture of opportunities and risks (53 %) than entrepreneurs from SMEs (33 %). At the same time, the share of those who

see neither opportunities nor risks in climate change is much higher among SMEs than among large enterprises (25 % compared to 10 %). While the experienced are more pessimistic about climate change, the majority of the unaffected do not expect any positive or negative effects.

Figure 4: Overall climate change assessment



Source: IfM Bonn: Climate Change Survey (2022), extrapolated results.

Enterprises with a certain size and functional differentiation – not necessarily large enterprises – sometimes find it easier to systematically identify opportunities and risks arising from climate change and take appropriate measures.

> *"Especially in the area of business development, my horizon is already (significantly) broader than the next two or three weeks." (U5)*

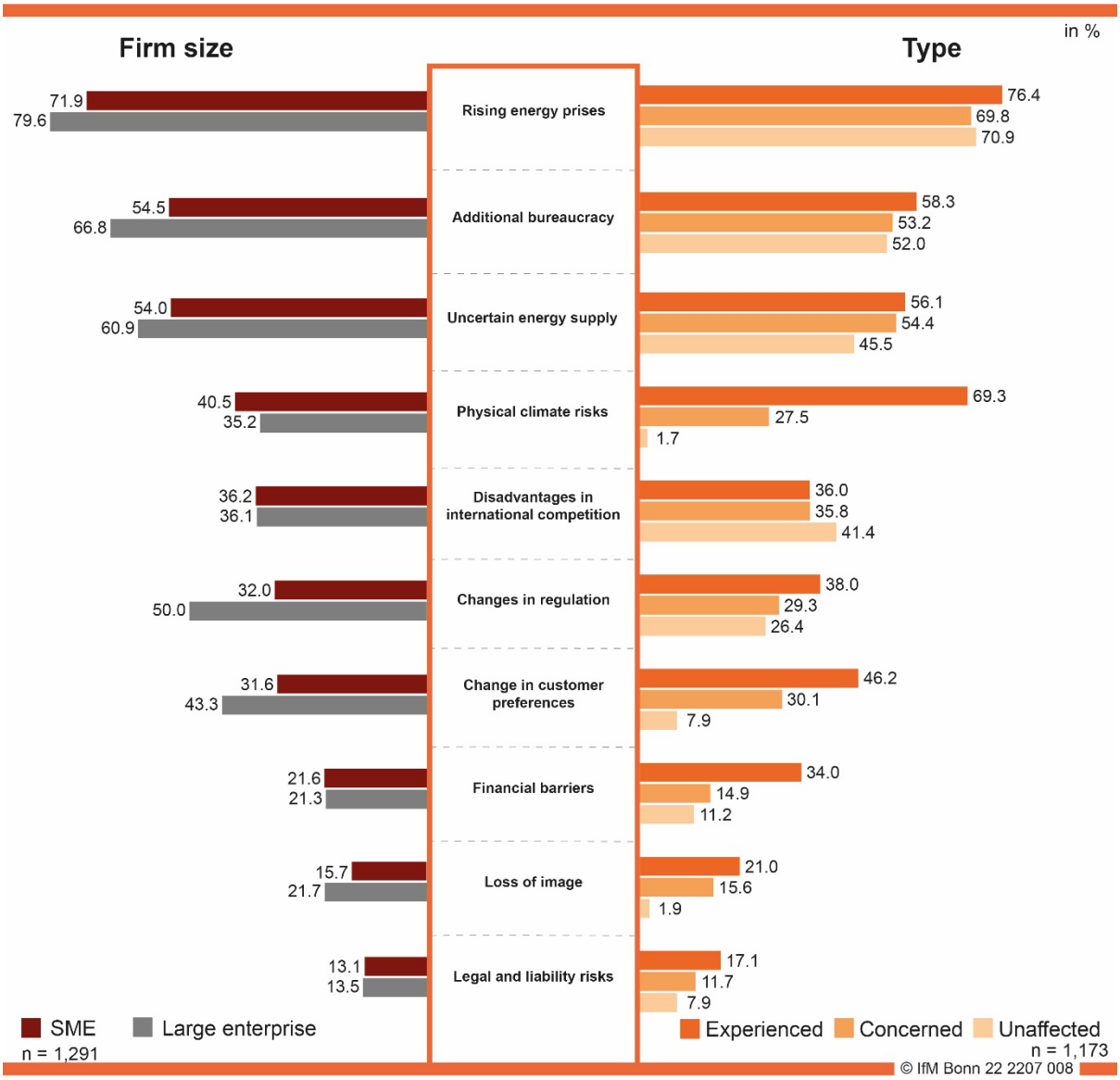
> *"We are certified according to ISO 9001, among other things. Accordingly, you naturally think more about risk assessments and things like that... You are also encouraged to think and question. All these topics – natural disasters, earthquakes, storms, fires, etc. – are then naturally part of the consideration." (U5)*

For many entrepreneurs – regardless of company size and attitude type – particularly, the transitory risks of climate change are of high importance (see Figure 5).

> *"These are our fears that, so to say, in the requirements that the political climate change places on us, the core service that we also provide – first of all, we do care and not climate – that this will be forgotten or not taken into consideration." (U2)*

The dominant issues among entrepreneurs are the increase in energy prices during the transition to emission-free energy production and additional bureaucratic requirements. Possible image losses or increased legal and liability risks due to climate-damaging corporate activities are of secondary importance to entrepreneurs.

Figure 5: Absolute assessment of possible climate change impacts



Source: IfM Bonn: Climate Change Survey (2022), share of enterprises that consider climate change impacts relevant, extrapolated results.

There are clear differences between large enterprises and SMEs in assessing possible regulatory changes. While every third SME considers this topic relevant, it is relevant to even every second large enterprise. This could be because many regulations explicitly exclude SMEs to reduce their bureaucratic burden.

As expected, in contrast to the differences across size classes, the attitude types differ primarily in assessing possible physical climate risks. When assessing transitory risks, the differences decrease, in some cases, substantially.

