Cross-Border Collaboration in Disaster Management

Zur Erlangung des akademischen Grades eines

Doktors der Ingenieurwissenschaften
(Dr.-Ing.)

von der KIT-Fakultät für
Wirtschaftswissenschaften
des Karlsruher Instituts für Technologie (KIT)

genehmigte

DISSERTATION

von

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Tag der mündlichen Prüfung:	20.10.2021
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Abstract

When a disaster strikes, a rapid and coordinated response by the various crisis management actors is essential to limit the consequences. This interaction is made more difficult when the disaster affects multiple countries, as cooperation across national borders creates additional obstacles. In addition to different regulations and systems, cultural influences such as language barriers or lack of trust also play a crucial role. Although borderland resilience is of fundamental importance, it is still underestimated in the scientific literature.

The first part of this thesis presents an agent-based model to study inter-organizational collaboration during disaster response operations in a borderland. By extending communication protocols from the literature to a borderland context, the model analyzes the global dynamics resulting from local decisions. A scenario-based approach shows that while improved trust leads to significantly better coverage rates, reducing language barriers is even more efficient, especially when agents speak the other country's language directly rather than relying on a general lingua franca. The study of coordination shows that information flows along the hierarchical structure of organizations are most successful, while spontaneous collaboration through an established informal network of private contacts can further complement information exchange and provide an advantage in dynamic environments. Moreover, the involvement of spontaneous volunteers in disaster operations doubles the coordination effort. However, coordination across both dimensions, within disaster operations and across borders, leads to the best provision of resources to the affected population.

In a second part, this thesis presents a novel empirical study design based on transnational social capital and Weiner's motivational theory to quantify people's connections across national borders by taking regional connections within countries as a basis for comparison. Data collected through representative telephone interviews in Germany, France, and the French-German border region support the hypothesis that social capital and willingness to help across the French-German border is at least as high as regional social capital and willingness to help within each country.

Consequently, this work provides valuable insights for decision makers to reduce substantial barriers in cross-border disaster relief and thus, improve cross-border cooperation in future disasters. Implications for today's world in terms of globalization versus emerging nationalism and impacts of (natural) disasters are discussed.

Kurzfassung

Wenn sich eine Katastrophe ereignet, ist eine schnelle und koordinierte Reaktion der verschiedenen Krisenmanagementakteure unerlässlich, um die vorhandenen Ressourcen bestmöglich einzusetzen und somit ihre Auswirkungen zu begrenzen. Dieses Zusammenspiel wird erschwert, wenn die Katastrophe mehrere Länder betrifft. Neben den unterschiedlichen Regelungen und Systemen spielen dann auch kulturelle Einflüsse wie Sprachbarrieren oder mangelndes Vertrauen eine entscheidende Rolle. Obwohl die Resilienz von Grenzgebieten von fundamentaler Bedeutung ist, wird diese in der wissenschaftlichen Literatur immer noch unterschätzt.

Im ersten Teil dieser Arbeit wird ein agentenbasiertes Modell zur Untersuchung der organisationsübergreifenden Zusammenarbeit bei Katastropheneinsätzen in einer Grenzregion vorgestellt. Indem Kommunikationsprotokolle aus der Literatur auf den Kontext der grenzüberschreitenden Kooperation erweitert werden, analysiert das Modell die globale Dynamik, die aus lokalen Entscheidungen resultiert. Ein szenariobasierter Ansatz zeigt, dass höheres Vertrauen zwar zu signifikant besseren Versorgungsraten führt, der Abbau von Sprachbarrieren aber noch effizienter ist. Insbesondere gilt dies, wenn die Akteure die Sprache des Nachbarlandes direkt sprechen, anstatt sich auf eine allgemeine Lingua franca zu verlassen. Die Untersuchung der Koordination zeigt, dass Informationsflüsse entlang der hierarchischen Organisationsstruktur am erfolgreichsten sind, während spontane Zusammenarbeit durch ein etabliertes informelles Netzwerk privater Kontakte den Informationsaustausch ergänzen und in dynamischen Umgebungen einen Vorteil darstellen kann. Darüber hinaus verdoppelt die Einbindung von Spontanfreiwilligen den Koordinationsaufwand. Die Koordination über beide Dimensionen, zum einen die Einbindung in den Katastrophenschutz und zum anderen über Grenzen hinweg, führt jedoch zu einer optimalen Versorgung der betroffenen Bevölkerung.

In einem zweiten Teil stellt diese Arbeit ein innovatives empirisches Studiendesign vor, das auf transnationalem Sozialkapital und Weiners Motivationstheorie basiert, um prosoziale Beziehungen der Menschen über nationale Grenzen hinweg zu quantifizieren. Regionale Beziehungen innerhalb der Länder werden dabei als Vergleichsbasis genommen. Die mittels repräsentativer Telefoninterviews in Deutschland, Frankreich und der deutsch-französischen Grenzregion erhobenen Daten belegen die Hypothese, dass das Sozialkapital und die Hilfsbereitschaft über die deutsch-französische Grenze hinweg mindestens so

hoch ist wie das regionale Sozialkapital und die Hilfsbereitschaft innerhalb der jeweiligen Länder.

Folglich liefert die Arbeit wertvolle Erkenntnisse für Entscheidungsträger, um wesentliche Barrieren in der grenzüberschreitenden Kooperation abzubauen und damit die grenzüberschreitende Resilienz bei zukünftigen Katastrophen zu verbessern. Implikationen für die heutige Zeit in Bezug auf Globalisierung versus aufkommendem Nationalismus sowie Auswirkungen von (Natur-) Katastrophen werden diskutiert.

Acknowledgement

The present thesis is related to my position as a research associate of Institute for Industrial Production (IIP) and French-German Institute for Environmental Research (DFIU) at Karlsruhe Institute of Technology (KIT). It was accompanied by several persons and institutions, whom I like to thank at this point for their manifold support.

First of all, I like to thank my supervisor Prof. Dr. Frank Schultmann for the excellent scientific support during the course of my graduate studies, which has shaped my professional development as a researcher. Thank you to Prof. Dr. Marcus Wiens, the head of the Risk Management Research Group at IIP, for the helpful advices, driving impulses, and constructive feedback. I am also grateful to my examination committee, Prof. Dr. Orestis Terzidis, Prof. Dr. Kay Mitusch and Prof. Dr. Thomas Lützkendorf, for reviewing my thesis and conducting the defense.

My special thanks go to the Risk Management Research Group, Farnaz, Florian D., Florian K., Mariana, Markus, Max, Rebecca and Sascha, for the valuable discussions as well as the positive team spirit in our group meetings and even beyond. Moreover, it was a great pleasure to work with the entire IIP team. Thank you for the motivating working atmosphere and enjoyable coffee breaks.

This thesis is based on my research within the Franco-German project INCA, funded by the German Research Foundation (DFG) and the French National Research Agency (ANR), which I gratefully acknowledge. I like to thank the French project partners, Dr. Eric Rigaud, MINES ParisTech as well as Prof. Dr. Anouck Adrot and Nour Kanaan, University Paris-Dauphine and the German project partners Prof. Dr. Frank Fiedrich, Andreas Lotter, and Yannic Schulte, University of Wuppertal for the close and efficient collaboration. Thank you also to Prof. Dr. Luise Lemyre, University of Ottawa and Prof. Dr. Stephen Platt, Cambridge Architectural Research Ltd. and University of Cambridge for their engagement in the INCA steering committee. In addition, my thank goes to Prof. Dr. Monika Buscher, Lancaster University, Prof. Dr. Erik Borglund, Mid Sweden University, and Prof. Dr. Sofie Pilemalm, Linköping University as well as Dr. habil. Jacqueline Breugnot, Dr. Björn Brömmelsiek and Caroline Mohr, University Koblenz-Landau for interesting conversations on borderland studies. Furthermore, I thank the participants of the Upper Rhine Conference (disaster relief working group) and the Transnational Academy of Risks, established by the Territorial Fire and Rescue Service of

Bas-Rhin (STIS 67), for discussing transfer possibilities and practical implications of my framework. In particular, I like to emphasize Lieutenant Colonel Alex Roth and Martine Loquet-Behr for their commitment to improve disaster relief across national borders.

With regard to the empirical study that is included within this thesis, I thank the interviewees for their participation and careful answers to the questionnaire. Furthermore, I appreciate the support by GESIS - Leibniz Institute for Social Sciences in Mannheim and Forsa - Society for Social Research and Statistical Analysis Ltd.

Moreover, I thank the student assistants and students, who I had the opportunity to advise, for their reliable and enriching work.

In addition, I kindly acknowledge the funding from Karlsruhe House of Young Scientists (KHYS) that enabled me to spend a research visit at Adelaide Business School, University of Adelaide, Australia. I like to thank all colleagues who have been very welcoming and facilitated fruitful exchanges on different research topics, in particular my host Prof. Dr. Indra Gunawan.

Furthermore, I like to thank Prof. Dr. Christopher W. Zobel, Virginia Tech, Prof. Dr. Steven O. Kimbrough, University of Pennsylvania - The Wharton School, Dr. Ashkan Zarghami, The Australian National University for the inspiring research collaboration on topics that are not presented in this thesis.

Finally, I like to express my sincere gratitude to my family, my parents and my brother, who continuously believed in me and encouraged me, and of course to my beloved grandmother. To my friends for always having an open ear for me, but also for the countless fun activities we spent together. I am deeply connected and very thankful to my partner René, who accompanies me with so much patience and understanding. Dear René, thank you very much for giving me confidence.

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1 Introduction and Motivation

Borderlands are complex and dynamic environments. Although they imply the idea of separation, they are at the same stage points of contact within different levels (Fontal et al. 2021). Today, many borders are invisible since there is no border control in place anymore so that people and commodities can move for example all over Europe without noticing a checkpoint. As a consequence, a high level of economic and social activity appoints borderlands as driver for economic exchange and growth (Kuhn 2012, Rippl et al. 2010). However, in the Covid-19 pandemic it became apparent how fragile this perception of a *borderless Europe* is. Regardless, the Schengen agreement, which was negotiated in 1985 in the small village of Schengen in Luxembourg's border region to Germany and France, as an essential pillar of the area of freedom, security and justice of the European Union, countries within Europe reintroduced border closures and controls. Throughout the pandemic, there was no clear, coordinated, and comprehensive border strategy. Not even within single countries, decision-makers could agree on a uniform approach to respond to the pandemic as seen in the different and sometimes contradicting approaches between the Federal German States.

Moreover, border regions are particularly prone to disasters. They are exposed to a large extent to natural disasters as countries are often geographically separated by rivers or mountains. A case in point was the flooding of the river Oder in 2013. Since the Oder is functioning as the geographic border between Germany and the Czech Republic, Oder floods affect both countries simultaneously (Flemming 2011). In the future, this trend is expected to become even more intensified by climate change effects, which are supposed to increase the risk of extreme weather events such as hurricanes/typhoons, floods, heatwaves, drought, wildfires, volcanic eruption, or earthquakes. Above all, the interconnectedness and technologization of today's society also contributes to the particular vulnerability of border regions. Today's societies are increasingly dependent on critical infrastructure and rely on them so much that they cannot even imagine a failure. As a consequence, breakdowns can pose a major threat to the affected population (Rinaldi et al. 2001). For example, one critical infrastructure on which several countries are contemporaneously dependent, is the energy system, which is connected throughout multinational networks. Under normal circumstances, this interconnectivity increases the system's robustness, but in the event of a disruption, problems can cascade even across national borders, as the power outage in the United States of America that spread to Canada in 2004 (U.S.-Canada

Power System Outage Task Force 2004), or in 2006, when a power outage affected large parts of Europe (Union for the co-ordination of transmission of electricity (UCTE) 2006).

Knowing the extraordinary importance, the Third United Nations World Conference on Disaster Risk Reduction (WCDRR) established in 2015 the current Sendai Framework for Disaster Risk Reduction 2015 – 2030 providing concrete actions for "the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries" (United Nations 2015). In particular, for border regions, the European Commission motivates in its Practical Guidelines increased cross-border cooperation between member countries with the goals of eliminating the imbalances, inequalities and problems of the periphery caused by the barrier effect of national borders. Moreover, regions are supported in their function as *engines of cross-border cooperation* enabling the citizens who live in a border area to develop a shared sense of history and find or revive a common mindset that is focused on an European future (European Commission and Association of European Border Regions (ABER) 2000). Especially in disaster response, assistance across national borders offers tremendous potential. For example, affected areas can sometimes be reached much faster from neighboring countries due to shorter distances. In addition, spare capacities can be utilized if a neighboring country is not hit as hard and can still share its available resources of personal and equipment. However, regional assistance is, in general, the first level of response. Due to the familiarity with the local circumstances, it can be more efficient and more accepted also across borders than the slowly starting support from the country's capital organized by the central government.

It is also important to note that in cross-border disasters, the number and heterogeneity of actors involved increases (Murphy et al. 2016), making response much more difficult. In addition to professional disaster response teams, in the recent past there is observed a new group of actors in the crisis response setting, namely spontaneous and unaffiliated volunteers who - driven by the event itself and without prior training - provide their help in various ways. In order to exploit this potential efficiently, the necessity became evident for effective integration into the crisis management procedures since otherwise, the complexity of the situation may lead to coordination problems as perceived in past events. Such coordination problems are further exacerbated when the disaster occurs in a border region, and international decision-making is required such that the actors have to collaborate across borders. In addition to technical interoperability, there may be different political or legal systems, as well as cultural differences including language barriers.

At this point it is important to hint at the interesting fact that border regions sometimes already have their own unique identity facilitating collaboration (Adrot et al. 2018). Due to history, it may happen that regions are already deeply connected across today's national borders. Such a phenomenon holds for the Alsace region in France at the border to

Germany. In the course of history, its affiliation shifted between France and Germany several times so that still today, many Alsacian people speak the German language, which does not hold as much within the younger generation. Such bonds help to facilitate borderland collaboration, but they are not spread far enough to eliminate all coordination and decision-making problems, especially since the disaster response systems are based on national requirements (i.e. laws), and in the best case, there is a higher-level supranational institution working on the alignment of (political) agreements.

For these manifold reasons, cooperation in disaster situations in borderlands is a particularly intricate, complex, and important issue, which should be examined in more detail in this thesis since despite their high relevance, border regions are barely addressed in disaster response literature. Thereby, two focal points are set to shed more light on the determination of success factors in a cross-border context: the first is the interorganizational collaboration between professional disaster control actors, and the second refers to the social bond and willingness to help within the population in a border area. In the following, these two aspects are outlined in more detail and with regard to the theoretical approach that they are addressed within this thesis, namely agent-based simulation and empirical analysis.

Although agent-based modeling and simulation is a very young method to map complex systems, it finds already application in a wide field. Agent-based modeling is an appropriate and insightful research method if it comes to a large number of actions, which make interdependent and rule-based decisions. Agents can store resource attributes, they are adaptive and can interact with others or the environment changing their behavior (Gilbert 2008, Macal and North 2005). The resulting dynamics may also effect other agents such that the complexity increases. Hence, the future is not fully predictable and it might happen that local optimal decisions result in globally inefficient outcomes. In this regard, the tool of agent-based modeling is appropriate to picture the dynamics of a complex situation as an emergency since it allows to simulate different types of agents representing the various stakeholders. As mentioned in Crooks and Wise (2013), agent-based simulation is appropriate even more for crisis situation since it allows to simulate unclear dynamic situations where no global information is available. Hence, such a model is especially suitable for investigating efficient interorganizational collaboration in disaster response focusing on the actors' information exchange. In this regard, the present thesis outlines the different actors involved in disaster response including organizations, the affected population as well as spontaneous volunteers. It sets up different layers to study different demand patterns of the affected population, and response strategies for the organizations focusing on interorganizational collaboration for information and resource exchange as well as including a coordination framework for bringing spontaneous volunteers efficiently into the process to use their potential. Moreover, the model has an underlying infrastructure layer representing the supply of needed goods and services. By

the scenario-based design, the model allows to compare different settings and thereby to quantify the effectiveness of the considered measures with respect to borderland disaster resilience. Even though overcoming these barriers is widely considered crucial for cross-border collaboration, cultural factors are barely regarded in disaster management research. Thus, special attention is paid to these traits of actors as they are very relevant for the potential of borderland collaboration. Agent-based modeling allows to define different characteristics for each agent distinguishing between agents from each country.

Another important point for borderland disaster resilience is the need for a positive and solidary mutual attitude between the citizens of two neighboring countries, which is called *transnational attachment* and mainly based on social capital and trust. The concept of social capital provides both a useful and established measure of social connectivity among people living in a region. It comprises factors relevant for the functioning of social groups which include shared norms and values as well as interpersonal relationships, trust and cooperation (Bjørnskov 2007, Ostrom 2003, Putnam 2001). Such relationships cannot be established easily in a dynamic and uncertain environment as in the aftermath of a disaster. Thus, the level of social capital and trust helps the decision-maker to estimate the self-help capacities of a population already in advance to a large-scale disaster. The self-help capacity of a population is widely seen as an important prerequisite for community disaster resilience (Nichols 2015, Group 2012). There are international strategies, norms and guidelines promoting citizens' self-help capacities by policy, but there are currently neither historical cases nor a data basis on which to assess the potential for self-help capacities in a cross-border region. In particular for border regions this is important as outlined before, all border regions are unique and some might have tensions or conflicting attitude towards their neighbors while others share an unique identity across the national borders. In order to understand this basis, the thesis presents a cross-regional and cross-country comparative empirical design on regional and national level taking into account that such attitudes are very sensitve with respect to the target group as highlighted by Stephany (2019) for the examples of North versus South Italy and East versus West Germany (Stephany 2019).

As a measure for border region attachment, social capital – and in particular trust as the most important component of social capital – and the helpfulness of citizens towards citizens of neighboring regions are chosen. Although social capital and trust are widely seen as important lubricants of multiple dimensions of the social and economic life, the main interest is in those characteristics of border region attachment which motivate people to be particularly supportive in times of crisis and thus enhance regional resilience. Trust serves as a facilitator for conflict resolution (Levi et al. 2004, Rousseau et al. 1998) and in recent literature, social capital and trust were identified as key factors in the context of disaster resilience (Toya and Skidmore 2014, Uslaner and Yamamura 2016). In the second part of the study the question is examined whether border region attachment is

a potentially valuable resource for crisis resilience as expressed by a high willingness to help of the people living in this area. Thus, inter-regional wilingness to help is uncovered for a hypothetical crisis scenario, as it is used for scenario experiments, and the data on hypothetical willingness to help are compared between neighboring regions with the cross-border levels. The driving factors for willingness to help are selected in accordance with Social Motivation Theory (Weiner 1993) since Marjanovic et al. (2009) proved this framework to be suitable for natural disaster situations. If there is a self-help capacity potential in the border region, this approach can be used to determine whether the self-help level is approximately comparable with the respective country levels and, if not, in which direction a deviation can be observed.

This study is applied by conducting representative telephone interviews in Germany, France and the German-French border region. Even though there is no specific survey of cross-border attachment in the literature to date, analysis of case studies and anecdotal evidence suggest that this border region could serve as candidate example (Vajta 2013). It is perceived to have its own borderland culture – especially in the Alsace area, in which borders that define Alsace have changed several times in the course of its history (Dehdari and Gehring 2019). Moreover, Europe is a political union for more than 25 years now and thus, a high degree of inter-connectivity prevails. Thus, the study is applied to this region and representative telephone interviews were carried out in both countries, Germany and France, paying special attention to also cover a representative sample of the border region.

When a disaster strikes, fast and well-coordinated response actions need to be established. Although the investigation of border regions and their complex interconnections is of fundamental importance to a variety of academic fields and has far-reaching practical implications in today's interconnected world, there is less evidence on research examining this topic. This thesis contributes to the understanding of border regions and its connections as well as collaboration effort in disaster response supporting the strategic planning for disaster resilience. On this account, the present thesis is structured as follows. It begins presenting the state of the art with respect to borderlands, risk and disaster management including the aspects of vulnerability and resilience. Then, it turns to the methodological emphasis comprising an agent-based model studying the interorganizational collaboration across a national border including an effective coordinating framework for the involvement of spontaneous volunteers. This is followed by an empirical investigation presenting a comparative framework to examine the social capital and willingness to help in borderlands based on representative telephone interviews in the German-French border area as well as within the respective countries. Afterwards, the results are discussed with respect to current developments in today's world pertaining to upcoming nationalism and collaborative disaster response. In the end, the results are summarized focusing on practical implementations and giving an outlook for further investigations improving borderland disaster resilience.

2 Theoretical Foundation

This thesis contributes to the understanding of border regions and its connections, so that first an outline on relevant definitions on borderlands, boundaries and frontiers are given and placed into the scarce literature of transnational concepts and cross-country bonds. Thereby, the focus covers various perspectives including geography, politics, legislation, economy, and culture. As the thesis deals with disaster response in borderlands, the second subsection covers risk- and disaster management outlining the concepts of vulnerability and resilience. Moreover, the theory of collaboration is briefly presented here with respect to an international context as this is the essential focus of the thesis. For details, it is referred to the respective parts of the theory section which are outlining interorganizational collaboration as well as personal bonds, social capital and willingness to help.

2.1 Definition of Borderland Terms and Concepts

The Oxford English Dictionary defines a border as "the line that divides two countries or areas". However, this definition is rigid and limited in its perspective and therefore, different disciplines come up with broader definitions including several aspects that are outlined in the following. Starting their argumentation from different points of view, many of these definitions extend to territorial boundaries including history, political or economic dimensions and refer in particular to the society, their demography and culture in terms of influence by the border.

A border is often seen as a barrier. In many cases, territorial borders coincide with geographical conspicuousness as rivers or mountains. Such natural borders by definition come along with some challenges to be crossed, which in fact was historically intended. But also artificial man-made borders can be built in such a way that they represent a barrier preventing the crossing of *outsiders*. From a theoretical perspective, Nail (2016) outlines in his book that borders are *between* states. He argues that a border has two sides and if both sides were touching each of the states and thereby belonging to these states respectively, there would be no difference between these two states. However, in this case, a border would not be required. Thus, he concludes that it also needs to be a third thing in between, namely the border itself, touching the states. He introduces a border as the fuzzy zone that is "not strictly a territorial, political, juridical, or economic phenomenon

but equally an aterritorial, apolitical, nonlegal, and noneconomic phenomenon at the same time" (Nail 2016). This implies that the study of borders cannot only focus on the aspect of division but also needs to include the *in-between* area, which cannot be reached by the social power of neither of the states. The result of thereby introduced borderlands' bifurcation as extensive and intensive at the same time is that the border is experienced as a continuity by some and as a discontinuity by others. In this regard, Parker highlights that "the terms boundary, border, frontier, and borderlands mean many things to many people" (Parker 2006) and provides a differentiation between them. In his definition, boundaries are the most general of these terms including the types of borders and frontiers that are distinguished with respect to their dynamic (i.e. borders are static while frontiers are fluid). An expanded version of his framework illustrates the five major categories of boundaries that occur in borderlands as geographic, political, demographic, cultural, and economic. He outlines that these are interconnected and vary in time.

In the historic logic of states coming along with their own political, legislative, and economic systems, borders divide these systems and distinguish one from another. However, this delimitation of systems does not always correspond to the cultural boundaries of people living in these regions. Anderson and O'Dowod mention that "social and communal boundaries are seen to be increasingly de-linked from territorial borders" and that "cross-border regions may have an underlying cultural unity not congruent with state borders" (Anderson and O'Dowd 1999). Thus, Kaplan (2000) distinguishes between *clean* borders where the political boundary coincides with the cultural one so that the break is clear in national and spatial identity and *messy* borders in which this is not the case so that the borderland becomes a zone of confusion. This may happen for various reasons: boundaries can be defined without regarding the underlying cultural dynamic for example when states borders shift due to welfare or political reasons, but also cultural boundaries can shift under remaining state borders for example due to migration or adaptation. In such cases, peoples' minds may feel more closely connected to people assigned to the neighboring states and the systems in force therein which leads to conflicting identities. However, there are different scales of identities, meaning that in addition to the influence of the borderland itself, there may be overlapping national identities. Thus, "borderlands are dominated by the interplay, overlap and competition of larger national identities" as shown in Figure 2.1. The illustration shows a national identity (ethnic group 2) that spans over its corresponding countries' geographical border to the territory of the neighboring country. Since the national identity of the neighboring country (ethnic group 3) is congruent to its territory, the national identities are overlapping in the borderland. In addition, there is ethnic group 1, which is a local identity affiliated with the borderland itself. This mix of identities of course leads to asymmetry, however, at the same time, it provides the opportunity to establish a new borderland specific identity that connects the encompassed identities by enabling the different groups to embody themselves in a manifold set

of identities. This view is shared by cultural anthropologists who focus on borderlands as regions where new communities have developed and are developing across or around (Pavlakovich-Kochi 2016, Donnan and Wilson 1994). In this regard, Adrot et al. (2018) formulate that borderlands can establish their own culture independently of their national identities.

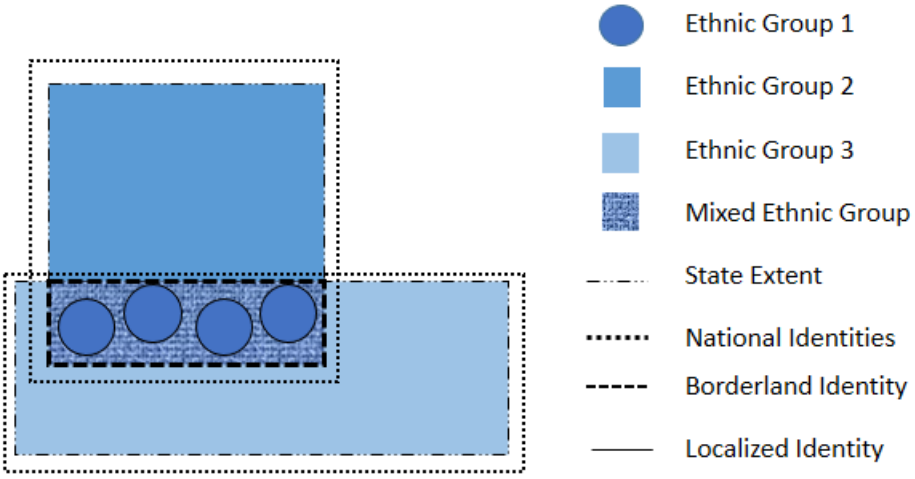


Figure 2.1: Borderland Identities According to Kaplan (2000)

Additionally, cultural psychologists are interested in the *citizens of a border*, their way of thinking, acting and feeling (Marsico 2016). Comparing Mexicans and Americans living in the border region, Cubero et al. (2016) show that residents from Matamoros (Tamaulipas, Mexico) are more personally involved into all the aspects related to the border compared their counterparts from Brownsville (Texas, United States). Border crossings belong to the Mexican way of life as they need to find better life conditions *out there*. Despite for them the border is asymmetric, it is permeable. However, the study clearly shows a cultural discontinuity asking for a narrative to cover all the borders' human drama. On the other hand, Americans do not recognize the border as having two parts. They do not need to cross the border searching for better conditions *over there* and thus, they do not even occasionally have the feeling of insecurity or strangeness (Cubero et al. 2016). This is in line with Rumford accounting personal circumstances on the people's experience on borders: "what constitutes a border to some is a gateway to others" (Rumford 2006). In addition, he highlights a higher freedom to connect with a whole range of others who share similar beliefs, fears, and preferences in today's globalized world.

From these conceptual considerations, the outline now turns to a comparison between different institutionalized forms of collaboration within border areas. In particular, the European Union as a creation of *supranational institution* targeting integrated economy and political space due to collaboration is often compared to the borders of the USA, Mexico on the one hand and Canada on the other, which are mainly driven around economic

interdependendencies as well as socio-economic and structural complementarities (Scott 1999). Perkmann (2003) highlights that in the European Union more than 70 municipalities and regional authorities cooperate across the national borders. Additionally, the European Union and the Council of Europe provide a framework such that cross-border cooperation among non-governmental organizations (NGOs) increases. Thus, within Europe a large number of projects and initiatives have been launched "with the expressed goal of opening up new spatial perspectives for co-operation between cities and regions in various areas of economic development and regional policy" (Scott 1999). They have encouraged *multilevel institutionalization* in order to "facilitate cooperation and the vertical and horizontal coordination of policy between different spatial levels" (Scott 1999). Providing incentives for creating groups of similar interests also across countries' borders, does not only facilitate to establish an European identity, but also to spread innovations in the areas of economic development, job creation measures and revitalization strategies among other things. However, this strategy is based on the advances in the Benelux countries and even in such culturally homogeneous border areas it is not fully examined. In this regard, too high administrative complexity is seen for collaboration (Scott 1999), local dependence on cooperation incentives is criticized (Johnson 2009) as well as that the advances only hold for the public sector excluding the establishment of connections between private enterprise systems or effective cross-border collaboration to achieve common land use policies or urban developments (Hassink et al. 1995).

However, compared to American border regions, the progress in established connectivity is enormous. This comes along with the different incentives. The North American motivation of regional integration is driven exclusively by economic concerns rather than any sense of a common *North American destiny* (Scott 1999). Thus, the negotiated agreements are more recent and limited to economic exchange, so the North American Free Trade Area (NAFTA) was established only in 1994 superseding the Free Trade Agreement between Canada and the United States of America (CUSFTA) from 1987. The economic bond between Ontario (Canada) and Michigan (United States), for example, is grown due to the automotive sector so that already in 1965 a sector-specific trade deal called the Canada-United States Automotive Products Trade Agreement was negotiated (Anderson 2012). From this origin, the border between Canada and the United States evolved to one of the more easily crossed borders in the world. However, this situation vividly changed after September 11, 2001 where the increasing security measures lead to longer delays. Given these circumstances, Anderson (2012) highlights that policies need to be able to serve both, security and trade facilitation. But he also acknowledges that for a *perimeter* approach eliminating all border functions by achieving complete policy harmonization between the states would not be realistic for the United States and Canada within the near future as they have not even established a customs union. Thus, the simplest way for border controls is

to increase the physical infrastructure at border crossing points including technologies that help to speed up the inspection processes.

A comparative study by Brunet-Jailly (2004) highlights that although the economies between Ontario and Michigan were more strongly interconnected compared to neighboring countries within the European Union, there is less cross-border collaboration between public actors in this area (Anderson 2012). This is underlined by Doran (1996) outlining that the NAFTA follows the idea of confining integration to regional connections on a basis of functionality "but does not envisage a *borderless* North America, nor a comprehensive policy-making process at the supranational level - at least not within the foreseeable future" (Scott 1999). This difference between North America and Europe is illustratively underlined by Blatter (2004) who compared four institutions in European and North American border areas (Figure 2.2) along his definition, which distinguishes four ideal types of cross-border political institutions as seen in Table 2.1.

	Territorial Governance	Functional Governance
Instrumental/Control	Commission	Connection
Identity-providing/Orientation	Consociation	Coalition

Table 2.1: Four Ideal Types of Cross-border Policitcal Institutions According to Blatter (2004)

On the first dimension, he distinguishes between instrumental control and identity-providing institutions as introduced by Göhler (1994). He argues that both kinds, institutions with the primary function of reducing *transaction costs* in the exchange as well as those of *ritual representation* which create mutual obligations and ties among the members of a group, are important to maximize individual and social welfare. Moreover, he distinguishes between territorial-centric and functional-centric governance on the other dimension. Traditionally, they are differentiated by the type of network interactions between the actors. A fully territorial governance would have a hierarchical network structure in which the information flows primarily within the national units and only *at the top* across the national boundary. Furthermore, the cross-sector exchange would take place on a national level and only public actors cooperate across. On the other hand, functional governance is defined by a policentric network allowing direct exchange on all levels. The concept of Blatter (2004) in this differentiation goes beyond also including factors like scope, geographic scale and stability along time and space to characterize the type of cooperation. Moving to a comparative illustration of the four types, Blatter chooses the Upper Rhine Valley and the Lake Constance Region in Europe as well as the Californias and Cascadia in North America. He notes that "whereas in Europe the most important institutions (Oberrheinkonferenz, Bodenseekonferenz) are purely intergovernmental and complemented by institutionalized meetings of legislators, North American institutions are

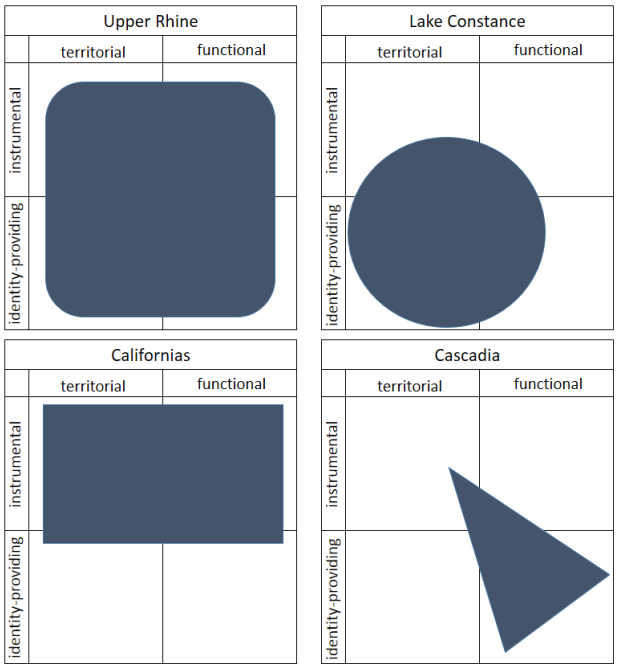


Figure 2.2: Illustration of the Institutional Profiles in Four Border Regions According to Blatter (2004)

much more open for direct involvement by private and non-profit actors" (Blatter 2004). In this regard, Figure 2.2 provides an illustrative characterization of the institutional profiles of four border regions. The Upper-Rhine region with its highest level of institutionalization is represented by a square covering the advances in all dimensions. Furthermore, the circle mapping the Lake Constance region shows the regions' achievements in the establishment of a common identity. Since political collaboration is the emphasis of the Californias, this region is pointed out by a square encompassing the entire instrumental dimension. The forth region, which is Cascadia, is focusing on the functional identity building as shown by the triangle located at the bottom-right position. This is in line with the finding of Brunet-Jailly (2012). He outlines that the cross-border economic integration via connections of public and private institutions and managers to facilitate trade lead to clusters with regard to sectors and interests. These are not territorially bounded to the border region, but rather allow for transboundary governance in arbitrary dimensions by means of spreading networking activities (Brunet-Jailly 2012).

In summary, it can be said that border regions are various in their nature, ranging from their geography and their economic, political and legal systems to the social bonds among people living in a border region. While borders have historically been viewed as barriers, re-bordering, that may lead to differentiation between cultural and territorial border, as well as intense government programs to establish regional development have resulted for some border regions in the establishment of their own identity and connections between people across the states' border. Other border areas are still characterized by hostility, although it it is also to note that there are borders with asymmetric perception between

people living on one side and people living on the other side. Thus, a framework to study border regions, and especially collaboration, needs to be very flexible allowing to include individual characteristics of the region.

2.2 Risk and Disaster Management

Formally, "risk is a function of the probability of particular hazardous event and the losses it would cause" (Khan et al. 2008). Since risks are present in all areas of daily life, risk management is an important discipline outlining strategic approaches to deal with them. This does not mean, however, that every risk has to be eliminated regardless of any costs, contrariwise a strategic assessment is required. Thus, systematic and strategic risk management consists of the four phases risk identification, assessment, response, and controlling (Pritchard 2010). It is to note that risks are very different in nature which makes their handling individual. While an accident in the roads may lead to a delay, a fire in the building might cause severe injuries of people. Thus, a detailed risk identification is fundamental. Thereafter, the various risks need to be assessed which is often done by clustering them in form of a matrix. Each of the two dimensions "occurrence probability" and "impact" is divided in the levels low, medium, and high resulting in nine fields for which an individual risk response strategy is adequate. A well-established strategy to cope with high occurrence probability and high impact risks is their transfer to an insurance company. Medium risks of the same type can be pooled while diversification of different types also reduces the risk. On contrary, risks with low occurrence probability and low impact not necessarily need to be eliminated. As a matter of fact, the chosen strategy to deal with different types of risks is also depending on the individual risk preference of the decision-maker. However, the process of risk management needs to be monitored continuously. Moreover, it should be controlled and adapted in order to minimize the potential for undetected events, so called *black swans* that cause high damage. Most risks have minor impact and the strategies to deal with them are routines.

In some cases, risks go beyond the normal range causing damage with the potential to turn into a disaster that is "a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources" (United Nations International Strategy for Disaster Reduction 2009). As the outlined risk assessment strategy is convenient for self-contained surroundings, an alternative concept of risk assessment is now presented which considers the dimension of interconnections like societies or economies. Figure 2.3 outlines "that risk has two elements, the first is associated with the inherent conditions of the country that is exposed to external shocks and the second associated with conditions developed to absorb, cope

with or bounce back from adverse shocks" (Briguglio et al. 2009). Thus, this review

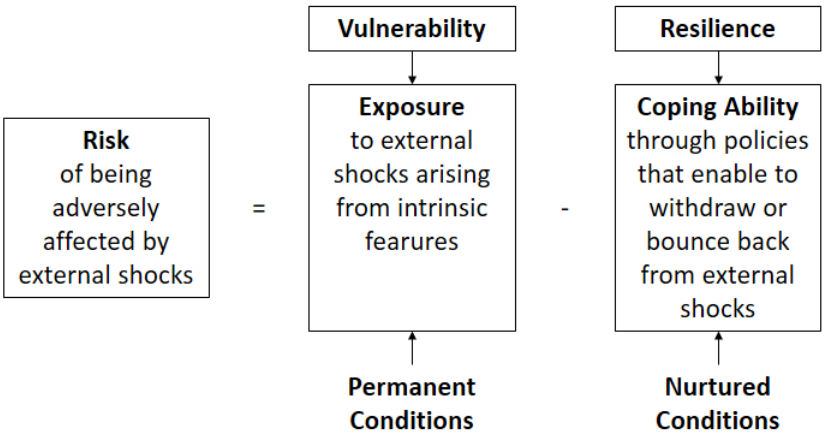


Figure 2.3: Risks Associated with External Shocks According to Briguglio et al. (2009)

turns to a closer look on the vulnerability of a society and its capabilities to become resilient. Vulnerability can be defined as "the degree to which a system, subsystem, or system component is likely to experience harm due to exposure to a hazard, either a perturbation or a stress/stressor" (Turner et al. 2003). Despite it is unclear what exactly drives vulnerability, most analysis "share an explicit concern for losses that directly relate to human welfare, in terms of damage to property, damage to livelihoods, forced migration, morbidity, or mortality, for example" (Turner et al. 2003). Flanagan et al. (2011) explicitly deal with vulnerability to hazards and name factors as age, income, the strength of social networks, and neighborhood characteristics as influences for vulnerability. In this vein, Davis et al. (2005) highlight the factors influencing community resilience on the example of health provision which include infrastructure in the build environment, the access to high-quality, culturally competent and well-coordinated public and private services as well as structural factors (such as racial relations and a stable economy) and social capital. Often, "resilience and vulnerability are viewed as opposite sides of the same coin" (Twigg 2007). However, Manyena et al. (2011) does not share this view and points out the notion of *bouncing back* as the decisively factor. Since disasters are accompanied by change, the authors "posit that resilience should be viewed as the ability to *bounce forward* and *move on* following a disaster" (Manyena et al. 2011). The term resilience originally came from the psychological literature understanding the ability to deal with adversity and stressful life events, as trauma (Wu et al. 2013). However, today it is understood in a much wider sense applied in various fields. Economic considerations see resilience as approaches targeting "the ability to reduce the risks of large shocks, to absorb quickly and smoothly those shocks that occur, and to recover from shocks through well-governed economic markets as well as efficient reforms of structural policy settings and institutional frameworks" (OECD 2021). With regard to disasters, resilience is linked to the notion of *build back better* by the United

Nations International Strategy for Disaster Reduction (2009) including "the use of the recovery, rehabilitation and reconstruction phases after a disaster to increase the resilience of nations and communities through integrating disaster risk reduction measures into the restoration of physical infrastructure and societal systems, and into the revitalization of livelihoods, economies, and the environment" (United Nations International Strategy for Disaster Reduction 2009). In this regard, Platt et al. (2016) outline that resilience needs to be considered from different perspectives:

- "Technical performance of physical systems"
- "Organisational ability to cope, especially of lifeline critical facilities"
- "Community and social and economic robustness, including self-help"
- "Decision support of emergency management, relief agencies and local administration"

From this starting point, the authors distinguish in their assessment between robustness and resilience in order to include the ideas of "resisting the impact" and "recovering from losses" (Platt et al. 2016). Thus, Figure 2.4 illustrates the loss and damage directly after the event on the y-axis. The authors picture two levels of robustness: R1, i.e. 50% of households are affected, and R2, i.e. 25% of households are affected, which reflects a higher level of robustness because the same disaster caused less damage on existing households. On the x-axis, the timeline is shown, which illustrates the speed of recovery as a measure of resilience. Slowly, people rebuild their houses and move back, so that after some time the number of households from before the disaster is reached. The faster this process happens, the more resilient the location is. The graph shows two examples, the green s-shaped curve that reaches the 100% rebuilding level earlier than the red line. A similar idea is taken by Zobel and Khansa (2014) who characterize the resilience of

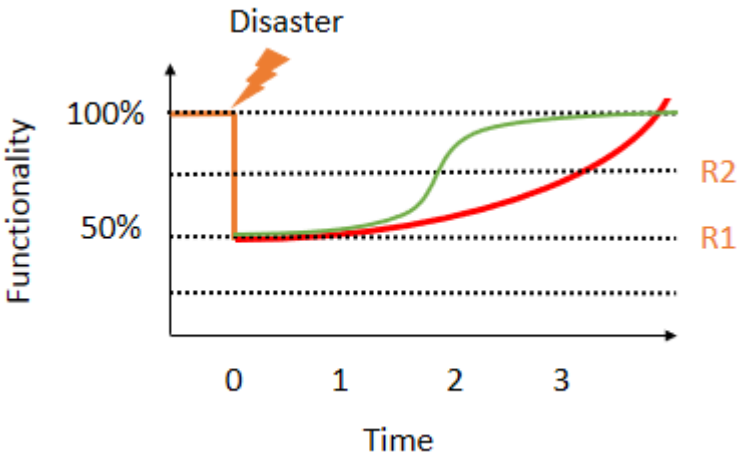
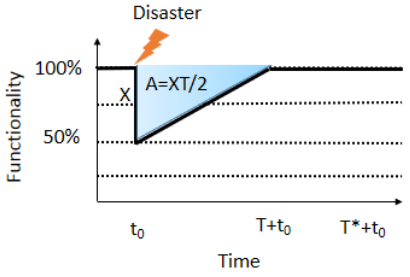


Figure 2.4: Recovery Curves According to Platt et al. (2016)

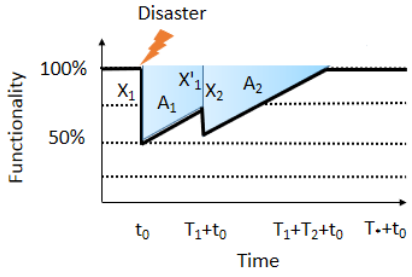
infrastructure and extend this concept to multi-events. "If a system has not had a chance to recover fully by the time the next related sub-event occurs, then the characteristic shape of the disaster curve will tend to look more like Figure 2.5b than like Figure 2.5a" (Zobel and Khansa 2014). Beginning with the single-event case, let X be the percentage loss of the functionality of an infrastructure and T the time needed to rebuild normal operations. Then the light blue triangle area, called A, in Figure 2.5a can be regarded as the loss due to the disaster as already explained previously. Thus, for a suitable fixed time interval T^*, the average resilience is $R = 1 - A/T^*$. If the recovery rate is assumed to be linear, then $A = XT/2$ so that the average resilience can be calculated as

$$R(X,T) = \frac{T^* - XT/2}{T^*} = 1 - \frac{XT}{2T^*},\ X \in [0,1],\ T \in [0,T^*]. \tag{2.1}$$

It is to note, that different shapes of the triangle lead to similar values for resilience.