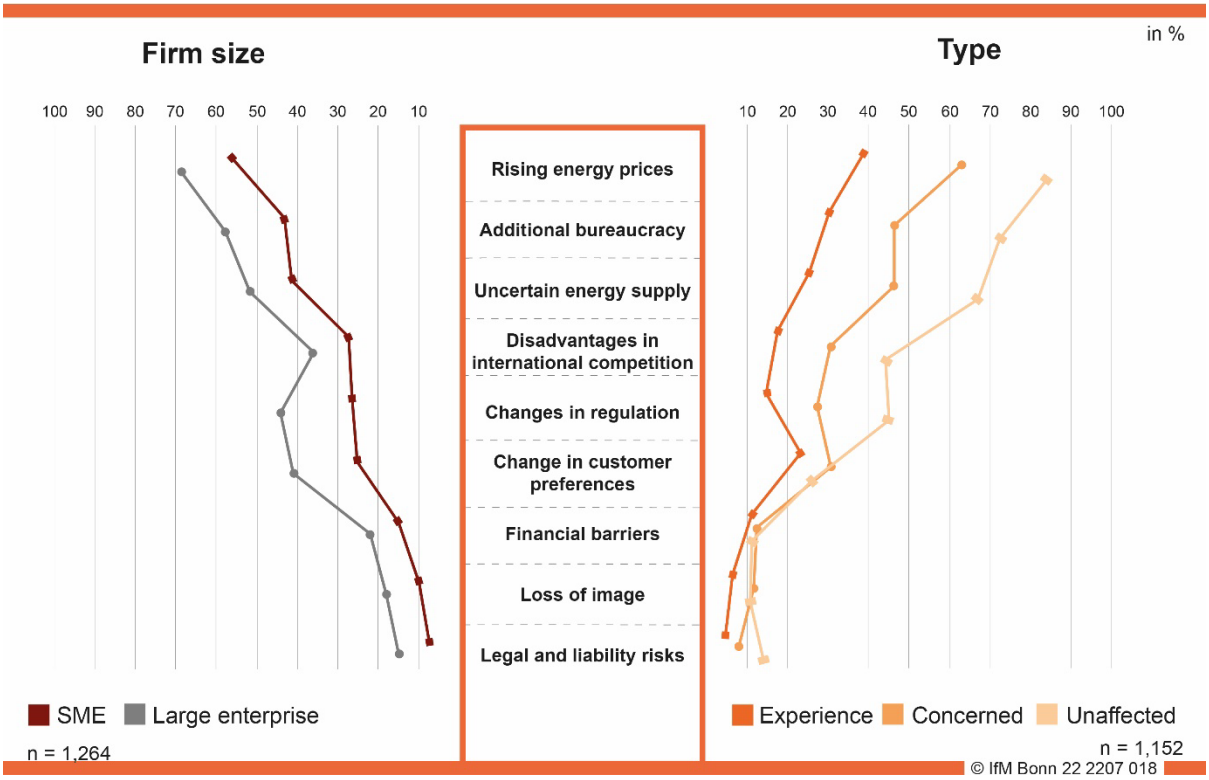
In addition to the absolute assessment of various consequences of climate change, their relative assessment is of interest. For example, an entrepreneur

might consider physical risks important but still prioritise transitory risks. Accordingly, the enterprise will take different adaptation measures than one that prioritises physical risks. Therefore, in the following, we shed light on the shares of enterprises that consider individual transitory risks more important than physical risks.

While SMEs and large enterprises do not differ greatly in the absolute assessment of physical climate risks, more nuanced differences emerge in the relative assessment of various transitory risks compared to physical risks (see Figure 6).

Among SMEs, most entrepreneurs attach greater importance only to the increase in energy prices resulting from the energy transition than to the physical risks associated with climate change. Among large enterprises, the majority also strictly prioritise the additional bureaucracy and uncertainty in the energy supply resulting from the transition to a zero-emission energy supply. The findings thus reveal differences between the size classes in prioritising various climate change impacts.

Figure 6: Relative assessment of possible climate change impacts



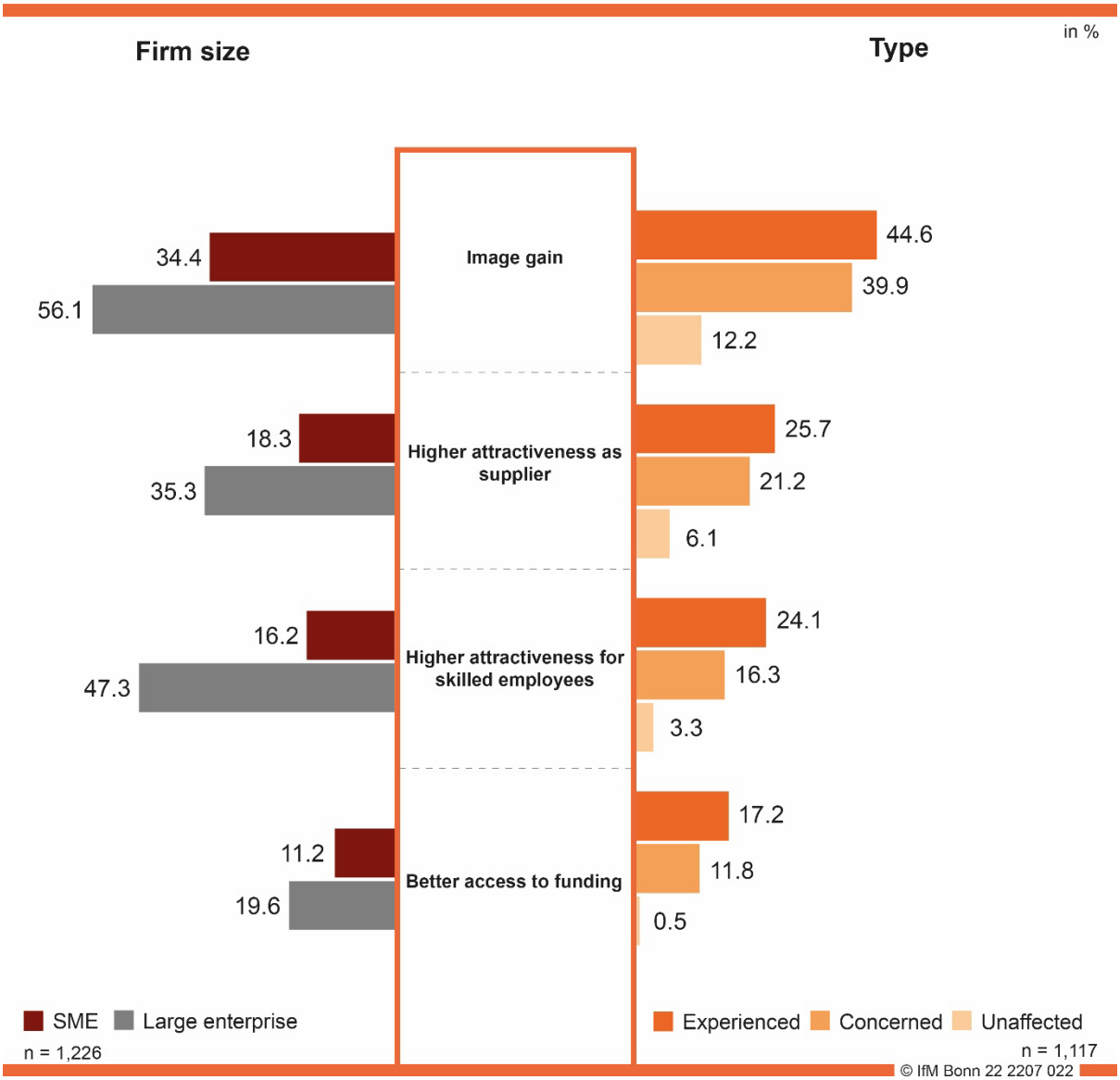
Source: IfM Bonn: Climate Change Survey (2022), share of enterprises considering climate change impacts more relevant than physical climate risks, extrapolated results.

This prioritisation also differs greatly between the attitude types. Most experienced consider physical risks to be at least as relevant as any of the transitory risks surveyed, including those during the energy transition. Among the concerned, the relative assessment depends very much on the concrete transitory risk with which the physical risks are compared. The increase in energy prices is considered more important by a majority of the concerned, regulatory changes or disadvantages in international competition, but only by a minority. Among the unaffected, higher shares see physical risks as subordinate to various transitory risks.

> *"This climate change is not a threat from the physical or the weather. This climate change is a threat to us, emerging from how politics deals with climate change." (U2)*

As shown at the beginning of this chapter, most entrepreneurs do not associate climate change with risks only. Rather, the changing business environment also offers opportunities. This is evident in enterprises that are actively involved in the "green transformation" of the economy, for example, by producing or installing heating systems primarily powered by renewable energies. Naturally, this only affects a relatively small part of all enterprises in Germany. But adapting to climate change can also bring advantages to many other enterprises. Switching to more efficient technologies can, for example, reduce production costs.

Figure 7: Benefits from adapting to climate change



Source: IfM Bonn: Climate Change Survey (2022), share of enterprises that rather/fully agree, extrapolated results.

In addition to these direct benefits of climate change adaptation measures, such measures also bring several indirect benefits. For example, in the future financial institutions will be obliged to consider climate risks when granting corporate loans. Likewise, large enterprises must assess and report climate risks in their supply chain (Löher et al. 2022). Better-adapted enterprises could thus have financing advantages and/or become more attractive as suppliers. These indirect advantages are only perceived by a minority of enterprises – especially among SMEs – at least so far (see Figure 7). Insufficient adaptation may thus also be because many enterprises neglect the indirect benefits of adaptation or consider them very small.

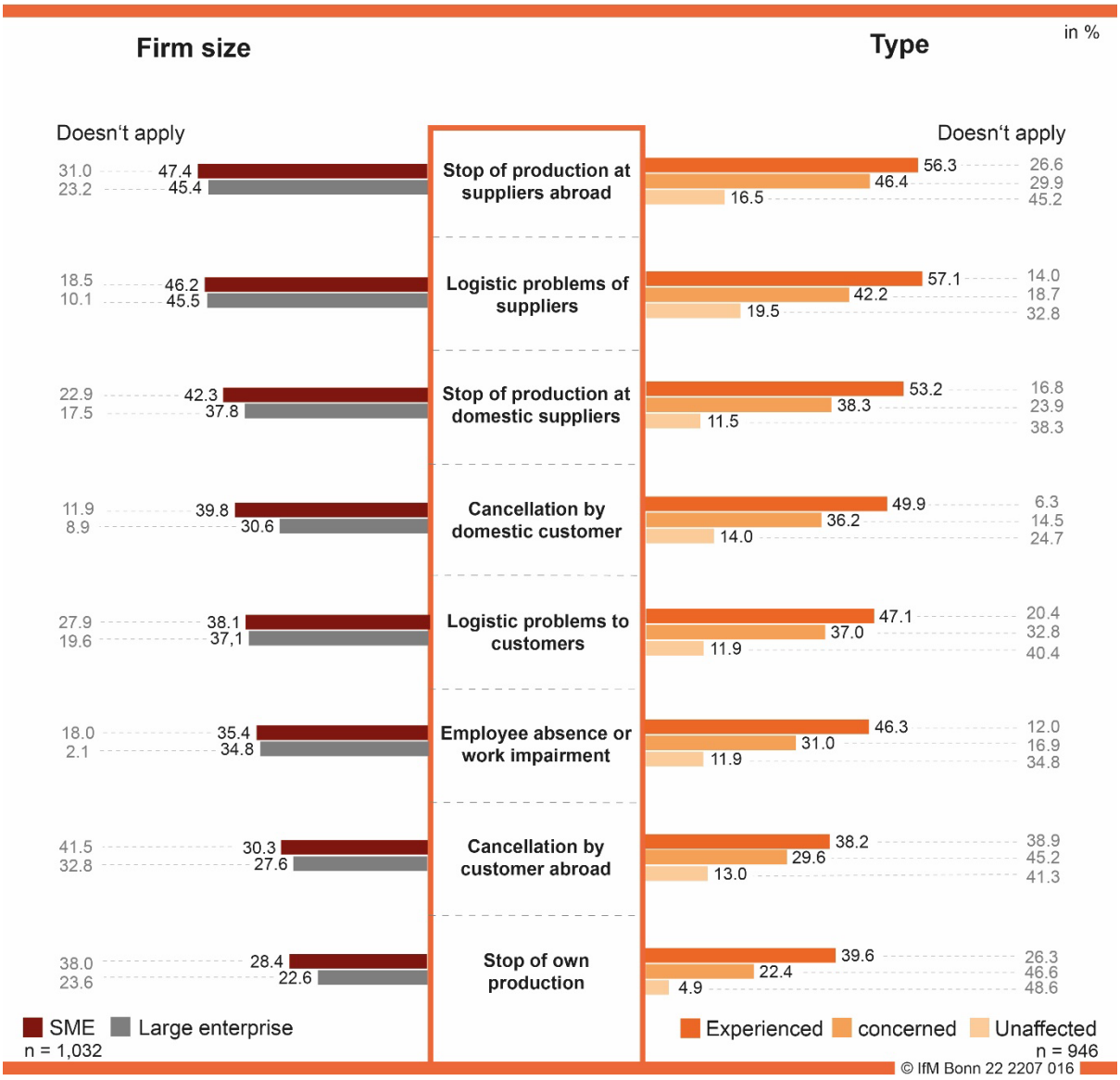
The consequences of climate change do not necessarily only affect an enterprise directly. Rather, they can also have an indirect impact through their supply chains. By nature, the value chains of SMEs are less dispersed because, for example, they are less likely to purchase products and services from abroad or sell them in foreign markets. Against this background, a higher share of SMEs indicates that interruptions in certain areas within the value chain are not relevant to them (see Figure 8).

On the other hand, SME entrepreneurs are aware that they can often only overview and assess supply chain risks related to their direct suppliers. Risks concerning suppliers further upstream (i.e., their own suppliers' suppliers, etc.) are much less in the focus of SMEs. They may not even see themselves in a position to manage them.

> *“As a first consequence, we source almost everything from Germany or Europe and less than 1 % of the purchasing volume internationally. However, some sources we buy from have production sites or procurement sites in countries where this could be problematic. But, of course, we can't influence or assess that at the moment, where does the stuff really come from in the end?" (U5)*

> *"When it comes to procuring medicines, we work with cooperating pharmacies, and they have to ensure they can deliver. From our side, I neither see any great possibility for action, nor great necessity, because we have never had any problems". (U2)*

Figure 8: Probability of impairment of the value chain as a result of climate events (if affected) and shares of those not affected



Source: IfM Bonn: Climate Change Survey (2022), extrapolated results.

Where relevant to them, entrepreneurs from SMEs and large enterprises mostly share their assessments of a future impairment of their business activity due to climate events. Within the next five years, they mainly expect climate-related supply problems. The loss of domestic customers and workforce problems are also possible.