(a) Predicted Loss for a Single-Event Disaster



(b) Average Loss for a Multi-Event Disaster

Figure 2.5: Abstracted Single- and Multi-Event Resilience According to Zobel and Khansa (2014)

Moreover, for the multi-event case the area consisting of a frequency of overlapping triangles, as highlighted corresponding to the two-event case in Figure 2.5b, can be calculated as the sum of the single segments

$$A = \sum_i A_i = \sum_i \frac{(X_i + X_i')T_i}{2}. \tag{2.2}$$

From the formula for average resilience calculates as

$$R = 1 - \sum_i A_i = \sum_i \frac{(X_i + X_i')T_i}{2}, \tag{2.3}$$

the authors conclude that each multi-event case can be compared to a single-event case of average loss.

After this conceptual excerpt on measurement of resilience, the question remains how to reach a resilient community. First of all, there is a risk that an hazardous event occurs,

for example by a natural disaster or man-made attack. As noted before (Platt et al. 2016, Zobel and Khansa 2014), two components play together to cope such a situation. The greater the robustness of a system or community, the less harmful is the external shock (i.e. the hazardous event) and the greater the capacity of the system or community to recover, the less impact is caused by the hazard. Thus, the degree of a disaster is not only in the physical dimension but also depending on the socioeconomic conditions of a society. A crisis or an emergency can result in a disaster if they are neglected or mismanaged (Shaluf et al. 2003, Sawalha et al. 2013). In this regard, successful work of emergency organizations can prevent the escalation on an early stage (Quarantelli 1988, Farazmand 2001). Paton (2008) highlights that in addition to institutional environment, the social support within the community as well as the personal characteristics of the actors are important to derive a resilient community. "Thus, disaster occurs only when hazards and vulnerability meet" (Khan et al. 2008). However, a disaster is distinguished from a crisis or an emergency by its dimension. A disaster affects more people and has more far-reaching and devastating consequences including that the public is needed to be extensively involved in response (Alexander 2015). Summarizing, Al-Dahash et al. (2016) classify the

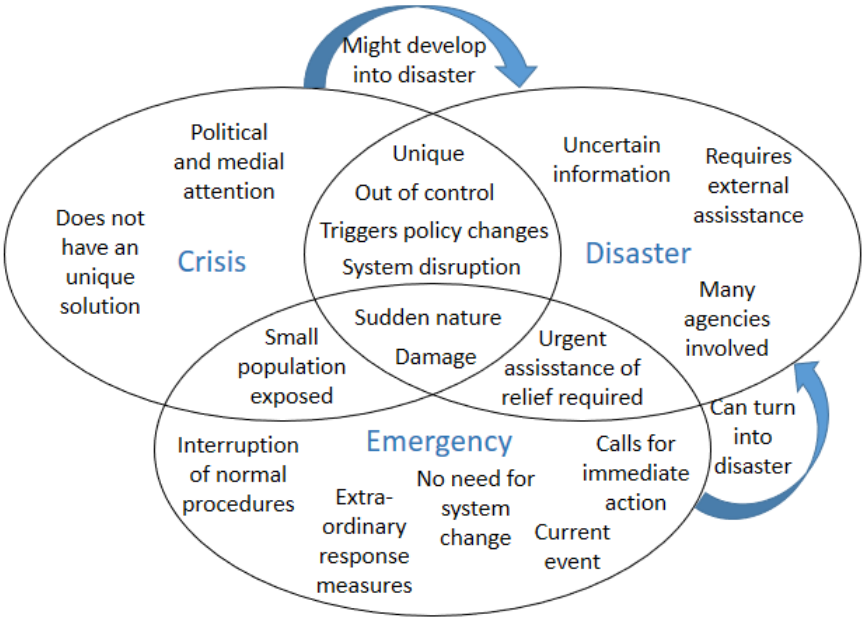


Figure 2.6: Differentiation between Disaster, Crisis and Emergency According to Al-Dahash et al. (2016)

terms of disaster, crisis and emergency by systematic literature review as seen in Figure 2.6. Therefore, they analyze free flowing text by qualitative data analysis techniques and critically review arguments and counterarguments by conceptual content analysis and a cognitive mapping approach. After categorizing the dominant concepts, the relationship between the supporting information and the themes is uncovered by cognitive mapping technique. Lastly, a cross analysis is performed to discuss similarities and differences between the terms.

However, such a situation cannot be dealt with easily on the fly, so that it makes sense to think about the occurrence of certain scenarios already in advance. Therefore, research came up with the concept of a disaster management cycle (Figure 2.7) including - besides the direct response to disasters which is the immediate intervention - the stages of recovery and mitigation. Between these two stages, the time line switches from *post-disaster phase* to *pre-disaster phase*, which hints at the bouncing back better notion. Furthermore, it includes preparedness with the components of risk assessment and prevention in order to learn for the next disaster and to be better positioned regarding external shocks. Anticipating future disaster events, the cycle outlines the continuous need for improvement. Besides this

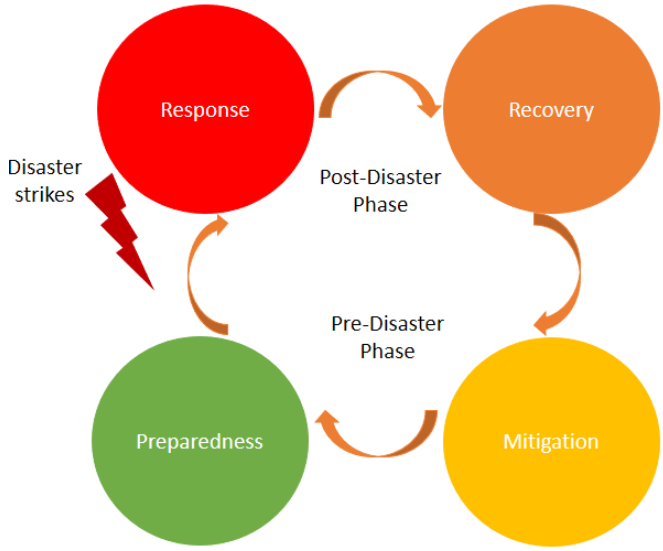


Figure 2.7: Disaster Management Cycle According to Khan et al. (2008)

framework is criticized for being too simplistic and abstracting from synergies, it still can be useful as it in general holds for all types of risks and can be grouped together within the concept of *global change* (Le Cozannet et al. 2020). However, Alexander (2015) outlines that plans need to be realistic and pragmatic taking into account the resource limitations for response. Therefore, "dealing with disaster is a social process that requires public support for planning initiatives and participation by a wide variety of responders, technical experts and citizens" (Alexander 2015). He mentions that the challenge lies in the foresight on the one hand and in planning on the other hand in order to connect elements into coherent response strategies. In case the capacities of the local institutions are overwhelmed, an up-scaling can be required to the use of national or even international capacities. As a result, many more actors than normal come together, which extends the need for planning in order to improve the ability of multi-agency collaboration. Especially, for such a case he points out the trade-off between the different characteristics, resources and objectives of the actors leading to the target of finding an "optimum balance [...] between integrating these

forces and allowing them a degree of autonomy and freedom of action" (Alexander 2015). In this regard, disaster management has the task "to cope with complex and sophisticated transfers of human and material resources" (Alexander 2015). Thus, the next section outlines important aspects that need to be considered in the planning process for disaster response across national borders.

2.3 Disaster Response Collaboration Across Borders

After this theoretical outline on boundaries and borders as well as on disasters including vulnerability and resilience, this section brings both concepts together and presents approaches for disaster response collaboration in an international setting. As outlined before, disasters are triggered by a hazardous event and the outcome is depending on the robustness of the system as well as its reaction. In this thesis, collaboration between the involved actors is examined as an important driver for adequate reaction and improved resilience.

According to Wood and Gray, the elements of collaboration in general are "common interests or shared goals while seeing different aspects of the problem or having differences in acting, deciding or managing to explore it constructively via shared institutions, rules or norms as a temporary structure as well as an (interactive) process with respect to a problem domain or issue to search for solution and to produce change beyond their limited visions and abilities to decide the future of the shared domain" (Wood and Gray 1991). Moreover, Gray (1985) notes that problem-solving efforts are enhanced when stakeholders expect that the benefit of collaborating will outweigh the costs. Hardey et al. add that collaboration includes strategic effects like building capacities through transfer or pooling of resources, knowledge creation, and political effects as networks of linkages shape their interests and thus, "collaboration not only transfers existing knowledge among organizations, but also facilitates the creation of new knowledge and produces synergistic solutions" (Hardy et al. 2003). In this regard, Chiu states "collaborative design is an activity that requires participation of individuals for sharing information and organizing design tasks and resources" (Chiu 2002).

Especially in times of increased number of natural and human-made disasters, it becomes ever more essential to improve disaster resilience across borders requiring international collaboration (Adrot et al. 2018, Garrick and Hall 2014). According to Perkmann, "cross-border cooperation can be defined as a more or less institutionalized collaboration between contiguous subnational authorities across national borders" (Perkmann 2003). Today, cross-border interactions range from total lack of cooperation or even hostility and conflict to full collaboration including consultation, coordination and communication (Guo 2015). It depends on the existence of a cross-border policy at all political levels, on a local relay

of this policy by civil society, as well as on the existence of a cross-border culture and dynamics carried by economic actors (Brunet-Jailly 2007). Nevertheless, with regard to disaster response, local and regional planning are predominant, but there are less international response strategies. According to Alexander (2015), this results from higher difficulties in their predictability as a *transboundary crisis* is usually characterized by multiple domains and multiple manifestations. Due to its nature, there are converging different polices so that first of all a responsible leader has to be determined and a common perspective needs to be established. Moreover, after an incubation, such an event turns to rapid escalation which makes it hard to chart. This fact has become particularly evident by the exponential spread of the Corona virus leading to the Covid-19 pandemic which affected during 2020 nearly all countries around the globe. Often data are lacking in a transnational disaster as they are not collected by the same organizations and aside from that due to different methodology or scales the available data may be not comparable. In addition, there are multiple actors resulting in conflicting responsibilities so that no ready-made solutions can be applied (Boin 2019). Disaster resilience in general requires the smooth interplay of various groups of actors. Already in the prevention phase, these include local authorities that decide on land use plans and enforce construction work to mitigate the vulnerability to natural hazards as floods or earthquakes. These need to be coordinated with neighboring regions. One level above, that is on national level, regulations are established for disaster prevention and funds can be created to support investments. Here, also reinsurance companies play a role in assessing the probabilities and costs of potential disasters. International organizations as the "United Nation Office for Disaster Risk Reduction strengthening the governance of risks, as recommended by the Sendai Framework for disaster risk reduction" (Le Cozannet et al. 2020). But also in the response phase, a colorful bouquet of actors comes together for each country comprising local emergency response teams with the responsibility for the treatment of victims, NGOs performing search and rescue, authorities coordinating resources, and the government that set up policies and action guidelines. For transnational disasters, this is multiplied by the number of countries involved, and in addition, the differences in their structures add complexity. As this on one hand may lead to higher number of available resources and bundled knowledge as well as positive preconditions for unfolding creativity, on the other hand the already mentioned challenges need to be overcome. "However, it will become increasingly necessary to guarantee international interoperability, common supply chains, reciprocal aid arrangements, and procedures for working together across borders" (Alexander 2015). Besides the usual challenges in disaster response as a high degree of uncertainty, need for providing capacities and organizing a response as well as communicating with the public (Ansell et al. 2010), an efficient response to a transboundary crisis adds, after the detection of vulnerabilities, transboundary sense-making and the establishment of transboundary decision-making powers (Boin 2019).

Consequently, Edwards (2009) addresses the need for cross-border disaster cooperation in all stages of the disaster cycle. Already in the preparedness phase, operating procedures have to be standardized and coordinated. Stoto et al. (2017) go even beyond by concretely outlining the need for a systematic approach to managing resources and responsibilities in emergency response, including communication between all agencies to ensure effective coordination of prevention and treatment efforts as well as trust-building in risk and crisis communication strategies informing the population. These points are especially concerned within this thesis. In addition, this thesis investigates the effect of so-called spontaneous volunteers providing their help in the aftermath of disasters which should be integrated into well-prepared in risk and crisis communication strategies of the response organizations.

Recent developments in public involvement after a disaster show a trend from the engagement in voluntary aid organizations to spontaneous on-site help. Dynes already in 1970 pointed out that people gather around after catastrophes and offer their help. He divides the people, which appear on the scene in the aftermath of a disaster into four groups: the established organizations in disaster response (such as professional fire brigades), voluntary aid organizations (such as Red Cross), community organizations without link to disaster response (such as music associations), and individuals that become active on their own after a disaster (as seen after the Central European flood in 2013) (Dynes 1970). As outlined, spontaneous help is not a new phenomenon, however, it has risen in relevance during the last years. Due to social media, the radius of influence has increased so that a higher number of people first of all notice the disaster and thereby become emotionally involved and develop the need to support. For example in the aftermath of Hurricane Katrina in 2005, a large community outside the disaster area has been build up to coordinate housing offers and other assistance to disseminated persons (Kendra and Wachtendorf 2003). Wachtendorf and Kendra (2004) outline also the huge willingness to help in the aftermath of the World Trade Center attacks at September 11^{th}, 2001 where restaurants nearby offered food to search and rescue teams. Furthermore, they highlight that besides the good will, the spontaneous help has led to some additional obstacles to the already tense situation of response teams. For example, there were so many donations of cloth that have been barely manageable. Thus, response teams in the beginning of these extreme dimensions of spontaneous volunteering generated mainly by the use of social media, have rather been critical about the amount of support binding their own capacities to become organized. However, today the potential moves into the foreground (Stallings and Quarantelli 1985) and it is widely recognized that the planning for disaster needs to consider above all the efficient involvement of spontaneous volunteers so that they support and not hinder the response missions.

Up to now, spontaneous volunteering has not played a major role with regard to borderlands. Reasons for this are manifold. First of all, volunteers need to be motivated to help across national borders. As the motivations are in general personal involvement due to distance

or personal relationships (Barraket et al. 2013), the event of a disaster is a precondition for spontaneous volunteering in a borderland. In addition, due to the separating nature of a border, the personal network often is not as strong across a national border as it is within a country (Dahles and van Hees 2004). However, this may not hold true for all border regions. Adrot et al. (2018) outline that there are borders exhibiting their own identity so that in such cases, spontaneous volunteers can function as a deepening of connections instead of separating nationalities. Moreover, the pure willingness to help may be stronger compared to the mere existence of borders. Thus, the border crossing of spontaneous volunteers might become relevant in the response of future disasters so that a few aspects should be considered in the planning phase. As already within some countries, the definition of spontaneous volunteers differs between organizations (Barraket et al. 2013), it is to expect that there is no unique definition holding in a cross-border area. Moreover, legal issues need to be clarified. Despite there exists a norm for the coordination of spontaneous volunteers (ISO 22319:2017-04 2017), it leaves room for flexible adaptions and does not ensure that the regulation is interpreted in the same way in all countries. Thus, this thesis examines the motivation, that is the willingness to help across national borders in the example of the French-German border region but also perceived problems and in addition investigates a coordination framework to organize the spontaneous volunteers efficiently in the whole disaster area.

2.4 Cultural Influences to Collaboration Across Borders

Since border regions come along with a clash of culture (Nostrand 1970), it is essential to include cultural aspects into cross-border disaster response frameworks. Thus, a short general outline on this topic is interposed, details with regard to the specific considerations of the agent-based model and the empirical study are given within the respective parts (Section 3.2 and 3.15). First of all, it is to note that culture has many facets and that the focus here is on the social relations which in particular include two critical components: trust and communication. Hofstede defines culture as "the collective programming of the mind which distinguishes the members of one group from another" (Hofstede et al. 2010). In this regard, culture differentiates between behavior and habits within a society which also comprise knowledge and beliefs. It is organized via norms that people are risen with and that codifies acceptance within a group. Thus, the social theory differentiating between in-group and out-group persons influences various studies. However, in order to achieve a smooth interplay between various cultures, *intercultural sensitivity* is required (Bennett 1998). In this regard, Schwartz et al. (2001) even noticed that cultures do not only differ, but also have some traits in common so that they derive a set of universal values that are found in all major cultures. These comprise ten values including tradition as the respect of past representation of the identity, security that means people aim for stability of the society, but

also personal achievement which outlines the individual competencies with respect to the environment, and power in the sense of a high social status. Moreover, Delhey and Newton (2005) examine factors that influence the feeling of belonging to groups and in particular increasing generalized trust in societies. Welter and Alex (2015) study trust in different cultures and find that trust is established through familiarity with similar mentality and habits whereas prejudices, retention and stereotypes can hinder the emergence of trust. Moreover, Brewer et al. introduce *international trust* as "a generalized belief about whether most foreign countries behave in accordance with normative expectations regarding the conduct of nations" (Brewer et al. 2005). In his study among Americans, they even find a correlation between trust in other people and international trust. Furthermore, Kalkman and de Waard (2017) highlight that a distinction between interpersonal and inter-organizational confidence-building is required and that trust is built over time. Lai (2012) investigates cross-border cooperation between voluntary organizations and found that the role of informal connections and past working experience or trust between them emerged as central, especially at the level of community and self-organizing groups. Similar findings are derived by Kapucu (2006) and Boin (2019). However, the establishment of relationships and trust building measures need not only to be performed between professional disaster response actors but also in the population. This is required as people start to develop self-helping strategies if they do not trust crisis response actors from their own or the foreign country. Jameson (2007) highlights that cultural identity is affected by close relationships that may change with time. Moreover, it can be negotiated through communication.

Falkheimer highlights that "multicultural and cross-cultural communication can often be characterized as *Chinese whispers* – what one communicates is seldom what others hear or see" (Falkheimer and Heide 2006). In this regard, Hall and Hall (2001) distinguish between high- and low- context cultures differing in the context needed to get the information. In that way, "intercultural communication can be defined as the study of heterophyllous interpersonal communication between individuals from different cultures (Rogers and Hart 2002)". A couple of general intercultural communication models already exist (Spitzberg (2000), Hall and Hall (2001), Jameson (2007)). In these models, language serves as a communication tool, though it is also a *system of representation* for perception and thinking. Habitual patterns of thought are manifested in communication behavior. In many ways, the crux of intercultural communication is how people adapt to other cultures, which may range from acceptance via adaption to integration (Bennett 1998). However, communication problems can, among other things, result from the lack of a common language that each actor speaks at the same level (Traum 2009). Furthermore, with respect to disaster response not only the personal communication is necessary but also the long-distance communication between agencies that require adequate media. Thereby, it is to note that some technologies can fail within disaster response so that alternatives need to be taken into account. Lee et al. (2011) highlight that information system models from

business sector may not be able to deal with such complex and dynamic environments as they occur in a disaster requiring high information exchange and coordination among a large number of organizations. Moreover, an adequate and aligned communication strategy needs to be defined for risk and crisis communication to the population also across borders.

A significant problem of research in this field is that contributions aiming to improve borderland cooperation are mainly case studies considering a specific border. Simon et al. (2015) study the social media usage for disaster cooperation at the Jordanian–Israeli border and Joyce and McCaffrey (2015) investigate the border between the Republic of Ireland and Northern Ireland. Murphy et al. (2016) also investigate the Ireland border stating "crises management becomes increasingly difficult when events cross geographical borders and indeed, policy boundaries. More participants, which tend to be geographically dispersed and often operating to divergent agendas, become involved". Moreover, Davis and Friske (2013) investigate cross-border logistics at the US-Canadian border and Kaminska (2016) examines volunteers' collaboration across this border. Boersma and Engelman considered the German-Dutch borderland finding "no uniformity in concluding and using cross-border agreements for emergency assistance, the language problem, the material and equipment problem, differences in organizational autonomy" as the main problems suggesting the following solutions "new routines by joint training sessions, bilingual information systems, technical standardization of communication, building trust on the basis of insights into each other's routines" (Boersma and Engelman 2012). Dahles and van Hees studied the collaboration between firefighters at both sides of the border and found problems in organizational structures and legislation, technical equipment and compatibility but also highlight that the organizations both have the same mission and companionship (Dahles and van Hees 2004). These challenges due to an increasing number and diversity of involved actors as well as the unpredictability in disaster response are (among others) also raised by Balcik et al. (2010). Despite the valuable contributions for regional decision-makers, in the authors' view, it is crucial to develop more generic frameworks to improve the understanding of joint relief initiatives for disaster response in borderlands. Thereby, it is to outline that cross-border collaboration frameworks need a high degree on flexibility or a comparative nature as it was highlighted in the first subsection that borderlands vary in their circumstances. In this regard, the thesis presents a framework to examine success factors for efficient cross-border collaboration between the various actors involved in disaster response. Thus, it provides valuable insights for decision-makers to reduce current barriers in borderland collaboration and increase disaster resilience. The holistic framework consists of an agent-based model to study institutional collaboration on the one hand and an empirical study to investigate self-help capacities and spontaneous volunteering of the population. In this general state of the art section only a brief overview of these

two essential factors is given. However, a detailed literature review on the interorganizational collaboration as well as social capital and willingness to help will be outlined in the respective parts in the theory section.

3 Theoretical Framework to Study Cross-border Collaboration in Disaster Management

This section is divided into two parts, the first one presents an agent-based model to simulate inter-organizational collaboration across national borders concerning disaster response. The model is implemented in several layers so that it allows for a detailed representation of various aspects of the collaboration including optimal information flows and the efficient involvement of spontaneous volunteers. As the model is dedicated to study a border area, specific attention is paid to model the characteristics of the agents with regard to intercultural collaboration[1].

The second part introduces an empirical study to gain insights on the social capital and potential populations' willingness to help in a border region. The novel design allows examining a border region as a comparative study on the cross-regional and cross-country level. This framework is applied to the German-French border region carrying out representative telephone interviews in both countries, ensuring that a determined proportion of respondents are residents of the border region[2].

[1] Parts of this part have been published in the course of the development of this thesis in collaboration of the author:
Klein, Miriam; Rigaud, Eric; Wiens, Marcus; Adrot, Anouck; Fiedrich, Frank; Kanaan, Nour; Lotter, Andreas; Mahdavian, Farnaz; Schulte, Yannic; Schultmann, Frank. "A Multi-Agent System for Studying Cross-Border Disaster Resilience". Proceedings of 15th International Conference on Information Systems for Crisis Response and Management. 2018
Klein, Miriam; Mahdavian, Farnaz; Wiens, Marcus; Schultmann, Frank; "A Multi-Agent System to Improve Resilience of Critical Infrastructure in Cross-border Disasters". Proceedings of 11th International Forum on Urbanism (IFoU). 2018
Schulte, Yannic; Klein, Miriam; Wiens, Marcus; Fiedrich, Frank; Schultmann, Frank. "Spontaneous Volunteers Across National Borders: An Agent-Based Comparison". Proceedings of 16th International Conference on Information Systems for Crisis Response and Management. 2020
Rigaud, Eric; Adrot, Anouck; Fiedrich, Frank; Kanaan, Nour; Klein, Miriam; Mahdavian, Farnaz; Schulte, Yannic; Wiens, Marcus; Schultmann, Frank. "Borderland Resilience Studies". Proceedings of the 16th International Conference on Information Systems for Crisis Response and Management. 2020

[2] Parts of this part have been published in the course of the development of this thesis in collaboration of the author:
Wiens, Marcus; Klein, Miriam; Schultmann, Frank. "Border Region Attachment - An Empirical Study on Regional Social Capital in the French-German Border Area". In: Wiens, Marcus. "Resilient Systems – an Economic, Operational, and Behavioral Perspective". Habilitation. Karlsruher Institut für Technologie (KIT). 2021

Part I Agent-Based Analysis

3.1 Introduction to the Presented Agent-Based Model

As illustrated before, disasters are triggered by a hazardous event, and the outcome depends on the robustness of the system and its reaction. Moreover, the disaster management cycle outlines that there are possibilities of adjustment in all stages from direct response via mitigation to preparedness for future events, which should be an improved level compared to the previous situation by following the idea of *bouncing back better*. Thus, this thesis addresses the planning for improved reaction by targeting to examine success factors concerning the establishment of borderland collaboration. These factors are investigated by an agent-based model that aims to build the disaster response phase for a borderland as a holistic framework. Thereby, the focus is on inter-organizational collaboration, including coordination and communication between all actors involved in disaster response. However, as outlined, cultural aspects and identity building play an essential role for borderlands, so that these are in particular addressed.

Thus, an agent-based model is designed that allows for different types of analysis addressing the inter-organizational collaboration across a national border. It comprises a rich set of actors involved in such a response situation, the affected population, different professional disaster response organizations, as well as spontaneous volunteers. The overall idea is that the affected population demands its various needs from different organizations that aim to achieve an optimal distribution of resources by collaboration across the border. In detail, several demand patterns are investigated. Thus, the approach allows to examine a dynamic demand structure resulting from the increase of the populations' needs during time. In addition, a herd behavior is modeled to cover demand structures as they were observed during the first wave of the Covid-19 pandemic. Moreover, coordination patterns are implemented to allow a scenario-based analysis focusing on effective coordination and communication among the actors. Therefore, communication protocols from the literature are adapted to study information exchange in border regions. A trade-off comparison is included between the efficiency of information flows, once coordinated along the hierarchical organizational structure and once, directly as a personal exchange between disaster response actors. Furthermore, the model determines efficient structures to involve spontaneous volunteers in disaster response operations. An underlying infrastructure layer enables the characterization of the borderland and to build several disaster scenarios. The following literature review presents already existing agent-based models with respect to these fields of research.

3.2 Literature Related to Agent-Based Analysis

Since the present study is embedded primarily in the field of agent-based-models, this section is dedicated to this research. First, an introduction to agent-based models in general is given, before such frameworks with respect to human behavior and decision-making in disaster response are presented. These are followed by an outline on spontaneous volunteers. Afterwards, inter-organizational collaboration is investigated comprising the topics of coordination and communication. In the end of this section, agent-based models with cross-border context are addressed.

3.2.1 Agent-Based Modeling and Disaster Response

In the 1990s, the approach of agent-based models became more and more popular as it allows to create simple caricatures of reality (Axtell and Epstein 1994). Software agents are commonly seen as heterogeneous, discrete individuals that are located in an artificial environment. They are divers, have resource attributes and dynamically interact with other agents or the environment (Macal and North 2010). Moreover, they follow behavior rules and are able to perform flexible and autonomous actions in order to meet their design objectives (Wooldridge 1997).

As this thesis is dedicated to disaster response, the applicability of agent-based models to this field is outlined. Due to a disaster, the environment can change with regard to damage (for example, in case of a flooding, infrastructures may be broken, or bottlenecks in the supply may become larger over time after a hurricane) so that an adaption of prioritization becomes necessary. Thus, agent-based modeling allows to detail an environment and, furthermore, to assign each of the actors involved its individual characteristics and objectives. It is a dynamic setting so that these specificities may change over time. Thereby, agent-based models allow to analyze the resulting dynamics of individual interactions. Moreover, Gilbert states that agents "pass informational messages to each other and act on the basis of what they learn from these messages" (Gilbert 2008). In this regard, agent-based modeling helps to investigate interactions of different groups of actors who do not have overall information but need to generate their knowledge about the current situation through communication with other actors and the environment, which is (exactly mirroring) the case in the aftermath of a large-scale disaster. Since rapid action is required after a disaster strikes and, because of the dynamics, it is usually impossible for actors to obtain a global information perspective, so that it is natural to take decisions from a local perspective.

Concluding, agent-based models support the strategic planning phase as the impact of individual decisions in the overall context can be examined by comparing alternative

configurations. Thus, this method analyses the interplay of different groups in information exchange and decision-making and thereby it has much to offer to the understanding of crisis response. For this reason, there exist already various agent-based models covering various aspects of disaster response. In the next section, some of these are outlined with a focus on understanding of human behavior and decision-making in disaster situations.

3.2.2 Human Behavior and Decision-Making in Disaster Response

As the properties of agent-based models provide the chance to model a variety of actors and interactions during crisis response, there are agent-based models in various fields of civil disaster management. A strong focus is on evacuation studies of, for example, single buildings in case of fire (Joo et al. 2013) as well as whole areas in case of earthquake or tsunami evacuation (Mas et al. 2012, Wafda et al. 2013). Pan et al. (2007a) find that in their model herding behavior is often observed during the evacuation of a crowd in a room with two exits – one exit is clogged while the other is not fully utilized. They investigate peoples' behaviour during evacuation and find that individuals under stress shift decisions from rational thinking to following instincts (Pan et al. 2007b). Similar results are seen in Akopov and Beklaryan (2012) and in Helbing et al. (2002). Kullu et al. (2017) extend their evacuation scenario by a realistic communication among the agents to study crowd behavior. Although their concepts of communication and information are on an abstract level (without including specific forms such as sentences or languages), they find that simulation trajectories for evacuations are closer to real trajectories in terms of straightness in the case when agents are communicating. Moreover, Bourgais et al. (2016) develop a model to study social relationships distinguishing between several emotions during an evacuation procedure. Similarly, the model by Hoogendoorn et al. (2010) includes emotions on the process of information flows during evacuation and identifies fear as a shrinking factor of people's thought-action repertoires. Turning to other disasters than evacuation, Fikar et al. (2018) study the impact of transport disruptions on disaster relief distribution by also taking into consideration that residents share their experience about the availability of relief goods. Crooks and Wise (2013) study humanitarian relief at the individual level after a natural disaster using data from a Geographic Information System (GIS). They discuss that agents seek resources basic to survival to the exclusion of all other activities. Therefore, the agents in their model are motivated by Maslow's hierarchy of needs (Maslow 1943). As especially in the aftermath of a natural disaster, there is high uncertainty, the authors include rumour spreading into their considerations of world-of-mouth communication. Similarly, Zare et al. (2012) describe two rumour spreading models to investigate information spread in disaster scenarios and Zhu et al. (2011) examine the impact of information credibility on earthquake risk perception. Players turn to be

perceived credible, when the expectation or experience is present, that their statements and their entire communicative acting turns out to be true and consistent.

Furthermore, Quillinan et al. (2009) highlight the dynamics of a crisis situation where many highly interconnected and unforeseen factors influence the performance requiring a quick evaluation of change and adequate decision making. This makes it hard to evaluate a priori a design or strategy and foresee its implications under different circumstances. In particular, decision making in case of emergency is more complex than *every day* decision making (Kamissoko et al. 2014). Snowden (2011) states that dealing with low probability high impact events needs to differ from traditional risk management and highlights that one needs to "balance efficiency against effectiveness and robustness with resilience" in order to gain more flexibility. Moreover, he cites the Cynefin framework (Snowden and Boone 2007) which distinguishes four categories of response: emergent to complex situations, good practice to complicated situations, novel to chaotic situations and best practice to simple situations in order to make the point that each situation must be evaluated by itself instead of just following universal frameworks. In this regard, he also identifies early detection, fast recovery and fast exploration to increase resilience and addresses the need for contextual awareness and diverse approaches to manage dynamics and uncertainties. Sieck et al. (2007) investigate the construction of a sense-making model for uncertain decisions. By comparing experimental results executed with experienced and novel Army leaders, who got a set of 11 to 17 noisy situation reports with multiple themes and story lines, they found that decision-making is done in a rather fragmental than complex way. Although most experts rely on local cause-effect connections, rules of thumb, patterns of cues and other linkages, they showed a higher relationships between sense-making and decision-making process. In order to establish their framework, a forth and back strategy was carried out. This procedure is also recommended by Mitroff and Emshoff (1979), who develop a strategy to deal with ill-structured problems and recommend team-building and organizational development in policy and planning approaches. More deeply, Majchrzak et al. (2006) highlight four keys in emergent situations, which are the continuous discourse with potential participants in order to get a good overview and be able to evaluate the situation from different perspectives, continuous updating of knowledge maps as circumstances are changing, blurring boundaries between those inside and outside organizations in order to achieve a better set of current information, and governing through reputation networks for deriving innovative solutions. However, there are already frameworks studying decision-making with regard to the medical assessment of casualties in general, as Hawe et al. (2012) outline in their broad overview on agent-based models for large-scale disasters. In this regard, the work of Wang et al. (2012) focuses on the medical response to mass casualties including triage procedures. Furthermore, Bae et al. (2017) propose an agent-based model describing the cooperation among the responders during the overall

process in the disaster response from transporting patients to their definitive care. Ramchurn et al. (2016) use decision theory to solve the task allocation problem under uncertain and dynamic conditions as they occur in emergency response planning. Salihu et al. (2013) build an agent-based model to study the complex situation of disaster response teamwork distinguishing between intra-coordination (which is seen within the mobile organizational teamwork, such as first aid team members, geographical disaster field, and information team members) and inter-coordination (which occurs among the different types of team workers, such as a municipality team and a team of doctors). Parikh et al. (2016) present a detailed simulation of what-if scenarios in the aftermath of a disaster including both, critical infrastructure (cell phone network, transportation network, healthcare system, and power system) and behavioral patterns of the population. Their agents are generated individually by data from demographic distributions and sampled household information and the agents' decision-making considers information about their health state, family members, the current situation, and their environment. After outlining models addressing the affected population, the next subsection specifies the topic of spontaneous volunteers.

3.2.3 Spontaneous Volunteers

Research about spontaneous volunteers covers empirical studies addressing the volunteers' motivation, optimization approaches dealing with task assignment to volunteers regarding their availability, and pre-disaster registration tools to assess volunteers' qualification. Moreover, there already exist some coordination frameworks. The integration of spontaneous volunteers has been specified in an international standard in 2017 (ISO 22319:2017-04). The standard describes various framework requirements that are necessary for the involvement, such as clarifying responsibility and liability, but also identifying tasks, selecting volunteers, and offering appreciation. Moreover, Fernandez (2007) develop a basic system for volunteer management including a registration after arrival and credential verification before assignment as well as a briefing and finally the deployment. Hashemipour et al. (2017) present a decision support system to "predict response-operation performance and take necessary steps to improve it. These include choosing appropriate coordination methods and task-allocation approaches and training volunteers based on specific job priorities". Herath et al. compare in their work organized and disorganized team productivity. By modeling their agents' attributes from a real-world data set of 226 volunteers at five different types of non-profit organizations in Southwest England, the authors conclude that "disorganization is more conducive for problem solving efficiency than organization given enough flexibility (range) to search and acquire resources" (Herath et al. 2017). Similarly, Lindner et al. (2017) define a set of 25 attributes of spontaneous unaffiliated on-site volunteers including group affiliation, motivation, information channel,

experience, resources, and task preferences. In 2019, Lindner et al. came up with an agent-based framework for disaster volunteers focusing on scenario based information exchange. This topic is also investigated by Fischer and Wang (2020) who model an agent-based communication network between emergency response organizations and spontaneous volunteers in order to uncover the most efficient lines of communication in disaster response. Paret (2020) start by a strategy for finding the optimal assignment of spontaneous volunteers based on a Markov Decision Process before presenting a framework for convergence of regional involvement of spontaneous volunteers following a disaster.

However, there is no framework especially studying the coordination of spontaneous volunteers across national borders. Besides the affected population and spontaneous volunteers, professional crisis response actors affiliated to an organization are an important group to cope with the disaster. However, in general more than one organization is involved in disaster management. Thus, in the following models for the inter-organizational collaboration are detailed.

3.2.4 Inter-Organizational Collaboration

Miller argues that "agent-based modeling holds the potential to contribute to advancing organization theory" (Miller 2015) and there are already agent-based models investigating organizational theory. Chang and Harrington Jr. (2006) describe a general framework for agent-based modeling in organizations considering an organization to consist of three structures: the allocation of information, the allocation of authority, and the organizational norms and culture. Fioretti (2013) highlights the component of interaction as a central issue in agent-based simulations, where he distinguishes between interactions within the organization and across the organization. Pardo et al. go a step beyond highlighting that "multi-organizational collaboration can depend heavily on effective knowledge sharing across boundaries" (Pardo et al. 2006). Gittell and Weiss suggest that coordination capabilities developed within an organization can even be extended to achieve coordination across organizations: "the similarity of intra and inter-organizational design (e.g. routines, information systems, team meetings, boundary spanners) improves quality and efficiency performance by strengthening the interface between intra and interorganizational networks" (Gittell and Weiss 2004). Moreover, Hasan and Koning (2020) show that one can impact the establishment of ties from an organizational perspective. The model of Wang et al. (2009) examines the interaction process of organizational knowledge sharing via agent-based modeling. Their model simulates scenarios concerning employee decision strategies and organizational interventions that affect identifiability, benefits, and costs. Nissen and Levitt (2004) design another agent-based model visualizing knowledge flows in enterprises based on Virtual Design Team (VDT), a computational model to analyze complex project organizations.

Turning to disaster response, Lai (2012) investigates cross-border cooperation between voluntary organizations and finds that the role of informal connections and past working experience or trust between them emerged as central, especially at the level of community and self-organizing groups. Majchrzak et al. highlight "the memory (or expertise) specialization (i.e. the tendency for groups to delegate responsibility and to specialize in different aspects of the task), credibility (i.e. the beliefs about the reliability of members' expertise) and task (or expertise) coordination (i.e. the ability of team members to coordinate their work efficiently based on their knowledge of who knows what in the group)" (Majchrzak et al. 2007) as the most important characteristics for emergent help. Thus, collaboration among organizations includes both components, coordination and communication, which will be outlined in the following.

3.2.5 Coordination

In general, organizations are constructed hierarchically as hierarchical structures are proven to be most efficient in the number of connections for information sharing (Malone and Smith 1988, Bolton and Dewatripont 1994, Krackhardt 1994). Moreover, Comfort et al. find that "innovations in organisational structure and information processes have had the welcome effect of legitimising improved personal communications among members of large organisations, but have proven regrettably unreliable in practice" and that self-organization may result in "inefficient use of scarce resources and time for the community under threat" (Comfort et al. 2004). On the other hand, Borch and Andreassen (2015) highlight the need for flexible adaptations in volatile environments and Krackhardt et al. "believe that personalized ties are a reserve resource which provides the potential for the coordination needed to meet rapidly changing circumstances" (Krackhardt and Stern 1988). Thus, especially in complex and dynamic disaster situations, informal contacts via a personal network can be an efficient resource (Guimerà et al. 2006, Kichikawa et al. 2019) as actors are "interdependent rather than independent" (Gittell and Weiss 2004).

As outlined, the opinions on personal contacts are rather diverse, so that a broad literature investigates the question how to engineer organizational structures, which take these contacts into consideration. Burton and Obel (2018) show that in collaborative communities, individuals follow the system on a common basis to achieve their goals. In the organizational context, Cross et al. (2001) distinguish between information sharing among work group members in the same functional sub-culture and hierarchical position as they likely share similar perceptions, have similar needs as well as information sources and social interactions as employees also may seek help from members that they interact with frequently because they have developed a trusting relationship which allows them to expose their information needs, or share innovative information. Furthermore, Diefenbach and Sillince (2011) find by studying common types of organizations that informal hierarchy

increases whenever formal hierarchy decreases. In addition, Soda and Zaheer argue that "consistency between the formal authority and informal networks is positively associated with individual organizational actor performance" whereas "inconsistency between the sequentially interdependent formal workflow and the informal networks lowers individual organizational actor performance" (Soda and Zaheer 2012).

Most of the models apply a network as underlying structure for the agents' connections as seen in Rodrigueza and Estuar (2018) and Tsvetovat and Carley (2004). Gilbert and Hamill (2009) present a simple structure for use in agent-based models of large social networks. Aros and Gibbons (2018) address the need for effective communication within centrally coordinated disaster response networks using agent-based modeling. Gao et al. (2015) study organizational routines in dependence of individual characteristics of the agents as well as their relationship network and find that the network topology characterizes the dynamic organizational routines. Despite the influence of individual characteristics, the scale-free network which is known to be a robust system against random failures always performs better and obtains higher coherency and routinized levels of collective behavior. Briggs (2018) also investigates network structures in organizations focusing on the impact of informal networks on the work flows. In their agent-based model, the bottleneck of the leaders' level plays an important role and induces people to use their informal network in order to complete their tasks. Their results show that the influence of personal networks goes so far that at least in some places, work could almost come to a standstill without them. Bristow et al. (2014) study cooperative and competitive behavior under conflict and find that in cooperative agent-based frameworks, individual agents have intrinsic motives to work together and avoid conflicts.