At the same time, those entrepreneurs from SMEs who assume that they will be affected by climate change consistently consider an interruption of the value chain to be more likely than large enterprises. This result is in line with the considerations made in Chapter 2. Compared to SMEs, large enterprises can be

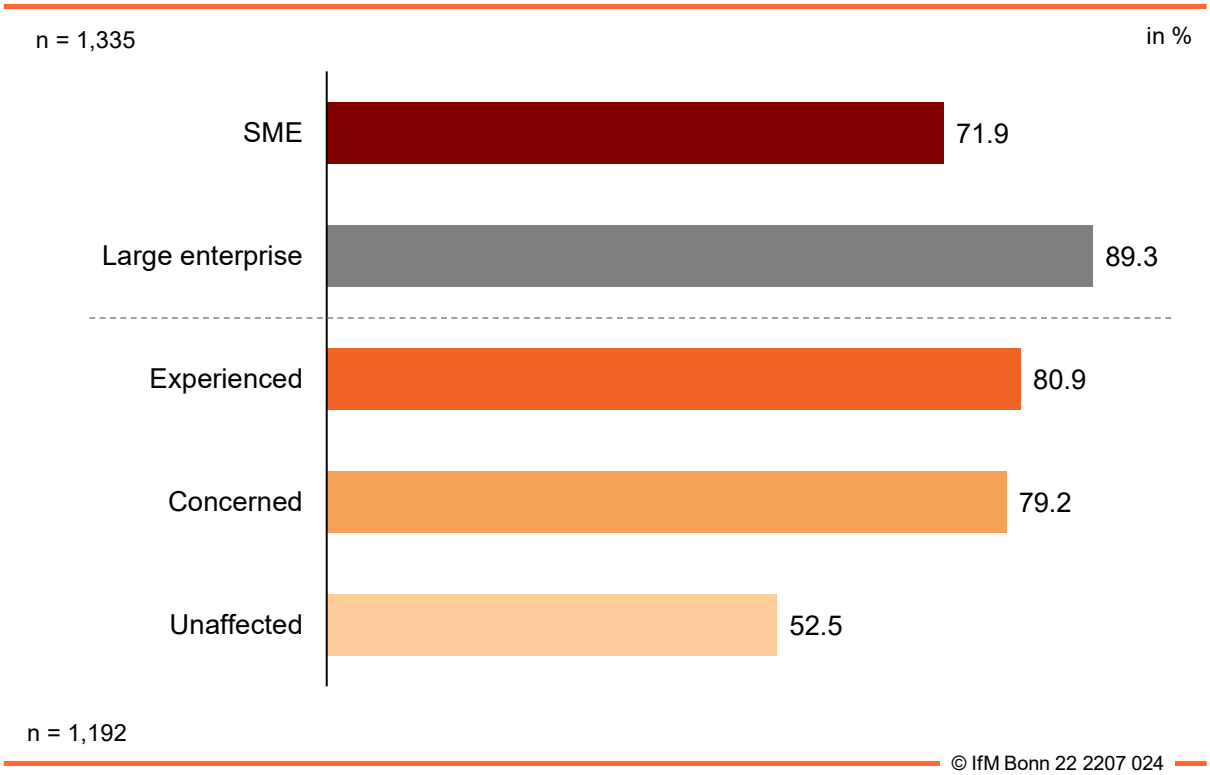
affected in many different ways. Still, at the same time, the extent of the potential damage is economically less drastic.

Consistent with our previous findings that the types differ mainly in assessing physical climate risks, the "concerned" and "unaffected" assign a lower probability to the different ways physical climate risks can manifest in their value chain.

4.2 Business responses to climate risks

In the course of the study, it became apparent that most entrepreneurs believe climate change has or will impact their businesses (see Chapter 4.1). In this chapter, we will now investigate how this assessment has prompted entrepreneurs to act. This is often the case: more than 70 % of SMEs and even almost 90 % of large enterprises have taken action (see Figure 9). Differentiated by attitude type, this is predominantly the case for both the experienced and the concerned. Even among the unaffected – among whom the corresponding share is much lower, as expected – approximately every second entrepreneur has reacted to climate change.

Figure 9: Share of enterprises that have actions



Source: IfM Bonn: Climate Change Survey (2022), share of enterprises that have implemented at least one measure because of climate risks, extrapolated results.

At first glance, the measures primarily address transitory risks (see Figures 10 and 11). Adapting existing and developing new products and services are among the most frequently implemented and planned measures.

> *"In case of doubt, maybe someone else would build it rather than us. (...) That also happens without us. But of course, it also happens with us. And we are quite happy to go along with it." (U5)*

However, the most common measure already taken by enterprises across all sizes is the use of digital solutions. The interviews illustrate the wide range of applications of digital solutions that also contribute to managing physical risks. They range from the use of weather reports and warnings as information tools for weather-related hazardous situations (U2), the visualisation of energy consumption (U1) and the reduction of resource use (U3) to the digital backup of knowledge (U3).

> *"If, for example, a natural disaster happens here, (...) then we would certainly be in a position (...) to rebuild a site (...) that would eventually offer the same status as the one we have now. Of course, we cannot work only with machines, only with a hall as such. The digital information – in our case, very strongly drawing-based data – huge data sets and developments, and the know-how we have digitised over decades are ultimately the most important thing. You can buy new machines. The know-how we have acquired over decades and then also digitised, not only in people, is, of course, irreplaceable." (U5)*

For the future, every third enterprise intends to become more self-sufficient in energy and water supply, especially through photovoltaics – although its use is not viewed completely uncritically and is sometimes discussed in a contrary manner. Inadequate storage options, for example, hinder enterprises' efforts to achieve greater to complete independence (U6) or contribute to the energy transition's success.

> *"We could contribute to the energy transition, but we wouldn't really be contributing to the stability of the electricity supply in our house. (...) We need electricity all the time." (U2)*

While on the one hand, the resources needed for the production of photovoltaic systems (U4) raise concerns, on the other hand, the potential for more widespread use is discussed in the entrepreneurial landscape. For example, there is

a lack of sufficient information about photovoltaics' economic benefits and pay-back period (U1).

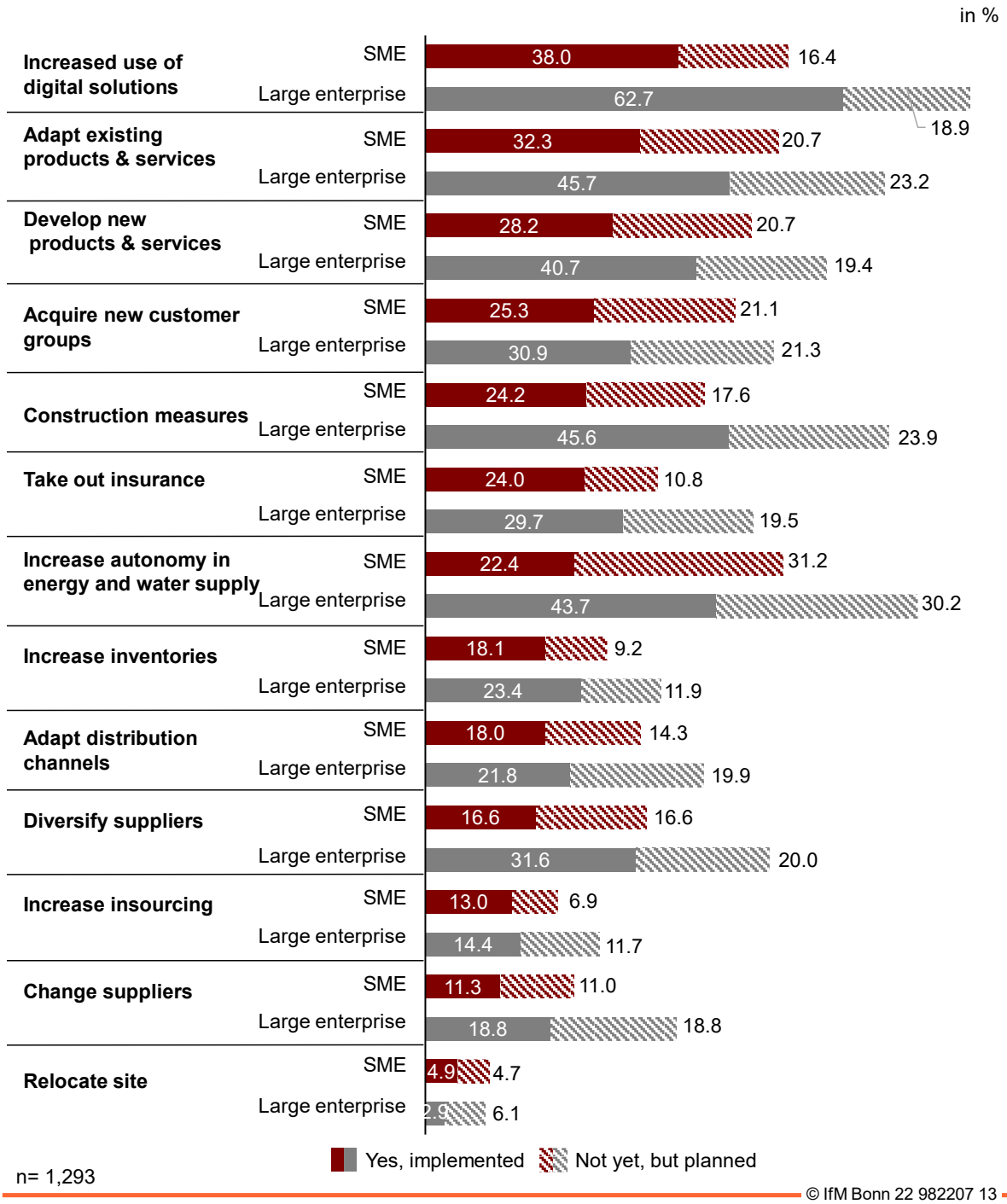
> *"For enterprises with high electricity consumption, switching to energy systems such as photovoltaic systems and electromobility is economical. A PV system pays for itself for large commercial enterprises after only six or seven years. It's a pity that (many) enterprises don't even know they can do something in this area. ... In the long run, it is definitely worth it." (U1)*

Measures that are suitable for reducing physical risks tend to be taken by SMEs as a lower priority. At the same time, there is a clear discrepancy between SMEs and large enterprises. To date, the increase in climate risks has prompted large enterprises to implement construction measures or take out insurance policies much more frequently than SMEs. Given the planned measures, this trend will continue. Meanwhile, it should be noted that relatively few enterprises – less than a third of large enterprises and less than a quarter of SMEs – insure themselves against climate risks.

In the case of SMEs, proximity to large enterprises – for example, through integration in supply chains – can prove advantageous when identifying suitable measures.

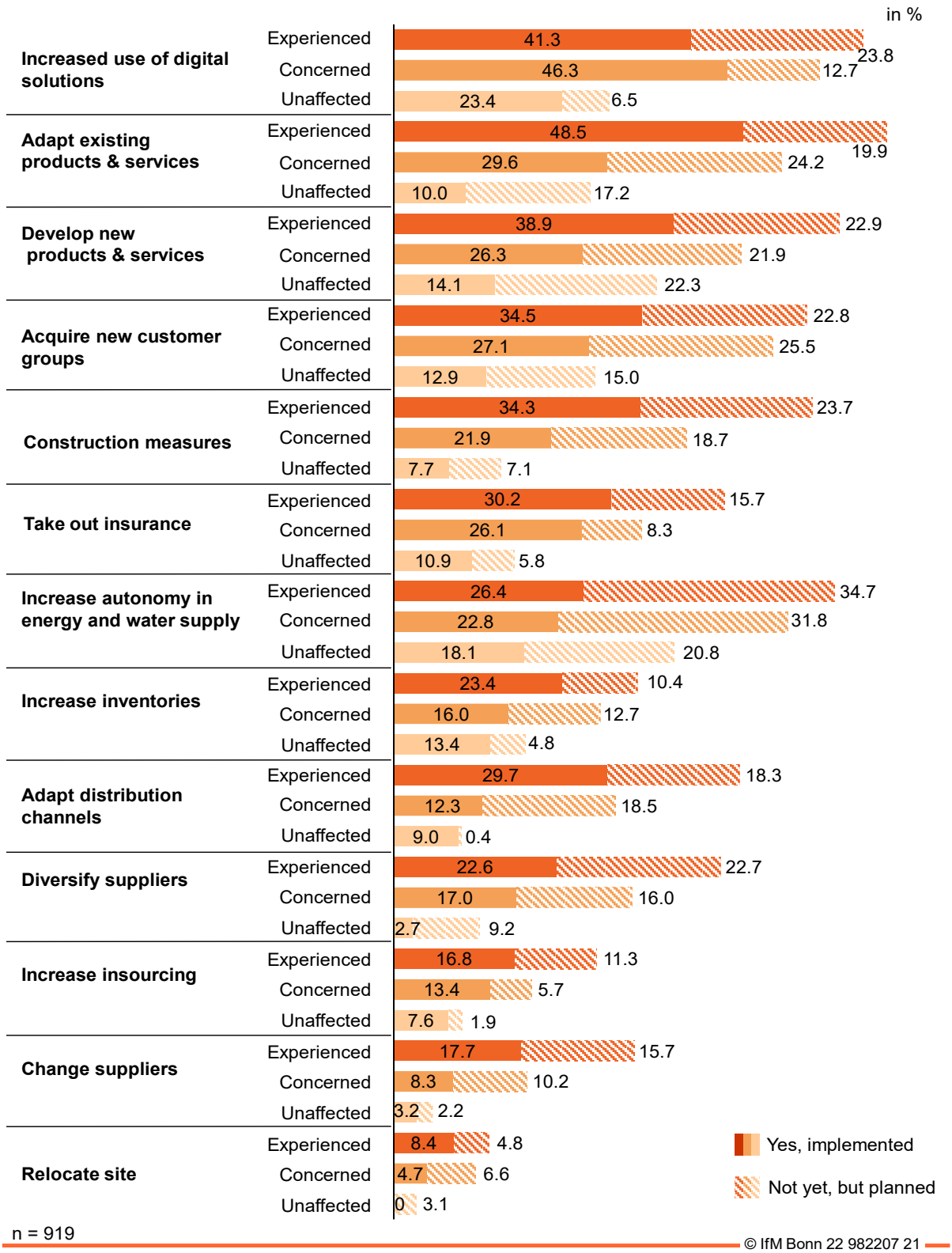
> *"We also have to deal with larger enterprises than ourselves. That is a factor in thinking a bit bigger and then, of course, also getting impulses. In the end, you also come into contact with people with similar problems in larger enterprises and usually start dealing with such issues earlier. " (U5)*

Figure 10: Measures taken and planned due to the increase in climate risks by size



Source: IfM Bonn: Climate Change Survey (2022), share of enterprises that have implemented/plan to implement measures, extrapolated results.