Aldewereld et al. (2011) analyze the effect on interaction structures to coordinate the different organizations involved in crisis response by comparing the efficiency of (combinations of) hierarchical and network structures. Schraagen et al. (2010) support this statement by providing empirical insights into the efficiency of information sharing during crisis management in hierarchical network teams compared to teams with a flat network structure. They find that network teams are overall faster and more accurate under challenging scenarios than hierarchical teams. Moreover, they share more knowledge in these challenging scenarios compared to more straightforward scenarios. Crowder et al. (2009) use agent-based modeling to explore how individual level, team level, and task level influence team performance in an engineering environment. The research by Lu et al. (2010) also focuses on the relationship between the distribution of authority in a firefighting team and its team performance. They develop an agent-based model distinguishing between supervisor-centered factors, including rescue, fire control, and the self-managing factor of fire extinguishment. Results show that the self-managing factor has a major impact on team performance and that the relationship between the distribution of authority and team

performance is nonlinear. Moura and Oliveira (2007) also study firefighting as an agent-based coordination model and mention that centralizing decisions has its drawbacks. First, there is the danger of creating a bottleneck on the leading agents. Another problem with centralized coordination is that if communication fails or the leader fails, the team coordination is lost. Concluding, "sharing information, willingness to collaborate, and shared values are important factors for network formation" and "because structured communication channels may not work in emergencies, boundary spanners can play a significant role in effective communications in emergency and crisis management" (Kapucu 2006). Comes et al. (2020) highlight along similar lines that decision-making processes during disaster response are emergent and continuously adapting. Therefore, they underline the need for structured information exchange laterally between regions and hierarchically between operational and strategic levels to avoid the persistence of coordination-information bubbles in uncertain disaster situations based on case studies. In this regard, Altay and Pal (2014) prove clusters as information hubs to encourage better information to facilitate disaster response. Moreover, they address information quality, the willingness to share information, and the trust between organizations in their agent-based model and find that the factors information quality and trust play an important role in increasing cooperation. This requires communication so that this topic is investigated in the next subsection.

3.2.6 Communication

As communication is a main driver for collaboration, in this subsection an overview of established communication models for disaster cooperation is presented. On the one hand, there are tools for practical usage in the event of a disaster supporting the response phase. First of all, technical interoperability is a requirement for inter-organizational collaboration and especially for communication. This comprises several components such as the exchange of sensor data, applications of GIS data, or networks and communication tools. Especially in disaster response, it is convenient to work with GIS data in order to get a detailed picture of the current situation as routing, locating of warnings and alerts, or decision-support by scenario analysis. GIS interoperability can provide enormous benefits to the disaster and emergency management community since a real-time assessment is necessary which is simplified by simultaneous data access and exchange so that all decision-makers have the same information at the same time (Abdalla et al. 2007). However, organizations often have their own graphical tool to work with, which is not compatible with the tools of other organizations. In this regard, the framework of Iannella and Henricksen (2007) describes the technical challenges in information exchange between disaster response organizations and provide a uniform tool to facilitate the process including the components incident notification and resource messaging. Moreover, Genesereth (1997) presents a technology which includes standard communication

languages, subroutine libraries to assist programmers in writing interoperable software, and system services to facilitate inter-operation at runtime. Furthermore, the framework Ubimedic2 by Domnori et al. (2011) offers real-time data collection and communication, and a decision-making support and thereby overcomes the bottleneck in the Operative Center. Ochoa et al. (2007) present a platform for group decision-making among all involved actors including first respondents. FireGrid project is a next-generation software system that can support command and control for large-scale fire-fighting in the built environment (Han et al. 2010). Noda et al. (2001) focus in their simulation at RoboCup Simulation League the language design for rescue agents and distinguish between four layers in communication, i.e. the knowledge layer, the attention layer, the device layer, and the transmission layer. Although there is an investigation in natural picturing of language, the framework simplifies in terms of a formalized communication between public actors which needs to be extended for civilian communications. Etuk et al. (2017) introduce the TIDY framework, a trust based assessment model to evaluate information credibility by learning similarity metric from historic data.

On the other hand, there are strategic analyses and tactic planning instruments. Xuan et al. (2001) interpret communication, i.e. whether to communicate or not, as a decision model and conclude that communication effort is rational unless the costs are too high which depends on the uncertainty in the system. In the model of Crowder et al. (2012) agents communicate either in form of requests or to provide information. Another decisive factor used in the aftermath of a disaster is world-of-mouth communication. The article of Mueller et al. (2017) includes potential links, i.e., persons who do not know others directly but via a third party. If one can fall back on such potential links providing help in a natural disaster, this can specifically increase the resilience of a society. Moreover, de Bie and de Boer (2007) show by examining language diversity through Social Impact Theory (Latané 1981) that different language patterns can exist at the same time. Civico (2019) builds an agent-based communication model in a multilingual context to study the unbalanced accumulation of knowledge across groups speaking different languages. He shows that groups are formed agreeing on a common language such that only agents who can speak the majority language of their group can participate in communications and thus, gain knowledge. Concluding he states that agent-based modeling suits well to the exploration of language-related dynamics and that there are still open issues that need to be investigated. Cross et al. study communication in the context of information processing among organizational relationships and highlight that in successful communication "people often receive some combination of five benefits when seeking information from other people: solutions, meta-knowledge (pointers to databases or people), problem reformulation, validation of plans or solutions, and legitimation from contact with a respected person" (Cross et al. 2001). Thus, not only the message itself is in the focus of successful communication, but also the relationship towards the addressed person. Thus, another

aspect that is important in cross-border communication, besides a common language (Endrass et al. 2013), is also a trusted relationship between sender and receiver (Doney et al. 1998). In this regard, Klein and Marx (2018) build an agent-based model studying the emergence and stabilization of generalized trust. Therefore, each actor can perform the roles of trustor or trustee in a single trust game repeatedly in several rounds with new partner constellations. In both roles the agent can gain new information about whether or not it is worthwhile to place trust, which implies updating the agents' prior belief by Bayesian sensor integration with individual weights. Results show the two equilibria of universal trust and distrust, respectively as well as that a long-term trust-level of a society is depending to a large extent on its initial trust configurations. Moreover, low mobility results endogenously in higher degree of clustering between trusting and distrusting agents so that immobile societies are much less likely to develop high trust levels. Fu et al. (2016) investigate in the field of supply chains the role of trust and the length of relationships on the information sharing process by an agent-based model. Another interesting aspect studied via agent-based simulation is that persons often interact in informal network connections with persons being similar to themselves. In this regard, Cruciani et al. (2017) deal with the evolution of cooperation based on peers' similarity. They presented an agent-based model of groups in informal settings, where collaboration is built through perceived similarity and show that knowledge about group members as well as memories supports cooperation over time, building more stable groups. In the model of Rouchier and Tubaro (2011), agents are characterized by their opinion and uncertainty. Moreover, they have three basic ways to choose whom to communicate with: By authority as stressed by Blau (1955, 1964) who introduces that people seek advice from others higher up in the hierarchy; by reputation as Klein et al. (2004) and Lazega et al. (2006) mention that people seek advice from those who are most sought out by others, or by homophily as McPherson et al. (2001) state that persons seek advice from similar persons (i.e. who share the same opinions). Findings include that a mix of authority and reputation gives the best result for their simulation, but for future work, homophily has to be redefined to make it more dependent on structure (age classes, for example). Moreover, CONSTRUCT is a widely validated agent-based model with a focus on information spreading and change of beliefs where agents communicate prior with those they feel connected due to similarities (e.g., homophily) which is a proven cross-cultural phenomenon (Osgood et al. 1975). In this regard, the next subsection outlines models studying a cross-border context.

3.2.7 Cross-Border Models

All these agent-based models investigating disaster response and collaboration do not consider cross-border phenomena. Such investigations are undertaken in other fields of study. Bower et al. (2011) address management challenges for companies whose

activities stretch across national boundaries and Roozmand et al. (2011) include cultural variables in their agent-based model studying consumer decision-making. Herzog (2020) discusses issues like transfontier labor markets, consumer markets, services, housing and land markets, as well as the ecosystem and the cross-border plannings and coordination for the Mexican - United States of American (USA) transfrontier metropolis. Moreover, Ruiz et al. (2014) set up a model to study driving factors for international migration. Many models start from individuals to study the emergence and development of cultural similarity. "Because culture influences how people perceive their social reality, it is important to have agent models that explicitly consider social elements, such as existing relational factors" (Mascarenhas et al. 2016).

Last but not least, Alisan et al. (2018) perform an optimization model on sheltering of a special needs population and showed a noticeable improvement in the assignment of people by cross-county cooperation applying to a case study in the USA. Additionally, there are already existing decision support tools for the cross-border collaboration on an operational level, which are for example the S-Help framework by Neville et al. (2016). Moreover, the CascEff framework (Lönnermark and Lange 2016a,b), the Improver framework (Petersen et al. 2017), and the EHR4CR framework (Daniel et al. 2016) are examining border regions, too. But these projects are dedicated mainly to the aspects of technical interoperability and barely consider cultural aspects. Thus, they are not taking an agent-based analysis focus.

Concluding, no strategic model exists that studies efficient collaboration in a borderland which is especially important for fast and adequate disaster response. The proposed generic agent-based model contributes to an understanding and improvement of resilience for border areas in several ways. First, the design of an underlying infrastructure layer for disaster response investigates the dynamics of inter-organizational resource sharing for the adequate supply of the affected population with essential goods. Second, the human behavior of an affected population is analyzed, guided by Maslow's hierarchy of needs. Third, the thesis contributes to efficient communication procedures for information sharing including the analysis of cultural risks. Fourth, the inter-organizational collaboration for disaster response is examined by comparing the efficiency of hierarchical and informal information procedures in a dynamic setting. Fifth, the potential of spontaneous volunteers supporting the disaster response is examined. The model is designed to support local decision-makers from a tactical planning perspective and organizational planning strategically from a global viewpoint. The developed model supports the understanding of crisis response as the impact of individual decisions in the overall context can be examined by comparing alternative configurations. Thus, it highlights the interplay of different groups in information exchange and decision-making and thereby facilitates disaster resilience for borderlands.

3.3 An Agent-Based Model for Cross-Border Collaboration

The presented model is dedicated to quantify success factors for cross-border collaboration in disaster response covering both, communication and coordination. Thereby, not only interoperability between organizations is focused but also cultural aspects that are relevant to study a cross-border setting are included. It is an overall model to consider different actors involved in disaster response, which yields the possibility of investigating interaction processes and identifying potential improvements for more efficient collaboration structures. Therefore, a border region is modeled on several layers. First, there is the layer of citizens who are affected by the disaster and aim to maximize their utility according to Maslows' hierarchy of needs (Maslow 1943) adapted to a disaster situation as shown in Figure 3.1.

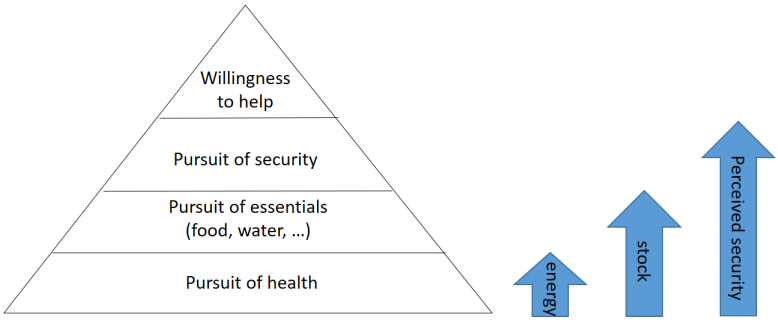


Figure 3.1: Hierarchy of Needs According to Maslow (1943) Adapted to Disaster Response Context

As a model always is a simplification of reality in which only relevant factors are modeled, the citizens' needs are restricted to a four-level hierarchy of needs. Considering a large-scale disaster, the first level of needs is the provision of health to the disaster victims. On a second level, the provision of the affected population with essentials, comprising food and water, is considered. The need of security has to be fulfilled on a third level. If all these needs are fulfilled, the citizens result in a satisfied state, in which they may be willing to help others. It is to note that bottlenecks in these four categories may become more prominent over time. As a long-term disaster is considered, the variables corresponding to the hierarchical levels decrease in time and in order to achieve the next level, the variable corresponding to the citizens' current level needs to be above a critical threshold. In order to get an increase in the variables, the affected agent has to demand its needs to a respondent. Thereby, it is to distinguish that not all variables can be fulfilled by each respondent. So, health and security can only be provided by professionals, while spontaneous volunteers can support by providing essential stock. Therefore, several patterns are implemented which allow the agents to demand their needs to different receivers so that various dynamic

demand structures are resulting among the population that can be analyzed. These include a dynamic resulting from the constant decrease of status variables as well as heard behavior.

Moreover, the professionals in disaster response are modeled on an organizational layer. They are distinguished between operating agents and coordinating agents of an institution. Coordinating agents prioritize the victims' needs by targeting to maximize the global supply rate in the whole area comprising of both countries. Operating agents are responsible to fulfill the citizens' needs. In order to fulfill the various needs that are requested by the population, there are pictured different organizations with their procedures. Starting on the operative level, providing health means in this regard that a paramedic drives its ambulance to the victim and collects it to bring it to the hospital. Provision of security is done by police forces moving with their police cars to the respective region and showing presence. The demand for stock can be fulfilled by organizations as the voluntary fire brigade or by spontaneous volunteers supplying the affected population with essentials. However, these operations need to be organized, and in the best case, optimally coordinated in the complete area comprising both countries. To find the most efficient collaboration structures in order to provide the resources best to the population, several coordination patterns are introduced on a coordinating level. Thereby, the closest distance can be examined as well as the investigation in different communication network structures comparing hierarchical information flows with the use of polycentric networks.

In the recent past, more and more volunteers are seen who help spontaneously without having completed appropriate training. This group of actors must also be involved in crisis management planning in order to be able to coordinate them effectively when it comes to the worst. Thus, the model additionally includes so-called spontaneous volunteers who target to fulfill the disaster affected citizens' needs but additionally are interested in group affiliation and appreciation. The citizens post their demands to simulated social media groups to which the spontaneous volunteers are assigned. The efficiency of coordination procedures are analyzed distinguishing between two dimensions, once the embeddedness in organizational structures of professional disaster response actors and, once the embeddedness across the border.

Besides the personal layers, there is an infrastructure layer allowing to adapt the disaster extent and covering all facilities to provide the demanded needs. These include hospitals for the provision of health, supermarkets dedicated to the fulfillment of the need for essentials, and police stations responsible for security. Moreover, gas stations allow to refuel cars.

As a specificity of agent-based models they allow for differentiating the agents' individual characteristics including knowledge and resources. Thus, besides differentiating among different roles in disaster response, the model sets a high value on the agents' characteristics with respect to borderland. As the most relevant traits in inter-organizational collaboration

are language and trust, these are determined in detail. Therefore, each agent has individual character variables picturing their language levels and trust towards the other agents.

Thereby, the model allows to study a variety of effects which all can be turned on and off to be able to conclude their impacts one by one. For a scenario-based approach, there are defined two reference scenarios. The worst case scenario is a disabled borderland collaboration where each nation is supplying the citizen itself. The best case scenario is always a perfect borderland collaboration without hindering factors. The structure of *Gaia* methodology for agent-oriented analysis and design is followed, which allows specifying and designing models and software using the multi-agent system paradigm (Wooldridge et al. 2000). The program is implemented using the *Repast Simphony* toolbox (North et al. 2013). This toolkit is written in the Java programming language and belongs to the Repast Suite, a family of free and open-source agent-based modeling and simulation tool-kits.

First of all the structure of the model is outlined before turning to three detailed studies which analyze different factors for efficient borderland collaboration among organizations to fulfill citizens demand in disaster response.

3.3.1 Environment

In a two-dimensional coordinate system of patches (x, y), a theoretical border region of two countries A and B is created which are separated by a river that can be passed via a bridge. While each side of the river belongs to one *Country*, the river is regarded as a neutral area, while the bridge across the river has both nationalities. A boolean *Blocked* is indicating if agents can move to or across this patch or not; this value is assigned true for all patches except from river patches. Moreover, a boolean *Disaster* distinguishes whether this patch is affected by the disaster or not. It is assumed that the disaster hits one nation and the other nation supports the affected one by providing resources. The model runs in a discrete time frame $t = 1, \ldots, T$ in which each step $t \to t + 1$, called a *Tick*, is updating the time-dependent variables. The described environment is static and does not change over time.

3.3.2 Agents

This section introduces the agents considered in the model. They consist of a set $P = \{p_1, \ldots, p_n\}$, $n \in \mathbb{N}$ of persons. In the presented simulation, all persons are placed at a patch *Home* in the grid and their *Nationality* is assumed to be equivalent to their locations' country. Moreover, they have a patch *Destination* which is initially their home location.

Furthermore, the set of persons P is divided into the subset of *Public Actors* in disaster response, i.e. $P_1 = \{p_1, \ldots, p_k\} \subset P$, $k \leq n$, the subset of *Spontaneous Volunteers*, i.e.

$P_2 = \{p_{k+1}, \ldots, p_l\} \subset P$, $k \leq l \leq n$, and the subset of *Citizens*, i.e. $P_3 = \{p_{l+1}, \ldots, p_n\} \subset P$ representing the affected population. A *Maslow State* variable is modeled for the citizens comprising the four states, pursuit of health, pursuit of essentials, pursuit of secure, and satisfied that may lead in the willingness to help others. Besides the global Maslow state variable, for each state a separate variable is modeled showing the fulfillment of the needs and gives insights on further needs (compare Figure 3.1). This allows to leap Maslow levels, for example a citizen that is injured due to the disaster, but has enough stock and feels secure, directly *jumps* to the top level Maslow state after its treatment. In particular, each citizen has a variable *Energy* representing its health status (cf. Crooks and Wise (2013)). The energy variable is ranging from 0 (i.e. death of an agent) to the maximal energy. A critical level $\tilde{e} \in \mathbb{N}$ is also defined. If the energy level of an agent is below $\tilde{e}$, the agent is assumed to require professional treatment by public actors. In a similar manner, the agents have a *Stock* and a *Perceived Security* variable. The security state of an agent can be increased only by professionals while the stock variable also by spontaneous volunteers. As these needs are assumed to increase over time, in each tick the variables are updated by the *Update Energy*, *Update Stock*, and *Update Perceived Security* methods, respectively and the corresponding Maslow state is adapted by the *Update Maslow State* method. The citizens' goal is to maximize their utility, which means they first fulfill the need of health, then the need of stock, then the need of security and afterwards they are satisfied. The citizens try to receive the fastest individual care by requesting help which activates a demand procedure. Therefore, three demand patterns are implemented. There is a dynamic pattern by which the citizens demand their needs to the receptive professional disaster response organization directly when their need fulfillment variable drops below the critical threshold. In addition, a herd demand structure is implemented. Therefore, each citizen has an individual probability of demand and the herd dynamic is resulting since this individual demand probability is increasing if a demand is observed within the neighborhood. Such a herd phenomenal is relevant for example to simulate the Maslow state of being insecure. In case the perceived insecurity of the persons in the neighborhood is high, the own feeling of perceived insecurity may be tightened. However, a similar demand structure was also observed in terms of panic buying within the beginning of the Covid-19 pandemic. The last demand pattern is regarding the influence of social media. Thus, citizens can in addition to demanding their needs also address them in one or more of the simulated social media groups. This covers the fact that citizens start self-help activities in case there is low trust towards professional disaster response.

The organizations are guided by the utility function of maximizing the overall fulfillment of demands. This is examined on the operational level by fulfilling the respective tasks and on the coordination level to align an optimized utility of capacities. Thus, public actors can be *Coordinating Agents* or *Operating Agents*. Each organization is constructed

along a hierarchy with coordinating agents on the top and operating agents on the bottom. Depending on the considered organization, operating agents comprise the subsets of *Paramedics* or *Police Officers*. They have a boolean status variable showing their *Availability* and their objective is to *Fulfill Demands* that they become allocated according to the priority assigned by the coordinating agents. The embodiment of demand fulfillment will be detailed within the case study following in Subsections 3.4, 3.7, and 3.10. The organizations' target is to provide the optimal overall care for the disaster victims and therefore, they *Prioritize The Incoming Demands* and forward them to be executed by the operating agents. Furthermore, they have the ability to *Request Additional Capacities* from organizations in the neighboring country in case of bottlenecks as well as to *Fulfill Incoming Requests*, respectively, if they have available capacities. It is distinguished between different organizations, each of them is responsible to fulfill a single type of needs. Moreover, coordination of resources across borders is studied on several coordination patterns. In case an organization is overwhelmed, it requests additional capacities form the neighboring country which in fact are operating agents of the corresponding organization. It is assumed that the disaster is heavily striking so that the resources from the own country are also dense. The dynamic coordination pattern of closest distance simply chooses the nearest coordination center across the border requesting additional capacities which are directly send in case of availability. In order to analyze the network coordination pattern, two underlying network structures are implemented that are an hierarchical network that allows coordination only on the top level and a polycentric network that allows coordination among all connections. The details of the network structure follow in Section 3.7.

Furthermore, spontaneous volunteers can support the fulfillment of citizens' needs as providing essential goods. This procedure is outlined in Subsection 3.10. Spontaneous volunteers are organized in simulated *Social Media Groups* that similarly to the organizations aim to complete incoming requests. However, their prioritization is differently. As the organizations prioritize according to the needs, the spontaneous volunteers prioritize according to the attractiveness of an area to help that is all volunteers choose the area with most demands being placed within the social media group that they belong to.

In the presented model, different aspects of efficient cross-border collaboration are applied to a routine for the distribution of resources focusing on medical health, essential goods and security of the affected population in a large-scale disaster. This routine of distribution requires an infrastructure layer. Therefore, *Buildings* of the type *Supermarket*, *Coordination Center*, *Hospital*, *Police Station* and *Gas Station* are located in the grid equipped with an integer *Current Capacity* as well as an integer *Maximal Capacity*. Each coordination center has also an array *Priority Queue* and the hospitals have an array *Patient List*. Moreover, coordinating actors are initialized at the locations of coordination centers, paramedics are initialized at the location of hospitals and police officers are located at police stations.

Additionally, *Cars* can have a person as *Driver*, and other persons as *Passengers*. They are assigned an integer *Speed*, an integer *Current Gas* as well as an integer *Maximal Gas*. *Ambulances* are a subclass of cars that can only belong to a paramedic and *Police Cars* are also a subclass of cars that only belong to a police officer.

3.3.3 Movements

If the destination of an agent deviates from its current location, the *Move* method checks whether the agent is assigned a car or not. If not, it moves to the neighboring patch in the Moore neighborhood (i.e. on the 8 patches adjacent to its current patch) in direction to the destination on the shortest path. In order to reach destinations in the neighboring country, the shortest path consists of the shortest path from its current location to the bridge added to the shortest path from the bridge to the destination. If a car is assigned, it allows to pick other agents up becoming passengers or displace them. In this case, it calculates whether the fuel is sufficient to reach the destination and if so the associated car carries the driver and all passengers speed patches in direction of the destination by shortest distance (calculated as described above). The current gas decreases by the number of moved patches. If the gas is not sufficient to reach the destination, *Refuel* starts setting the destination to the location of the closest gas station and then driving similarly to this location. If the car runs out of fuel before the gas station is reached, it stops. Otherwise, at the gas station, refuel starts shifting distributable capacities from the gas station to the car.

3.3.4 Communication and Coordination

After defining the infrastructure layer which locates the health care facilities and in which agents can move in order to supply, now the communication and coordination protocols are considered as these are the key components of borderland collaboration. Communication occurs in two ways, either as a demand from the population to the professionals or spontaneous volunteers or between organizations to coordinate on the optimal fulfillment of the demands. Therefore, a *Receiver* is chosen. During both types of communication, problems may occur with regard to technical incompatibility, language barriers or distrust between the sender and the receiver of a message. To be able to communicate in general, the agents either need to be in the neighborhood or the technical availability needs to be fulfilled. In particular, the agents have a variable *Availability of Technical Communication Channels* (shortly Tech) displaying whether each communication channel is available or not distinguishing for communication channels for country A and B. The method *Calculate Tech* checks whether the technical systems of the sender and receiver match making communication possible. This is relevant as in a power blackout for example,

the internet and telephone is not available which means that crisis response actors need to communicate via radio. However, this technology does not have a uniform standard and may differ among the countries. Is the technical barrier resolved, communication can take place. Thereby, it is distinguished between the languages spoken by sender and receiver. Considering the three languages, language of country A, language of country B, and a lingua franca, the agents communicate in that language in which they receive the highest multiplicative value. This is represented by a three dimensional array *Language* for each agent showing its language skills for each of the three considered languages. The corresponding method *Calculate Language* determines the maximal language level that can be achieved between sender and receiver of the message. In case they reach a perfect level, communication results are as intended. Otherwise misunderstandings may occur leading to inexact prioritization or even communication stop. After the communication process, a trust check is implemented. Therefore, each agent has a set of trusted agents distinguishing between personal trust towards other citizens and organizational trust for both countries separately. In particular, an array *Trust* is given for each agent including the agents that are trusted. The *Calculate Trust* method estimates the trust level between sender and receiver. If the sender of a message does not trust the receiver to be able to fulfill the request, it turns to another receiver repeating the request which leads to doubling of needed capacities. In case, the demand of a citizen to an organization is set up successfully, it is saved in the demanding citizens' *My Demand* variable. Similarly, a successful request of an organization towards an other organization in the neighboring country in order to coordinate on available capacities is saved in the *My Request* variable. As outlined before, the type of demand as well as addressed organization is depending on the citizens' Maslow state. In particular, in case the Maslow state is pursuit of health, its energy variable is below the critical threshold, it demands a paramedic via calling the closest coordination center. In case the energy is above the critical level, but the stock is below the critical stock level, the agent is in the need of essential Maslow state and demands essentials either from professionals or via posting it in a social media group. Moreover, the Maslow state of pursuit of security requires the fulfillment of perceived security within the environment which demands sending out a police officer via a local coordinator responsible for the area in which the agent lives. Has an agent all variables fulfilled above the corresponding thresholds, its Maslow state is satisfied so that the agent does not set-up any demands and may be willing to help others. Moreover, communications are between organizations to coordinate their capacities of demanded resources in order to provide best support for all citizens. Coordination mechanisms comprise getting available capacities from the neighboring country via shortest distance or via network communication which distinguishes between requests coordinated along the organizational hierarchy or direct requests via the informal personal network among the agents.

A simplified Unified Modeling Language (UML) class diagram is given in Figure 3.2.

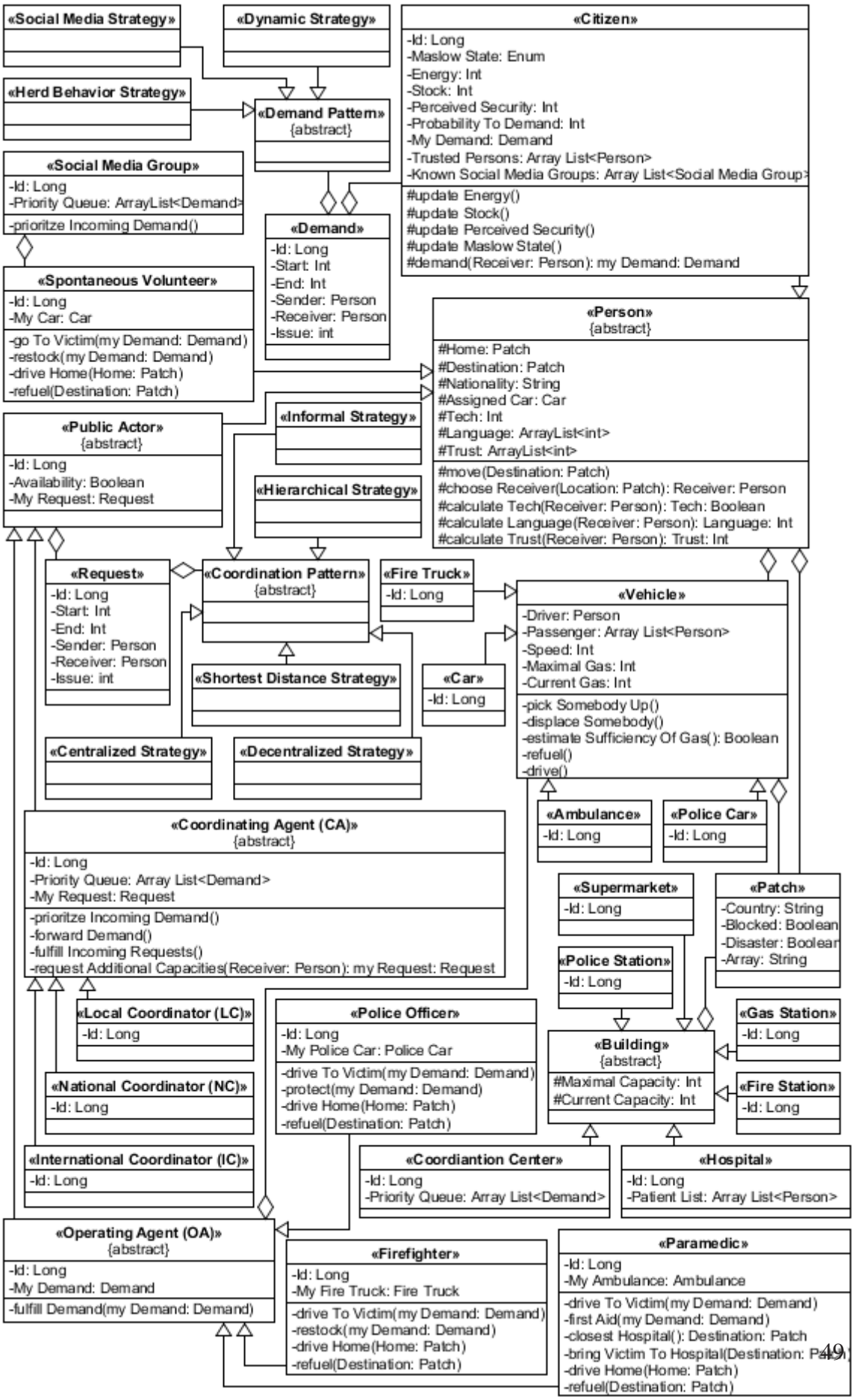


Figure 3.2: Class Diagram of the Agent-Based Model

3.3.5 Overview Studies I-III

After illustrating the general mechanisms of the model, now three case studies are performed investigating relevant issues in order to determine success factors for borderland collaboration in disaster response. These are guided by Stoto et al. (2017) who addresses the need for a systematic approach to managing resources and responsibilities in emergency response, including communication between all agencies, to ensure effective coordination of prevention and treatment efforts as well as trust-building in risk and crisis communication strategies informing the population. In this regard, each of the studies fixes one of the presented demand structures and one collaboration structure, where studies I and II investigate interorganizational collaboration in two ways and study III examines the involvement of spontaneous volunteers.

In detail, study I is quantifying the impact of culture for borderland collaboration, in particular, it simulates increased uncertainty due to language barriers in comparison to the impact of blocked capacities via doubling requests due to distrust. To exclude external effects, all citizens are assumed to be in the lowest Maslow state requiring health provision. This can only be fulfilled by professionals so that the citizens demand dynamically their energy-needs to the closest coordination center. The coordinator forwards the request to the next available operating agent which is a paramedic in this case and this paramedic moves in the infrastructure layer to the citizen and fulfills its need by transporting it to the nearest hospital. Afterwards, the paramedic moves back to its home location and the citizen also moves back to its home location after treatment in the hospital. In case the own resources are overwhelmed, the coordinator request additional capacities by the closest distance coordination strategy. If it is in the neighboring country, the individual traits of language and trust result the supply where language increases uncertainty and trust doubles requests which leads to blocked capacities.

Study II investigates a detailed coordination structure among the professional organizations. The question is whether the exchange of resources is more efficiently via a coordination procedure along a hierarchical network or via a fast exchange along direct contacts in an informal network. Therefore, the model is extended by a network structure. Instead of only one level of coordinating agents, the coordinator, there are now four levels detailing the hierarchy of the organizations comprising a local coordinator, a regional coordinator, a national coordinator, and an international coordinator. Note that the coordinator in the first setting corresponds to the international coordinator. Moreover, a network of personal contacts is implemented connecting the coordinators by a polycentric representation. The citizen in this study are assumed to be all in insecure Maslow state demanding increase in their perceived security variable. Moreover, the demand structure is pictured by a herd behavior. In case of scarce resources, the coordinator can decide whether to request additional capacities via the formal or informal network in order to fulfill all incoming

demands by the citizens. They are fulfilled by sending out an operating agent, a police officer in this case, to the location of the citizen which then feels safe. After some ticks, the police officer moves back to its home location.

In Study III, efficient coordination of spontaneous volunteers is investigated including them into a routine of disaster response. It outlines a coordination framework along two dimensions, once with regard to embedding to the organizational structures of professionals, and once with regard to coordination across the countries borders. To quantify the coordination success, the border region is divided into areas. Professionals in disaster response have a systematic apportionment where all areas are of similar size and one area is next to the other. The apportionment of the spontaneous volunteers is not as exact and it may happen that areas overlap. In order to exclude external effects, this study assumes all citizens to be in the Maslow state in which they pursuit of essentials. Citizens in need decide whether to demand their needs to one of its known social media groups or to professionals in disaster response which are in this study firefighters. Spontaneous volunteers prioritize their help according to the area in which most demands are posted within the social media group that they belong to. With the purpose of not destroying the feeling of group affiliation and togetherness, which is always reported by spontaneous volunteers, it is assumed that all volunteers belonging to the same social media group choose the same area to provide their help. Assuming that professionals in disaster response can better estimate the citizens' needs, they prioritize the demands by the fulfillment of the stock variables. Both, spontaneous volunteers and firefighters, have the restock method to increase the citizens' stock variable by the same amount.

For each of the case studies, in the following the setting is detailed then the parameters of the simulation experiment are specified before the results are outlined. It is to mention that these analysis are special cases to extract effects of the model and conclude success factors influencing borderland collaboration without being artifacts from external effects. However, the agent-based model also allows any other combination of parameter settings to investigate additional effects. For example, language and trust can also be included to the network coordination mechanism or the requests to spontaneous volunteers. As the model is complex, these case studies are intentionally kept simple to avoid noise in the identification of the underlying dynamics.

3.4 Setting Study I

Perfect borderland collaboration can be interpreted as the merge of all capacities available in the environment so that the neighboring country's capacities can compensate for higher needs of an affected border region. However, often coordination failures result in the collaboration. To uncover the effects of those, this study integrates the two aspects of culture – language and trust – of cross-border collaboration into a routine for the distribution of resources focusing on medical health care of the affected population in the context of a large-scale disaster affecting one side of the border. In detail, the process of emergency calls is analytically examined. On the infrastructure layer, citizens request medical assistance via a coordination center to paramedics who pick up the person in need and bring it to the closest hospital where medical care is provided. On the organizational layer, resource bottlenecks due to language barriers and distrust are quantified, since these are crucial factors in collaboration and interoperability. Therefore, the three basic scenarios are analyzed: (I) no communication at all, (II) imperfect communication due to misunderstandings and (III) perfect information exchange in the communication procedure between sender and receiver of a request for medical support. Moreover, the consequence of misunderstandings are that emergency services make mistakes in the prioritization of assistance, which means that the patients' perceived health status is allowed to randomly vary within a given interval. Moreover, distrust leads to second and alternative requests: If a sender of a request is forwarded to an operator of different nationality and has doubts that this person will provide the requested help, the sender can send a second request to a receiver of its own nationality. While misunderstandings increase uncertainty in the communication process, distrust leads to additional requests and delays.

3.4.1 Communication Across the Border

In order to analyze miscommunication, language skills ranging from 0 (no skills) to 2 (perfect skills) are distinguished for each of the three considered languages, i.e. the language of country A, the language of country B and a third language representing a lingua franca. Thus, each agent has a 3-dimensional array *language* with $language_i \in \{0, 1, 2\}$. It is assumed that each agent has perfect skills in the language of its nationality and a varying proportion of population having language skills in the language of the other country as well as having language skills in the lingua franca is analyzed. Moreover, in order to analyze distrust, each agent is assigned a 2-dimensional *trust* array distinguishing trust towards the own countries' authorities and the neighboring countries' authorities. The integer trust level $trust_i \in \{0, 1\}$ indicates whether an agent is trusting or not and similar to misunderstandings, also a varying number of trusting agents is examined. Let

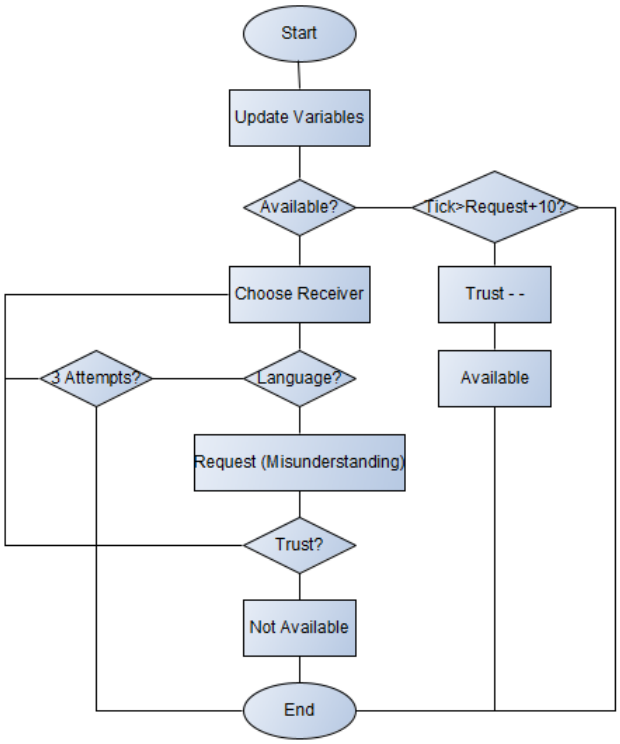


Figure 3.3: Process Diagram of Communication Procedure

$p_j \in P$ be the sender of a message and $p_{j'} \in P$ be the receiver of a message, then for each communication procedure the communication language availability l is calculated as

$$l = \max_i \{language_{ij} \cdot language_{ij'}\} \in \{0; 1; 2; 4\}.$$

If both, sender and receiver of a message, find one language, they are fluent ($l = 4$) and communication works perfectly. If $1 \leq l \leq 2$, then misunderstandings occur. In case the maximal value equals $l = 0$, no communication takes place. In a second step, the $trust$ level of the sender $p_j \in P$ towards the receiver $p_{j'} \in P$ is checked. If it is above a critical level $\tilde{t}$ then the request receiver is trusted, otherwise distrust occurs. This procedure is shown in Figure 3.3 where true if-conditions lead to pathway downwards and false if-conditions lead to the left/right hand side pathway.

3.4.2 Dynamic Demand Creation and Coordinated Fulfillment

According to the *Update Energy* method, the citizens' energy level decreases by $e^- \in \mathbb{N}$ each tick. If the energy of an available citizen falls below $\tilde{e}$, it starts a requesting procedure as described in Section 3.4.1. The request receiver is determined as a coordinator located closest to the citizen's position. In case of perfect communication, the victim is assumed to be sorted in the priority queue of the coordinators' associated coordination center correctly

(which is simplified by ordering the priority queue among the energy state of the included victims), but in case of misunderstanding a random position of $+/-x$ from the correct position is taken. In the case of no communication, the interaction stops and the citizen starts requesting to a new receiver, where it has up to 3 chances per tick. Otherwise, in a second step a trust check is implemented. If it is below a critical level $\tilde{t}$, the sender is assumed not to trust the receiver providing the requested issue and therefore, the sending agent starts requesting its issue to a new receiver without canceling the first request. Hence, distrust doubles the requested capacities. In case the request is successful, the citizen's status turns to not available. If an affected citizen is waiting for more than x' ticks after starting a request, its trust decreases and its status is set to availability again meaning that in the next tick another request will be sent. If its status is changed to availability after a treatment in hospital, the citizen moves to its home location.

In each tick, the coordinator takes the first request from its associated coordination centers' priority queue, calculates the available operating agent, i.e. paramedic, closest to the requesting citizens' location as request receiver, forwards the request to the chosen paramedic where misunderstandings and distrust may occur similarly as described in the request procedure and deletes it from the priority queue.

Hospitals have the method *Admit Patient* which adds a citizen on the hospital's patch to its patient list if there are free capacities and decreases the hospital's capacity by 1. Furthermore, they have the method *Discharge Patient* which removes all patients with an energy level higher than $\tilde{e}+e'$, $e' \in \mathbb{N}$ from the patient list, increases the hospital's capacity by 1 and turns the citizen's status to availability. The energy level of all citizens currently included in the patient list increases by $e^+ > e^-$, $e^+ \in \mathbb{N}$ in every tick by the method *Treat Patient*.

Paramedics are initialized at the patch of one of the hospitals and assigned an ambulance. In case they receive a request, their availability status turns to occupied and they set the ambulance's destination to the requested location. Arriving at the location via repeating the movement method as described in Section 3.3.3, it is checked whether the patient is there. If not, the ambulance drives back to its home position and the paramedics status is turned to availability. If so, the method *First Aid* is increasing the patient's energy level by $e'' \in \mathbb{N}$. The ambulance's method *Pick Somebody Up* is started putting the patient into the ambulance and its destination is set to the closest hospitals' location with available capacities. Arriving at the hospital's location, the method *Displace Somebody* removes the patient from the ambulance. If the hospital is located at the paramedic's home, its status turns to availability. Otherwise the ambulance's destination is set to the paramedic's home location. If the current gas variable drops below $1/2$ times maximal gas, the paramedic starts the refuel method driving to the closest gas station and shifting

distributable capacities up to maximal gas from the gas station to the ambulance before it turns back to its home location.

For all gas stations, which are not affected by the disaster, the capacities are increased to initial values every fixed number of ticks.

A simplified Unified Modeling Language (UML) class diagram is given in Figure 3.4.

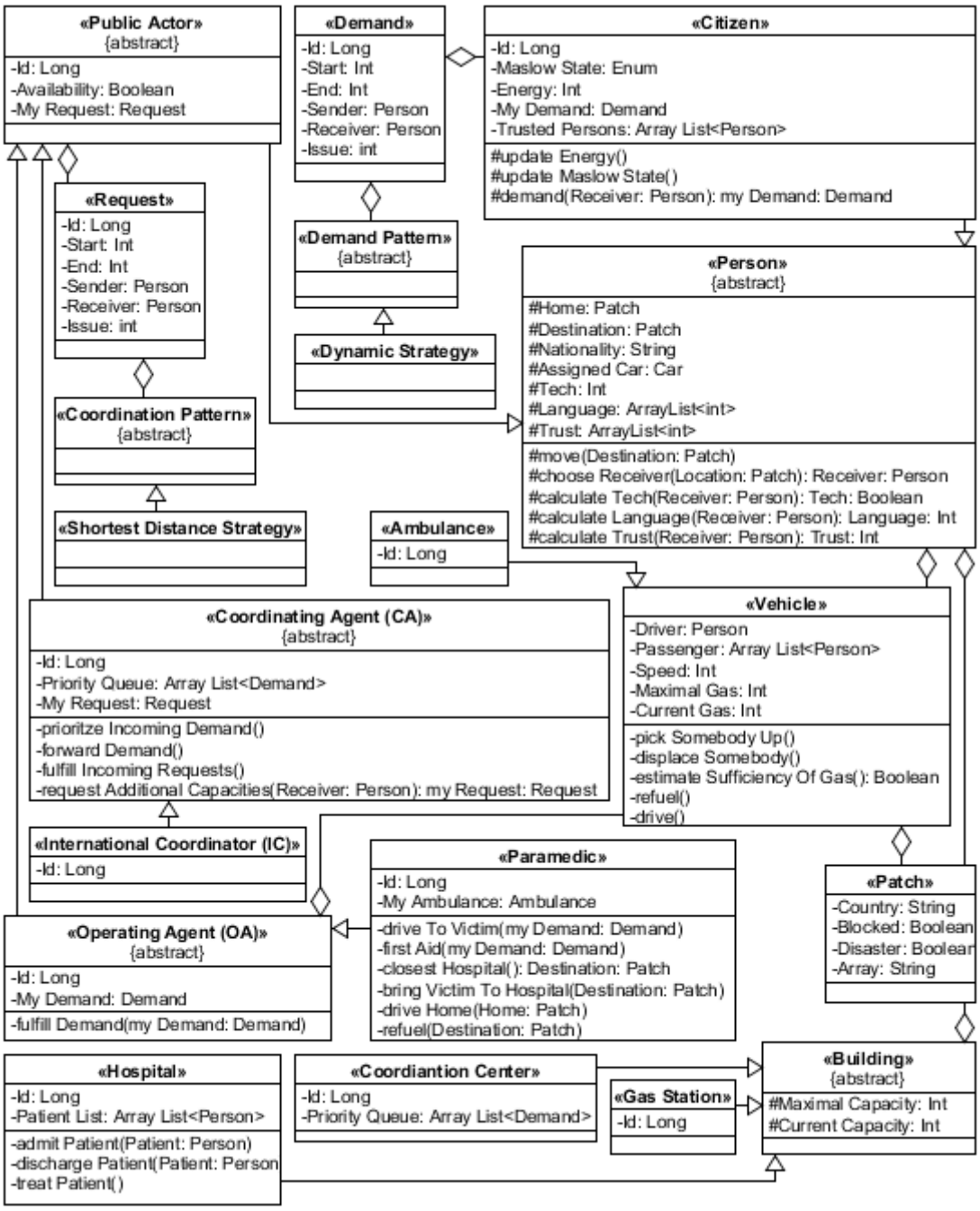


Figure 3.4: Class Diagram of Study I

3.5 Simulation Experiment Study I

A border region is modeled representing two countries separated by a river that can only be crossed by a bridge as seen in Figure 3.5. In detail, a grid of 200×200 patches is considered, where the patches with negative x-values get the name *country A* as start value and the patches with positive x-values get *country B* assigned. The patches with an x-value of 0 form a border river and are initialized as *country 0* and *blocked*, except from patch $(0, 0)$ forming the bridge between the two countries, being initialized as *unblocked*. All other patches have the value *unblocked*.

In the simulation experiment, a population of 2000 citizens is modeled uniformly distributed in the environment (in case a blocked patch was chosen, a new agent is created). They receive the nationality of the country in which they are initialized. 20% of the population are assumed to be in the neighboring country when the disaster happens. Therefore, an agent i is randomly picked and its initial location is changed from (x_i, y_i) to $(-x_i, y_i)$ until 20% of the population is reached. The citizens' initial energy is normally distributed with mean of 384 and standard deviation of 288. In case the initial energy is negative, the agent is assigned a random energy between 0 and 672. Assuming that a tick is a quarter of an hour in real time, the energy of an agent corresponds to a mean of 4 days with standard deviation of 3 days surviving in the aftermath of the disaster without medical care. In each tick, the energy decreases by 1, the critical energy level $\tilde{e}$ is set to 25. First aid once provides additional energy of 2 and the treatment in hospital increases the energy level by 4 each tick.

A coordination center is located at each side of the border, i.e. at coordinates $(-10, 0)$ and at $(90, 0)$. Both have a capacity of 10, which equals the number of associated coordinators placed at their locations. Moreover, 3 hospitals are placed in the environment, one of each side of the border roughly with the same distance to the border and the third one right next to the border river. The coordinates are $(-61, 9)$, $(81, -7)$ and $(5, 0)$ and their capacities equaling the size of the patient list are 24, 420 and 28. The number of ambulances and paramedics placed at the hospitals' locations are 4, 36 and 8. The ambulances speed is 12 and its maximal gas is 500. gas stations are located at patches $(-10, 10)$ and $(10, 10)$ with capacity of 5000 each.

If distrust occurs in communication procedures, an agent sets up another request after waiting for 10 ticks without fulfillment of its current request. If misunderstandings occur, the coordinators assign the patients' health randomly within an interval of $+/-4$ positions in the priority queue.

It is assumed that the disaster hits the region at the starting time 0 and a simulation duration of 240 ticks is studied. By running the model, the effects of an imprecise process

of incoming requests due to language barriers and doubled requests due to distrust are evaluated.

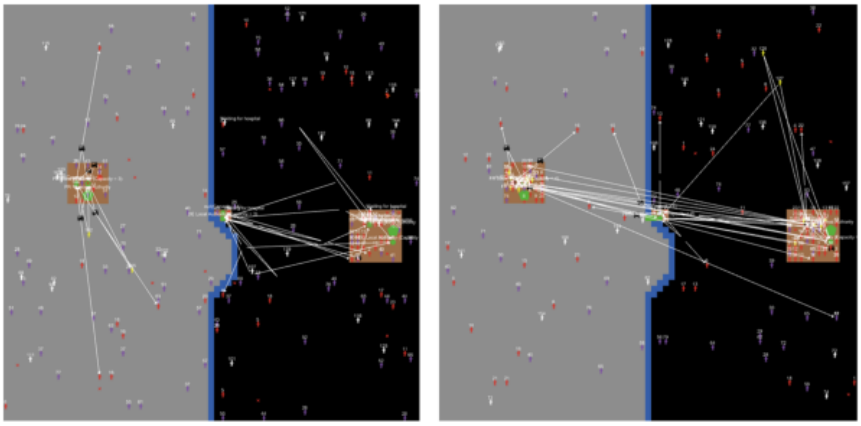


Figure 3.5: Study Region with Disabled and Enabled Borderland Collaboration

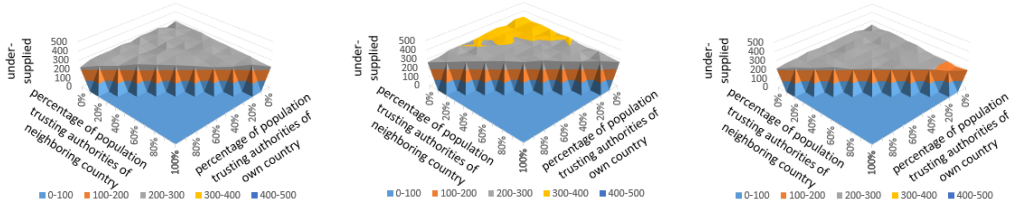
3.6 Results Study I

The parameters of *Distrust* and *Language* are varied and the performance indicators of *Number Of Undersupplied Citizen* and *Perfect Request Ratio* are measured.

In order to present the models' mechanism, in the first scenario a symmetric disaster is considered affecting the whole environment. A situation of perfect cross-border collaboration without language barriers (i.e. for all agents, the language skills of all three languages are 2) and distrust (i.e. the trust level for all agents is 1) is compared with a situation of disabled cross-border collaboration where each country is dealing with its own requests using the own capacities. With the parameter setting of the simulation experiment, there is a clearly positive impact of cross-border collaboration. Tracking the number of undersupplied citizens in 10 runs per scenario, a mean of 217.2 is achieved with standard deviation of 22.4 in the scenario of disabled borderland collaboration compared to a mean of 167.0 undersupplied with standard deviation of 18.5 in the scenario of perfect borderland collaboration. In the next step, the effects of an asymmetric disaster affecting only one country are uncovered. Therefore, all 2000 agents are initialized in country A which is assumed to be hit by the disaster. All other conditions are kept similar, including the initial movement of 20% of the population to the neighboring country, country B in this case. This is a simplification to make the scenarios comparable. It is to note that country B would also have to supply their medical dependent citizen on a regular basis. Again, a situation without cross-border collaboration is analyzed resulting in a mean number of 388.2 undersupplied with a standard deviation of 31.3 compared to perfect cross-border collaboration leading to 221.2 undersupplied with a standard deviation of 21.9. Changing

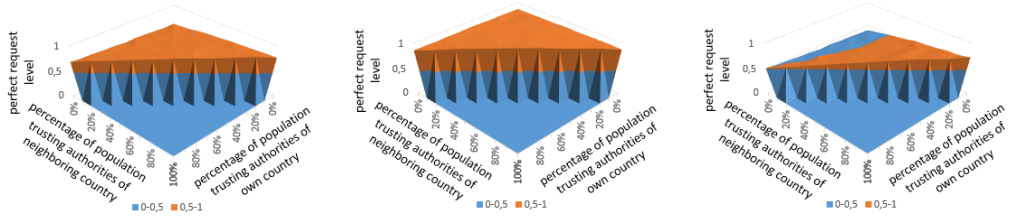
the asymmetry to country B with a population of 2000 citizens being affected, a number of 71.8 undersupplied is achieved with standard deviation of 10.1 without cross-border collaboration and a number of 108.3 undersupplied with standard deviation of 20.7 with perfect cross-border collaboration. The smaller number of undersupplied citizens results from the unequal equipment with health facilities of both countries. Interestingly, the scenario without borderland collaboration leads to a better overall supply than with perfect borderland collaboration which results from the fact that the coordination centers on each side of the border have only a local focus and do not synchronize their actions globally. The implications are discussed in Section 3.13.1 at point four.

After getting familiar with the basic structure of the model, the impact of language barriers and distrust on capacity reduction are analyzed. First, the analysis of distrust is presented.



(a) symmetric **(b)** asymmetric country A **(c)** asymmetric country B

Figure 3.6: Mean Undersupplied per Trust Level



(a) symmetric **(b)** asymmetric country A **(c)** asymmetric country B

Figure 3.7: Perfect Request Rate per Trust Level

Figure 3.6 shows the number of undersupplied per trust level and Figure 3.7 shows the mean of perfect requests per trust level. The trust-effect is evident: The number of undersupplied increases with declining trust-levels. The biggest impact is seen for an asymmetric population distribution concentrated in country A as this country is considered to have the least health facilities. In this regard, the least distrust occurs in an asymmetric population distribution with focus in country B.

We now calculate the perfect request rate

$$r_{\text{distrust}} = \frac{\text{number of perfect requests, i.e. without any distrust}}{\text{number of posed requests}}.$$

and show in Figure 3.8 the mean of undersupplied per perfect request level of a symmetric disaster in both countries.

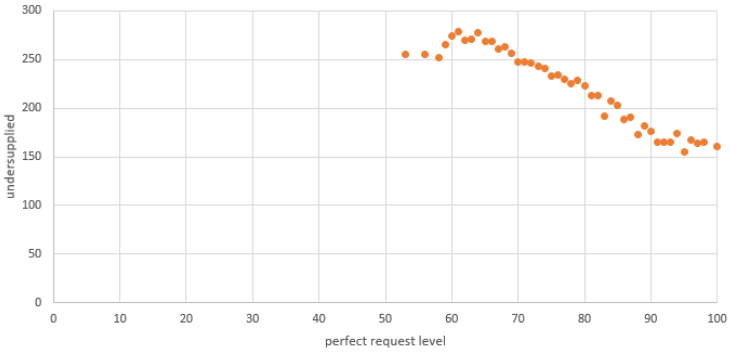


Figure 3.8: Distrust Symmetric Population Distribution

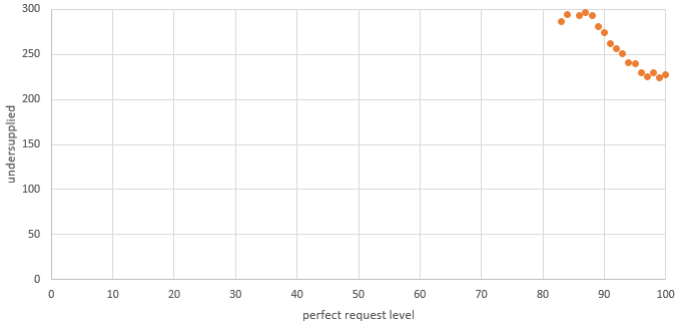


Figure 3.9: Distrust Asymmetric Population Distribution Focussing Country A

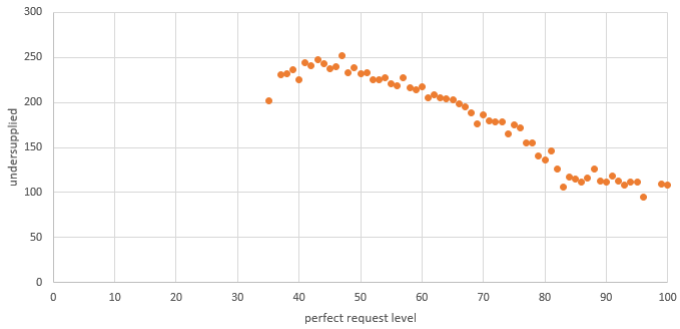


Figure 3.10: Distrust Asymmetric Population Distribution Focussing Country B

Interestingly, the decrease of undersupplied by increasing perfect request rate is mirrored S-shaped. This is interpreted as overall linear decrease asymptotically approaching the lower bound given by capacity constraints. It is to note that the curve starts at a perfect request level about 50% since requests that are handled within one country are always performed perfectly and that there occur higher variances in the beginning and the end of the curve due to less frequent occurrence of these cases. Analogously, Figures 3.9 and

3.10 show the mean undersupplied per perfect request level with asymmetric population distribution focusing country A and B, respectively.

Now, the analysis of language barriers is presented. In a first step, it is distinguished between a situation where an increasing percentage of the population speaks the language of the neighboring country and the situation where an increasing percentage of the population speaks the lingua franca. Again, the perfect request rate is calculated as

$$r_{\text{language}} = \frac{\text{number of perfect requests, i.e. without any language barriers}}{\text{number of posed requests}}.$$

Figure 3.11 shows the number of undersupplied per perfect request level for the case of a symmetric disaster with a population of 2000 spread over both countries. Figure 3.12

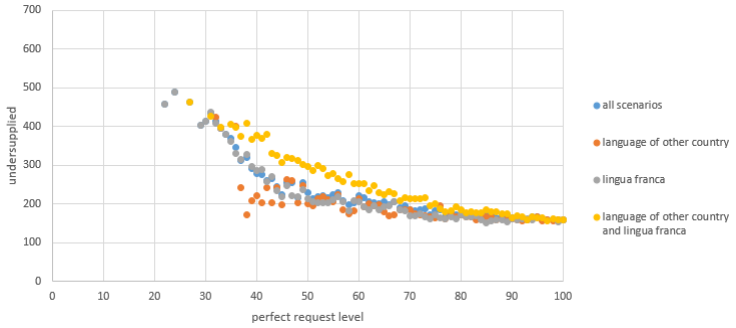


Figure 3.11: Language Barriers Symmetric Population Distribution

shows the number of undersupplied per perfect request level for the case of an asymmetric disaster when a population of 2000 is located in country A. Figure 3.13 shows the number of

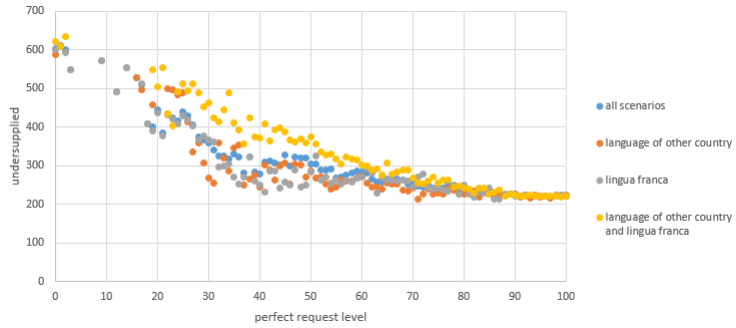


Figure 3.12: Language Barriers Asymmetric Population Distribution Focussing Country A

undersupplied per perfect request level in case of an asymmetric disaster with population of 2000 is located in country B. It is seen an exponential decrease of undersupplied with increasing perfect request rate asymptotically approaching the lower bound given by capacity constraints.

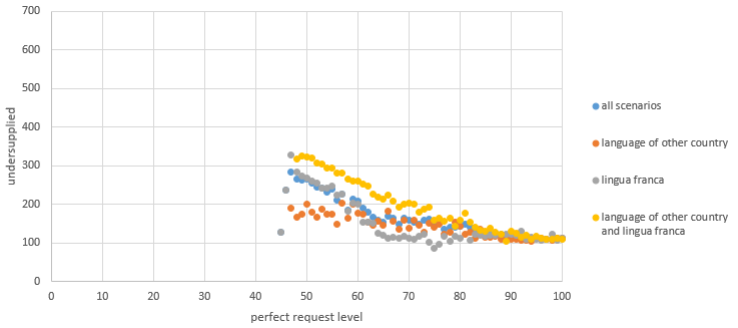
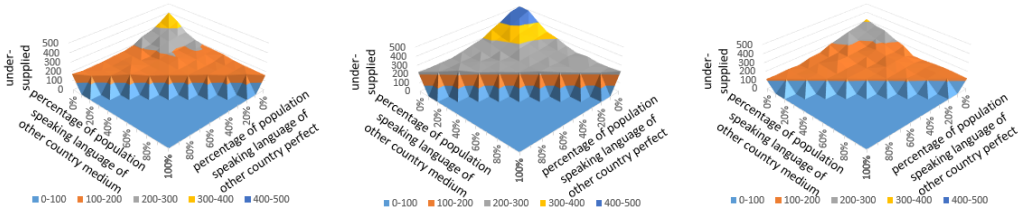


Figure 3.13: Language Barriers Asymmetric Population Distribution Focussing Country B

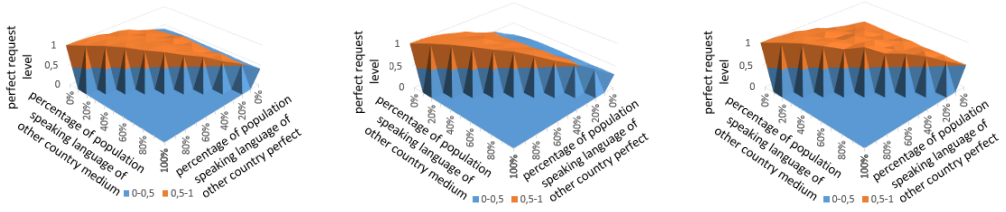
The following graphs present the details of undersupplied per language level as well as perfect requests per language level. As expected, the number of undersupplied is highest in case of no faculty of speech and decreases with an increasing share of the population speaking the language of the neighboring country and the lingua franca, respectively. Moreover, the number of undersupplied is highest if the disaster occurs in country A due to the lower number of health facilities, see Figures 3.14a and 3.14c. There is not much variation in the number of undersupplied comparing medium and perfect language skills. Similarly, the number of perfect requests increases with perfect language skills



(a) symmetric **(b)** asymmetric country A **(c)** asymmetric country B

Figure 3.14: Mean Undersupplied per Language Level Considering Language of Neighboring Country

while medium language skills lead to misunderstandings as shown in Figures 3.15 and 3.18.

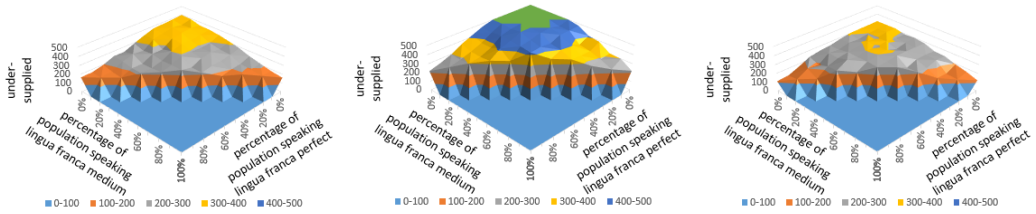


(a) symmetric **(b)** asymmetric country A **(c)** asymmetric country B

Figure 3.15: Perfect Request Rate per Language Level Considering Language of Neighboring Country

After studying the difference between medium and perfect language skills for both scenarios (increase skills in the neighboring country's language and increase skills in the lingua

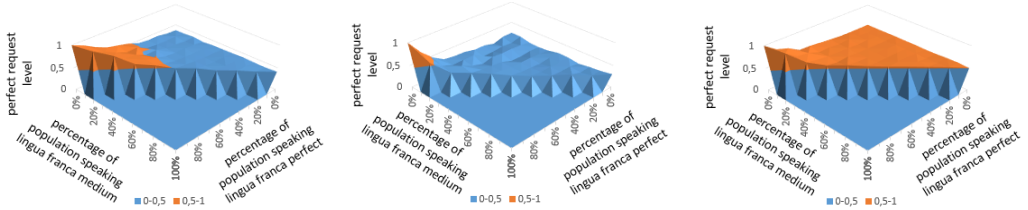
franca), now the comparison between perfect language skills in the neighboring countries' language versus perfect language skills in the lingua franca is presented. Comparing lan-



(a) symmetric **(b)** asymmetric country A **(c)** asymmetric country B

Figure 3.16: Mean Undersupplied per Language Level Considering Lingua Franca

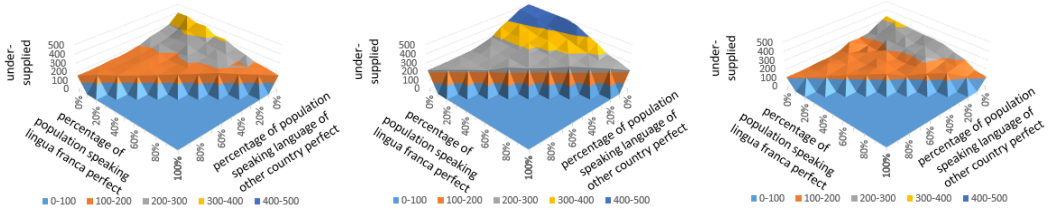
guage skills of the neighboring countries' language (Figure 3.17) versus the lingua franca (Figure 3.16) separately leads to a stronger rise of the number of undersupplied. Thus, there is an increased number of unsupplied for the same ratio of population speaking the lingua franca.



(a) symmetric **(b)** asymmetric country A **(c)** asymmetric country B

Figure 3.17: Perfect Request Rate per Language Level Considering Lingua Franca

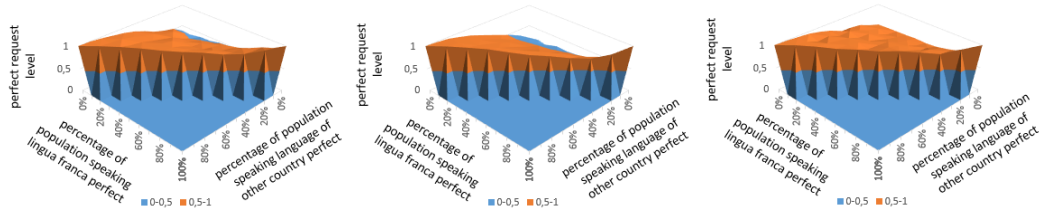
Furthermore, there are many more perfect requests in case of agents speaking the language of the neighboring country compared to the same ratio of agents' population speaking the neutral lingua franca (Figures 3.15 and 3.17). This analysis is summarized in Figures 4.3 and 3.19 showing the ratio of perfect language skills in the language of the neighboring country compared to the lingua franca. Thus, it can be concluded that an investment in language skills of the neighboring countries' language has a positive impact and is especially for border regions recommendable. A direct comparison of these can be found



(a) symmetric **(b)** asymmetric country A **(c)** asymmetric country B

Figure 3.18: Mean Undersupplied per Language Level in Both Languages

in Figures 3.18 and 3.19. Moreover, comparing trust impact to language impact supports



(a) symmetric **(b)** asymmetric country A **(c)** asymmetric country B

Figure 3.19: Perfect Request Rate per Language Level in Both Languages

this statement since missing trust results in a number of 300 undersupplied and missing language knowledge results in a number of 700 undersupplied (see Figures 3.8 and 3.11). Furthermore, an increasing language level leads to exponential decrease of undersupplied while increasing trust level leads to (overall) linear decrease.

3.7 Setting Study II

This study is a theoretical consideration to quantify the efficiency of coordination procedures. Therefore, the organizational layer is extended to quantify the trade-off between slower but coordinated response in a hierarchical network via faster direct exchange in an uncoordinated manner of informal personal contacts (see Figure 3.20). The efficiency of both strategies is quantified depending on the networks' size and structure, i.e., the direct exchange between agents compared to the formal hierarchical exchange. In a second step, an organizational theoretic perspective is investigated and it is simulated how to react to local decisions from a global perspective to achieve a balanced distribution of resources. Moreover, the model is integrated in the underlying infrastructure layer which is dedicated to rebuild a realistic demand structure putting the organization into need for adequate reaction and thus, to provide a dynamic setting in which efficient coordination is required due to changing circumstances.

Each of the two countries A and B in the border region has a hierarchical structured organization so that its members are the public actors. The members of the organization are assigned to the organization in their country and vary in their position in the hierarchy, where those on the lowest level are called *Operating Agents* ($OA \subseteq P$) and all others *Coordinating Agents* ($CA \subseteq P$). The set of coordinators divides along the hierarchy into the subsets of *Local Coordinators* ($LC \subseteq CA$), *Regional Coordinators* ($RC \subseteq CA$), *National Coordinators* ($NC \subseteq CA$) as well as an *International Coordinator* ($IC \subseteq CA$) for each nation.

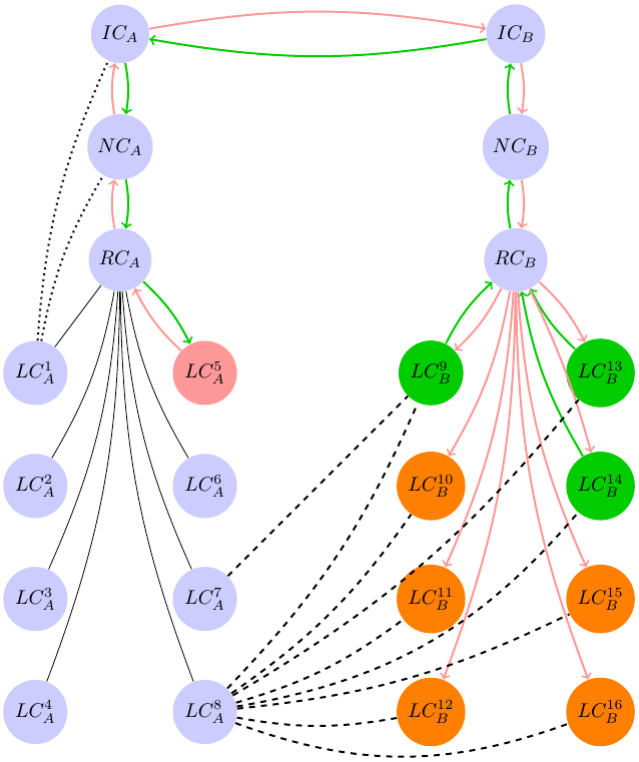


Figure 3.20: Hierarchical versus Direct Information Exchange

The decision-makers in the model are the local coordinators whose objective is to optimally fulfill the population's demand occurring in their responsible area by sending an adequate number of operating agents. Thereby, the local coordinators have a local view and are only concerned about performing best in their area. If they do not have enough capacities to fulfill all demands, they can request additional capacities from the organizations' unit in the neighboring country as it is assumed that the capacities in the own country are already fully utilized so that they cannot support. Therefore, the local coordinators have two strategies, either requesting via the hierarchical procedure of the organization or sending a direct request to the neighboring country via their network of personal contacts. First, the layer of organizational structure is described with focus on the procedure of requesting additional capacities within the organization and then the infrastructure layer is detailed with focus on the procedures of demand creation by the population and their fulfillment by the local coordinators sending available capacities, i.e. operating agents. Note that the operating agents represent the connection between the infrastructure layer as they can move within the environment and the organizational layer as they are assigned to a corresponding local coordinator.

3.7.1 Requesting Additional Capacities via Networks

First, the construction of the hierarchical network is considered. Here, requests about further capacities are forwarded to the coordinating agent on the next hierarchical level above the sender in the same unit. If the sender is the international coordinator, all incoming requests are coordinated and forwarded to the international coordinator of the corresponding organization in the neighboring country. Thus, the international exchange takes place only among the international coordinators. Then, the received request concerning additional resources from the organization of the other country is forwarded to all coordinators on the next level below the sender in the same unit until the level of local coordinators is reached. There, the number of available respondents, i.e. operating agents, is calculated and this information is sent back upwards the hierarchy to the international coordinator. The international coordinator coordinates the available capacities from all sub-units and sends them via the international coordinator in the neighboring country back to the initial requester across the border. In case there are no capacities from abroad, the demanding citizen cannot be supplied until resources from the own unit is available.

The hierarchical network is defined as a directed graph $G = (V, E)$. Let each coordinating agent $i \in CA$ be represented by a node v_i. Moreover, let the units of both countries be in a rooted-tree representation and the arcs between nodes are in both directions (i.e. in-tree and out-tree at the same time) to allow requests in one direction and responses in the opposite direction. It is assumed that the agents can only communicate with those agents that they are directly connected via an arc. Each communication takes one tick of time. The networks of different hierarchies varying in their number of levels are compared: (I) for each country, the network pictures a tree with an international coordinator as root on level zero connected via arcs with the set of local coordinators on the first level as leaves (II) on each tree, the internal nodes of national coordinators are added on level one so that they have a connection to the root on level zero and to the local coordinators on level two (III) between the level of national coordinators and the level of local coordinators, also the level of regional coordinators is added as internal nodes. For all representations, there is defined another pair of arcs $e_{i,j}$ and $e_{j,i}$ between the two international coordinators $i \in IC_A$, $j \in IC_B$, where $IC_A \subseteq IC$ is the set of nodes that represent the international coordinators in country A and $IC_B \subseteq IC$ is the set of nodes that represent the international coordinators in country B. Thus, 3 hierarchical scenarios are studied: local coordinators directly communicate their needs to the international coordinators in their country which exchange the information about needed capacities across the border as exemplary seen for country A by the dotted arc from LC_A^1 to IC_A in Figure 3.20 (scenario $h = 1$); local coordinators communicate their needs via national coordinators to the international coordinators in their country which exchange the information about needed capacities across the border as exemplary seen for country A by the dotted arc from LC_A^1 to NC_A combined with the red

arc from NC_A to IC_A in Figure 3.20 (scenario h = 2); local coordinators communicate their needs via regional coordinators and national coordinators to the international coordinators in their country which exchange the information about needed capacities across the border as exemplary seen for country A by the red arc from LC_A^5 to RC_A then to NC_A and to IC_A in Figure 3.20 (scenario h = 3).

Next, the construction of the informal network is considered. The additional needed capacity is forwarded to an available local coordinator known to the sender via the informal network. Thus, the exchange is directly on the level of local coordinators from one country to the other. If available, the receiver sends the requested capacities directly to the requesting coordinator. Otherwise, the requests cannot be fulfilled until resources from the own sub-units become available. As the requests between local coordinators passing the national border are of interest, only edges that cross this border are relevant for the considered information paths. Hence, the private networks themselves are not relevant in their full existence but only those edges that are in the cut between the two countries are interesting to examine so that only these are pictured. Let $LC_A \subseteq LC$ be the set of nodes that represent the local coordinators in country A and $LC_B \subseteq LC$ the set of nodes that represent the local coordinators from nation B, then $E(LC_A, LC_B) = \{e_{i,j} \in E : i \in LC_A, j \in LC_B\}$ is the set of relevant edges in the cut. Hence, the cardinal number of the cut, i.e. the number of border crossing edges in the informal network, is considered as the relevant network structure that the derived statements are depending on. The following cardinal numbers are compared (0) $|E(LC_A, LC_B)| = 0$, (I) $|E(LC_A, LC_B)| = 1$, (II) $|E(LC_A, LC_B)| = |LC_A|$, (III) $|E(LC_A, Y)| = |LC_B|$ and (IV) $|E(LC_A, LC_B)| = |LC_A|^{|LC_B|}$. Therefore, in the graph G the arcs $e = \{i, j\}$ are added between local coordinators i in country A and j in country B according to the cardinal numbers. Note, that the informal network is not necessarily symmetric. Thus, 5 personal contact scenarios are studied: No cross-border contacts in the personal network (scenario p = 0); only one agent has one contact on the other side of the border as exemplary seen for country A by the dashed arc from LC_A^7 to LC_B^9 in Figure 3.20 (scenario p = 1); each agent from country A knows all agents from country B but no agent from country B knows an agent from country A as exemplary seen for country A by the dotted arcs from LC_A^8 to LC_B^{9-16} in Figure 3.20 (scenario p = 2; and vice versa in scenario p = 3); all agents know each other (scenario p = 4). Note that the requests can be passed from a sender to a receiver only via a direct arc in the network in each tick. After receiving the additional capacities from either the hierarchy or the personal network, the sender of the request evaluates it by its personal utility function $u : [0, 1] \times [0, 1] \to [0, 1]$ consisting as a function of time ratio

$$t = \frac{t_{\text{arrival}} - t_{\text{requested}}}{t_{\text{expected}}} \in [0, 1],$$

i.e. time until the additional capacities arrive divided by expected arrival time and of capacity fulfillment rate

$$c = \frac{\text{number of operating agents arrived}}{\text{number of operating agents requested}} \in [0, 1],$$

i.e. ratio between capacities arrived and capacities requested. Thus,

$$u_i(t, c) = \frac{1}{2} \times t + \frac{1}{2} \times c.$$

The expected arrival time depends on the requesting agent as well as its current request strategy. In the case that the arrival time is higher then the expected arrival time, the time ratio is set to 1. Depending on the utility, the request strategy is adapted. In case $u_i(t, c) < \frac{1}{2}$, local coordinator $i \in LC$ changes the request strategy, otherwise not.

In a second step, also a global view from an organizational theoretic perspective is taken. In the first settings, the fulfillment of demands has been maximized from a local perspective of the local coordinators, but now the impact of the organization is extended by considering intervention measures to maximize the fulfillment of demands from a global view. An additional scenario is considered in which the organization itself provides an overall storage of resources. In cross-border disaster response context, this could be a storage provided by the Federal Emergency Management Agency (FEMA) in the United States of America or as built in response to the Covid-19 pandemic by the European Union in frame of the "rescEU" project. Instead of requesting additional capacities across the border, the local decision-makers request the needed capacities from this storage (scenario $g = 1$).

Furthermore, a situation is considered in which the objective of the coordinator on top of both organizations units, i.e. the international coordinator, is to achieve an as balanced as possible performance among the sub-units of the organization (scenario $g = 2$). Therefore, the coordinator can change the distribution strategy from equal distribution among all requests to a distribution depending on the performance of the requesting agent so that agents with lower performance get additional capacities to increase their performance. The performance is still measured by the fulfillment of the citizens' demanded needs. Note that the different request strategies, i.e. choosing the adequate request receiver, are realized by a strategy pattern implemented in the agents.

3.7.2 Dynamic Demand Creation and Local Fulfillment

The citizens are affected by the disaster and demand their needs of security by a dynamic herding procedure to the police organization which needs to supply them. The demanding and fulfilling procedures are described in this section. Citizens' demand is generated by a

random process and amplified by a dynamic imitation mechanism. Initially, the individual perceived security $p \in [0, 1]$ is uniformly distributed within the population. It reduces in each tick and once, the critical threshold of $\tilde{p} \in [0, 1]$ is reached, the corresponding citizen sets up a demand. The herd dynamic is implemented as follows. All other citizens in the Moore neighborhood observe the demand and increase their own probability of demand by decreasing the perceived security variable. The dynamics of demand follows classical herd behavior and is particularly relevant for crisis situations. In the context of perceived security, persons already may feel insecure when they hear from people around that have the feeling of insecurity. Thus, the feeling spreads around and creates additional need for resources in form of police forces. However, this is not the only application case. For example, the phenomenon of herd behavior translates to panic buying and hoarding as it could have been observed during the *first-phase* of the Covid-19 pandemic. Over the EU-countries alone, there has been a high variability of requested items observable. In Germany for example there occurred extensive hoarding of toilet-paper, but not so in Italy where the demand for wine demand increased. In this case, the demand is saved in the corresponding police stations' priority queue. If an operating agent, i.e. a police officer, is available at this station, the request is deleted from the priority queue, the operating agent changes its status to *On Way To Somebody* and moves to the affected persons' location to respond to the request. The movement is executed as follows. If an agent's destination deviates from its current location, the *Move* method checks whether the agent is assigned a car or not. If not, it moves to the neighboring patch in the destination's direction on the shortest path. To reach destinations in the neighboring country, the shortest path consists of the shortest path from its current location to the bridge added to the shortest path from the bridge to the destination. If a car is assigned, it calculates whether the available gas is sufficient to reach the destination, and if so, the associated car carries the driver and all passengers *Speed* patches in the direction of the destination by shortest distance (calculated as described above). The gas-level decreases by the number of moving patches. If the gas is not sufficient to reach the destination, *Refuel* starts setting the destination to the location of the closest gas station and then driving similarly to this location. If the car runs out of gas before the gas station is reached, it stops. Otherwise, at the gas station, refuel starts shifting distributive capacities from the gas station to the car. If the demanding person i is reached, its demand is completely fulfilled ($p_i = 0$) but the capacities also affect persons in the neighborhood so that the probability to demand variable of all citizens in the direct neighborhood is decreased by a fixed value p'. The operating agent changes the status to *On Way Back* moving back to the operating agents' home location similarly as before. Arriving at the home location, it changes its status back to *Available*.

Figure 3.21 presents simplified the corresponding class structure of the model in Unified Modeling Language (UML).

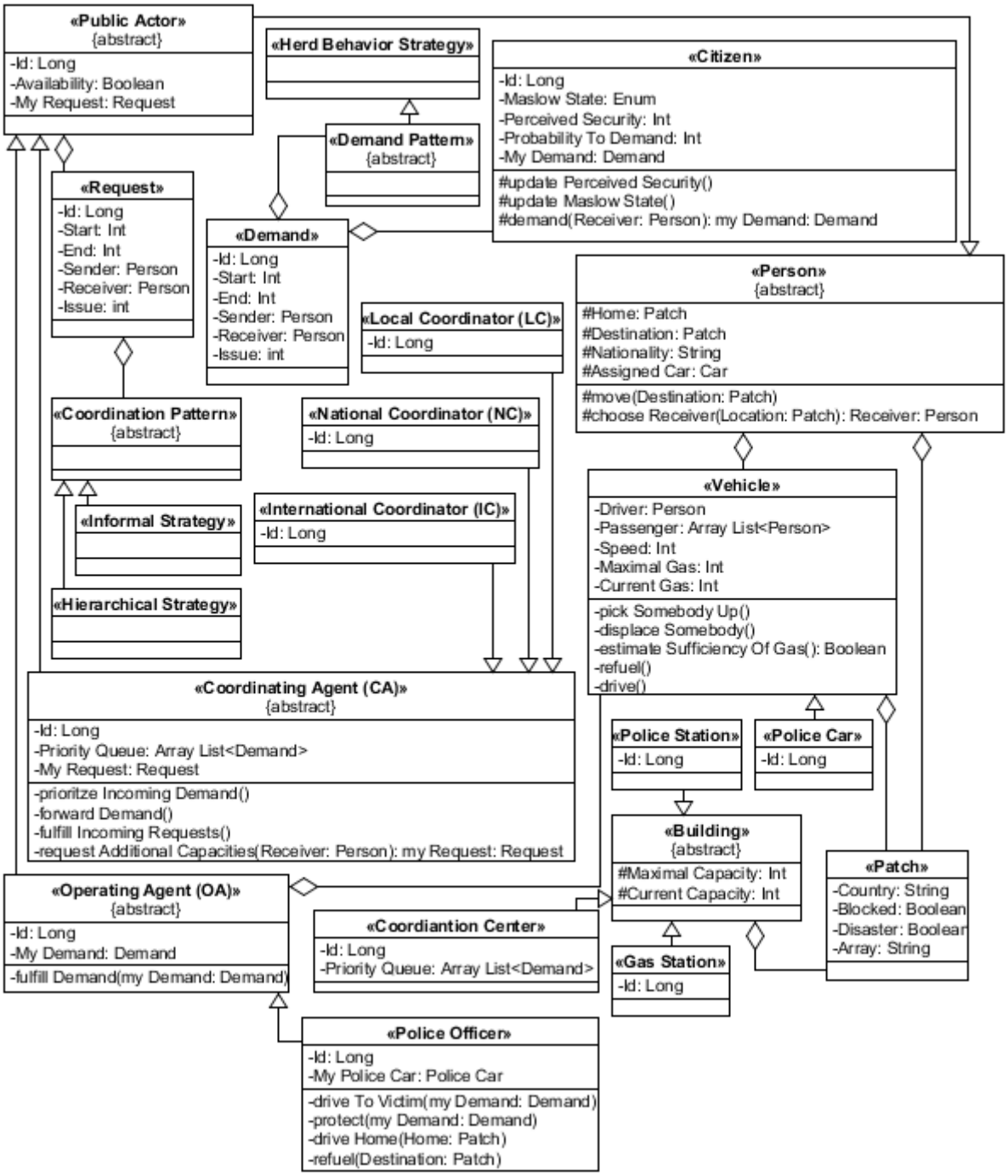


Figure 3.21: Class Diagram of Study II

3.8 Simulation Experiment Study II

This section is dedicated to specify the initial parameter settings. In a two-dimensional coordinate system of patches (x, y), a grid of 200×200 patches is considered, where the patches with negative x-values refer to country A and the patches with positive x-values are related to country B. The patches with an x-value of 0 form a border river which

is regarded as a neutral area, while the bridge across the river at patch $(0, 1)$ has both nationalities. All patches except river patches are unblocked so that agents can move to or across this patch. In this environment, a population of 2000 uniformly distributed citizens is modeled (in case a blocked patch was chosen, a new agents' position is created). They are assigned the nationality of the country in which they are initialized. 20% of the respective home population is assumed to be in the neighboring country when the disaster happens. Therefore, randomly an agent i is picked and its initial location is changed from (x_i, y_i) to $(-x_i, y_i)$ until 20% of the population is reached. The citizens follow the dynamic demand creation procedure as detailed in Section 3.7.2. In this simulation setting, each demand that is observed in the neighborhood decreases the own perceived security by 0.3 and a demand is set-up when the critical value of $\tilde{p} = 0.1$ is reached. An arriving police officer fulfills the demand and increases the perceived security variable to $p = 1$ reducing the probability of further demand to 0. Furthermore, the police officer shows presence so that the perceived security variable for all agents in the Moore neighborhood increases by 0.2.