Figure 11: Measures taken and planned due to the increase in climate risks by attitude type



Source: IfM Bonn: Climate Change Survey (2022), share of enterprises that have implemented/plan to implement measures, extrapolated results.

It should also be noted that the measures taken are not always considered exclusively as a reaction to climate change. Instead, dealing with climate change comes in the decisions of entrepreneurs as a relevant aspect alongside other aspects, e.g., general cost savings (U5) or increasing customer benefits (*"because of comfort",* U2). Thus, entrepreneurs consider the consequences of climate change for their enterprises when making pending investments.

> *"By having climate as an issue on the screen, the moment you renew or maintain something, you definitely go a little step further" (U2).*

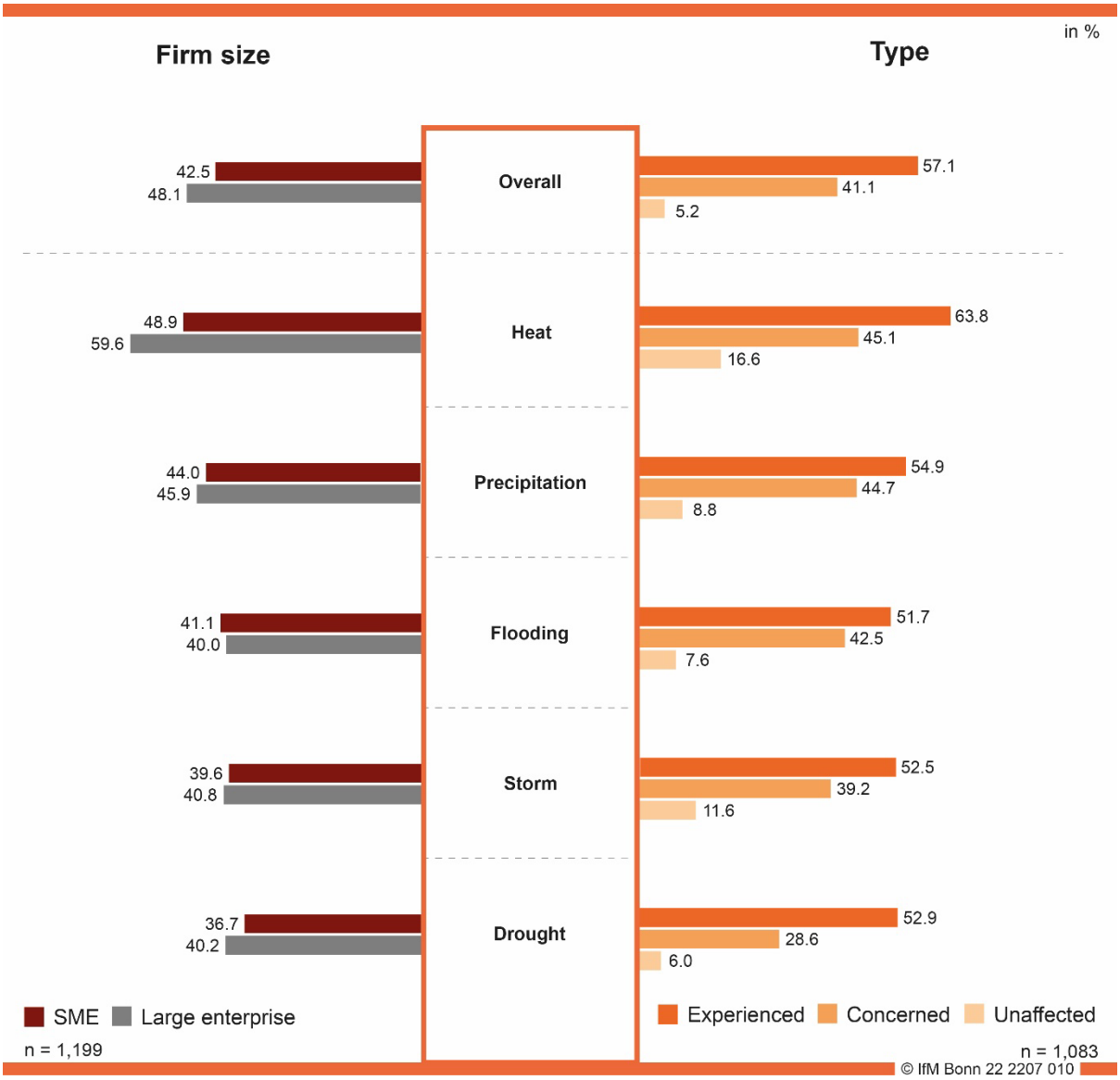
Analogous to the perception of climate risks, the experienced types head the list for almost all measures already implemented. However, noticeably, the experienced have not only already carried out many measures more frequently, but they also plan to do so more often than the concerned. This suggests that, in addition to a perception of risk, a concrete reason is also required – such as one's own experience of an extreme event – so that the perception leads to concrete action. The unaffected groups take far fewer measures to counteract climate risks than the other groups. However, they also need to take action – be it to adapt to changing consumer behaviour as a result of climate change or to execute bureaucratic requirements.

The enterprises are divided in their assessment of the measures already taken. Many entrepreneurs feel sufficiently protected against physical climate risks by the measures taken and see no need for further action. Extreme weather is *"of course, an extraordinary event. But what happens physically in the long term is something that can be planned and observed"* (U5). The local conditions at the respective location and the previous experiences of the entrepreneurs play a role in the assessment.

> *"There has already been rainfall, 135 litres per square metre in one hour – nothing happened at all. (...) Nothing would happen at all if the river overflowed its banks." (U4)*

At the same time, a non-negligible share of entrepreneurs does not yet feel sufficiently protected (see Figure 12).

Figure 12: Share of enterprises that consider themselves not (yet) sufficiently protected against a climate risk



Source: IfM Bonn: Climate Change Survey (2022), extrapolated results.

In comparison, entrepreneurs of large enterprises are more pessimistic in their assessment than entrepreneurs of SMEs. This may result from a better overview of the risks due to more systematic risk management. In addition, climate events are more likely to affect them due to their usually higher number of production sites and partners in the value chain.

In particular, many entrepreneurs of SMEs and large enterprises feel inadequately protected against extreme heat. This raises the question of what prevents business leaders who feel their enterprise is inadequately protected from taking (further) measures to safeguard against physical climate risks.