The locations of the organization are represented as police stations in the environment. Each station is initialized with a set of 20 operating agents, i.e. police officers, and an area for which it is responsible. Thus, the environment is divided into 16 quadratic areas of similar size, 8 on each side of the border, and for each of them a local coordinator is responsible to respond the disaster affected citizens' demands by sending an operating agent. The number of 16 police stations are located at the patches $(-100, 100)$, $(-50, 100)$, $(-100, 50)$, $(-50, 50)$, $(-100, 0)$, $(-50, 0)$, $(-100, -50)$, $(-50, -50)$, and $(1, 100)$, $(51, 100)$, $(1, 50)$, $(51, 50)$, $(1, 0)$, $(51, 0)$, $(1, -50)$, $(51, -50)$, so that the corresponding local coordinators are responsible to fulfill the citizens' demands in the 50×50 area right hand side and downwards up to the next station. If the number of operating agents is not sufficient to fulfill the demand within the corresponding area, the local coordinator turns to the organizational layer and starts the procedure of requesting additional capacities via network as described in Section 3.7.1. In the simulation setting, there are gas stations located at patches $(-10, 10)$ and $(10, 10)$ with capacity of 5000 each. Each operating agent has a car with speed 12 and maximal gas 500.

The disaster is assumed to hit the region at the starting time 0 and study a simulation duration of 240 ticks. Consequently, the system is stressed highly in the beginning, but in the course of the simulation it reaches stability so that no additional cross-border requests are tracked. By running the model, the effectiveness of cross-border collaboration is quantified by comparing the adequate provision of resources via an hierarchical network and via informal contacts.

3.9 Results Study II

3.9.1 Decision-Making from a Local Perspective

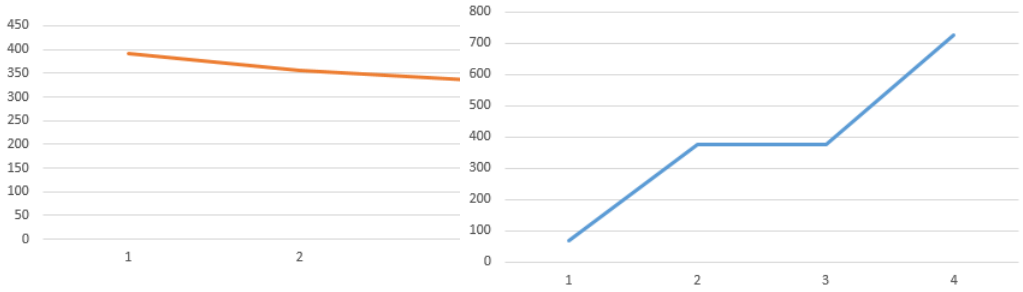
This study contributes the understanding how different network structures affect knowledge sharing by comparing a coordinated exchange via the hierarchical network between institutions with the direct exchange via private contacts between its members. Therefore, 15 scenarios are considered as each combination of the 3 hierarchical networks and the 5 informal networks. Each scenario is repeated 10 times where the mean values are taken. The *Number Of Formal Requests* and the *Number Of Informal Requests* are tracked. Furthermore, the performance indicators of

$$\textit{Completeness Rate} = \frac{\text{fulfilled demands}}{\text{actived demands}} \in [0;1]$$

is measured. Additionally to the *Number Of Cross-Border Requests* it is tracked in how many cases the decision-makers, which are the local coordinators in the model, did not change their strategy, i.e. the *Number Of Unaltered Strategies*. All these indicators are considered aggregated over the whole setting, i.e. comprising both countries.

To become familiar with the model's mechanism, the situation is analysed in which all requests of local coordinators are sent via the formal hierarchy compared to the path via personal contacts. Allowing only formal requests leads to a completeness rate over all scenarios of 0.9 and the mean number of cross-border requests is 360.4 with standard deviation of 26.0. Allowing only requests via the personal network shows higher variance between the scenarios which is obvious: If the agent does not have personal contacts it cannot request via this network. On the other hand, a large network leads to a high number of requests as the receiver may not have enough capacities and the network is large enough to request missing capacities in a new trial. Similarly in this case, the completeness rate over all scenarios is 0.9 and the mean number of cross-border requests is 386.3 (now with standard deviation of 232.6). The following Figure 3.22 shows the posed requests by scenario, (a) allowing only the formal request strategy, (b) allowing only requests via personal network.

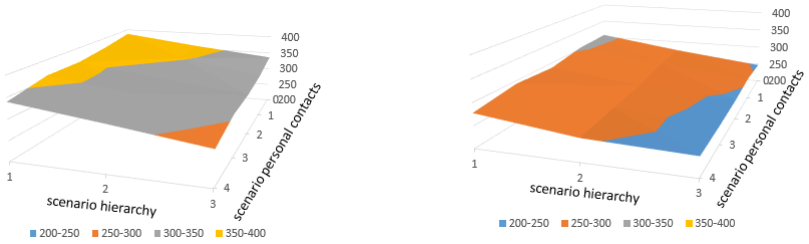
Now, the evaluation of requests is considered by utility and the resulting changes in the agents' request strategies. Initially, all agents request via the formal hierarchy, but after evaluating the request they are now allowed to change their strategy to informal. The completeness rate over all scenarios remains 0.9 and the mean number of cross-border requests is 363.8 with standard deviation of 28.9. The number of formal requests and number of informal requests as well as the number of unaltered strategies are shown in the following Figures 3.23 and 3.24.



(a) Number of Formal Requests per Scenario

(b) Number of Informal Requests per Scenario

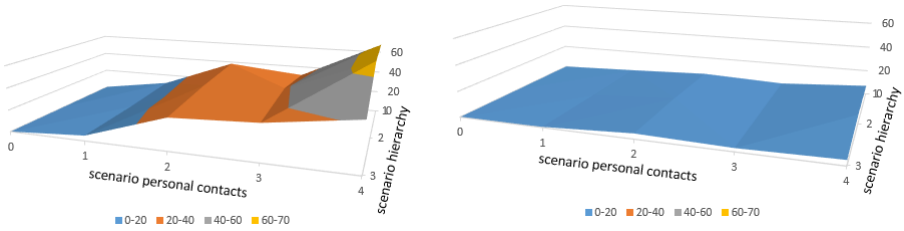
Figure 3.22: Formal and Informal Requests



(a) Number of Formal Requests

(b) Number of Unaltered Formal Request Strategies

Figure 3.23: Formal Requests and Unalterings of this Strategy



(a) Number of Formal Requests

(b) Number of Unaltered Formal Request Strategies

Figure 3.24: Informal Requests and Unalterings of this Strategy

The number of formal requests slightly decreases with increasing levels of hierarchy. At the same time, the number of informal requests is increasing with the increase of known persons across the national border in the personal network. Moreover, the same shape is seen for number of formal requests/number of informal requests compared to the respective number of unaltered strategies in both figures although the number of unaltered strategies is much smaller than the number of posed requests in both cases, i.e. via formal and informal network contacts. However, the total number of formal requests outnumbered highly the number of informal requests.

In a next step, the number of unaltered strategies per scenario is presented in detail (see Tables 3.1 and 3.2).

h \ p	0	1	2	3	4
1	306.4 (5.8)	303.2 (10.0)	287.4 (15.5)	292.8 (6.7)	277.8 (16.4)
2	273.9 (6.1)	273.9 (7.7)	260.4 (8.3)	256.9 (7.3)	251.4 (6.6)
3	247.1 (8.3)	253.0 (6.3)	245.9 (3.4)	243.8 (6.8)	244.0 (7.2)

Table 3.1: Mean and Standard Deviations of Unaltered Formal Request Strategies

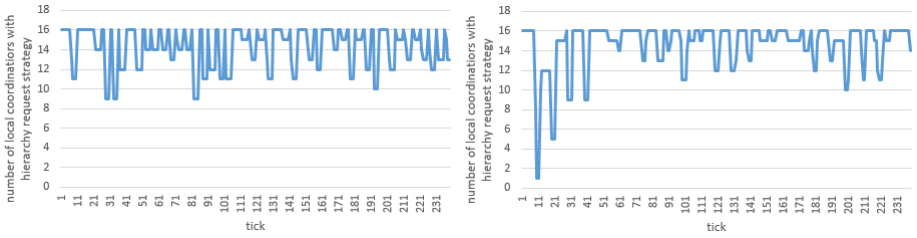
h \ p	0	1	2	3	4
1	0.0 (0.0)	2.3 (1.4)	5 (2.7)	2.5 (1.4)	7 (2.7)
2	0.0 (0.0)	1.1 (1.0)	5.4 (3.0)	2.8 (1.1)	7.6 (2.4)
3	0.0 (0.0)	0.5 (0.7)	4.1 (2.8)	2.6 (1.5)	4.0 (2.0)

Table 3.2: Mean and Standard Deviations of Unaltered Informal Request Strategies

It can be seen that in this simulation the increase of one hierarchy level implies a mean decrease of 8.3% in number of unaltered strategies of formal requests with standard deviation of 1.8% (in detail, there is a mean decrease of 10.3% between scenario $h = 1$ and $h = 2$ with standard deviation of 1.2% and mean decrease of 6.2% between scenario $h = 2$ and $h = 3$ with standard deviation of 2.5%). Considering the increase in cross-border contacts in the personal network, for the simulations it is noted that the increase from scenario $p = 1$ (only one cross-border contact per country) to $p = 2$ (all contacts for country A to B) yields a mean increase in number of unaltered strategies by 73.1% with standard deviation of 13.5%. Similarly, values resulting in the change from scenario $p = 1$ to $p = 3$ (increase of contacts for country B to A) are showing a mean number of unaltered strategies of 27.5% with standard deviation of 16.9%. Furthermore, a change from scenario $p = 2$ to $p = 4$ (all cross-border contacts) increases the mean number of unaltered strategies by 22.0% with standard deviation of 16.8% and similarly, a change from scenario $p = 3$ to $p = 4$ yields a mean of unaltered strategies of 57.2% with standard deviation of 24.8%. Similar results are observed if all agents initially request via their informal network and are allowed to change their request strategy to formal after evaluation of the informal request as well as when starting by half of the agents having a hierarchy request strategy and the other half has a informal request strategy. This indicates that these values are depending on the ratio between citizens in need and available capacities. The capacity bottleneck in this simulation is the number of police officers. This can be illustrated by varying the population size at a similar level of capacities to vary the ratio. Initializing 1000 instead of 2000 citizens yield to a maximum of 179.2 formal requests in the scenario $h = 1$, $p = 4$ and a maximum of 0.3 informal requests in scenario $h = 3$, $p = 2$ but still have a completeness rate of 0.9. Furthermore, a number of 3000 citizens results in a number of maximum of 420.7 formal requests in the scenario $h = 1$, $p = 0$

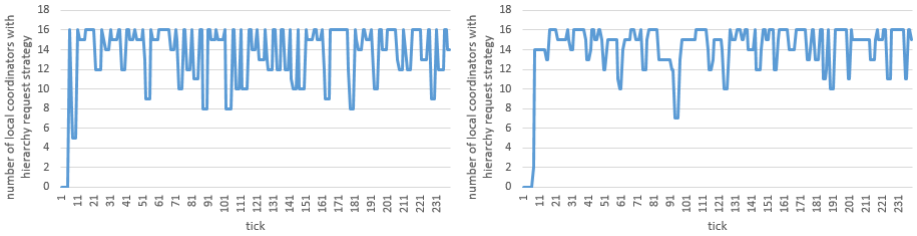
and a maximum of 100.4 informal requests in scenario $h = 2$, $p = 4$ and a decrease in the completeness rate which is 0.8. Concluding, it is seen that the completeness rate is independent of the request strategy but depending on the availability of capacities.

Further insights are gained by taking a look at the dynamics. Figure 3.25 shows the number of local coordinators with hierarchy request strategy per time where all local coordinators initially run a hierarchy request strategy compared to the scenario where they have an informal request strategy.



(a) Timeline of Scenario $h = 1$, $p = 0$ **(b)** Timeline of Scenario $h = 3$, $p = 4$

Figure 3.25: Initially Hierarchy Request Strategy Without Pre-Check

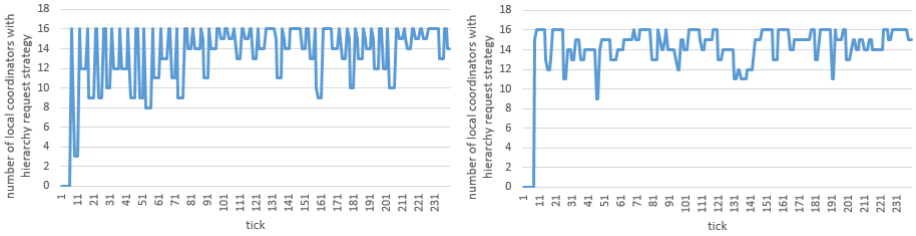


(a) Timeline of Scenario $h = 1$, $p = 0$ **(b)** Timeline of Scenario $h = 3$, $p = 4$

Figure 3.26: Initially Informal Request Strategy without Pre-Check

As the local coordinators change their request strategy to hierarchy very fast, they are allowed in a next step to decide among three of potential request receiver in the personal network whom to ask for help. Therefore, a pre-check is executed simulating that the local coordinators only requests the first or second potential receiver in case they have available capacities at all, if none of them has any capacities the third one is requested anyway. This makes the simulation more realistic as it is plausible that a local coordinators will ask three of his personal contacts before he decides to change the strategy. But this procedure leads to a higher chance that the request receiver has additional capacities and the local coordinator is confident with this strategy.

Comparing scenario $h = 1$, $p = 0$ in Figure 3.25, there have all 16 local coordinators a hierarchical request strategy in 86 ticks and in Figure 3.26, this is the case in 80 ticks. In scenario $h = 3$, $p = 4$, this difference even gets larger. Again, there have all 16 local coordinators a hierarchical request strategy in 86 ticks but in Figure 3.27, this is the case



(a) Timeline of Scenario $h = 1$, $p = 0$ **(b)** Timeline of Scenario $h = 3$, $p = 4$

Figure 3.27: Initially Informal Request Strategy and Pre-Check

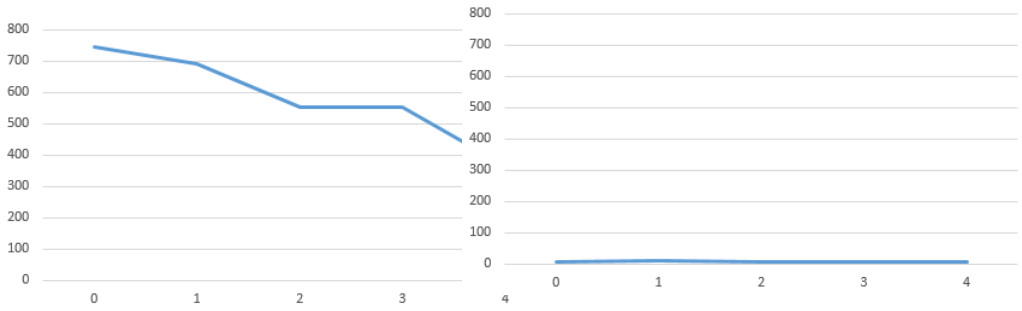
only in 73 ticks. However, still a tendency to hierarchy request strategy is seen concluding that the hierarchy is a preferred request strategy. Thus, the effect of some small number of agents not following the hierarchy will not have large consequences in a dynamic disaster situation in which never an optimal distribution of capacities can be achieved as the demand can only be forecasted on an uncertain database. However, it can be helpful if some agents have additional resources in form of the personal network to get the required capacities which in this case are police officers. As long as this remains an exceptional strategy and does not occur frequently, there is not seen a need to set additional incentives for local coordinators to follow the hierarchy.

3.9.2 Global Perspective and Organizational Theoretic View

A completeness rate of 0.9 is quite impressive and as this result depends on the available capacities at first glance, there is no need to react from an organizational perspective despite providing additional capacities. However, a deeper analysis uncovers that the performance of the completeness rate varies across the different stations (i.e. those using private networks perform better than others) and it might be interesting from an organizational point of view to have a quite similar completeness rate across the stations so that the question comes up of how organizations can compensate the use of private networks.

The scenarios are now changed to $g = 1$ taking into consideration the possibility of an international distribution center providing additional capacities that can be requested by both sides countries (as for example in Europe, there are capacities provided by the European Union in the framework of "rescEU"). Therefore, a distribution center is installed on patch $(-10, 10)$ with 16 police officers in the simulation. These capacities can be requested by the international coordinator of each country via the hierarchy. In the simulation, one police officer from each police station is moved to the central distribution center. Thus, the overall number of police officers is kept so that the results are comparable to the scenarios before. Simulating this scenario with 2000 citizens shows a similar completeness rate of 0.9, but the number of cross-border requests increases to a mean of 733.3 with standard deviation of 8.3. The following Figures 3.28 and 3.29 provide

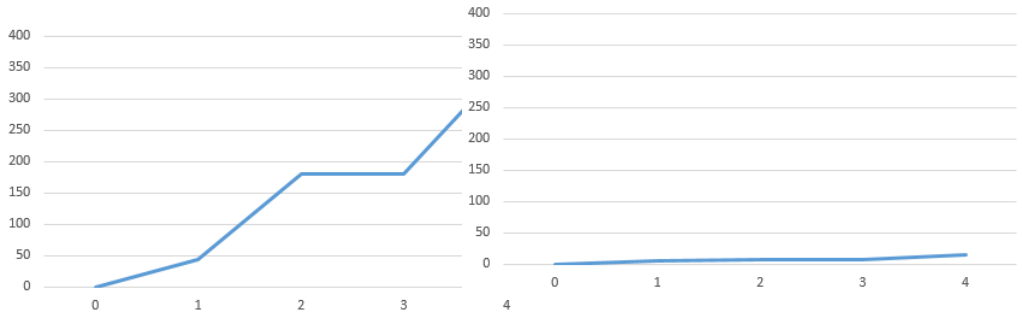
information on the number of formal and informal requests in this scenario. Here, the general number of requests doubled and it is also seen that there are very small number of unaltered strategies. This is due to the small number of additional capacities. There are only 16 police officers available in the distribution center and in comparison there are 128 police officers on each side of the border in the scenarios before. Thus, nearly all requests are unfulfilled and so the request strategies changed. However, the number of formal requests is still twice as high as the number of informal requests.



(a) Number of Formal Requests

(b) Number of Unaltered Formal Request Strategies

Figure 3.28: Formal Requests and Unalterings of this Strategy Regarding Central Distribution Center



(a) Number of Informal Requests

(b) Number of Unaltered Informal Request Strategies

Figure 3.29: Informal Requests and Unalterings of this Strategy Regarding Central Distribution Center

In a last step, scenario $g = 2$ is considered allowing a distribution of resources depending on the performance of the stations. Up to now, the distribution has been equalized along the requests. Therefore, the *Fulfilling Rate* is calculated as number of requested operating agents in one country divided by the number of available police officers in the other country and in a next step, the requested capacities of each station is multiplied by the fulfilling rate to get the number of police officers sent to the corresponding police station.

In formula, let $I = \{1, \ldots, n\}$ be the set of stations in one country and $J = \{1, \ldots, m\}$ the set of stations in the other country, then

$$\textit{Fulfilling Rate} = \frac{\sum_{i \in I} \text{available operating agents}_i}{\sum_{j \in J} \text{requested operating agents}_j} \in [0, 1]$$

and let $K = I + J$ be the set of all stations, then

operating agents sent to station k =

requested operating agents in station k × fulfilling rate.

Instead of distributing the available capacities equally among the requests, now the coordinators are allowed to distribute the capacities by the following formula. Then

$$\text{completeness rate} = \sum_{k \in K} \text{local completeness rate}_k$$

and the assignment of station $k \in K$ is

number of available capacities/completeness rate × local completeness rate$_k$.

If the requests in the hierarchical network are assigned to the stations depending on their local completeness rate, the organization can achieve less variance between the local completeness rates among the stations. The following Tables 3.3 and 3.4 show this for a sample simulation in the scenarios $h = 1$, $p = 0$ and $h = 3$, $p = 4$. It can be seen that this effect depends on the use of the private network. In case there is no private network, there is no big difference observable. In fact, the variance moderately increases which might be due to the cumbrous adaption of the new distribution method. But in case the private network is used, the new distribution method significantly decreases the variance.

	Scenario $h = 1, p = 0$	Scenario $h = 3, p = 4$
1	0.812606474	0.738853503
2	0.818035427	0.814606742
3	0.807909605	0.718204489
4	0.841091493	0.82806574
5	0.855146125	0.8140625
6	0.871391076	0.867667121
7	0.871650212	0.893317702
8	0.824615385	0.841317365
9	0.878205128	0.867591425
10	0.885927505	0.878431373
11	0.862348178	0.891350211
12	0.910577972	0.909580194
13	0.894949495	0.926215278
14	0.904320988	0.947280335
15	0.903960396	0.880213904
16	0.911792015	0.920967742
Mean (Std)	0.865907967 (0.034846822)	0.858607851 (0.061960819)

Table 3.3: Completeness Rates in Different Scenarios with Equal Distribution

	Scenario $h = 1, p = 0$	Scenario $h = 3, p = 4$
1	0.807453416	0.798058252
2	0.817905918	0.835016835
3	0.814417178	0.756487026
4	0.820945946	0.846350832
5	0.825617284	0.860896445
6	0.844067797	0.873072361
7	0.846256684	0.844121532
8	0.845609065	0.880986938
9	0.867175573	0.871702638
10	0.88241206	0.876363636
11	0.87994723	0.904891304
12	0.876615746	0.876787679
13	0.920443102	0.895633653
14	0.944050433	0.920812183
15	0.923076923	0.936532508
16	0.918331885	0.892972973
Mean (Std)	0.86464539 (0.042536523)	0.866917925 (0.04335523)

Table 3.4: Completeness Rates in Different Scenarios with Adapted Distribution

3.10 Setting Study III

The phenomenon of spontaneous volunteers occurring at a disaster to offer their help accelerates the coordination effort. Professionals not only need to coordinate themselves across national borders, but they also need to coordinate the volunteers, who have in general no training in disaster response and insufficient equipment and routines to cope the disaster. However, they are motivated and bring workforce, which is worthwhile so that the provision of a coordinator brings decisive advantage to the disaster response organizations. Thus, the study targets the examination of efficient involvement of spontaneous volunteers in disaster response processes via integration into existing disaster management procedures. Therefore, the effectiveness is quantified along two dimensions by a scenario-based approach. First, the degree of centralization (i.e. involvement of spontaneous volunteers in professional crisis response coordination) and second, the degree of cross-border coordination resulting in the following four scenarios: (I) spontaneous volunteers in both countries acting on their own, which means that there is no coordination at all (II) spontaneous volunteers of both countries coordinate themselves without involvement in professional disaster response operations, which is a rather hypothetical scenario considered for sake of completeness (III) both countries include spontaneous volunteers separately into their professional disaster response operations, which is the focus of the current body of literature (IV) common coordination of both countries including spontaneous volunteers to their professional disaster response, which outlines a perfect coordination also across national borders.

3.10.1 Coordination Framework

In this framework, a set of *Social Media Groups* is implemented, which are followed by *Spontaneous Volunteers*. The affected population has the possibility to communicate their needs of essentials by demanding help either from professional crisis response actors via calling the *Coordination Center* or to post the requests in a social media group. Therefore, each citizen has an array of *Known Social Media Groups* that also may be the empty set in which the citizen cannot post its demands to spontaneous volunteers but to professionals in disaster response. The professionals in disaster response in this case are *Firefighters* that have an associated *Fire Truck* to move to the victims. Each incoming request either in the coordination center or via social media is assigned to an area depending on the requesting actors' location. Thereby, the areas' decomposition for professionals is a systematic apportionment where all areas are of similar size and one area is next to the other comparable to a chess field and the areas' decomposition of spontaneous volunteers is is not as exact and it may happen that areas overlap in their system as illustrated in Figure 3.30.

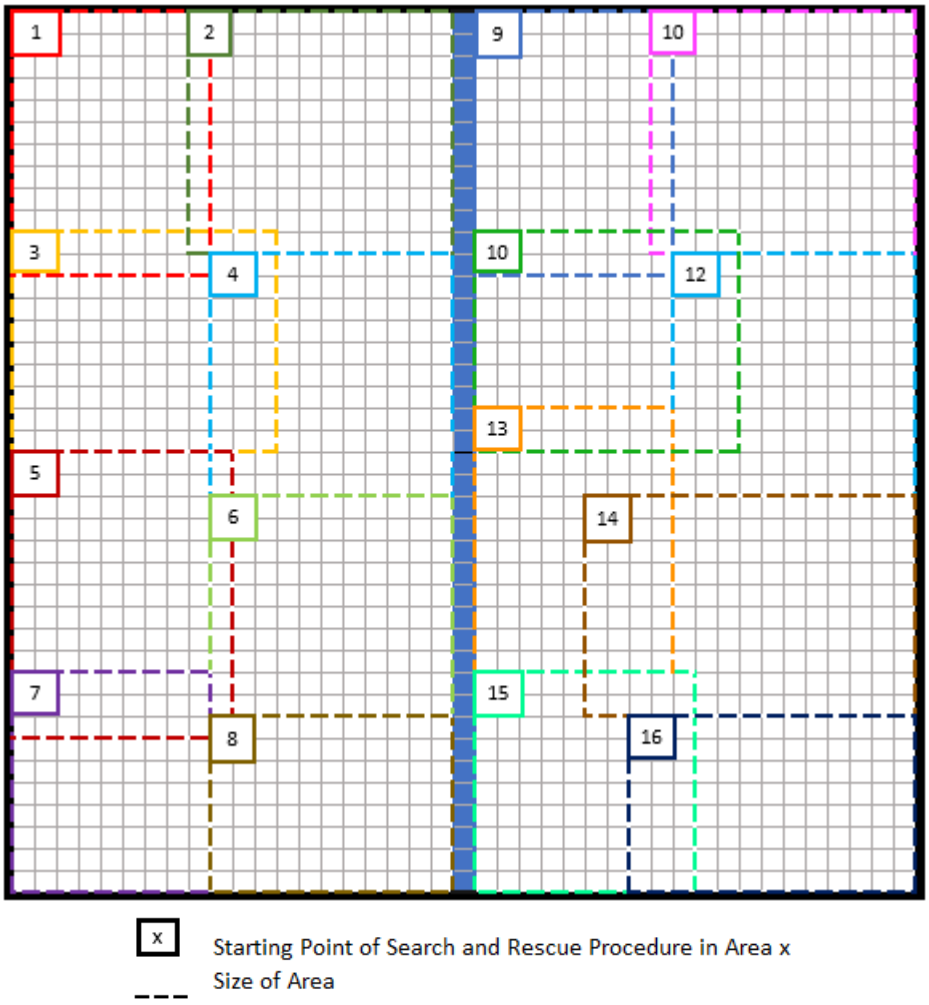


Figure 3.30: Simulation Enviornment

The provision of help is done by picking an area and start a search and rescue procedure. It is checked if elderly or other vulnerable people are living in this area and what help they need. Note that the help provided by spontaneous volunteers is restricted to the provision of essentials including food and water to the affected population. Therefore, the *Restock* method is similarly implemented for spontaneous volunteers as for professional firefighters. Both increase the *Stock* variable of the affected citizen by a fixed amount. It is to highlight that those areas, which are not covered by the search and rescue procedure of spontaneous volunteers in a coordinated manner, are left to the professionals increasing their already dense workload due to fulfilling the serious requests. Hence, the presented coordination framework quantifies the potential of spontaneous volunteers: The better the distribution of workload is carried out, the better spontaneous volunteers support the crisis response teams by taking responsibility of minor problems and leaving them more capacities for emergencies. The framework compares cooperation in two dimensions: the degree of centralization (i.e. involvement of spontaneous volunteers in professional

	Separated Coordination per Country	Cross-border Coordination
Decentralized Coordination	Spontaneous volunteers in both countries acting on their own	Spontaneous volunteers of both countries coordinate themselves without involvement in professional disaster response operations
Centralized Coordination	Both countries include spontaneous volunteers separately into their professional disaster response operations	Common coordination of both countries including spontaneous volunteers to their professional disaster response

Table 3.5: Overview of the Considered Coordination Scenarios

crisis response coordination) and the degree of cross-border coordination as shown in the following Table 3.5.

In general, spontaneous volunteers can belong to several social media groups, but once it comes to the provision of help, they only can follow one group. Moreover, it is assumed that all volunteers belonging to one social media group decide to provide their help at one hot spot to not destroy the feeling of group affiliation and common sense that is always reported by spontaneous volunteers. Thus, for this simulation, groups are considered as homogeneous entities. However, the framework also would allow for variations. Initially, all social media groups have their individual set of information while the professionals have one common set of information. The professional crisis response actors and the social media groups are implemented by different strategies to set priorities of response. Professionals pick the victims according to their needs. As spontaneous volunteers cannot estimate the status of victims very well and in addition they are interested to be at the center of the action, they pick the area where most demands are posted in. In the first scenario, the uncoordinated scenario, each group of volunteers ranks the area of needs separately by summing up all requests they received from an area and choose the area of most requests. Then, each individual from the group moves to the chosen area and provides help by a search and rescue procedure without any coordination of the chosen areas (i.e. the areas chosen by the groups are not aligned and may be similar or overlap). In the second scenario, the group-coordination scenario, all social media groups share their information and prioritize the response by summing up the number of received requests over the whole set of information. They choose areas for each group in a way that one group addresses the first area and the other group addresses the second area and so on, beginning at the area with highest priority. Each group starts their search and rescue procedure in the assigned area. As the volunteers would need some time to get to the area, it may happen that the professionals, who work independently, already fulfilled the need when the volunteers arrive. This is improved in the third Scenario, the countrywide-coordination scenario,

where spontaneous volunteers are included in the professional crisis response, but for both countries separately. Here, the prioritization is done by the professionals so that adequate needs are addressed and delays are avoided. In scenario four, the cross-border-coordination scenario, the prioritization is carried out by considering the overall setting of professionals and volunteers including both countries.

Figure 3.31 presents simplified the corresponding class structure of the model in Unified Modeling Language (UML).

3.11 Simulation Experiment Study III

The simulation environment is a two-dimensional coordinate system of 200×200 patches modeling a borderland with a river dividing two neighboring countries. The origin is in the center and the patches with negative x-values refer to country A while the patches with positive x-values refer to country B. A bridge across the river at the zero coordinate allows the exchange of resources. A number of 1000 affected individuals is randomly distributed into this environment so that 500 are in each country. Per country, there exist five groups on social media. Additionally, the number of professionals is chosen for each country, such that they can deal with five areas simultaneously. Note that both regions' decomposition, the one by the professionals as well as the one by the social media groups have 16 areas. The available resources of each agent are given in a stock variable ranging from 0 to 14. The populations' need of stock is initially modeled by a normal distribution with mean of 2 and variance of 4. This variable is decreasing every 24 ticks by 1 as long as there is no care undertaken. Agents are in good state (do not need any assistance) if their stock is at least 3, otherwise they need help. In each tick, the affected persons can decide to set up a help request to professionals or a social media group in her or his country. The volunteers associated with the corresponding social media group are receiving the request and decide to provide help along the helping strategies defined in Table 3.5. Similarly, the professionals start their provision of help always in the areas with highest priority. The help is realized by a search and rescue procedure over the chosen area. In detail, a helper (either professional or volunteer) starts in the upper left corner and moves field by field to the lower right corner. If there is an affected person on the current field, the helper supplies it with a fixed amount of essential goods. It is assumed, that the helpers have enough goods to supply all affected persons in an area. After finishing the search and rescue procedure for one area, the helper takes the next area in their priority queue to provide help. For spontaneous volunteers, this takes some ticks as they need to check their social media accounts and decide for the next area.

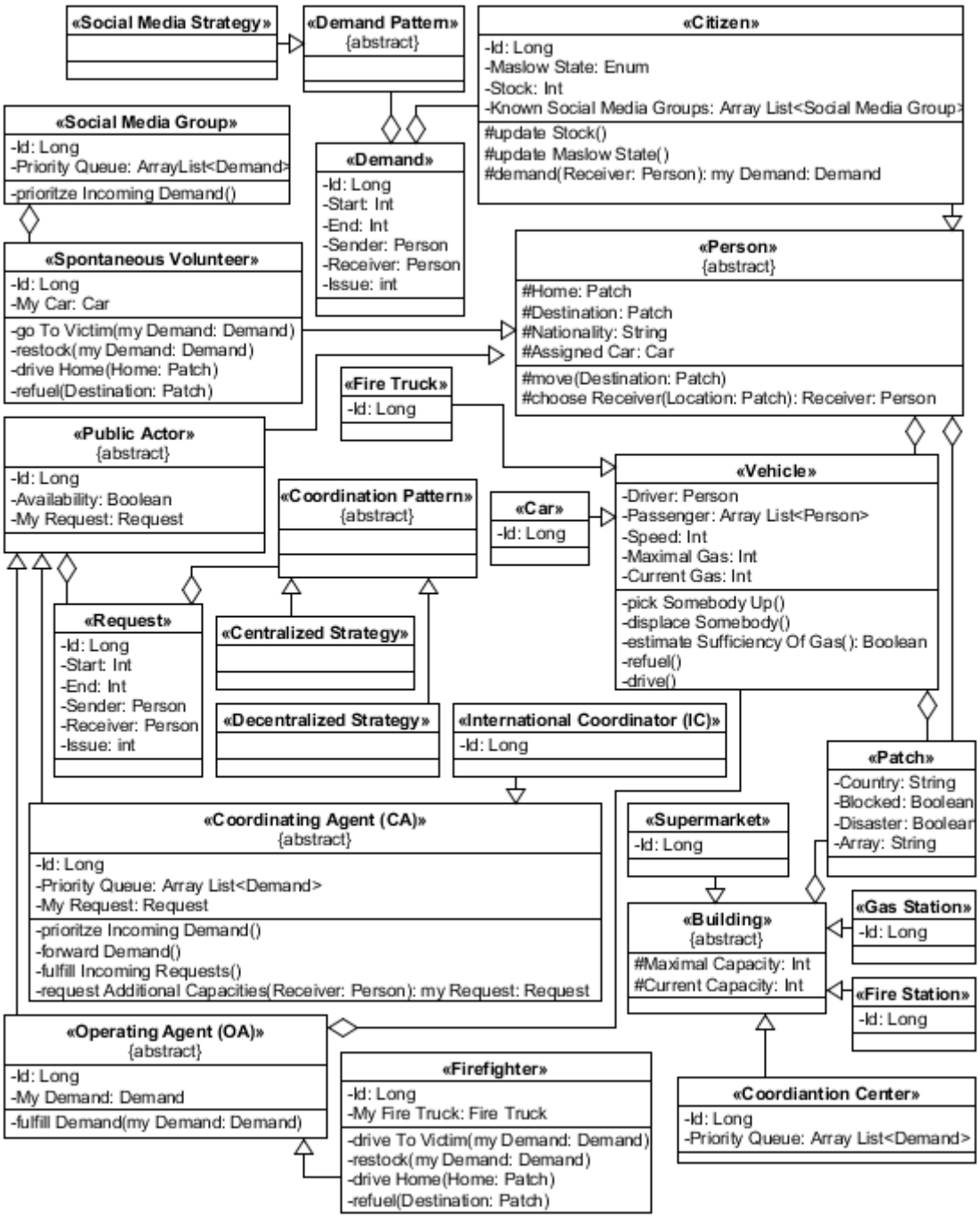


Figure 3.31: Class Diagram of Study III

3.12 Results Study III

The framework Repast Simphony allows an integrated parameter tracking over time. Comparing the level of undersupplied persons at simulation duration (i.e. at tick 240), it is seen that the first scenario leaves a number of 2.1% undersupplied people. This number is reduced by noticeable 57.1% considering the third scenario, where professionals and

	Mean of Undersupplied Persons	Standard Deviation of Undersupplied Persons
Scenario I	2.1%	0.2%
Scenario II	1.4%	0.9%
Scenario III	0.9%	0.3%
Scenario IV	0.8%	0.2%

Table 3.6: Overview of Simulation Results

volunteers cooperate. This highlights the importance of cooperation among professional crisis response actors and spontaneous volunteers in general. Specific in the border area, an improvement of 33.3% is seen comparing the first and second scenario. Scenario four considers the highest level of coordination and thus, leads – as expected – to the lowest rate of undersupplied persons in the affected region. In this case, 0.8% of affected individuals remain undersupplied, which is a decrease of 11.1% compared to scenario three and a decrease of 42.8% compared to scenario one. Although the improvement from scenario one to two is smaller than comparing scenario one and three, a higher level of resources is observed. If now an asymmetric crisis is considered, where the affected population is not equally distributed in the area, but 90.0% of affected people concentrate in one country, we see an immense reduction of undersupplied by 56.3% comparing scenario one and two. In addition, the results highlight the importance of self-help capacities in the population. Doubling the initial resources allows for a reduction of 56.3% leaving less than half of the disaster victims undersupplied even in the uncoordinated scenario. Summarizing, the following Table 3.6 shows the comparison of the four scenarios varying the degree of coordination along the two dimensions: embeddedness in the official crisis response and across the nations. It is suspected that the higher variance in scenario two results due to a larger set of possible assignments between affected person and helper.

3.13 Summary and Discussion of Agent-Based Analysis

The establishment of fast and well-coordinated response actions is a critical factor of efficient disaster relief. This study's particular focus lies in the analysis of collaboration between disaster response organizations of different countries. The higher number of involved actors with their various characteristics increases disaster management's complexity for border regions. Collaboration among these disaster response actors from different nations in a border area is outlined, analyzing interoperability, particularly communication procedures, between organizations, including the actors' cultural characteristics.

3.13.1 Key Success Factors for Cross-Border Interventions

Investigating the effects of various characters collaborating, the necessity to consider the local peculiarities is emphasized to understand driving factors for efficient cooperation and improved disaster resilience for border areas better. This manifests itself in several central outcomes of the presented study.

Border regions are unique and need to be regarded as special areas with their own, individual characteristics. Though it might be challenging to support beneficiaries with additional resources from their own country, support from the other side of the border can significantly reduce the population's burden. However, multiple barriers need to be overcome to ensure efficient cross-border collaboration. Therefore, on one hand the impacts of two key barriers, language and trust, on the outcome of a cross-border collaboration are analyzed with the help of an agent-based model. On the other hand, efficient ways of coordination are examined.

The model aims to establish a holistic model for borderland collaboration including the various actors involved. So, the model includes the affected population demanding its needs according to Maslow's hierarchy of needs adapted to a disaster situation. It also considers organizations of professional crisis response actors. For sake of simplification, NGOs are not included as they have a similar organizational structure and regular training so that they can compared with professionals despite their differences. Furthermore, unbounded spontaneous volunteers are included as they in general do not have an organizational structure and regular training so that a coordination structure needs to be established to use the volunteers' potential. Thus, the model is comprehensive and allows various analyses for strategic planning of borderland disaster resilience. However, some aspects are analyzed more in depth which will be presented before the model in general is discussed.

First, the focus lies on Study I. The objective is to study cross-border collaboration by quantifying the impact of misunderstandings (i.e. incorrect prioritization) due to language problems as well as doubling requests due to distrust in command and control procedures in context of resource distribution organizing the medical care of causalities. It can be stated that in the simulation of this study, the number of undersupplied people could be reduced by up to 43% through cross-border cooperation in the asymmetric case, which clearly demonstrates the importance of cross-border cooperation in the event of a disaster. Additionally, in the symmetric case where the disaster strikes both countries, there is a reduction of 23% in the presented simulations.

Considering distrust that leads to additional requests and delays, it becomes evident that the capacity shortage is significantly amplified, underlining the importance to build trustful relationships. As discussed in Gupta and Gupta: "we need to identify the promoters and inhibitors of building effective relationships" and "examine the role of national cultural

differences between firms in the success and stability of international joint ventures and international mergers and acquisitions" (Gupta and Gupta 2019). Therefore, it is crucial to establish a professional risk and crisis communication to the population. However, this can be very challenging in a cross-border-context since it is more likely to work with an organization if it has a good reputation (Zhao et al. 2012), which comes down to trust in these organizations (Garnett and Kouzmin 2007).

Furthermore, the simulation experiments' results indicate that people speaking the neighboring country's language have higher communicative success compared to the same number of persons speaking a neutral lingua franca. Consequently, it is better to learn the neighboring country's language than taking the detour via a third language. This finding holds despite occurring communication failures due to a low level of language knowledge. Imperfect language proficiency leads to a higher level of misunderstandings. However, our results only indicate a minor impact of misunderstandings on the level of supply coverage, which again emphasizes that it is not problematic if the other country's language is not perfectly mastered. In this context, Gray and Massimino further highlight that a non-native communication language "may force non-native speakers to converse in a language in which they are not proficient and which is inconsistent with their internal thought processes" (Gray and Massimino 2014). Although the presented model does not provide a cognitive explanation, it is interesting that it can draw a similar conclusion based on efficiency considerations of communication processes. This effect might be of different significance in each border region. For example, it may be less relevant in the border region between the English speaking part of Canada and the USA, even though the different technical terms and organizational structures are still likely to cause misunderstandings (Endrass et al. 2013). Another extraordinary border can be found in the Alsace region of France, bordering Germany. Due to the historical developments and wars, in which the Alsace region switched between France and Germany several times, most elder and middle-aged people still speak German (Hartweg 2002). Therefore, communication problems with the inhabitants of the border region's German side are less likely to occur. However, the region's crisis response actors told the author that, according to their experience in daily interactions and joint exercises, bilingualism exists less among younger people. Thus, the crisis response is already likely to face problems, which will increase in the next years when more active bilingual persons retire. Consequently, the presented results underline the importance of investing in language learning. Here, participating in language courses for people from both sides of a border will be required to keep exchange on a high level. Moreover, these courses can help understand the foreign culture better so that peculiarities are realized and accepted instead of disapproved. This way, a higher trust level can be achieved. Note that although language is more important than trust in the presented simulations, trust still contributes significantly to increase capacities. Besides, good knowledge of the other language generally lowers the inhibitions to communicate

with the other country's inhabitants and participate in joint political and cultural events. This, in turn, lowers prejudices and the potential for conflict. In this sense, the value of maintaining bilingualism is seen as an essential element of citizen-oriented social capital and the increased efficiency in crisis communication as a necessary by-product.

Since reduction of language barriers as success factor is a focal result of the model, the results were discussed and validated with the disaster relief working group of the Upper Rhine Conference, an institutionalized collaboration organization between Switzerland, France, and Germany, in Colmar on March 22th, 2018. Therefore short survey was conducted, in which a vast majority (10 out of 11 participants) regarded "language issues" as the most significant type of misunderstanding in cross-border cooperation, followed by "different organizational forms" (9), "technically compatible equipment" (4), "technical or professional terms" (3), and "a lack of time for coordination" (2) (Multiple answers were possible). The experts strongly agreed that language misunderstandings are the most crucial hindering factor for efficient borderland cooperation.

The study highlights the challenges arising from a high degree of capacity utilization. In such a constellation, local optima are not sufficient, but the system requires a form of global coordination. In particular, it was not sufficient for the population to contact the nearest coordination center. The coordination centers also have to coordinate and prioritize requests in a shared system. Otherwise, one coordination center receives only requests by citizens with minor injuries that are supplied with resources. Simultaneously, there remain more serious cases untreated, resulting from congestion at the other coordination center and a lack of global information. An international coordinator with a global overview could allocate the injuries optimally to the resources, which would lead to the best outcome. Moreover, this issue could be tackled with cross-border IT-solutions. However, inter-agency collaboration comes along with an even more significant number of challenges than IT projects for an individual entity. According to Gil-Garcia, "these challenges include data and technological incompatibility, the lack of institutional incentives to collaborate, and the politics and power struggles around a pervasive silo structure in most governments, among many others" (Gil-Garcia 2012). Furthermore, he highlights that "there are clear trends towards greater inter-organizational collaboration, information sharing, and integration, which could lead, soon, to what might be called a smart State" (Gil-Garcia 2012). Due to the complex decision context of crises characterized by interconnected and unforeseen factors, this trend seems to be promising (Quillinan et al. 2009). Such situations require a fast evaluation of changes to achieve flexible adaptations in volatile environments to ensure a compelling interplay of organizations (Borch and Andreassen 2015). Besides the technical comparability of equipment, costs and data protection also need to be addressed. However, this can constitute an obstacle if, for example, police organizations are reluctant to share sensitive information in a terror attack (Schwell 2008, Wimmer et al. 2016).

In a next step, study II is discussed in detail. When a disaster strikes, the environmental conditions change requiring organizations to adapt dynamically. Thus, the presented model investigates the efficient response to uncertain demand via inter-organizational collaboration. The trade-off between coordinated action via the hierarchical procedure of the organizations which requires some time compared to fast but uncoordinated action via the personal network of informal contacts between the agents is considered. Thereby, the focus is on two issues. First, the perspective of the local decision-maker and the conditions under which he/she decides for which strategy and second, the organizational perspective and its possibility to examine strategical intervention measures from a global planning perspective. The results show that the number of hierarchical requests slightly decreases with the increase of hierarchy levels where at the same time the number of personal requests increases in the number of personal contacts. However, the hierarchical strategy remains preferred, which is in line with the finding of Bolton and Dewatripont (1994) proving hierarchy as an optimal structure for organizations. Moreover, in this contribution informal contacts are seen as an alternative strategy especially for dynamic or uncertain circumstances, which is also in line with literature, i.e. "we believe that personalized ties are a reserve resource which provides the potential for the coordination needed to meet rapidly changing circumstances" (Krackhardt and Stern 1988). Literature findings additionally see these contacts as essential in the case of bottlenecks on a hierarchy level (Briggs 2018). In this simulation, the request strategy via informal contacts was chosen rarely, which might have the reason that the capacities within the requested station have been scarce, too. The research of Cross et al. (2001) shows besides task independence on the organizational side, significant influence of trust and friendship on the social side of information benefits. It is already mentioned in the beginning, that persons are interacting more likely with those that they perceive similar to themselves (McPherson et al. 2001). In this regard, Granovetter (1983) classified the strength of relational ties. He argues that weak social ties are responsible for gaining new information while information transmitted via strong ties considerably overlaps with what is already known as close friends move in the same circles like the person himself/herself. Following this line it is noted that personal relationships which are referred as "social capital" (Lin 1999) play a crucial role. Lin put the resources that can be mobilized through social relationships in the focus but he also mentions that one needs to invest in social relationships in order to be able to acquire these resources. This includes that besides knowledge of each other in an organizational context, also a personal relationship and trusting atmosphere need to exist. Thus, organizational norms, values and beliefs (Aktaş et al. 2011) can help to establish contacts across sub-units within or across the organization. Moreover, "the collective action research has shown that actors will increase their level of cooperation when they have been rewarded in the past for cooperating" (Isaac et al. 1994). Despite these opportunity was rarely used in the simulations, nevertheless the author believes that it can be very helpful for organizations to establish contacts across

sub-units which can be gained via common organizational norms, values and beliefs. Moreover, the findings of Hasan et al. "show that an individual's direct and indirect network connections can be changed through joint task assignment" (Hasan and Koning 2020). Thereby, it should be considered that weak ties are more efficient in distributing new information and that the organizations' hierarchy is still respected and not substituted by personal contacting (Soda and Zaheer 2012). Gulati and Puranam outline that "the resulting inconsistencies between formal and informal organization are widely viewed as unavoidable and significant costs of reorganization (Amburgey et al. 1993, Oxman and Smith 2003) that can even enhance the hazards of organizational mortality (Hannan et al. 2003)" (Gulati and Puranam 2009). Concluding, formal and informal contacts should go hand in hand. Informal contacts are an important component of organizational structure in particular to adaptation in changing environments or bottlenecks so that managers should set high value on their establishment and development especially in those relationships that connect across boundaries. However, the author also suggests that organizations should keep track on the informal contacts so that they are staying on a supporting level and do not turn to erode or substitute the hierarchy given by the organization.

Therefore, the second focus is the organizational perspective, especially on intervention measures for reaction to the decisions as the organization is interested in balancing capacities. Instead of distributing the available capacities equally among the requesting stations, another strategy is implemented distributing the available capacities with regard to the performance ratio of the stations so that sub-optimal performing stations receive more resources than well-performing station. The results show that by the second strategy it is even under uncertain demand conditions possible to get an almost equal performance among the stations. With respect to the results, an additional finding is that the capacity limitation appears as upper bound on the performance. Thus, the possibility that the organization itself provides central capacities are investigated. However, it needs to be considered that such a provision has constantly running costs which is not addressed in the simulations. Therefore, gaining additional resources via inter-organizational collaboration might be a more efficient solution, despite this form of collaboration also have costs like establishing interoperability (and of course requires contacting). Nevertheless, is widely seen an important goal.

In the following, study III is analyzed. This study investigates the efficient involvement of spontaneous volunteers. It is not surprising that the coordination along both dimensions, embeddedness to disaster response operations and across borders, shows the highest provision of resources to the affected population. However, it should be taken into account that spontaneous volunteers expect to keep their freedom at first glance and do not want to be driven by fixed structures. This fact is taken into account in the framework. In this regard, the groups are not divided i.e. all volunteers belonging to the same social media group are assigned tasks in the same area. This should not destroy the feeling of group

identity and affiliation consistently reported positively by these volunteers. However, another point that should be considered is the motivation of spontaneous volunteers. The idea of grass-root support is for sure not being affiliated with a voluntary aid organization. Thus, the inclusion into the coordination framework may sound antithetical, resulting in a situation of conflict that reduces the motivation for volunteers. However, the motivation for spontaneous support is mainly driven by the direct observation of high need, as discussed in the literature section. Furthermore, it is to assume that spontaneous volunteers understand that they cannot fulfill all tasks and that it can be helpful if the professionals assign them a task. Thus, there might be a high acceptance towards the framework, especially since it only assigns areas to help and leaves the coordination within this area open to the spontaneous volunteers. Note, that only those tasks that can be fulfilled by spontaneous volunteers are considered within the ares. If there additional tasks in the areas, which require professional disaster response actors, professional forces are send to fulfill these. Independently of the number of spontaneous volunteers already working in the area, these type of tasks are disregarded by them.

The more interesting point is the general motivation to volunteer across national borders, which needs to be examined. Up to now, there was no event, in which spontaneous volunteers crossed national borders on a grand scale. This could be due to the fact that the phenomenon is relatively new and a disaster in a border region has to occur first. Although spontaneous help was always observed, it is grown and newly formed by the rise of social media. However, as border regions also have hindering factors, it is hardly to predict whether crowds of spontaneous volunteers, which are driven by social media, would cross national borders or not. Since the framework would only make sense in case this phenomenon could be expected, this requires empirical investigation. As the simple question "would you be willing to spontaneously help within another country" anticipates the shortcoming of social desirable answers, a comparative study design based on social capital and Weiners' motivational theory is presented in the following part of this thesis.

Summarizing, the presented model quantifies cultural risks in cross-border collaboration, highlighting the interplay of different groups in information exchange and decision-making, thereby facilitating the understanding of crisis response. Therefore, the developed model supports the strategic planning phase as the impact of individual decisions in the overall context can be examined by comparing alternative configurations. The model is also a starting point to consider cultural aspects in the strategic planning phase for disasters in border areas. The results of the simulation experiments efficiently show that cross-border collaboration significantly increases the impact of a relief intervention. Moreover, the results indicate that language might be a more severe barrier than trust. Considering coordination aspects the simulation experiments show that despite the hierarchy is the preferred strategy, informal contacts can be helpful in dynamic situations in which established communication channels for information exchange and approved decision-strategies do not

work anymore. Additionally, a coordination framework to use the potential of unbounded spontaneous volunteers is presented showing that the highest involvement of spontaneous volunteers to disaster response organizations in a borderland leads to best utilization of resources. However, it focuses on the success factors for collaboration disregarding any initiation costs which might be high with regard to the cultural differences occurring in a border region that can reach from legislation, via organization to practical issues. Since enhancing the understanding of disaster resilience for a borderland is a challenging task, this study is seen as an essential contribution to start for future studies that aim to make border regions more resilient.

3.13.2 Strengths and Weaknesses of the Model

After discussing the results, now some methodological remarks are outlined highlighting strengths and weaknesses on the methodology of agent-based modeling. Three important aspects are emphasized.

First, Eoyang (1997) states that complex techniques are required if the problem is new, unknown, non-linear or has a high number of agents involved. Oakden (2010) modifies the definition and introduces key characteristics that need to be fulfilled so that it is worth using complex techniques instead of the traditional approaches. In particular, the problem should not be solvable by traditional approaches. In this regard, Checkland and Poulter (2010) propose an action-oriented framework for an organized way of studying (social) situations. In the mid-1990s agent-based modeling came up as a computational approach to deal with decentralized problems (Gorod et al. 2014). It is an approach to analyse the complex interplay of different agents acting by their own objectives. Agents are defined in this context as discrete individuals, that are heterogeneous and self-directed. This means that they are able to perform flexible, autonomous actions in their environment to achieve their design goals (Jennings 1999). Moreover, they are adaptive and allow the modeler to study dynamic decision situations (Macal and North 2010). Thus, "agent-based modeling is particularly suited for developing theories of interactively complex epistemologically-emergent phenomena" (Miller 2015). Furthermore, agent-based models allow to picture complex real-world phenomena by creating "caricatures of reality" (Axtell and Epstein 1994). However, Bonabeau highlights "a model has to serve a purpose" so that it has to be designed on an accurate level of detailing description to serve its purpose which "remains an art more than a science" (Bonabeau 2002). In this regard, Muelder and Filatova (2018) address the influence of the models' formulation to the simulation results. Although Smith and Conrey see similar weaknesses as a "lack of training in modeling", "difficulty of identifying the correct balance between simplicity and complexity", and "resistance to expressing human behavior in computercode" (Smith and Conrey 2007), they believe that agent-based modeling is more suitable than other current approaches to capture complex

and dynamic interaction processes. Epstein (1999) further supports this argument, stating that many social processes cannot be decomposed into subprocesses whose separated analyse allow conclusions of the process as whole. In this regard, agent-based modeling is suitable to study the interplay, especially collaboration, between various actors in dynamic situations as they occur in the aftermath of disasters.

To be a holistic approach to examine borderland collaboration, the presented model itself is very complex as it comprises various actors with individual traits as well as several coordination patterns. However, there are extracted some detailed studies that are intentionally kept simple so that the underlying mechanisms become clear and allow to determine success factors of borderland collaboration. Nevertheless, already the human decision-making process itself is extremely complex and ambiguous. Lee et al. (2008) classify modeling of human decision-making processes into three major categories, namely economical, psychological, and synthetic engineering-based. All these approaches have their limitations and it is the modelers' task to find a suitable trade-off between simple rules accepting imperfections and comprehensive models where validation with the real human decisions is difficult. Therefore, an approach introduced by Crooks and Wise (2013) is implemented taking Maslow's hierarchy of needs as a reference for the affected populations' disaster decision-making. Miller argues furthermore that "agent-based modeling holds the potential to contribute to advancing organization theory" (Miller 2015). Thus, the current study demonstrates that agent-based models can simulate organizational theoretic perspective to explore under which conditions members decide between sources of information flows. As the primary objective is to understand information exchanges for dynamic situations in a rather general context, and not necessarily to validate it for a particular organization, the input data in the simulation experiments are artificially generated. The model easily allows for other input parameters, so that empirical work could support here to embed the model in a specific context, e.g. by examining the social relationships for a specific organization.

However, the model faces a set of assumptions. Thus, there are considered only three levels of language skills such that agents can either have no knowledge, be intermediate, or be fluent. With regard to trust, the model is only distinguishing between trusting and non-trusting agents. Moreover, the effects of misunderstandings (wrong prioritization of help assessment) as well as of distrust (doubling request) are similar for all agents. One could for example think of agents moving to the wrong location due to misunderstandings. Such add-ons are also left for future investigations. A central limitation is that only one type of needs is considered, which in the model reflects that all capacities are all exchangeable. In a more realistic setting, of course capacities between sub-units might not be exchangeable that easily and the procedure may cause transaction costs. However, in terms of a crisis costs occur very likely, i.e. due to disruptions, so that creative solutions to reduce them are required. For example, during the Covid-19 pandemic, different firms like car or clothing

companies started the production of protective face masks as this was a scarce good. For this example, the assumptions fit the real-life context.

Second, a scenario-based approach is taken and numerical experiments are chosen instead of real-world data, as this model serves analytically purposes in the first place. Therefore, it can be employed as a strategic planning tool to quantify language and trust impacts on communication and emergency operations. The model already has an underlying infrastructure layer to be able to study resource distribution. However, the structure is kept rather simple as it is intended to be a generic model to study borderland collaboration deriving success factors that hold in general. It allows a comparison and docking for analyzing global dynamics, taking into account the agents' different characteristics. Consequently, future research can expand the implementations towards a specific border region with its real-world data drawn from existing databases or derived by empirical research. In particular, the model allows to be applied to a specific border region by importing the corresponding data sets for the reference region. Exemplary, this is done for the open street maps data import using the geographical information system QGIS (QGIS Development Team 2009) for the city of Breisach, a small village in the German-French border area, comprising the Rhine river. However, data on cross-border disaster is limited, and

Figure 3.32: Exemplary Study Region Using Open Street Maps Data in GIS Representation

collecting data during an incident involves risks for the researcher and others, indicating that pursuing this objective will likely be challenging. Similarly, the model also allows to include other actors (as NGOs for example) or detailed cultural factors. Moreover, this model is flexible to include other decision strategies for the agents to choose a request

receiver and to perform the interactions which in turn also allows to study different aspects in organizational theory. It is already mentioned that relationships are very divers and that people for example tend to interact with those they are similar. Although the model in principle applies to any type of network, it can still be expanded - for example by introducing a weighting factor to account for different strengths of relationships. The dynamics in demand creation borrows from disaster response as there a areas which are more affected than others, so that patterns of demand rise if help is not provided in a timely manner. However, this is not the only interpretation. For example hypes on a product will create similar patterns of demand resulting from others observing a person that has a certain product which they believe to need as well. The second aspect namely border regions are of special interest in studying international relationships, which is a current topic in today's globalized and interconnected world. However, despite regional collaboration across a border is also beneficial with regard to regional economic stability and growth, its still an underestimated topic, not only in disaster resilience. Moreover, it is outlined already in the introduction that collaboration and pooling of resources within a company can bring advantages. The same holds true for relationships along a supply chain for example. Thus, the author thinks that these results are valuable across the context. The risk management and business continuity management perspective in complex project planning should in general be aware about communication structures besides the official channels. Identifying weak ties, i.e. boundary spanners, and placing well-directed impulses in the communication network can help to mobilize additional resources via collaboration. In closing, the author would like to encourage agent-based models to study such phenomena in other contexts as it allows strategic insights on decision-making based on a local perspective.

Third, this model is designed following the Gaia methodology (Wooldridge et al. 2000), and a step by step analysis verifies the results. It is especially important to remove errors in coding so that the program performs as intended. This was carried out in this case via tracing of variables in different stages of the runs. This means, that the intermediate status of variables was put out in each step and compared by manually computed reference values of variables at this stage. In the simulation experiments, all calculations matched which supports the verification of the model. As agent-based models, in general, have an extensive computational effort, this model also has an exponential running time. However, as this model is dedicated to strategic planning instead of being a real-time analysis instrument for emergent situations, computational time is not regarded as a relevant component. In a considerable surface of 2000 agents, the running time is still manageable. Thus, the model is simple enough to enable an empirical evaluation of the results. Simultaneously, it is also complex enough to emulate real-world situations and generate meaningful insights. Consequently, although the model has a high level of abstraction, it is a first attempt

to improve cross-border collaboration and highlight the need for cross-border disaster cooperation and attract research to increase borderland resilience.

Part II Empirical Analysis

3.14 Introduction to the Presented Empirical Study

The first part of this thesis illustrated the interorganizational collaboration and outlined the involvement of spontaneous volunteers. Recent developments in citizens' involvement in the disaster response show a clear trend moving from engagement into voluntary aid organizations to spontaneous volunteering which rises in particular popularity due to social media. However, up to now there has not been observed spontaneous volunteering across national borders. Thus, the second part of this thesis is interested in the motivation of people to help also across national borders in future disasters and to examine the borderlands' self-help capacities.

In addition, this part aims to shed more light on the transnational attachment, which indicates whether a positive and solidary mutual attitude between citizens of two neighboring countries exists. As such bonds are essential for the efficient utilization of resources and a fast recovery, it can be seen as a prerequisite for disaster resilience. An established concept to investigate social connectivity among people living in a region is the empirical measurement of social capital. This concept is mainly based on trust, but also comprises other factors of social interaction as shared norms, social affiliation or interpersonal relationships. However, despite such bonds are seen as success factor for collaboration, they cannot be established easily in a dynamic and uncertain environment as in the aftermath of a disaster. Thus, it is important for decision-makers to have an estimation about the regions' conditions already in the strategic planning phase. Although there is consensus that these personal bonds across borders are relevant not only in disaster response, there is no data base available to measure social capital and willingness to help for border regions.

To quantify these effects as important drivers of borderland resilience, an empirical study is designed comprising the targeted analysis of success factors for borderland collaboration. The data collection is performed via representative telephone interviews. The novel approach is a comparative design collecting data for both neighboring countries Germany and France on a regional basis to benchmark the French-German borderlands characteristics. Thereby, it can be controlled for social desirability bias. Besides the willingness to help (WTH), social capital and in particular trust are examined to uncover the borderlands' characteristics better. The following review outlines the current body of literature with respect to these fields of research.

3.15 Literature Related To Empirical Analysis

In addition to the state of the art, this chapter outlines the related literature with respect to empirical research in the area of social capital and willingness to help. The presented framework relates to several branches of literature. First, the central concepts of social capital and trust are described and their significance in terms of community governance and resilience is outlined. The second thematic block sketches the state of the art in research on the pro-social motivation to help with a special focus on the context of a crisis or disaster. In the last section, the approach is placed in the still scarce literature on transnational attachment.

3.15.1 Social Capital, Community Governance and Trust

In the 1970s and 1980s, Bourdieu came up with a classification of capital and introduced social capital as "the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition" (Bourdieu 1986). His focus is on individual power to gain status-determining influence in certain social matters. Similarly, Dynes gives a general definition stating "social capital appears as an aspect of social structure and actors are able to use social capital as a resource to achieve their goals" (Dynes 2002). In Coleman's definition social capital is a "variety of different entities that all consist of some aspect of social structure and that facilitate certain actions of individuals who are within the structure" (Coleman 1988). His concept sees social capital as a neutral resource that facilitates action but the improvement for society is depending on the individuals activities. Lin et al. (2001) also look at social capital from a social network perspective. Social capital facilitates the exchange of credible information while credibility is established by social ties and influential nodes in the network which contribute to norm enforcement. Among many others, this view is also shared by Bowles and Gintis (2002) and Grootaert et al. (2004), as "the effects of social capital operate through (at least) three mechanisms: sharing of information among association members, reduction of opportunistic behavior, and improved collective decision making" (Ostrom 2003). As social capital is based on self-commitment and norm-enforcement of group members, it facilitates cooperation within a group but could, under certain conditions, make out-group-cooperation more difficult. In his seminal contribution, Granovetter highlights the network component of social capital, which measures the amount and strength of ties between persons. He distinguishes between weak tie relationships and strong tie relationships stating "the problem is that, without weak ties, any momentum generated in this way does not spread beyond the clique" (Granovetter 1983). This distinction between "bonding" or "clique"-social capital, which is based on close-knit, strong-tie networks on the one hand and "bridging" social capital

based on weak-tie relationships on the other hand is widely accepted (Portes 1998, Ostrom 2003). For the first type, norm-activation is based on within-group similarity and cultural affinity which has the tendency to promote group segregation and out-group discrimination (Bowles and Gintis 2004, Leider et al. 2009, Binzel and Fehr 2013). The second type of social capital, which fulfills a bridging function, is rather based on inclusive norms of civic-mindedness as expressed by general trust in unknown "fellow citizens". Putnam stresses this latter variant of social capital as a factor of society-wide relevance and defined it in the 1990s as "the characteristics of social organizations, such as networks, norms and trust that facilitate action and cooperation for mutual benefit" (Putnam 2001). In this view, bridging social capital arises from the willingness of citizens to cooperate with one another and to provide mutual support because social interaction and joint activities strengthen generalized reciprocity, reinforce incentives for voluntary contributions and thus develop trust. He comes to this conclusion because he observed a close connection between the numbers of voluntary associations and the efficacy of the regional government. Where citizen tend to adhere to norms of generalized reciprocity, and interpersonal trust is higher, free riding occurs less common and governmental performance can be improved by influencing the level and nature of political participation, reducing rent-seeking, and enhancing public-interested behavior (Knack 2000, Adger 2003, Evans 1996). Another key component of social capital is trust, which is in many studies seen as the strongest and most practical indicator of social capital because it is measurable in surveys and experiments. Trust is defined as a "person's belief that another person or institution will act consistently with their expectations of positive behaviour" (Murtin et al. 2018, Coleman 1982, Cox 2004, Wiens 2013). Country studies usually refer to general trust as opposed to personalized trust (Guiso et al. 2011). Commonly, generalized trust is taken as a trust measure in social capital discussions and it is measured, for example, in earlier rounds of the WVS. Bjørnskov (2007) provides support for the use of generalized trust as a standard indicator for political and economic stability. He compares generalized trust in several countries over different periods using WVS data and identifies factors which positively influence trust (e.g. Protestantism and having a monarchy) and negatively influence trust (i.e. social polarization in the form of income inequality and ethnic diversity). In cross-country analysis, La Porta et al. (1997) confirm that trust is an important determinant of governance. Furthermore, the study by Uslaner and Brown (2005) supports the thesis that trust has a positive effect on communal participation. Additionally, Putnam shows that "regional governments in the more-trusting, more civic-minded northern and central parts of Italy provide public services more effectively than do those in the less-trusting, less civic southern regions" (Putnam 1993).

3.15.2 Social Capital, Natural Disasters and Community Resilience

After the concept of social capital was initially used to explain economic growth and social structure in general, it is now also seen as an important factor to cope with natural disasters as it increases the resilience of a country. In general, the resilience of a system describes its ability to cope with a sudden disturbance and to restore its ability to function (Ayyub 2014). With respect to countries, this ability depends crucially on knowledge, experience, networks and the ability to cooperate under conflicting circumstances. Aldrich and Meyer (2015) uncover the importance of social capital in community resilience by a literature review and conclud that social capital is still an underutilized resource for an adequate disaster preparation. In similar manner, Haque and Etkin (2007) set up a special issue in the Natural Hazards-Journal to stress the necessity to understand the social dimension, and social capital in particular, for disaster prevention. Although evidence is still scarce, the relevance of social capital for disaster resilience is explored by a couple of studies. For example, Aguirre et al. (1995) find that after a gasoline explosion in Guadalajara, Mexico "people did not participate in the search and rescue efforts at random. Instead, their participation was depending on the strength of their already existing social ties and inter-dependencies with the victims and fellow rescuers" (Dynes 2002). Dynes refers to the example of the 1980 Italian earthquake where the death rate for people living in single households had been 2.4 times higher than for households with one or more members. However, there is also evidence for the other direction, the effect of natural disasters on social capital and trust of a country or community. With respect to trust among citizens evidence is mixed although studies, which report a positive effect on trust and cohesion dominate the picture. In the studies by Moore et al. (2004) and by Hawkins and Maurer (2009), the authors interview people in the aftermath of a hurricane and find that most people were helping each other, mostly among family members and neighbors but also among strangers. However, they both also find few examples of riots, looting or other behaviour where people were taking advantage of the situation. Hawkins and Maurer mention that the helping behaviour disappears in the recovery phase. Similarly, Yamamura (2016) discovers that people were more likely to participate in community activities after the Kobe earthquake and that this effect decreased with the increase of distance between the peoples' place of residence and Kobe city where the earthquake happened. In contrast, findings from the study of Elliott et al. (2010) indicate that differences in social capital increase noticeably over the course of disaster so that the social safety networks of less priveleged citizens become inoperable over time. Castillo and Carter (2011) find that negative shocks might foster cooperation but too large might not. Recognizing that natural disasters change social capital in communities, Kang and Skidmore (2018) investigate various kinds of disaster in comparison. They determine a statistically significant positive relationship between cumulative damage costs per capita and social trust levels for the events of heavy rain, heavy snow, strong winds and waves but the opposite is seen in the

event of typhoons. Additionally, the authors recognize a more competitive attitude over limited resources, resulting in conflicts among the residents. They find that the way of handling disaster recovery by governments and other local organizations may affect social trust. While trust in fellow citizens can increase in the aftermath of a disaster, trust in government or in politics in general is a different aspect. The latter is predominantly influenced by people's perception about the responsibility for the situation as people are more likely to blame government for lacking prevention or mitigation of the disaster (Uslaner and Yamamura 2016). As an example, trust in national political institutions fell in Japan following the Kobe earthquake. And Nicholls and Picou (2013) find for the US that the negative experience with Hurricane Katrina was correlated with a low level of political trust. They conclude that government at all levels needs to enhance the effectiveness in dealing with such disasters. However, the effect on the trust among citizens is different: Rodriguez et al. (2006) interviewed people in the aftermath of Hurricane Katrina and finding high level of pro-social behaviour among first aid responders as well as among citizens. And if the government cannot be blamed for an event, people also judge differently: The 9/11 attacks in the United States led to "us against them" sentiments: "Americans became more trusting of most government institutions (especially the military) and of each other – and also were more likely to take part in community organizations and especially to donate to charitable causes" (Uslaner and Yamamura 2016). Shupp et al. (2017) find that for people who were affected by a tornado, trust in general, trust in the police and fire authorities and trust in friends increase.

After all, strong community resilience requires effective governance and the latter depends on both, a high level of community cohesion and high trust in political institutions and political leadership. Murphy (2007) highlights that the municipal government responsibilities and the community-level initiatives are interdependent, but separate aspects of local emergency management. Aldrich (2011) argue that informal social ties, in particular by neighbors, regularly take over the first responds in emergencies. Sherrieb et al. (2010) combine the indicators to components of economic development and social capital to derive an additive index of community resilience. This way, the authors are able to identify capacities that may predict a community's ability to "bounce back" from disasters. Waugh Jr. and Streib (2006) also highlight that besides a trustful relationship among the emergency response actors, the involvement of non-governmental actors build the communities' capacity to cope future disasters. Additionally, O'Sullivan et al. (2013) support the strategic planning phase by using the structured interview matrix facilitation technique. Thereby, they identify that besides awareness and connectedness in each community, solid and trusted relationships are the basis for collaboration, communication, mobilization of resources, and knowledge of population needs.

3.15.3 Pro-Social Behavior and Willingness to Help with a Focus on Disaster Situations

WTH is a complex topic (Rothman and Wiesenfeld 2007). There are situations where people are extraordinary courageous as seen in the aftermath of the attacks on 9/11 against the World Trade Center, but there are also situations where people tend to bystand without reaction to help. Sociology and psychology (in particular Social Motivation Theory) have identified the key factors that support or suppress the motivation to help (Bierhoff et al. 1991). In economics, WTH is considered from a utility perspective (Francois and Vlassopoulos 2008, Lynch and Cohen 1978, Bénabou and Tirole 2006) assuming that the motivation to help results from an implicit weighting of costs and benefits (Dovidio et al. 1991). Focusing on the situation of the needy person, empathy (Klimecki et al. 2016) and relationships (Clark and Mils 1993) are relevant factors to explain WTH. Klimecki et al. (2016) confirm that the effect of empathy increases altruism up to 40 percent in a Dictator Game. Although Settoon and Mossholder (2002) could not affirm the hypothesis that empathy leads to a stronger support of others, they could show that empathy promotes trust in others. From a joint psychological and game-theoretic perspective, the incentive to help others can be reduced due to diffusion of responsibility as described by the volunteers' dilemma (Diekmann 1985). Franzen (2013) analyze the effects of asymmetric preferences, timing, incomplete information, and cost sharing in the volunteers' dilemma and find that it is a pessimistic approach as participants in experiments show a higher probability to volunteer compared to the game-theoretic prediction. Among the seminal contributions to explain WTH is the work of Weiner (1993) introducing the Motivational Theory of Mutual Help. He develops a structural equation model to predict attributes influencing the WTH in various situations. He notes that people are less willing to help when they perceive that the needy person could have avoided the reason for the distress that he or she is in (own responsibility of misfortune). Moreover, Weiner explains attributes that influence the judgment of responsibility and how this evaluation is influenced by feelings of anger or sympathy, which directs the motivation to blame or help the needy individual (Weiner 1993). Based on this theory, Mackay and Barrowclough (2005) examine helping behaviour in the context of accidents and emergency staff's care of patients verifying the previous findings, in particular controllability being an important factor for helping behaviour. Additionally, gender, religion, mood and guilt play a role in helping behaviour (Rothman and Wiesenfeld 2007) but competence seems less so. For example, Bierhoff et al. (1991) examine data from Accident Research and find that helpers and non-helpers do not differ significantly with respect to feelings of competence. Instead, proven first responders characterize themselves to be more internal, to believe more in a just world, and to emphasize more social responsibility and empathy. Zagefka et al. (2011) investigate whether man-made or natural disasters entail a higher willingness to donate to people in need. Indeed, they observe higher donations in the context of natural disasters because

people tend to blame victims in man-made disasters for the unlikely situation that they face.

In this study, next to personal characteristics, the level of regional social capital is seen as an important predictor for spontaneous WTH in a crisis situation. The following paragraph briefly outlines the existing work in this area. Yang et al. establish a link between social capital and helping behavior. They find a strong and positive connection showing "that proactive personality positively relates to social capital, and that social capital further positively relates to interpersonal helping and negatively relates to voluntary turnover intentions" (Yang et al. 2011). Ng and van Dyne (2005) consider the factors cohesion, norms and task conflicts in groups to predict helping behavior in working groups. They point out that group cooperative norms and positive relationships between groups have important effects on helping behavior, and indeed find that group cohesion and cooperative norms are positively associated with individual helping, while group task conflicts are negatively associated with individual helping. Lee and Brudney (2009) find that peoples' engagement in their communities is a statistically significant driving factor for volunteering. Similar findings can be seen in Fattori et al. (2015) who highlight in their study among Italian participants a significant positive relation between social identification and collective action. Thus, the WTH is closely related to communities and their norms as social responsibility demands to help vulnerable persons within these communities. This holds true for all societies and is therefore seen as connected to the evolutionary principle of survival (Rothman and Wiesenfeld 2007). Aydinli et al. state "spontaneous helping is an unconscious and implicit process activated by automatic affective components, whereas the decision and action of volunteering is a more conscious and explicit effort, initiated by elaborate considerations" (Aydinli et al. 2013). Terry et al. (2000) highlight that people tend to classify others as "in-group or out-group members" and analyze the impact of this perception on decision making. They find that participants who hold attitudes congruent with their group are more likely to behave according to these attitudes than participants who are exposed to in-congruent attitudes. Similarly, Wagner et al. (1982) report a lower number of returned packages if the finder is less similar to the packet's loser and Stablein (2011) find that common experience or perceived similarity are driving factors for helping behaviour. In-group effects are highly relevant and present in a cultural context. Among all cultures, people are helping others more likely if these are in-group members. Investigating in-group competition, Jackson and Esses (2000) findings support the hypothesis that people who feel economic competition with immigrants are less willing to support their empowerment. In a context of natural disasters, the motivation for WTH in voluntary organizations is studied by various authors. In the aftermath of natural disasters, there is high mutual support, which is also referred to as a therapeutic or altruistic community (Perry and Lindell 2003). Li et al. (2013) support this hypothesis by deriving experiments measuring children's donation behaviour. They report a change

in donation behaviour in the direct aftermath of an earthquake, while three years after the earthquake the donation behaviour turns back to a before-earthquake level. Similar findings are seen in Rao et al. studying the Wenchuan earthquake in 2008 (Rao et al. 2011). In general, a mixture of altruism and egoism as personal fulfillment and personal growth is identified as volunteers' motivation while Aguirre and Bolton (2013) find that in crisis situations personal growth is a less relevant factor. Wolensky (1979) provide a framework of peoples' motivation to volunteer in disaster response along the dimensions of public and private interests distinguishing between the social forms "emergent" and "organizational". Clary et al. investigate the six components of the volunteer functions, which consists of values, understanding, enhancement, career, social and protective. Thus, they show a difference between non-volunteers' and volunteers' motivations as well as between the motivations of volunteers with more and less experience. Summarizing they state that "people engage in volunteering to satisfy important personal and social needs and goals, and apparently many individuals are pursuing more than one set of goals through their volunteer activity" (Clary et al. 1996). A more recent study by Atsumi (2004) criticizes the traditional approach and emphasizes the collaborative dimension of motivation. By finding that more than half of the respondents tick the answer of "something else" indicating their motivation to volunteer after the 1995 Kobe Earthquake, he suggests that socially constructed motivation, i.e. doing something only after discussing the action with other people, might be an additional motivational factor. Barraket reportes in his study helping and supporting others to be the most prominent factors for spontaneous volunteers. In detail, "the respondents felt the need to help, were upset at what was happening and had family or friends affected in the disaster" Barraket et al. (2013) and mainly state altruistic motives. Similar results are presented by Lowe and Fothergill (2003) in the studies of World Trade Center Attack at 9/11 in the USA. The results by Levine and Thompson indicate that people are distinguishing between perceived in-group and out-group persons with regard to offering help still in the aftermath of a natural disaster, i.e. "social category relations rather than geographical proximity or emotional reaction are most important in increasing helping behavior after natural disasters" (Levine and Thompson 2004). In this regard, Gillis and Hagan (1983) find that persons within the same territory are offered help more likely. The approach closest to the purpose of this study is the contribution of Marjanovic et al. who applied Weiner's model to natural disaster situations. They find that "judgments of victim responsibility were highly related to affective responses toward victims" (Marjanovic et al. 2009). This way, they prove the framework to be suitable for explaining helping behavior towards groups in natural-disaster situations.

3.15.4 Cross-Country Bonds, Culture and Transnational Attachment

Rippl et al. understand transnationality as the everyday crossing of the national borders between regions, and define these relations and their consequences as *transnational social capital*. Hence, they put special emphasis on the factors influencing this type of collective identity, but also trust in foreign neighbors and the people's attachment to their transnational region. They find that in the border region of Germany and France there is a relationship between accumulated transnational social capital and strength of transnational identity. For the Germans and the French holds "the more transnational personal relations and engagement, the stronger the regional attachment". It also becomes clear that "neither nationalistic attitudes nor the perceived burden of historical conflict, impact feelings of attachment to the transnational region or to Europe." (Rippl et al. 2010). The article by Kuhn (2012) further analyzes the underlying mechanisms of the *border effect* by testing the hypothesis that the greater involvement in transnational networks and interactions of border residents causes a lower likelihood of Euroscepticism among border residents. By introducing a *transnationalism index*, she finds the border effect in German border districts but not in French border districts and discusses reasons as lower transnational involvement of French border residents, vacation habits, different weight to foreign language training in school curriculums or the fact that a large portion of the French land borders is in mountainous areas. Alisan et al. (2018) perform an optimization model on sheltering of special needs population and show a noticable improvement in the assignment of people by cross-county cooperation applying to a case study in the US. Furthermore, Ansell et al. (2010) highlight the nature of increase in transboundary crisis and the need for efficient crisis management. They distinguish different dimensions of transboundary and addresses challenges faced in crisis response respective to a border area. Similarly, Edwards (2009) highlights the need for cross-border disaster management. Lai investigate in cross-border cooperation between voluntary organizations and find that the role of "informal connections and past working experience or trust between them emerged as central, especially at the level of community and self-organizing groups. Given the conditions of urgent stress, high demand, and tight time constraints across multiple jurisdictions, such informality enhances voluntary organizations responsiveness in an emergent multilateral network" (Lai 2012). Furthermore, in cross-national strategic alliances trust is a key to success (Doney et al. 1998). Durham and Blondell (2017) find that people have a high level of confidence in the medical advice they receive through informal contacts via world of mouth in their network and on this basis although consider crossing the national borders to receive a treatment which is anticipated to be adequate. Cerina et al. compare networks of US and European Patent-inventors and state "all in all, our findings reveal that Europe is still a collection of national systems of innovation and the European Research Area is still far from becoming reality" (Cerina et al. 2014).

Moreover, there are already a couple of cross-cultural studies in the field of social capital and WTH. Considering trust, main investigations are the comparison between low- and high-context cultures, as America and Japan. Yuki et al. (2005) perform a cross-cultural study investigating differences between relationship- and group-based trust and find that Americans are more likely trusting people that shared category memberships whereas trust for Japanese is given on the likelihood of sharing interpersonal links. Summarizing, Americans are more trusting towards ingroup members than towards outgroup members, but potential links of indirect relationships increase the trust towards outgroup members more for Japanese than for Americans. Furthermore, Yamagishi and Yamagishi (1994) states that networks of mutually committed relations play a higher role in Japanese society than in American society where against in comparison to Japanese respondents, American respondents are more trusting of other people in general, consider reputation more important, and consider themselves more honest and fair. Delhey and Newton conclude that "high trust countries are characterized by ethnic homogeneity, Protestant religious traditions, good government, wealth (gross domestic product per capita), and income equality" (Delhey and Newton 2005). Switching to an European context, Olivera (2015) investigates the link between trust and income inequality and found that GDP per capita is positively related to trust and that discrimination and crime rates are negatively associated to trust. Letki and Evans (2005) investigate the link between trust and democratization in Eastern-Europe and concluded a "top-down" process, in which levels of trust reflect the effectiveness of political and economic institutions. Hooghe et al. (2009) state that in Germany trust is a little higher than prejustice, but in France it is the other way round. Delhey and Welzel (2012) examine in-group and out-group trust and find by analyzing data from the WVS that Germany has a much lower out-group trust and a little lower in-group trust than France.

Scholars look at social capital from various disciplinary angles, using multiple methods and theoretical frameworks, but none of them is dealing with cultural aspects in a border area. Due to the multiple dimensions and the abstract nature of the term social capital, various definitions are suggested. In this thesis, a novel measure to quantify regional social capital is derived applying Weiners' motivational theory to explain factors of willingness across national borders.

3.16 An Empirical Study for Cross-Border Collaboration

As outlined above, the objective of the present study is to identify the unique features of a border-region with respect to social attachment and civic willingness to help, in particular for the context of crisis resilience.

3.16.1 Study Design

This approach goes beyond a simple cross-country comparison and measure social capital and WTH on a regional level. In particular, the effect of neighboring regions is taken into account. Since a border area consists of (at least) two regions of neighboring countries, the survey on these regions should be compared with neighboring regions within the two considered countries. This way, the coupled regions comprise a home-region and a neighboring region while the type of region (home or neighbor) depends on the location of each respondent. The novel approach of this study is that the border area is interpreted as such a coupled region and compare social capital (in particular trust) and WTH with coupled regions within the respective countries. This approach is applied to the case of the French-German border area.

With respect to social capital, the joint identity of home and neighbor region are compared which should be different from a rather rough and aggregated comparison of two countries. Concerning WTH, which implies a physical move *across the border* (from home to neighbor region), this approach controls for distance by design. In general, this design allows for an empirical measurement of inter-regional neighborhood characteristics and provides a decisive contribution to the understanding of transregional attachment in border areas.