Other current challenges are the most frequently cited obstacle for SMEs and large enterprises, ahead of a lack of financial resources.[5]

> *"Now [after Corona], we need a year of calm waters and a business evaluation, where we can see what we can achieve from our own market activity... whether we can achieve stability again, without a rescue policy." (U2)*

Likewise, for many entrepreneurs, the benefits of the available measures are unclear. This reflects that prevention measures – like all investments – have uncertain benefits but certain costs. The entrepreneurs then *"have an eye on the climate risks, yes",* and are *"protected from them, no. You can't protect yourself from that." (U6)*

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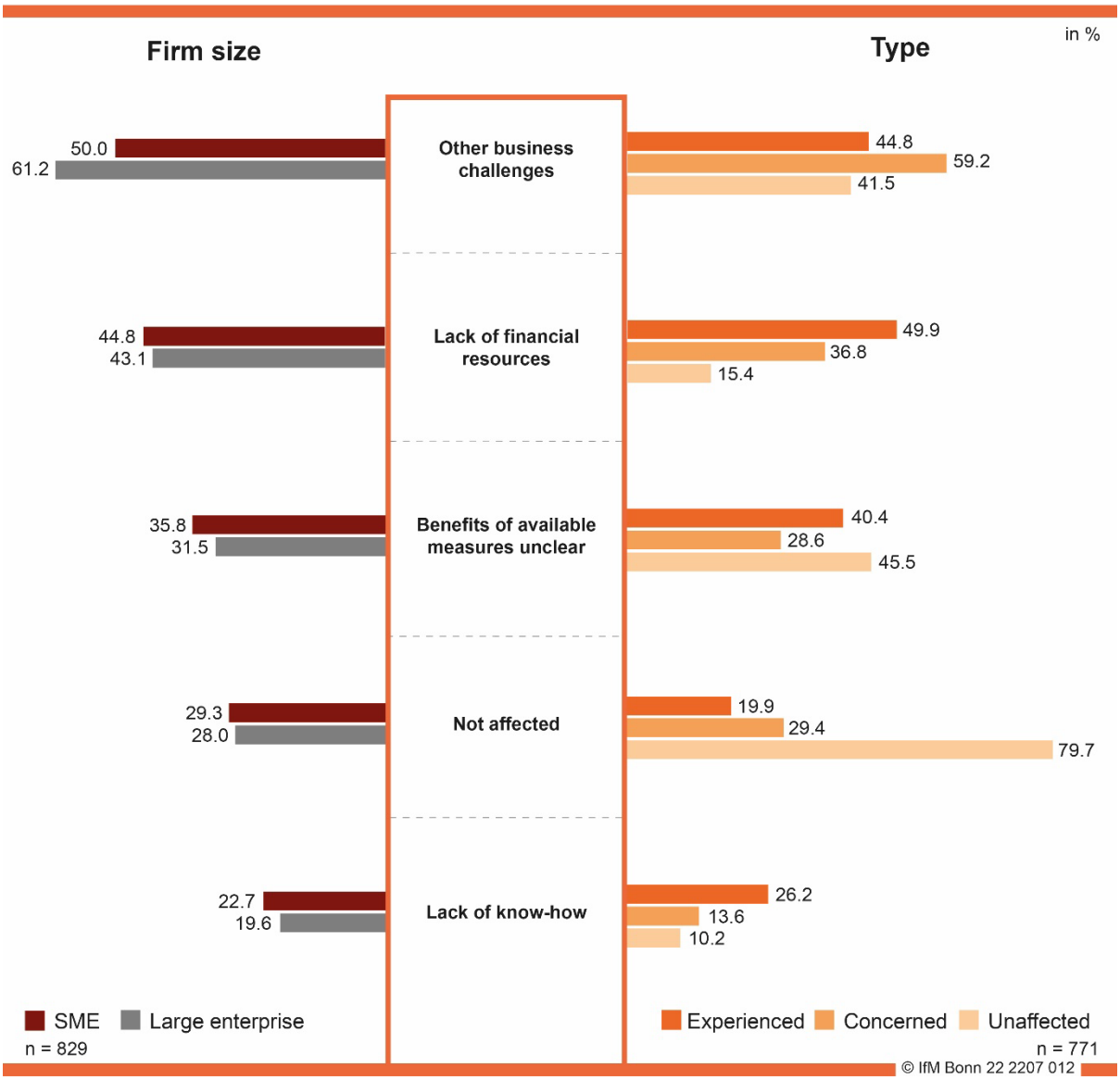
5 The frequent mention of a lack of affectedness is simply an expression of the fact that the perception of being affected by concrete physical climate risks varies greatly across enterprises. For example, an enterprise may feel affected by the flood risk and not sufficiently protected against it. At the same time, it does not feel affected by the risk of drought. A lack of further protective measures against physical risks may be due to a lack of financial resources in the case of the former risk and a lack of affectedness in the case of the latter risk.

Figure 13: Barriers to (increased) protection against climate risks



Source: IfM Bonn: Climate Change Survey (2022), share of enterprises stating obstacle reason, multiple answers possible, extrapolated results.

The most frequently mentioned obstacles vary among the attitude types. For the experienced, lack of financial resources is the main obstacle to taking (further) action. The concerned are involved in dealing with other current challenges. Among the unaffected, the lack of concern is the most frequently cited reason for not taking further adaptation measures.

5 Conclusion

Identifying and assessing risks – including those resulting from climate change – are among the very own tasks of entrepreneurs. However, the complexity of climate change-related developments may make it difficult for SMEs to consider all the consequences for their own business adequately.

Our results show that entrepreneurs are aware of the risks arising from climate change regardless of the size of the enterprise. However, it is noticeable that the perception of physical climate risks is more heterogeneous among SMEs than large enterprises. On the one hand, a higher share of SMEs belongs to the attitude type of the "unaffected", who do not expect any effects of climate change on their own business. On the other hand, a larger share of SMEs gives high priority to physical climate risks. These more extreme views among SMEs can have many causes. For one thing, the entrepreneurial personality – their expectations and experiences – is of greater importance in Mittelstand enterprises, which comprise a large share of SMEs. Our results suggest that own experiences are the central parameter for the awareness of future physical climate risks. For another thing, the higher heterogeneity in risk perception among SMEs could simply express a higher heterogeneity in actual affectedness.

For many enterprises, the transitory risks associated with climate change are highly relevant. In particular, higher energy prices are seen as very problematic. In this context, the recent developments certainly play an important role, which has clearly demonstrated the consequences of an increase in energy prices. In addition, SMEs and large enterprises alike worry about an expansion of bureaucratic requirements.

Despite the perception of climate risks, this does not always result in practical consequences. In particular, there is a large discrepancy between SMEs and large enterprises concerning the adaptation to physical risks. The reasons for this are complex. Some measures are simply not available to SMEs: for low production volumes, procurement cannot be distributed across a large number of suppliers to reduce the risk of a supply chain disruption through diversification. Other measures, e.g., constructional adaptation measures, represent fixed costs of production that disproportionately burden smaller enterprises.

Many enterprises consider themselves inadequately protected against the physical impacts of climate change. However, further adaptation measures fail due to a number of hurdles. These include a lack of financial resources and

prioritising other acute challenges. This raises the question of how policy can support enterprises' adaptation efforts.