The regions compared in the empirical study are constructed as follows. The reference regions on the German side are the German states ("Bundesländer") and the French regions ("Régions") on the French side. This classification corresponds to the NUTS-1-level and has the advantage that it allows for an approximate comparability with the border region in terms of population (Eurostat 2018). In addition, the focus on NUTS-1 keeps the survey manageable as it covers two entire countries. For the coupled regions within each country the respondents decide about their neighboring region because this study is interested in *perceived closeness* and wants to avoid that the respondents are distracted from the questionnaire by trying to estimate geographic distances. In particular, the survey participants of both countries are asked to mention the neighboring region that is fastest reachable from their home. Since the interest is in the perceived closeness, it is not important how the distance is bridged (e.g. by bike, car, train etc.) and how to deal with small discrepancies in cases where more than one neighboring region has a comparable

distance. Then, the participants are asked to keep the coupled regions consisting of their own region and the (perceived) closest neighboring region in mind for the ongoing questionnaire. For the respondents living in the border area a list of districts is provided which define the border region (more details in the next section).

Figure 3.33 provides a graphical illustration of the setting. In the map, the border area (red shaded circle in the middle of the picture) is highlighted and also two neighbored regions in each country (yellow and blue shaded circles). The examples in the graph show that the home region and respective neighbored region are determined by the respondent's location and the region the respondent perceives as the closest one to her/his place of residence. For example, for a German citizen located at point G the home region is Lower Saxony. The neighboring region depends on the respondent's own perception of travel distance (and not necessarily on the objective, geographical distance): E.g. if this person declares Saxony-Anhalt as the "fastest accessible neighbor region" the corresponding neighboring region becomes Saxony-Anhalt.

Figure 3.33: Schematic Study Design

3.16.2 French-German Border Region

The study considers Germany and France as well as the border region between these countries. Similar to Kuhn (2012), the definition of "border region" comprises at the German side all districts ("Landkreise") with a direct border to France as well as the independent cities ("kreisfreien Städte") that are less than 30 km direct distance from the border.

Thereby, 19 districts result which are Merzig-Wadern, Saarlouis, Regionalverband Saarbrücken, Saarpfalzkreis, Zweibrücken, Südwestpfalz, Pirmasens, Südliche Weinstraße, Germersheim, Landau in der Pfalz, Karlsruhe, Landkreis Karlsruhe, Baden-Baden, Rastatt, Ortenaukreis, Emmendingen, Breisgau-Hochschwarzwald, Freiburg im Breisgau and Lörrach. At the French side of the border, the corresponding administrative divisions of France ("Départements") are considered, which are Haut-Rhin, Bas-Rhin and Moselle.

As the border region is of special interest in this thesis, some key figures of this region are presented. The area of the considered region is in total around $25,000$ sqm of which $14,500$ sqm are in France. It consists mainly of small cities and villages with less than $5,000$ inhabitants. The considered region has a population of about 6.5 million people of which 46% live on the French side. The border region is characterized by similar geographic and economic conditions. Moreover, the region is an economic center with a per capita Gross Domestic Product (GDP) of $30,000$ Euro in 2012 and an activity rate of about 70%. In the region, there are 10 ports to the Rhine river and 5 airports. The region has about 600 cluster and company networks as well as about 20 universities and universities of applied sciences ("Fachhochschulen"). In 2012, there were more than $25,500$ cross-border commuters from France to Germany and $2,000$ from Germany to France. With more than 150 hospitals in the region, the health system is well established. Between the three countries Switzerland, France and Germany, there is a cross-border cooperation on a political level with the Upper-Rhine-Conference (URC) as the main coordinating institution. Among other working groups of the URC, there is one dedicated to cross-border crisis response activities which started its work after an incident in 1986 in Schweizerhalle when the Rhine turned red due to leaking chemicals caused by a fire at a chemical factory.

3.16.3 Conduction of the Study

In order to receive a representative sample ensuring that enough inhabitants of the border region participate in the study, telephone interviews are chosen as an appropriate method to carry out the survey. The participants' places of residents are identified via postal code. The study is designed as a questionnaire, which is divided into five parts:

- Social capital of the border region and of regions within the respective countries
- Personal attitude towards risk and trust in people of the own and neighboring region as well as in the own and neighboring country
- Perceived responsibility for and preparedness in crisis response
- Experience with disasters and disaster relief

- Willingness to help across a national border and across a regional border

A detailed description of variable names and corresponding items can be found in Table A.1 (see Appendix). To ensure comparability among the two countries, only closed questions with a four point Likert-scale are asked. An even scale is chosen in order to circumvent the error of central tendency. To avoid that people are not forced to choose an option and thereby falsify data, option to respond "I don't know" (i.e. non-response) is given. By designing the questions, well-established surveys (e.g. WVS, European Social Survey (Norwegian Centre for Research Data, Norway – Data Archive and distributor of ESS data for ESS ERIC 2018)) are taken as guidelines to make this study comparable to these. It is also checked for questions already proved in cross-country analysis.

The questionnaire has been developed in German language and its translation to French has been done by native speakers of EFG Consulting Worldwide. Attention has been paid to an exact translation also with regard to individual keywords and the context. Individual terms have been agreed in close cooperation. A similar understanding of the overall topic and the questions has been ensured with a specific focus on cultural differences between the two countries. The translation of the questions to English has been done by the authors, the original questionnaires in German and French can be found in the appendix.

Following the translation of the questionnaire, a pretest has been carried out with 30 respondents per country focusing in particular on comprehensibility and international comparability. In the pretest, there have not been seen any major problems with respect to comprehensibility. In the answers to additionally posed questions for the pretest, the survey has been rated as interesting and not too long. In general, there has been a low rate on non-response items. Although they have been realized in a higher amount on the trust and WTH questions, it has been decided to keep these questions without rephrasing as they make this study comparable to large-scale surveys (e.g. WVS). Nevertheless, a minor change has been requested for one specific item. As a high number of interviewees in France have stopped the interview at question four asking for activity in sports- arts- or religious societies, it appears that religion is a more sensitive topic in France than in Germany. Therefore, the type of "societies" has been changed to sports- arts- or cultural societies. This does not change the scope of this question as the interest lies in social relationships. Apart from that there are no noteworthy differences in how German and French respondents perceived the questions.

The main data collection has been realized from August 12^{th} to August 30^{th}, 2019 in Germany and from August 9^{th} to September 2^{nd}, 2019 in France. The computer assisted telephone interviews in Germany have been conducted by Forsa Gesellschaft für Sozialforschung und statistische Analysen mbH. In France, the interviews have been conducted by EFG Consulting Worldwide. The interviews have been carried out from central telephone studios by trained interviewers who were familiarized with the special features of

the planned study in advance so that they could respond appropriately to enquiries. The interviews have been carried out by native speaking interviewers in German and French, respectively. The average interview duration has been 15 minutes. The basic population of the survey is the German and French resident population aged at least 18. Sampling has been carried out by a multi-stage random sampling procedure, which ensures that each individual of the population has the same statistical chance of being included in the sample. A quota arrangement has not been specified. Overall in Germany, 723 persons have started to participate (response rate: 25%), and 700 have completed the survey of which 197 persons live in the border region. In France, 716 persons have started to participate (response rate: 22%), and 704 have completed the survey of which 202 persons live in the border region. The comparison of this sample with population statistics is provided by Table 3.7 and the regional distribution is given in Table 3.8 and Table 3.9.

	Germany		France	
	Sample	**Population**	**Sample**	**Population**
Respondents	700	83.02m	704	66.99m
Female [%]	47.9%	50.7% [1]	49.6%	51.3% [2]
20 – 29 years	2.0%	15.2% [3]	19.2%	13.3% [3]
30 – 39 years	6.7%	16.1% [3]	15.8%	15.7% [3]
40 – 49 years	18.0%	16.7% [3]	21.7%	14.9% [3]
50 – 59 years	23.3%	17.0% [3]	16.6%	20.4% [3]
60 – 69 years	23.3%	15.6% [3]	11.4%	15.7% [3]
70 – 79 years	17.0%	11.1% [3]	11.2%	11.6% [3]
80 – 89 years	8.0%	6.5% [3]	2.8%	7.1% [3]
90 – 99 years	0.9%	1.8% [3]	0.4%	1.4% [3]
100+ years	0.0%	0.0% [3]	0.0%	0.0% [3]
no formal education	1.3%	4.0% [4]	0.0%	0.0% [2]
primary school	11.9%	31.4% [4]	1.0%	15.5% [2]
GCSEs/O-level	26.7%	29.4% [4]	8.0%	29.6% [2]
A-level	22.6%	13.7% [4]	56.5%	17.8% [2]
university degree	36.4%	17.1% [4]	33.3%	37.1% [2]
other	1.1%	3.8% [4]	1.2%	0.0% [2]

[1] Data of German Government ("Statistisches Bundesamt")
[2] Data of French government ("Institut national de la statistique et des études économiques")
[3] United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2019 Revision. (www.populationpyramid.net)
[4] www.destatis.de; April 18th, 2019

Table 3.7: Sample Characteristics Compared to Population Characteristics (Gender, Age, Education)

States France	Sample	Population
Île-de-France	14.9%	18.8% [1]
Auvergne-Rhône-Alpes	9.8%	12.3% [1]
Hauts-de-France	8.7%	9.2% [1]
Nouvelle-Aquitaine	4.5%	9.2% [1]
Occitanie	3.8%	9.0% [1]
Grand Est	34.8%	8.5% [1]
Provence-Alpes-Côte d'Azur	4.5%	7.8% [1]
Pays de la Loire	3.8%	5.8% [1]
Normandie	4.5%	5.1% [1]
Bretagne	2.8%	5.1% [1]
Bourgogne-Franche-Comté	3.7%	4.3% [1]
Centre-Val de Loire	3.7%	3.9% [1]
Corse	0.3%	0.5% [1]

[1] Data of French government ("Institut national de la statistique et des études économiques")

Table 3.8: Sample Characteristics Compared to Population Characteristics (French Regions)

States Germany	Sample	Population
Nordrhein-Westpfahlen	15.0%	21.6% [1]
Bayern	12.3%	15.7% [1]
Baden-Württemberg	25.9%	13.3% [1]
Niedersachsen	9.9%	9.6% [1]
Hessen	4.3%	7.5% [1]
Rheinland-Pfalz	5.6%	4.9% [1]
Sachsen	3.9%	4.9% [1]
Berlin	3.7%	4.4% [1]
Schleswig-Holstein	2.9%	3.5% [1]
Brandenburg	2.0%	3.0% [1]
Sachsen-Anhalt	2.6%	2.6% [1]
Thüringen	2.7%	2.6% [1]
Hamburg	1.9%	2.2% [1]
Mecklenburg-Vorpommern	1.1%	1.9% [1]
Saarland	6.1%	1.2% [1]
Bremen	0.0%	0.8% [1]

[1] Data of German Government ("Statistisches Bundesamt")

Table 3.9: Sample Characteristics Compared to Population Characteristics (German Regions)

	Border Region Germany		Border Region France	
	Sample	**Population**	**Sample**	**Population**
Respondents	199	3.5m	202	2.9m
Female [%]	49.2%	50.5% [1]	50.0%	51.2% [1]
20 – 29 years	2.0%	15.2% [1]	20.0%	30.9% [2]
30 – 39 years	4.0%	15.2% [1]	18.5%	
40 – 49 years	14.5%	14.9% [1]	17.0%	34.8% [2]
50 – 59 years	20.1%	20.2% [1]	16.0%	
60 – 74 years	40.1%	20.7% [1]	21.5%	22.5% [2]
75+ years	19.6%	13.7% [1]	5.5%	11.9% [2]

[1] www.regionalstatistik.de/genesis; April 20th, 2020
[2] Data of French government ("Institut national de la statistique et des études économiques")

Table 3.10: Sample Characteristics of Borderland Compared to Population Characteristics (Gender and Age)

3.16.4 Research Hypotheses

This section presents the research hypotheses of the study in detail. As highlighted in the literature review, *social capital* is a broad concept considering different angles of society. Several surveys such as the WVS, the ESS, the General Social Survey (Smith et al. 1972-2018), Eurobarometer (Commission 2008), and the German Socio Economic Panel (SOEP) (SOEP 2018) (among others) collect direct measures of attitudes, values and beliefs. In most studies on social capital and cross-national attachment, trust and in particular generalized trust is considered as an equivalent measure for social capital as it captures a positive attitude towards others endowing a sense of cooperativeness and common identity. As it also allows for a high comparability with other studies, *trust* is considered as a first proxy measure for social capital and attachment. Since there are some concerns about the general trust questions which are discussed later and the interest is in cross-regional and cross-country comparisons, the respondents in the presented study are asked for their *specific trust* in people of their own region, their neighboring region, their own country and their neighboring country (e.g. Germany for French respondents).

The first two hypotheses are not linked to the border area as they primarily serve to classify the study with respect to regional and national attachment in general. The first refers to a possible preference of respondents for their own region (home region) and the second refers to a preference for their country (home country). To measure and compare this preference the (specific) trust questions is used. With regard to regional trust, it is assumed that respondents have a higher level of identity with their own home region and therefore a higher level of trust is expected in the home region than in the neighbor region (H1).

There are two versions of this hypothesis, one based on a cross-regional comparison and one based on a region-to-country comparison.

H1a (Regional identity, cross-regional comparison): Trust in people in the home region is higher than trust in people of the (closest) neighboring region.

H1b (Regional identity, region-to-country comparison): Trust in people in the home region is higher than trust in people of the home country (the country in which the home region is located).

With regard to country comparisons there is a similar concept with the so-called *home-bias*. The home bias assumes a preference for one's own country (usually place of residence) over other countries, which is investigated in particular for investment decisions (Guiso et al. 2009, Camerer and Weber 1992).

H2a (Home Country Bias): Trust in people living in the own country is higher than trust in people living in the neigboring country (abroad).

The specific trust of inhabitants of one country in the inhabitants of another country has so far only been systematically surveyed by the European Election Survey (EES) up to the year 2004. With regard to the mutual trust of the inhabitants of Germany and France, these data provide an interesting finding related to the general trust question (choice between "trust" and "no trust" only): In the 2004 survey, 88.1% of French people state trust in French and 82.6% state trust in Germans. By contrast, 75.8% of the surveyed German citizens state trust in Germans and 70.3% state trust in French. Thus, on overall, trust of French people is higher than that of German citizen and not only in French people but in German people, too. Since this survey is also a representative study, a similar result with respect to the within-country and cross-country trust-levels is expected. According to hypothesis H2b, the trust level of French respondents in Germans should be higher than that of German respondents.

H2b (French-German trust, EES-replication): Trust of French respondents in German people is higher than the trust of German respondents in German people.

The next pair of hypotheses should shed light on one of the main research questions with respect to the border region. Higher trust is expected by people living in the border region than by people living outside the border region with respect to (a) their closest neighbored region and (b) the neighboring country (France or Germany).

H3a (Border area regional trust): Trust in people living in a neighbored region is higher in the border area than outside the border area.

H3b (Border area trust in the foreign country): Trust in people living in the neighboring country is higher in the border area than outside the border area.

Apart from trust, there are further variables which proofed to be good proxies for social capital and which are also relevant in the context of citizens' support. The world bank's social capital questionnaire by Grootaert et al. (2004) comprises the following six categories: groups and networks, trust and solidarity, collective action and cooperation, information and communication, social cohesion and inclusion, empowerment and political action. Narayan and Pritchett follow this approach and define social capital as a respondent's "membership in groups", "the characteristics of those groups in which the households were members" and "the individual values and attitudes, particularly their definition and expressed level of trust in various groups, and their perception of social cohesion" (Narayan and Pritchett 1999). Guided by this questionnaire, the respondent's frequency of participation in group activities and the group members' homogeneity with respect to age, religion, education or political attitude are also asked. Finally, it is asked how the respondents perceive the general WTH in their region as well as their own social affiliation to this region. All questions are formulated to be responded on a 4-point Likert scale. From all factors together, an index is formed, which serves as a regional measure of social capital and social attachment. Based on this measure, the fourth hypothesis is stated regarding social capital in the French-German border region (H4) in both a weak and a strong version.

H4a (Social capital in a border region, weak version): The social capital in the border area is at least as high as the social capital of comparable regions within the countries.

H4b (Social capital in a border region, strong version): The social capital in the border area is higher than the social capital of comparable regions within the countries.

Yang et al. (2011) link the helping behaviour to social capital and verify that social capital is strongly interlinked with helping behaviour. This is taken as a starting point for the second part of this study as social capital and WTH in natural disasters are expected to be connected and it is furthermore expected to find a borderland-specific connection in the studied sample. The key research question is whether WTH extends across regional or country borders. In the questionnaire, the participants are confronted with a hypothetical natural disaster scenario: "Now, please imagine that the [neighboring region/neighboring country] was hit by a severe natural disaster (similar to a hurricane in the USA). The state of

emergency already lasts for a week and has meanwhile led to a lack of of essential goods. In addition to the help provided by civil protection agencies and voluntary aid organizations, volunteers from the population are needed. How likely is it that you would drive into the affected area to support people on site? In any case, rather likely, rather unlikely or in no case". The "crisis in the neighbored-area"-scenario has two advantages. First, it is ensured that the people themselves or close bys are not affected and thus no prioritization of help is necessary (in the last case helping locals is expected to be preferred, see e.g. (Yamamura 2016)). Second, it is avoided that geographical distance becomes too much an obstacle for the motivation to help as Gillis and Hagan (1983) find that to be an important influence factor on WTH. In addition, the scenario is fictional and has solely been created for the purpose of the survey. To mitigate the problem of the hypothetical nature of the scenario and to make it easier for respondents to imagine such an extreme situation the participants are also asked if they already experienced a disaster and if they already have provided help in former disasters ranging from donations via social media assistance to volunteering on site as Marjanovic et al. (2012) find a strong correlation between WTH and provided help. In order to get a more differentiated picture, it is asked whether the respondents would welcome help provided by people of a neighboring country or neighboring region if their own region was affected. Expected help is highly positively correlated with WTH according to Guiso et al. (2011). Regarding expected help the participants are asked how they consider the helpfulness of their own region. Perceived helpfulness is both, a proxy for a region's helpfulness and an element of social capital because it gives people a feeling of safety. In accordance with the hypotheses on social capital and trust it is therefore expected that the perceived helpfulness should be higher in the border area than outside the border area (H5).

H5 (Perceived willingness to help in the own and neighbored region): The perceived WTH is higher in the border area than outside the border area.

However, the main interest lies in the willingness to provide help for the (affected) neighboring country and whether this motivation is higher in the border region than outside the border region. With hypothesis H6 it is expected on overall a higher WTH abroad in the border area. Therefore, the straightforward WTH-question is taken as outlined above.

H6 (Border area WTH in the foreign country; two factor test): The WTH towards people living in the neighboring country is higher in the border area than outside the border area.

As WTH is an intricate concept where a variety of influencing factors - and also confounding factors - are at work, an in-depth analysis of the determinants of WTH is performed. The first factors that are considered relevant in the context of crisis aid are individual risk aversion and openness towards other cultures. To measure the respondents' risk attitude, the general risk question is included ("Are you generally a person who is willing to take risks or do you try to avoid taking risks?"), as regularly applied in the SOEP. Although, this question usually is asked in an 11-point Likert-scale, it is transformed to a 4-point Likert-scale in order to make it comparable to the other questions. In addition, the personal trait variables cosmopolitanism and open-mindedness towards other cultures are considered as important influencing factors. According to Koster (2007), openness describes the participation of countries in cross-border economic, social and political linkages with respect to communication, tourism and migration. In his comparison across 26 countries, he finds that religious denomination, higher level of education, being female and living with a partner in a stable relationship are positively related to the willingness to help others. People between 35 and 65 years are most willing to help compared to younger and elder persons. Similarly, people living in a medium-sized town are more willing to help compared to people living in smaller and larger towns (Koster 2007). The many facets of openness are also analyzed in Cucu-Ciuhan and Răban-Motounu (2012) and Caligiuri et al. (2000). The questions are restricted to the experience dimension and ask for different areas of life whether the respondents already experienced contact to other cultures in that dimension (see Appendix). The aggregated level of openness is then calculated by summing up the number of positively confirmed dimensions of experience.

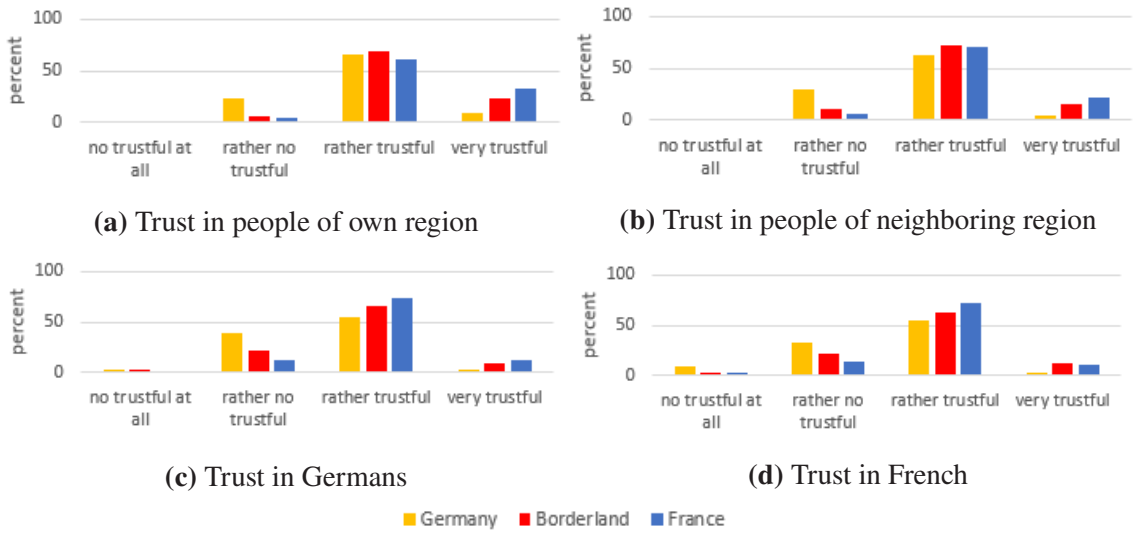
According to Weiner's theory, for the motivation to help being activated, it is crucial whether or not the needy person is perceived to be responsible for his or her own plight (Weiner 1993). Marjanovic et al. (2009) prove this framework to be suitable for studying natural disaster situations. Therefore, it is accounted for the perceived responsibility for disaster preparation and it is asked whether government, aid organizations or the citizens themselves are considered to be responsible. Additionally, it is asked for respondents' confidence that aid will be provided and to what extent the population feels prepared. If the respondents have been already affected by a disaster which required help from outside, they should tell whether the received aid is rated positively or not, depending on whether the help has been provided by state actors, voluntary organizations or private persons. Note that the personal trait variable *altruistic tendency* ((Rushton et al. 1981)) is not considered in this study, since it assumes that there are about the same number of altruistic persons in both countries (i.e. that the countries do not differ significantly with regard to this criterion). Further control variables are socio-demographic variables such as gender, age, and education as they are used in various models to control for socio-demographic effects. Taking all these factors and controls into account, hypothesis H6 is re-analyzed according to H7.

H7 (Border area WTH in the foreign country; multiple factor regression): The WTH of people living in the neighboring country is higher in the border area than outside the border area.

3.17 Results of Empirical Analysis

3.17.1 Trust and Social Capital

This section is started by analyzing the results of the four trust questions asking about trust in people in the own region, in the neighboring region as well as trust in German and French people in general. Figure 3.34 shows the frequencies of responses in percentage.



(a) Trust in people of own region

(b) Trust in people of neighboring region

(c) Trust in Germans

(d) Trust in French

Figure 3.34: Proportions of Trust-levels with Respect to Citizens of Different Geographic Entities

Comparing the four trust-items, the values look very similar at first glance. But a detailed analysis uncovers interesting aspects. First, the regional trust-levels in general are rated a little higher than the countries trust levels. Considering the regions, one can say that there is no big difference between the indicated trust level of the own region and the neighboring region. With hypothesis H1 it is expected to find a *regional identity*-effect with respect to all considered regions of the sample. To answer H1a the level of trust in the own region is compared with the trust in the neighbored region (Regional identity; cross-regional comparison). The level of trust in inhabitants of the own region is 3.09 whereas the trust-level in people living in the neighbored region is 2.96. According to a t-test this apparently small difference is highly significant. However, the difference between trust in the own region with trust in people of the own country is clearly more

evident: the trust level in people of the own country is just 2.77 and the difference is highly significant, too. The results hold true if the French and the German sample are considered separately. To summarize, a highly significant effect is found with respect to regional identity based on the specific trust question. The *identity-differential* between own region and own country is clearly larger than the difference between own region and neighboring region. As expected, geographical closeness and regional scale matter for trust already within the own country.

Hypothesis 2a addresses the *home bias* expecting a higher trust-level with respect to citizens of the own country than to citizens of the neighboring country. German respondents state an average trust-level of 2.59 with respect to German citizens compared to 2.54 to French citizens. This effect is just weakly significant. However, for French respondents it is the wrong direction: Trust in French people (2.96) is slightly lower than trust in German people (2.97), which is remarkable but not significant. On overall, the home-bias-hypothesis can just be weakly confirmed for the German sample. Hypothesis H2b is inspired by the European Election Survey and formulates the expectation that the trust-level in German people is higher for French respondents than for German respondents. This can be confirmed clearly, the difference between the trust-level of French (2.97) and German respondents (2.59) is highly significant. Taken together, an asymmetry of country-specific trust between France and Germany is identified: Trust in German citizens is significantly higher for the French sample and French people have even more trust in German people than in their fellow-citizens (although, as described, this last effect was not significant).

Hypothesis H3 refers to trust-comparisons involving the border area. H3a is interested in whether the regional trust is higher within the border area compared to the benchmark-regions outside the border area. This can be confirmed: The regional trust-level of the border region is 3.02 compared to 2.93 for regions in France and Germany outside the border area. This difference is significant on a 1%-confidence level (t-test, one-sided). However, a separate look at German and French respondents reveals that this effect is mainly driven by the German side: The difference in trust-levels for German participants is 0.13 (2.83 within border region and 2.70 outside the border region) compared to a difference of just 0.04 on the French side (3.18 within border region and 3.14 outside the border region). The difference of the German participants is still significant on a 1%-confidence level (Bonferroni-corrected t-test, one-sided) whereas the difference of French respondents is not significant. These values show that the asymmetry between Germany and France is not due to the fact that French participants of the border region have less confidence in absolute terms. On the contrary, the confidence of French respondents is on overall significantly higher than that of German respondents, but the trust-level in the border region on the French side does not stand out remarkably.

Asking for the respondents' perceived or felt affiliation with respect to the border area a weakly significant result is also found: On average, the felt affiliation to the border region was higher compared to the outside border area ($3.36 > 3.29$; $T = 1.789$; $p = 0.037^{*}$). In absolute terms, the perceived sense of affiliation is greater on the German side of the border than on the French side, but this does not differ significantly from the perceived sense of belonging of other regions in Germany. For the French sample this is exactly the opposite: Although the average perceived affiliation is lower than in the German sample, it is significantly higher than in other French regions. The slightly higher affiliation to the border region is only due to the French sample and is possibly related to the identity-forming specificity of the Alsace region.

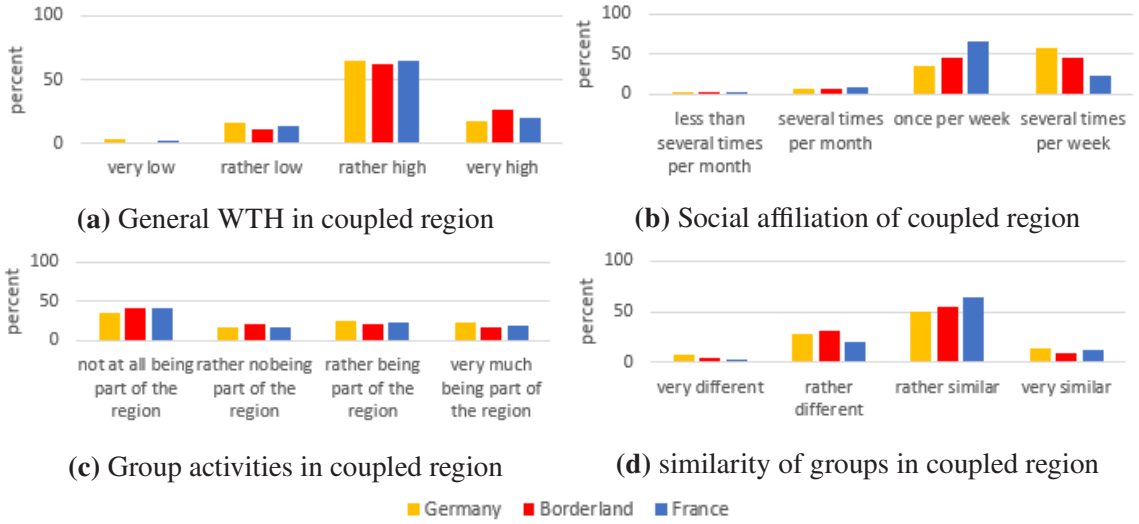
H3b refers to country or nationality-related trust. Table 3.11 shows that the trust level towards German and French people are much closer for respondents living in the border region compared to respondents living within the countries.

Respondents	Trust in Germans		Trust in French		Trust difference
from	mean	variance	mean	variance	of means
Germany	2.59	0.356	2.51	0.473	0.08
Borderland	2.81	0.391	2.84	0.426	0.03
France	2.96	0.314	2.91	0.348	0.05

Table 3.11: Trust Comparsion by Means

The trust-level of the border region towards both, German and French people, lies in the middle of the trust-levels of German and French respondents outside the border region. A closer analysis of the data uncovers that the French part of the border region is adapting to the level of the French and the German part of the border region is adapting to the German level, but the trust level towards all four groups is higher in the considered part of the border region than in the respective countries.

For H3b trust in people living in the other country abroad is measured expecting that this nationality-related trust-level should be higher in the border area. On overall, the hypothesis H3b can be weakly confirmed. The trust-level of people living in the border region to citizens of the other country (2.81) is higher than outside the border region (2.76) and this effect is weakly significant on a 5%-confidence level (t-test, one-sided). A separate look at the French and German sample reveals that this effect is too weak to survive the Bonferroni-correction. A further look at Table 3.11 also shows that the (nationality-related) trust-level in the border region rather matches the lower trust-level of German respondents (in French people) than the higher trust-levels of French respondents (in German people).



(a) General WTH in coupled region

(b) Social affiliation of coupled region

(c) Group activities in coupled region

(d) similarity of groups in coupled region

Figure 3.35: Further Components of Social Capital

In a second step, this study goes beyond the specific trust questions and takes a more differentiated look at the concept of social capital. As described in Section 3.16, in the questionnaire it is also asked for further factors relevant for civic mindedness and a cooperative attitude. These factors are general willingness to help in the joint region (own and neighbored region), social affiliation to the joint region, group activities of respondents in her/his joint region and in-group similarities besides trust-level towards people in the own region. A reliability analysis of the data is performed, which leaves the three remaining factors general willingness to help in the joint region, social affiliation to the joint region and trust towards people in the own region. From these three values, a mean index, the SCI is calculated with a Cronbach's alpa of 0.611. Moreover, factor analysis only finds one component such that the measure is considered as well appropriate.

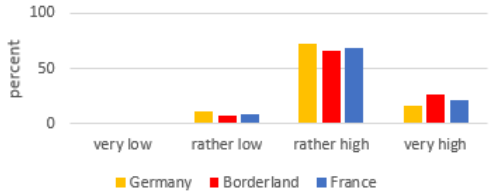


Figure 3.36: Social Capital Index (SCI)

The SCI is used to test hypothesis H4 stating that the average level of social capital should be at least as high (H4a) or even higher (H4b) in the border region than in all other regions of the sample. The result is unambiguous: The level of social capital in the border region (3.19) clearly exceeds the level of social capital outside the border region (3.08) by 0.11 index-points. This difference is highly statistically significant on a 0.1%-confidence level

(t-test, one-sided). This remarkable finding even confirms the strong variant of hypothesis H4 and thus automatically confirms the weak version, too. Looking at French and German respondents separately, it becomes evident that there is no country-related asymmetry with respect to the SCI. Both sides of the border region display a higher SCI than the outside-borderland-regions of the respective country. The SCI for the German sample is 3.14 for the German side of the border compared to an SCI of 3.04 in all other German regions (outside the French-German border). The picture is similar for the French sample despite the higher SCI-level in absolute terms: The SCI for the French side of the border region is 3.23 compared to a level of 3.12 for all other regions in France outside the border area. Both reported nationality-related differences are still weakly significant (5%-confidence level; Bonferroni-corrected t-test). Table 3.12 summarizes the statistical tests for the set of hypotheses H1-H4 with respect to trust and social capital.

		Mean	Test	N
H1a	trust own region	3.09	$9.358(0.000^{***})$	1301
	trust neighbored region	2.96		
H1b	trust own region	3.07	$16.856(0.000^{***})$	1281
	trust own country	2.77		
H2a	trust own country	2.79	$0.237(0.813)$	1172
	trust neighbored country	2.78		
H2b	trust GER → GER	2.59	$-11.792(0.000^{***})$	673
	trust FRA → GER	2.97		
H3a	trust neighbored region BR	3.02	$2.457(0.007^{**})$	372/938
	trust neighbored region \BR	2.93		
H3b	trust neighbored country BR	2.81	$1.127(0.023^{*})$	372/864
	trust neighbored country \BR	2.76		
H4	Social Capital Index BR	3.19	$3.273(0.001^{***})$	399/1004
	Social Capital Index \BR	3.08		

GER=Germany
FRA=France
BR=Border Region
\BR=full sample except Border Region

Table 3.12: Test-results of Hypotheses H1-H4

3.17.2 Willingness to Help

The second part of the study focuses on the WTH across national borders as motivated by the natural disaster scenario. First, there are reported some general insights in people's

experience with natural disasters and their attitude towards the social and political conditions for providing and receiving spontaneous help to and from other people. Second, the test results with respect to hypotheses H5 and H6 are provided. In the disaster scenario, the target group of help is either the neighbored region or the nearest country abroad. Unlike the trust question, which is a quite powerful proxy for positive social attitudes towards other (groups of) people, the willingness-to-help-question provides at best mixed and even contradictory results in comparative hypothesis testing. This is not only due to the hypothetical nature of the question but is also related to the fact that the motivation to help hinges on a large number of activation conditions as already outlined in Subsection 3.16.4. Therefore, in a final step, the results of a regression analysis are presented, which provides more differentiated insights into the WTH towards other citizens across a national border, mostly along the lines of Weiner's motivation theory. Considering the complete dataset of 1404 respondents, only 122 respondents (8.7%) have experienced already a natural disaster that required help from outside. For France, this number corresponds to 5.6% of French respondents, which is lower the proportion of the German sample with 11.9% of German respondents. Interestingly, individuals living in the borderland have been more often involved in natural disasters as the mean of both countries indicates. With regard to own provided help in a disaster situation, it is distinguished between donations, direct help on site, help via social media, help as a member of voluntary organizations and help as a professional task. Figure 3.37 illustrates the frequencies for the French, the German and the borderland sample. The self-reported help of the German sample is clearly higher than the French one which is also true for each category. The by far largest fraction of help refers for all respondents to donations.

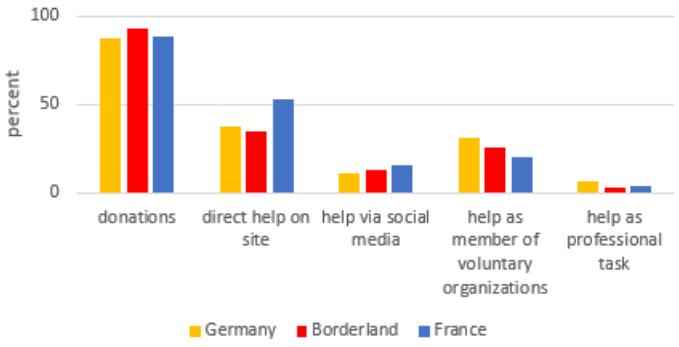
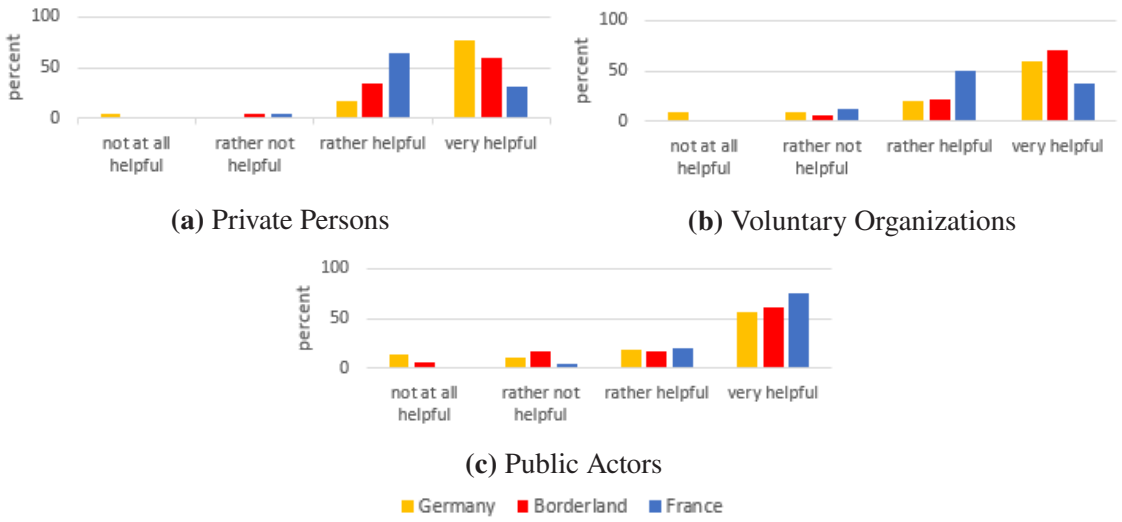


Figure 3.37: Provided Help

Of those experienced respondents, 62.1% rate the received help from government as very helpful and only 7.8% rate the help as not at all helpful (in the questionnaire it it asked for "state support" comprising fire fighters, police and army). Considering the received help of volunteer aid organizations, 58.2% rate it as very helpful and 4.1% rate it not at all helpful. Furthermore, 61.7% rate the received help from private persons as very helpful and only 2.6% rate the help as not at all helpful. Figure 3.38 outlines the figures by region

and Figure 3.39 shows the correlations (Spearman-Rho) between the received help of all three groups of actors, significant correlations at a level of 0.01 (two-sided) are highlighted by **.



(a) Private Persons

(b) Voluntary Organizations

(c) Public Actors

Figure 3.38: Experience of Received Help by Source (Frequencies)

Interestingly, there is a significant correlation between the experience of received help from aid organizations and the government as well as between the rating of helpfulness of voluntary organizations and private persons, but not between private persons and the government. This hints at the important intermediating role of voluntary organizations in a disaster context.

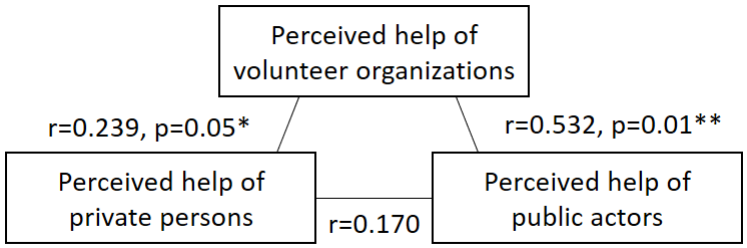


Figure 3.39: Experience of Received Help by Source (Correlations)

In addition to the experienced helpfulness of different actors the perceived responsibility for emergency help is also asked. As expected, in both countries the majority of the population clearly considers the state being responsible for providing for the population, in France somewhat more (81.3%) than in Germany (60.3%), where voluntary aid organizations are held more accountable (10.1% in the French sample compared to 34.4% in the German sample). The population itself is not considered to hold the main responsibility in both countries (8.6% in France compared to 5.3% in Germany).

Furthermore, there is a significant correlation (Spearman-Rho of 0.341) between the perceived helpfulness of government and the respondents' confidence that the government manages to support and supply people in the aftermath of a natural disaster. However, there is no significant correlation between the perceived helpfulness of private persons and the confidence in the population being able to deal with a natural disaster. Moreover, the Spearman-Rho is a negative number of -0.183. However, this finding is somewhat plausible. While civil protection is the task of the government, which disposes over the required resources (i.e. technical equipment, infrastructure and competence), the population is first of all a victim of natural disasters. Whether people are affected or can provide help to each other depends to a large extent on the concrete circumstances. Experienced respondents are less confident that a natural disaster can be handled adequately. Only 20.7% of them have confidence that citizens can deal with a natural disaster without professionals while among people without experience the proportion is similar, albeit slightly higher (24.0%). With respect to professional help, the optimism of unexperienced people is even more expressed: While 33.6% of experienced respondents are confident that professionals can handle the situation but a remarkable 43.5% of respondents without disaster experience hold this belief. In both countries, there is very strong confidence in the abilities of government support, nevertheless it is somewhat higher in France (in France 94.9% agree or rather agree (full agreement at 55.1%) compared to 81.4% agree or rather agree (full agreement at 28.3%) in Germany).

Regarding the expected help on the one hand and the provided help on the other there is an interesting asymmetry observable between French and German respondents. French respondents consider the self-help potential of the population to be higher (79.7% agree or rather agree) than those in Germany (49.1% agree or rather agree). However, in Germany 67.1% of the respondents have already provided assistance to others whereas in France this proportion was only 24.6%. Based on this, one could cautiously conclude that the French interviewees are too optimistic and the German respondents are too pessimistic about the help they could expect from their fellow citizens. Moreover, it is to highlight that respondents in the borderland answer these questions according to their national identity in contrast to the previous findings that trust and social capital are reported higher by respondents living in the borderland.

Considering the risk attitude of respondents, it can generally be said that 6.3% of respondents rate themselves as highly risk seeking, 42.0% as rather risk seeking, 39.2% as rather risk averse and 12.5% rate themselves as highly risk averse. In general it is plausible to expect that people who are rather risk seeking should express a high confidence in the population's SHC whereas a rather risk averse individual should express the opposite attitude. In addition, a risk averse individual should express a higher level of confidence in the state's capability to cope with a disaster. However, the personal risk attitude of

the respondents does not influence their confidence in the ability to deal with a natural disaster.