First of all, our results suggest that further awareness-raising measures do not promise to have much success. For example, the group of the "unaffected" who does not expect any impacts of climate change is a clear minority. And even for this group, which does not share the assessment of the experienced and concern regarding climate risks, it cannot necessarily be concluded that these are people who deny climate change. Rather, it is conceivable that they assess the physical climate risks for their enterprise by weighing up the local conditions, their business model, and their value chain – but have so far concluded that the adaptation effort is not worthwhile from an economic-rational point of view.

Concerning entrepreneurs' prioritisation of other business challenges, the political room for manoeuvre is naturally small. Little can be done about the management's sole responsibility for entrepreneurial decisions in SMEs. Likewise, the scope for economic policy to influence general developments, such as the COVID-19 pandemic and the war in Ukraine, which additionally require entrepreneurs' attention, is limited. Influence is thus possible, at best, indirectly. For example, it would be helpful to reduce bureaucratic burdens, which, in many SMEs, require the attention and time of management.

Another bottleneck factor is the lack of financial resources. At first glance, the idea of expanding corresponding support offers appears obvious. In times of limited fiscal leeway, however, care must be taken to ensure that financial support also achieves the desired effect. This is questionable here. Many adaptation measures are structural. Suppose state subsidies further increase the demand for them, while the supply can only be expanded to a limited extent due to a lack of capacity in the craft and building trades. In that case, the state subsidies will ultimately not result in more adaptation measures but only in price increases. A more promising policy would be to expand the supply of adaptation measures. This includes streamlining and accelerating approval procedures or measures to alleviate the shortage of skilled workers. If an expansion of the supply succeeds, this will be accompanied by price reductions, lowering the financial hurdles to adaptation.

In conclusion, it remains to be said that adapting to entrepreneurial risks – which increasingly include climate change-related risks – is part of entrepreneurial responsibility. While a structural perception or information deficit could justify government intervention, we find no evidence of such deficits. In particular, we find

no evidence that SMEs systematically underestimate these risks. This does not mean that the state has no scope for action to support enterprises' efforts to accelerate society's adaptation to advancing climate change. Here, however, reducing regulatory barriers or coordinating public and private adaptation efforts at the municipal level would be more promising than further awareness-raising or promotional measures. Business associations, in turn, could expand their advisory and information services on local risks and further promote the exchange of experience among entrepreneurs on climate change adaptation.

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Appendix

Overview A1: Demographics of the entrepreneurs interviewed

No.	Industry	Size
U1	Craft, Installation Renewable Energies	Small enterprise
U2	Health & Social Services	Small enterprise
U3	Freelance, scientific services	Medium-sized enterprise
U4	Manufacturing industry, glass and metal construction	Micro enterprise
U5	Manufacturing industry, mechanical engineering	Medium-sized enterprise
U6	Property developer	Micro enterprise
U7	Hospitality	Medium-sized enterprise

Source: IfM Bonn: Climate Change Survey (2022).

Table A1: Regression results for type membership

	Attitude type		
Influencing factors	The experi-enced	The concerned	The unaffected
Size of enterprise (Ref.: large enterprise)			
Micro enterprise (yes)	-0.0538	-0.0477	0.1015***
	(0.284)	(0.345)	(0.002)
Small enterprise (yes)	-0.0014	-0.0961**	0.0975***
	(0.974)	(0.031)	(0.000)
Medium-sized enterprise (yes)	-0.0145	-0.0169	0.0314
	(0.745)	(0.711)	(0.234)
Industries (Ref.: Manufacturing)			
Agriculture and forestry/fishing	0.4064***	-0.2429***	-0.1636***
	(0.000)	(0.001)	(0.001)
Mining, quarrying stones	0.2545*	-0.1726	-0.0820
	(0.094)	(0.229)	(0.490)
Energy and water supply	0.2906***	-0.0906	-0.2001***
	(0.006)	(0.392)	(0.000)
Construction	0.1565**	-0.0537	-0.1028**
	(0.019)	(0.405)	(0.023)
Trade, car repair	0.0724	-0.0020	-0.0704
	(0.210)	(0.972)	(0.114)
Transport & Storage	0.1175	0.0091	-0.1266***
	(0.109)	(0.901)	(0.007)
Hospitality	0.2499***	-0.0905	-0.1594***
	(0.002)	(0.250)	(0.000)
Information & Communication	-0.0598	0.0485	0.0113
	(0.398)	(0.522)	(0.850)
Finance & Insurance Services	0.0402	-0.001	-0.0401
	(0.650)	(0.999)	(0.544)
Real estate and housing	0.1069	-0.0117	-0.0952*
	(0.261)	(0.899)	(0.087)
Freelance, scientific services	0.0250	0.0455	-0.0705
	(0.743)	(0.558)	(0.189)
Other economic services	0.0510	0.0002	-0.0512
	(0.516)	(0.998)	(0.366)
Education & Teaching	0.1817*	-0.1142	-0.0676
	(0.059)	(0.214)	(0.331)
Health & Social Services	0.0942	-0.0015	-0.0927**
	(0.127)	(0.981)	(0.039)
Arts, Entertainment, Education	0.2309**	-0.2213***	-0.0097
	(0.010)	(0.004)	(0.892)
Other services	-0.0544	0.0563	-0.0019
	(0.438)	(0.428)	(0.973)
Regions (Ref.: West Germany)			
Northern Germany	-0.1699***	0.0984**	0.0716**
	(0.000)	(0.037)	(0.043)
East Germany	-0.1241***	0.0544	0.0697**
	(0.005)	(0.208)	(0.022)
Southern Germany	-0.0746**	0.03623	0.0383
	(0.047)	(0.325)	(0.114)
Mittelstand (yes)	-0.0310	0.0119	0.0191
	(0.370)	(0.731)	(0.443)

Continuation of Table A1:

	Setting type		
Influencing factors	The experi-enced	The concerned	The unaffected
Dependence on a market partner (yes)	0.0813***	-0.0098	-0.0715***
	(0.009)	(0.753)	(0.001)
Locations			
Coastal	0.1311**	-0.0365	-0.0947***
	(0.044)	(0.561)	(0.000)
Near a stream or river	0.1140***	-0.0587	-0.0552**
	(0.002)	(0.104)	(0.022)
Low groundwater level	0.0894*	-0.0509	-0.0386
	(0.090)	(0.303)	(0.227)
Depression/valley	0.0515	-0.0845	0.0330
	(0.417)	(0.168)	(0.475)
Near the forest	0.0963**	-0.0732*	-0.0230
	(0.019)	(0.062)	(0.422)
Urban location	0.0526	-0.0564	0.0038
	(0.149)	(0.127)	(0.885)
Hill	-0.0191	0.0249	-0.0057
	(0.686)	(0.603)	(0.852)
Number of observations / pseudo R^2: 1,040 / 0.0812			

Note: average marginal effects of an ordered logit regression with robust standard errors, p-values in brackets. Results are statistically significant at the *** 1 %, ** 5 % and * 10 % level.

Reading aid: Micro enterprises (up to 9 employees) are significantly 10.15 percentage points more likely to belong to the unaffected type than large enterprises (more than 249 employees).

Source: IfM Bonn: Climate Change Survey (2022), own calculations.