As a last aspect of the overall data analysis, the descriptive statistics on the variable "general openness towards foreign countries" is also briefly reported. In general, it can be stated that 85.8% of respondents agree to at least one of the surveyed possibilities to be in contact with people from other countries. In detail, the option "having relatives or friends in another country" is picked by 64.0% from all respondents. This is followed by "spending holidays regularly in another country" with 54.7% agreement. 45.8% of respondents consume literature or media from another country. Additionally, 26.2% are volunteering for people abroad or for foreigners in their home country and 24.6% of all respondents work in another country or have regularly exchange with international colleges. The specific answer frequencies of these five items for the French and German sample as well as for respondents living in the border region are illustrated by the bar charts of Figure 3.40.

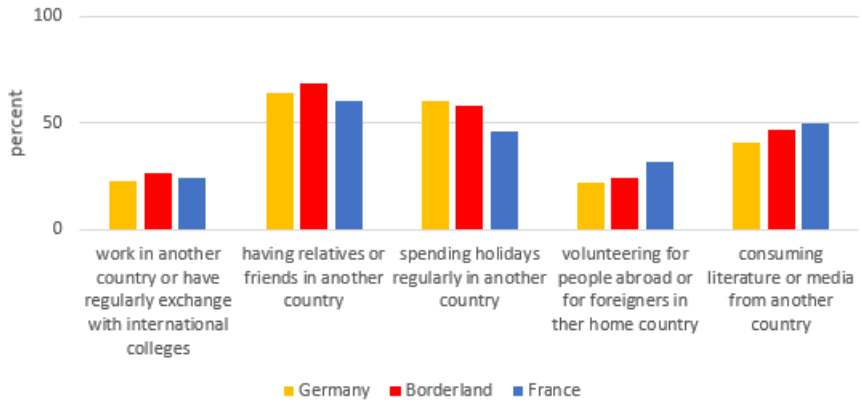


Figure 3.40: Openness

These five items are aggregated to one openness-index and crosschecked for the relationship between openness and risk preference. Figure 3.41 shows a strongly positive relationship for the extreme ranges of highly risk averse and highly risk seeking individuals but no difference for moderate risk preferences in the middle range (rather risk averse and rather risk seeking).

After this first overview on disaster relevant attitudes and perceptions now the hypotheses H5 and H6 are presented with respect to noteworthy differences in the WTH abroad between the border area and the regions outside the border area. In general, the expressed WTH in the hypothetical scenario is high for the respondents of both countries: 72.8% of the German respondents would rather or definitely help and 70.4% of the French sample claim to help (rather or definitely). This is also in line with the perceived WTH in both countries. The mean rating of (perceived) WTH in the own region is 3.00 for German

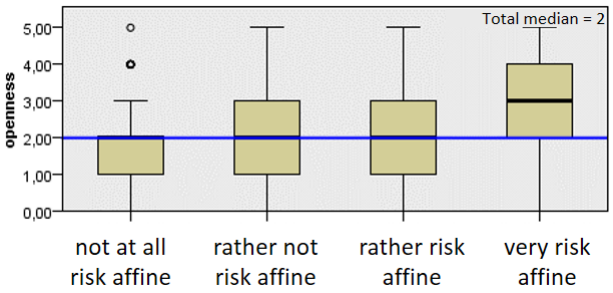


Figure 3.41: Relation between Openness and Risk Attitude (Median Test for Independent Samples)

regions and 3.07 for French regions. On overall, this already high expectation is even higher in the border region (3.13) than outside the border area (3.00). Since this result is also highly significant on a 0.1%-level (one-sided t-test, $T = 3.416,\ p = 0.0005^{***}$), hypothesis H5 can be confirmed. A closer look at the data shows that there is also a significant difference in the expected direction in both countries while the higher expectations (or more positive or optimistic beliefs) are found again in the French sample. On the French side of the border region, the average score for perceived helpfulness in the extended region is 3.19 (on the German side this number is 3.03) compared to 3.03 for the rest of France (and 2.97 for the rest of Germany). The respondents' WTH in the closest neighboring country is somewhat lower but again on a similar level in both countries: 55.6% of German respondents would help in their neighboring country compared to 57.7% of the French sample. With respect to hypothesis H6 it can be stated that the WTH abroad is larger in the border area (2.71) than outside the border area (2.61). However, this effect is just weakly significant ($T = 1.701,\ p = 0.0445^{*}$) and is mainly driven by the German respondents: The difference between the WTH-values of the border area and outside the border area is +0.20 for the German sample (2.81 within the border area compared to 2.61 outside), which is even strongly significant ($T = 2.454,\ p = 0.007^{**}$). In contrast, the mean values for the French respondents are identical at a level of 2.61 ($T = 0.013,\ p = 0.445$).

While there is an asymmetry between France and Germany with respect to an increased WTH in the border region, there is clear evidence of a welcome culture between both countries: Among German respondents, 96.6% hold the belief that during a crisis foreign helpers would be welcome and 98.0% among French respondents hold this view. This positive perception is slightly higher in the border area but this difference is not significant.

As outlined above, it is more difficult to measure WTH by a survey compared to general attitudes and beliefs. In addition to the hypothetical crisis scenario there are a number of drivers but also obstacles for help in an extreme situation. In particular, helping across a border comes with additional problems and risks which is why it is explicitly asked for the most evident obstacles or "hurdles" for engaging in help: "The distance is too far for me", "there are communication/language barriers", "the culture of the neighboring country is unfamiliar to me", "the procedures of crisis management are unknown to me", "I would

be afraid to violate the laws of the neighboring country out of ignorance when helping", and "I don't know who to turn to for helping". As Figure 3.42 shows, the interviewees state some of these problems. According to the diagram, the most frequently mentioned problem by French and German respondents is the problem of unfamiliarity with the crisis management procedures in the respective country. The second most frequently mentioned problem by French respondents is problem of language and communication deficiencies. The fact that in the event of a crisis one would not know who to turn to is mentioned by the German participants as the second most frequent reason.

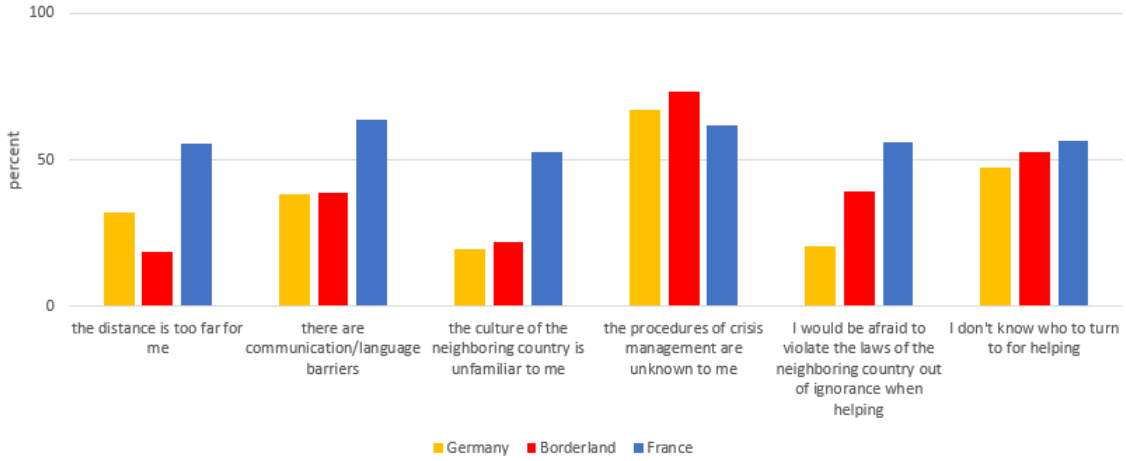


Figure 3.42: Perceived Problems in Helping Across a National Border

If, however, the assessment of the border with regard to disaster control is asked directly, a more positive picture emerges. Among all respondents, 13.8% see the border to the foreign country as a very big advantage, 48.6% as a clear advantage, 8.5% as a clear disadvantage and only 1.5% as a very big disadvantage. However, 21.3% also rate the border neither as an advantage nor as a disadvantage.

After a detailed analysis of the single driving factors for WTH in a hypothetical natural disaster scenario, now an in-depth analysis is presented highlighting the importance of each factor by a regression model. In detail, the SCI is taken as discussed in hypothesis H4 and transformed the responsibility variable into a binary variable with value 1 if people themselves are considered to be responsible and 0 otherwise. Also the variables openness and difficulties for helping abroad are taken into account. In the first regression, openness and difficulties are considered to be the sum of positive statements in the respective

variables. The data for WTH in a neighboring country can be found in Table 3.13. The analysis estimates the following regression-equation:

$$\begin{aligned} \text{WTH}_{\text{neighboring country}} = \alpha &+ \beta_1 * \text{SCI} \\ &+ \beta_2 * \text{Responsibility} \\ &+ \beta_3 * \text{Confidence}_{\text{private persons}} \\ &+ \beta_4 * \text{Confidence}_{\text{public actors}} \\ &+ \beta_5 * \text{ReceivedHelp}_{\text{private persons}} \\ &+ \beta_6 * \text{ReceivedHelp}_{\text{voluntary organizations}} \\ &+ \beta_7 * \text{ReceivedHelp}_{\text{public actors}} \\ &+ \beta_8 * \text{RiskPerception} \\ &+ \beta_9 * \text{Age} \\ &+ \beta_{10} * \text{Gender} \\ &+ \beta_{11} * \text{Education} \\ &+ \beta_{12} * \text{Openness} \\ &+ \beta_{13} * \text{Difficulties} \end{aligned}$$

Responsibility has a significantly negative impact on WTH. At first glance, it is surprising that the people who consider the population being responsible are less helpful, especially since the theory considers responsibility to be conducive to helpfulness. One plausible explanation is that these people perceive responsibility also as an individual task: If everyone behaves responsible and takes enough precautions, there is no need to expect help from outside or to provide help. Interpreted this way, an individual who sees affected people self-responsible for their faith of not taking prevention measures will certainly show a lower WTH. In addition, difficulties do have a significant impact while openness does not. Moreover, age, gender and education do not have any significant impact on WTH in both settings. Interestingly, also the SCI does not have a significant impact on WTH in a country abroad.

The readiness to help in another country also depends on the geographic distance. Therefore, when referring to a neighbored country, it is necessary to control for distance, which is not necessary for the regional comparisons ("control by design"). Initially, two ways are taken to control for distance: First, the aspect of distance is included in the battery for "difficulties for help across a border" where the respondents' could choose the option "The distance is too far for me". This is called "subjective distance" because it just depends on the respondent's own judgment whether the destination is too far or not. Second, for each region (each German "Bundesland" and each French "Région") the location of the *population center* is calculated and the direct distance from the population center to the

Model	Non-standardized coefficients		Standardized coefficients		
	Regression coefficient	Std.-Error	Beta	T	Sig.
constant	2.018	0.998		2.021	0.047*
SCI	0.069	0.165	0.043	0.421	0.675
Responsibility	−0.408	0.296	−0.147	−1.380	0.172
Confidence in private persons	0.117	0.100	0.123	1.167	0.247
Confidence in public actors	0.036	0.131	0.029	0.274	0.785
Received help by private persons	−0.020	0.140	−0.015	−0.144	0.886
Received help by voluntary organizations	−0.026	0.143	−0.024	−0.185	0.853
Received help by public actors	0.047	0.115	0.051	0.415	0.680
Risk perception	0.207	0.127	0.174	1.624	0.109
Age	0.003	0.006	0.049	0.478	0.634
Gender	0.012	0.184	0.006	0.064	0.949
Education	0.094	0.106	0.095	0.890	0.377
Openness	−0.079	0.078	−0.111	−1.012	0.315
Difficulties	−0.304	0.053	−0.587	−5.707	0.000***

Table 3.13: Regression $WTH_{\text{Neighboring Country}}$

closest neighboring country (closest point of the border) is measured. Roughly speaking, the population center is a region's center of gravity weighted by the population density. Unfortunately, the geographic coordinates of each respondent's place of residents are not known (it is not asked to grant the participants anonymity) to determine the distance directly. However, as this is a representative survey in terms of size and sampling procedure, the population center represents a good approximation. The distance between the population center and the border of the closest neighboring country is interpreted as the "objective distance". Correlation analysis showed that this measure of objective distance has the expected sign but is not significant (Pearson-Correlation-Coefficient of $r = -0.002$). However, for the measure of subjective distance a significantly negative correlation (Pearson-Correlation-Coefficient of $r = -0.367,\ p = 0.000^{***}$) can be stated. This difference is striking because it should be plausible that also the objective distance should matter, in particular for the French sample, where objective distances to neighboring countries are quite long. However, this finding is instructive as it shows that it is better to ask people directly for their perceived "handicap" instead of taking an objective value. Hence, just the subjective distance variable is included in the regression. Thus, another regression analysis is performed interchanging the variable difficulties by this subjective measure of distance, see Figure 3.14.

As another variant to measure WTH, it is also asked how welcome helpers are, which should be similar to the WTH-concept according to Guiso et al. (2011) and Deckop et al. (2003) as well as the variable "provided help". A higher average rating is found with respect to the "welcome helpers"-variable compared to the WTH-variable, which is seen as an indicator for honest replies as people were taking the efforts of providing help into account and less social desirability of responses. The positive correlation between WTH and provided help underlines this statement. In a last step of analysis, the border region is taken as additional factor in the regression to analyze WTH in neighboring countries. Therefore, a binomial Variable "region" is introduced distinguishing whether a respondent lives in the border region (i.e. region= 1) or not (i.e. region= 0).

Model	Non-standardized coefficients		Standardized coefficients		
	Regression coefficient	Std.-Error	Beta	T	Sig.
constant	0.931	0.991		0.939	0.351
SCI	0.117	0.168	0.073	0.699	0.487
Responsibility	−0.454	0.301	−0.163	−1.508	0.136
Confidence in private persons	0.082	0.101	0.086	0.811	0.420
Confidence in public actors	−0.006	0.133	−0.005	−0.047	0.963
Received help by private persons	0.053	0.141	0.038	0.375	0.709
Received help by voluntary organizations	−0.150	0.149	−0.135	−1.006	0.318
Received help by public actors	0.223	0.120	0.239	1.864	0.067
Risk perception	0.211	0.129	0.177	1.627	0.108
Age	0.004	0.006	0.067	0.642	0.523
Gender	0.151	0.188	0.080	0.803	0.425
Education	0.064	0.107	0.065	0.603	0.549
Openness	−0.006	0.079	0.008	0.076	0.940
Distance	−1.083	0.200	0.570	−5.424	0.000***

Table 3.14: Regression $WTH_{\text{Neighboring Country}}$ Detailing Distance as Driver of Difficulties

$$\begin{aligned}\text{WTH}_{\text{neighboring country}} = \alpha &+ \beta_1 * \text{SCI} \\ &+ \beta_2 * \text{Responsibility} \\ &+ \beta_3 * \text{Confidence}_{\text{private persons}} \\ &+ \beta_4 * \text{Confidence}_{\text{public actors}} \\ &+ \beta_5 * \text{ReceivedHelp}_{\text{private persons}} \\ &+ \beta_6 * \text{ReceivedHelp}_{\text{voluntary organizations}} \\ &+ \beta_7 * \text{ReceivedHelp}_{\text{public actors}} \\ &+ \beta_8 * \text{RiskPerception} \\ &+ \beta_9 * \text{Age} \\ &+ \beta_{10} * \text{Gender} \\ &+ \beta_{11} * \text{Education} \\ &+ \beta_{12} * \text{Openness} \\ &+ \beta_{13} * \text{Difficulties} \\ &+ \beta_{14} * \text{Region}\end{aligned}$$

Results are given in Table 3.15.

Living in the border region has a small negative impact on WTH in a neighboring region, which is expected to result from the larger distance because it is positively correlated with WTH in a neighboring country. It can be concluded that people living in the border region are more willing to help in their neighboring country than in their neighboring region. In this regard, hypothesis H6 is supported by the data and there is a somewhat higher WTH across national borders in the border region than within the respective countries.

Model	Non-standardized coefficients		Standardized coefficients		
	Regression coefficient	Std.-Error	Beta	T	Sig.
constant	2.031	1.002		2.028	0.046*
SCI	0.054	0.166	0.034	0.327	0.744
Responsibility	−0.436	0.299	−0.157	−1.458	0.149
Confidence in private persons	0.118	0.100	0.123	1.171	0.246
Confidence in public actors	0.049	0.133	0.040	0.370	0.712
Received help by private persons	−0.002	0.142	−0.001	−0.013	0.990
Received help by voluntary organizations	−0.051	0.147	−0.046	−0.351	0.727
Received help by public actors	0.055	0.115	0.059	0.477	0.635
Risk perception	0.205	0.128	0.173	1.608	0.112
Age	0.003	0.006	0.051	0.490	0.626
Gender	0.010	0.187	−0.005	−0.054	0.957
Education	0.088	0.107	0.089	0.820	0.415
Openness	−0.089	0.079	−0.124	−1.116	0.268
Difficulties	−0.297	0.054	−0.574	−5.482	0.000***
Region	0.162	0.216	0.080	0.753	0.454

Table 3.15: Regression $WTH_{\text{Neighboring Country}}$ Distinguishing for Respondents living in the Border Region

3.18 Summary and Discussion of Empirical Analysis

In this study a novel approach is developed to empirically measure unique characteristics, in particular social cohesion and attachment, of borderland regions, which play an increasing role in today's globalized world. In particular, the task to measure the borderland identity of the French-German border region is approached by comparing it to regional identity within the respective countries, which can be applied to study border regions in general. In the context of regional resilience, the findings of this study are relevant for organizations in the field of crisis management and crisis prevention in order to correctly assess regional SHC. But also policy makers can use this data basis to derive long-term action needs. This can be achieved by strengthening inter-regional cohesion, from which the regions concerned will benefit both socially and economically.

3.18.1 Key Success Factors for Borderland Resilience

In its "Practical Guide to Cross-Border Cooperation" the European Commission motivates an enhanced cross-border cooperation between member countries by the objectives "to redress the imbalances, inequalities and problems of peripherality caused by the barrier effect of national borders", to better enable regions in their function of a "motor of cross-border cooperation" and to give citizens living in a border area the opportunity "to develop a common historical awareness and to find or to revive a common way of thinking that [is] more strongly oriented towards a European future" (European Commission and Association of European Border Regions (ABER) 2000). As a substantial part of the regional development programs, EU-crossborder activities and policies span over a large spectrum of areas such as transport and infrastructure, environment, education or health and social services and is reflected by cross-country regional project initiatives such as the INTERREG-program. These measures show the great importance of cross-border cooperation. However, this political agenda can only succeed if the population is receptive to cross-border cooperation in its everyday life and has a sufficiently positive attitude towards the neighboring country. Borderland regional attachment and social capital can thus be seen as an important prerequisite in the sense of a critical potential for a deeper regional integration of two countries. To shed light on this potential, the objective of the presented study is to quantify borderland attachment taking the example of the French-German border. The focus is on regional social capital, trust and the WTH of citizens with respect to a hypothetical crisis scenario. The citizens' supportive attitude towards each other is of interest because this reflects a form of cooperativeness, which is of high importance when a part of the region is hit by a natural disaster or a comparable crisis situation in which spontaneous solidary and grassroot-support among citizens is of high value. With respect to social capital and trust, the existing databases provided by the

established large-scale surveys such as WVS or the ESS could not be used, because the data is too highly aggregated on a national level. To be able to run a regional analysis a novel approach is introduced comparing on a regional level the border area with regions within the countries. To define regions of roughly comparable size in both countries it was decided for the NUTS-1-level in Germany (corresponding to the Federal states, i.e. "Bundesländer") and in France (corresponding to French "Régions" as officially defined up to the year 2015). Although NUTS-1 is still rather large-scale, it appears as a good compromise between the necessary regional resolution on the one hand and the feasibility constraints for a study covering two entire countries on the other hand. For this study, a regional focus is a must as it needs to make comparisons with the border region: First, trust and social capital are influenced by factors such as identity and familiarity with the local conditions and thus comparing country-level trust with borderland trust-levels is inappropriate. This way, also country-wide discrepancies such as differences between North and South are accounted for. Second, to compare the respondents' WTH in a neighbored region requires regions of comparable size because geographic distance is a decisive factor for the motivation to help according to Weiner (1993). However, there could be a minor issue in that the regions of the two countries have a systemic difference in size: As the French "Départements" are in general larger than the German "Landkreise" and as France is a centralized and Germany a Federal country the regional focus in Germany might be stronger in general. For the borderland this could imply that the French people may feel somewhat less involved and connected to this area than the German inhabitants. However, for an aggregate comparison between the border area with all regions outside the border area, any country-specific difference should not impact the results due to the parallel design. The border area of France and Germany is chosen because it is widely seen as a region with an own regional identity. In the course of history, the Alsace-region did not always belong to France, instead it was switching between Germany and France several times. In spite of "the difficulties and perhaps even the impossibility of characterizing a collective identity over a long period of time", Anderson acknowledges "a much richer character" of the Alsatian community as well as "a very definite identity marking it off from other French and European regions" (Anderson 1972). Therefore, rather a regional identity than a national identity is expected following the distinction of Adrot et al. (2018). From a geographical and administrative point of view, the border area is defined according to Kuhn (2012). For all considered regions of this sample a regional identity effect is found by comparing the trust-level of the own region with both the neighbored region and the neighbored country. In addition, a specificity of country-level trust between France and Germany could be replicated, which has been also revealed by the EES before: French people show significantly higher trust in German people than Germans have themselves. With respect to the regional identity of the border area a significantly higher trust level for the border region is found compared to all other regions

of the sample outside the border area and a weakly significant effect if it is asked for the sense of regional affiliation. While the trust-level of the German respondents is lower on overall, the difference between the German side of the border area and the "rest of Germany" is the main driver of the result of hypothesis H3a. In contrast, for "sense of regional affiliation" the exact opposite finding is received: Albeit lower in absolute terms it is the French part of the sample which leads to the (weakly) significant effect. The last effect can most plausibly be contributed to the specificities of the Alsace-region as described above. However, it is still remarkable that the higher trust in the border area is less an "Alsace-effect" but rather stems from the German districts of the border area. In this study trust is used as a proxy for social capital, a concept which has been measured in various types of interviews and surveys by different instruments. Putnam has compared data of Americans over time and concludes "We are nowhere near having the same clear metric as years of education is for human capital and we are certainly not near having that kind of data over time. [...] But I think it is probably a powerful predictor of many things, enough so to make it well worth our attention." (Putnam 2001). Since there is no defined measure for social capital, it is a challenging task to find the right approach (Johannes and Vukenkeng 2016). This study examines social capital in a wider context which also comprises disaster solidary in the second part. To gain a more differentiated insight into borderland-specific factors of social capital, the most widely used proxies for social capital are taken which are established in the literature but also appropriate for the objectives of this study. In particular, the approach is based on the dimensions of Grootaert et al. (2004) in their World Bank study. Narayan and Pritchett define social capital in the World Bank study by first, "membership of respondents in groups; second, the characteristics of those groups in which the households were members; and third, the individual's values and attitudes, particularly their definition and expressed level of trust in various groups and their perception of social cohesion" (Narayan and Pritchett 1999). Since one focus of this study is on WTH in the aftermath of natural disasters, the presented approach additionally includes the perceived general WTH in the region. By doing this it is borrowed from the Perceived Neighborhood Social Cohesion Questionnaire by Dupuis et al. (2016), which validates the use for a French-German comparison. Thus, a measure of social capital is constructed going beyond the traditional measures which were mostly designed for economic studies. After conducting a reliability analysis (Cronsbach's alpha of 0.510), the variables WTH, trust group activities and sense of regional affiliation are found to capture some new aspect of regional attachment. Out of these three variables a SCI is constructed, which is found to be significantly higher in the border area than outside the border area. Interestingly, in contrast to the discovered effects when testing for trust or affiliation alone, this finding can not just be traced back to one country as a single effect-driver but remained (weakly) significant for both, the French and German part of the sample. This is a strong finding as it shows that the French-German border area is in fact a "high

potential"-area with respect to the formulated EU-policies for cross-border integration and cooperation. Note that this result is neither due to higher levels of attachment towards the neighboring country per se (which should be no surprise in a border area) nor due to pure regional identity (which was found to be equally strong over the whole sample). As it is controlled for country-specific and regional-specific effects by design, those elements of social capital can be extracted, which are unique to the considered border area. Albeit not within the scope of this study, the question follows to what extent this finding is generally characteristic of border regions (including the question whether borderland attachment could possibly also be a result and not just a prerequisite of EU policies) or whether it is a very specific feature of the regions at hand. These are further questions for future research. To answer such and similar questions, this approach could very easily be applied to e.g. the French-Spanish or the German-Polish border and thus different border regions with regard to the driving factors of regional social capital can be directly compared. At least for the French-German border region there is a borderland study with a somewhat different perspective conducted by Kuhn (2012). Analyzing Eurobarometer data from the year 2006, she finds that "living in a border district is a powerful predictor of individual transnationalism, which in turn has a strong negative effect on Euroscepticism." Although her concept of "individual transnationalism" is closer to the openness-index and does not include attachment-variables such as trust or regional affiliation, it is a supportive finding complementary to this study. Before turning to the discussion of the WTH-analysis, some methodological remarks with respect to the measurement of trust are made. As the study is conducted on a regional level, the presented data is of higher resolution than the aggregated data of most established surveys, which focus on the country-level. As e.g. Stephany shows, regional differences matter (Stephany 2019). In his study, which is based on ESS 6 data, he regionalizes trust on a NUTS1-level and identifies for Germany a clear East-West-discrepancy while France appeares quite homogenous. Apart from this contribution, there is no regional trust survey for whole countries available. However, the aggregated data seem to match the existing data quite well with one noticeable exception. France is very often perceived as a low trust culture while Germany is perceived to be a high trust culture (Fukuyama 1995). According to data from the World Value Survey (WVS) (2006), 18.7% of French respondents state that "most people can be trusted" while 80.8% are of the opinion that "one need to be careful in dealing with people" (Inglehart et al. 2014). In Germany, 33.8% of respondents belief that "most people can be trusted" while 59.7% state that "one need to be careful in dealing with people". The hypothesis of lower trust of French people is also supported by an economic lab experiment by Willinger et al. (2003) who analyze the results of an investment game (a similar variant of the trust game) between German and French students. As outlined above, there is no evidence for this effect in this study but rather the opposite: The trust-level of French people to their French citizens (2.96) is higher than the trust of German respondents with respect to

German citizens (2.59). Is is assumed that the reason for this difference lies in the way how trust was aksed for. Contrary to the WVS, which asks for trust in people in general, in this study a directed trust question is taken, which explicitly refers to a well-defined group of trustees (in this case defined by region or country). However, this does not explain the deviation from the experimental results from Willinger et al. (2003). Another explanation can be an anchoring effect: As the directed trust questions are asked one by one and started with trust in the own region, it is possible that the respondents have taken this first question unintentionally as an anchor which could have impacted the answers to the following questions. However, as all "own region"-trust-scores are high and nevertheless significant differences are found, this anchoring effect should be negligible. Finally, people living in the border region are over-represented in this study, which increases the mean level of trust. Similar to the presented study, the Eurobarometer in 1990 surveyed how strongly the countries in the European Union trust each other. Although these older records do not perfectly coincide with the presented findings, already here the hypothesis of France as a low-trust-nation is not confirmed (Germans trust other Germans on a level of 3.59 and French people on a level of 2.86 whereas French trust French with a trust level of 3.40 compared to 2.96 towards Germans). Another point to discuss in a cross-cultural context is which type of trust question is an appropriate measure and whether it is understood in a similar manner. Since long there is an ongoing discussion whether the standard, one-dimensional trust question as it is used in the WVS (Inglehart et al. 2014) ("Generally speaking, would you say that most people can be trusted or that you need to be very careful in dealing with people?") is a robust and reliable measure of trust. Johnson and Mislin (2012) validates the WVS trust question by an investment game experiment. Bellemare and Kröger (2007) find that the behavior in investment games constitutes a lower bound of behavior in a real life setting. Similar results are found by Sapienza et al. stating "If we accept that trust is the expectation about other people's behaviour, then both the answers to the WVS-question and the sender's expectation in a traditional trust game can be used as a measure." (Sapienza et al. 2013). In contrast to this, Glaeser et al. (2000) compare the answers in questionnaires with trusting choices in lab experiments and find that the general trust question rather measures trustworthiness than trust. Ermisch et al. (2009) and Gächter et al. (2004) come to similar conclusions. Reeskens and Hooghe (2008) doubt its validity for cross-cultural studies as a single measure and suggest a construct of at least three questions. Similarly, the study by Freitag and Bauer (2013) supports a three-dimensional trust model consisting of particularized, identity-based, and generalized trust. Concluding, one can say that both measures, the trust question in surveys and trust experiments, are loosely related so that they should be rather considered as complements (Murtin et al. 2018). The presented study deviates from this approach and decides for the directed trust question, which explicitly mentions the addressees of trust (people in a region or country) because this study is interested in groups of trustees on a regional

and also national level. The exact formulation of the trust questions is based on the measure introduced by Naef and Schupp (2009) who could confirm a positive correlation of the answers to trusting behavior in lab experiments. By this formulation two further drawbacks of the general trust question are circumvented. First, asking about trust towards a specific group of people the uncertainty in the interpretation of "most people" (Reeskens and Hooghe 2008) is avoided. Second, the formulation of the general trust question is criticized because respondents have to make a qualitative decision between trust and caution (Yamagishi et al. 1999). However, the "intensity" or level of trust is measured by a four-point Likert scale. Regarding the cross-cultural context, it can be problematic to ask the same trust question in different countries and cultural environments. For example, the study by Usunier comes to the conclusion that Germans have a different understanding of the term "Vertrauen" as French people have towards the term "Confiance" (Usunier 2010). However, Freitag and Bauer (2013) were able to validate the WVS-question for a German, French and Italy speaking sample in Switzerland. With respect to the German and French language, the Neighborhood Social Cohesion Questionnaire by Dupuis et al. (2016) demonstrates excellent homogeneity ($\alpha = 95$) and split-half reliability ($r = 0.96$) in an analysis of a sample of Swiss respondents. In this regard, Torpe and Lolle (2010) test in a cross-country analysis whether the general trust question is understood in a similar manner and find that this holds for comparison of countries in the Western hemisphere. Moreover, they see that asking the question considering trust in people meeting for the first time is more appropriate in a country-wise comparison. Therefore, it is assumed to be an appropriate question for this purpose and that the answers can be compared across the German and French population. Note again the advantage of the parallel structure of this study: As both the border area and the regions outside the border area are fractions of the same populations, at least the comparisons between the respondents belonging to one country are comparable in any case.

The second focus of the study looks at the helpfulness of the inhabitants of a border region in the context of a hypothetical crisis scenario (natural hazard). This study should find out the WTH in the other country if only this country is affected by the disaster. For this case study, the French-German border region, this WTH is expected to be at least as high as the WTH of people living outside the border region. For the control group it is referred to the (geographically) closest neighboring country. In addition, it is looked at people's disaster experience, their perceived disaster responsibility and helpfulness of civil protection agencies, voluntary organizations and citizens of their region and neighbored region and whether they would welcome helpers from abroad if their own region was affected by a disaster. On overall, between 6% (Germany) and 12% (France) of the respondents have been already (at least once) involved in a disaster. For the period 2000 to 2019, the International Disaster Database (EM-DAT) reports a number of $608,102$ affected people in France and $341,663$ disaster victims in Germany. This indicates that the

presented results are quite reliable. For this group of the sample, the received help is rated positively by almost all respondents so that it cannot be drawn further conclusion about how this affects WTH. Experienced respondents are satisfied with the crisis management of all three groups of helpers, the public actors, voluntary organizations and the population itself. However, experienced respondents are clearly less confident that a natural disaster can be handled adequately compared to respondents without disaster experience. It is difficult to judge whether this is realism or pessimism but it is quite plausible that respondents without prior disaster experience are too optimistic with respect to the society's coping capacities. All respondents see the main responsibility at the side of the government and also have high confidence in the governments' capabilities to handle the consequences of a natural disaster. With respect to the relationship between provided help and expected help both variables are found to be negatively correlated for the French and German sample but with an interesting asymmetry between the two countries: On average, French respondents have provided less help but have a positive expectation with respect to received help. Compared to this „optimistic" view, the German respondents state it the other way round: They have provided more help but expect to receive less. Although it is not possible to draw further conclusions out of this optimism-pessimism-asymmetry based on the presented data set, it is important to keep track of such differences and to understand the reasons. As trust-relationships are regularly based on reciprocal patterns of exchange as these are perceived as balanced and fair (Ostrom 2003, Vance 2014). Diverging expectations can lead to disappointment, which could be particularly problematic in extreme situations such as a natural disaster. However, with respect to hypothesis H5 the good news is that the perceived WTH in the border area is larger than outside the border area and this result is even highly significant. Thus, even if there is an issue with diverging expectations between the two countries this is not true for the border area which is the most relevant aspect because if cross-border assistance is needed this will be provided in the border area at first place. This finding is underlined by the answers to the question whether helpers from a neighboring country would be welcome. In addition, the question is asked how the proximity to the neighboring country is perceived with respect to the abilities to cope with a disaster situation and the result is evident: 62.4% see the border as a clear or even a very big advantage. For further studies it could be interesting to gain more insight into the reasons for this: Which advantages (and disadvantages) do people spontaneously associate with the proximity of the neighboring country? It can be promising to ask such a question for topics other than crisis resilience, such as migration, health care, education or labor market issues. The tests of hypothesis H6 shows a weakly significant difference between the WTH in the border region compared to outside the border region, which is driven by the German sample alone. To take into consideration the multiple factors influencing WTH together with better control over confounding variables a regression analysis is performed. First, the WTH is considered in a neighboring region. For the

regression model $R^2 = 0.284$ is achieved, which is quite high compared to other studies. Interestingly, responsibility has a negative impact on WTH: Individuals who see the population responsible to take preventive measures for natural disasters are less willing to help. This finding is in line with the criterion of "controllability" of the own situation: If people perceive the person in need to be responsible for the own situation the motivation to help is reduced (Weiner 1993, Reisenzein 1986). A later study by Marjanovic et al. (2009) based on Weiner's theory finds a significant negative correlation $(r = -0.18)$ between responsibility and WTH as well a negative correlation $(r = -0.09)$ between responsibility and helping behavior. Similarly, the study by Zagefka et al. (2011) finds a significantly negative correlation between willingness to donate and the disaster cause $(r = -0.22)$ meaning that persons are more willing to donate in the context of natural disasters than disasters of human cause. Moreover, they find a significantly negative correlation between willingness to donate and blaming a victim $(r = -0.37)$. A further driving factor, which has a positive effect on WTH is the respondents' risk perception as elicited by the simple risk question. This finding is in line with the model of Do et al. (2017) classifying less risk taking people as bystanders while risk taking people are distinguished to act in a pro- or antisocial way. Considering the measure of risk, Dohmen et al. (2005) could reliably predict results from a paid lottery-experiment by data from the SOEP 2004 measuring risk attitude by a 11-point Likert-scale. Thus, they conclude that a survey is a valuable instrument to measure an individual's risk attitude. Ding et al. (2010) also state weak correlations in the same direction between survey measures and experimental measures. Lönnqvist et al. (2011) support this statement and moreover, recommend to elicit risk attitudes rather by surveys (instead of lottery experiments), because they have a reasonably predictive power, they show a good construct validity and a very good test-re-test stability over one year. Additionally, the Social Capital-Index (SCI), trust and received help from private persons are driving factors for WTH. These results are expected as discussed in the design section. In a second step, WTH is considered in a neighboring country and with $R^2 = 0.387$ a high factor of explained variance is achieved. The main difference compared to WTH in a neighboring region is that social capital, received help from private persons and risk perception have less influence. For the variable risk perception an explanation cannot be provided. That social capital does not influence the WTH in a neighboring country is due to the fact that the SCI is purposely constructed as a regional index (within and across regions). Similarly, it is expected that the received help was provided mainly by persons living close by so that this has no impact on the motivation to help somewhere else. As expected, the variable "difficulties to help across a border" now becomes the main hindering factor for WTH in a neighboring country, which is intuitive. As a last modification of the regression model a borderland-dummy is included. This regression model provides $R^2 = 0.288$ of WTH in a neighboring region and $R^2 = 0.392$ of WTH in a neighboring country. As expected and also part of the main research question the

remarkable result is achieved that living in a borderland has a positive impact on the WTH in a neighboring country. Comparing the World Giving Index by charities aid foundation (Foundation 2019), it is seen that Germany is on rank 18 and France on rank 66 in the 10 years aggregate score and ranking. In detail, Germany is on rank 26 in helping a stranger, on rank 20 in donating money, and on rank 36 in volunteering. France is on rank 108 in helping a stranger, on rank 55 in donating money, and on rank 33 in volunteering. Thus, there is not a big difference in volunteering between Germany and France. This yields the conclusion that WTH is mainly depending on geographical and social distance which is in line with the finding of Gillis and Hagan (1983). Moreover, Uslaner (2002) finds a significant correlation between trust and volunteering in both ways, effects on trust from volunteering is $.505$ with a standard error of $.163$ and a t-ratio 3.090. The effect of trust on volunteering is $.410$ with a standard error $.100$ and t-ratio 4.113. This is also in line with the finding that the trust of people in their neighboring region and their WTH in the same region are highly significantly correlated with a correlation coefficient of 0.111. Furthermore, it is noted that the regression does not show any impact of demographics such as age, gender and education on WTH. Excluding these factors in an additional regression leads to slight differences in the parameters, but does not change the structure of the regression. Additionally, personal motivation variables, e.g. altruism and autonomy orientation, are not included since the focus is a border area and these variables are expected to be similarly distributed in both countries. The interested reader is referred to an extensive account of, e.g. Gagné (2003), Clary et al. (1996) or Kulik et al. (2016) and it could be an interesting question to be tackled by further research whether this assumption was justified.

3.18.2 Strengths and Weaknesses of the Model

This study has a set of limitations. First, a hypothetical case is considered as not many crises happened in the study area. Nevertheless, the results should be close to real helping behavior because addressing this issue it is also asked for provided help in past natural disasters and a positive and significant correlation is found. The correlation coefficients are $r = 0.201$ and $r = 0.217$ between provided help in past natural disasters and WTH in the closest neighboring region or the closest neighboring country respectively. Although the difficulty to conclude from stated intention to real action is a classic in empirical social science, there is evidence supporting such a link in the domain of prosocial motivation. For example, Ajzen et al. (2004) find a positive correlation of $r = 0.76$ considering intention and behavior of voting in a real referendum and Zuckerman et al. find in their study that "subjects who rate high on willingness to donate blood and ascription of responsibility to the self will be more likely to donate blood than all other subjects" (Zuckerman et al. 1977). Sheeran (2002) addresses his literature review to this topic and finds an average correlation of $r = 0.53$ between intention and behavior. Second, asking for WTH instead

of past action has the risk that more respondents are guided by social desirability instead of their real intention to help. However, the interest is in the difference between the regions and not in the absolute values. Therefore, a strong bias in the data is not expected and it has been decided to forgo an extra item battery detecting social desirability in the presented questionnaire to keep this shorter and prevent higher discontinuation rates. With regard to cross-country comparisons, Johnson and Van de Vijver state that "individuals from more affluent countries tend on average to show lower social desirability scores" (Johnson and van de Vijver 2003). Furthermore, they find that cross-national differences in social desirability can be related to cultural value systems such as the individualism and collectivism dimensions. Since Germany and France are both Western European countries of similar wealth, the differences are expected to be marginal. Moreover, it is looked at the welcome towards helpers to get a more detailed picture of WTH. It is interesting that the welcome towards helpers from a neighboring country is rated higher than the own WTH in a neighboring country. By literature, these values are expected to be similar (Guiso et al. (2011) highlighted that people adapt their norms and beliefs in response to the community they live in by considering the example of trust). Thus, it is assumed that people respond honestly and take into consideration that helping in another country yields higher effort for them and may cause problems as seen due to the significant negative correlation between perceived difficulties and WTH. The correlation coefficients are $r = -0.288$ and $r = -0.380$ between perceived difficulties and WTH in a neighboring region or neighboring country respectively. By contrast, if others are willing or able to overcome these problems, the help is appreciated. Moreover, the WTH is only estimated without addressing potential coordination problems in case it comes to help (Narayan and Pritchett 1999). In an additional discussion about the results with professionals in crisis response acting in a border region, the stakeholders have been surprised about the high level of welcome according to foreign helpers. They have doubts that this finding also applies to professional helpers (e.g. firefighters) because for these groups asking for help from a neighboring country is perceived as a sign of weakness and thus, it constitutes a hurdle for them which leads to hesitation. However, this does not contradict the presented findings: As seen in the study, people mainly consider professionals being responsible for coping with natural disasters which is in line with the attitude of the experts. Thus, the population does not feel responsible in the first place and has fewer barriers to accept the aid, which results in a different reaction among professionals and citizens. To summarize, it is neither social capital nor openness which drives the WTH in a foreign country and the main explaining factors are risk preference and the expected difficulties when helping across a border. For the latter, the strongest hindering factor is the subjective distance. However, even when controlling for this factor, living in the border area positively and significantly impacts WTH in the other country.

4 Conclusion

4.1 Summary

The Covid-19 pandemic and other disasters of smaller magnitude have shown that nations and their systems of critical infrastructure are still far from being well-prepared for disruptions and crises. Moreover, these systems are connected across several countries in today's globalized world so that in the event of a failure, the border region plays a crucial role as the first point of contact between the systems and countries. Therefore, the improvement of cross-border collaboration in order to increase disaster resilience is becoming an increasingly important topic. Thus, this thesis contributes to the strategic planning phase of borderland disaster resilience by the identification of sophisticated potential for improving cross-border collaboration, once theoretically from an organizational and risk management perspective, but also empirically to support decision-making for responsible stakeholders. A twofold research approach combining an agent-based simulation and an empirical study is carried out in order to identify important challenges and to derive success factors for cross-border collaboration. A particular focus lies on the efficient inter-organizational coordination and communication, the quantification of cross-border bonds between residents towards each other in the form of trust and social capital as well as the integration of spontaneous volunteers into disaster response procedures.

Agent-based models are often used to simulate disaster management operations. However, in the present thesis this approach is applied to the cross-border context for the first time which makes the analysis more challenging for a number of reasons. In addition to the quantification of hard key factors as distance and time also *soft factors* influencing the borderland resilience performance such as language and trust have to be taken into account. In particular, the model investigates efficient coordination between different organizations to optimize the use of scarce resources. Therefore, it entails a variety of stakeholders with their motivation represented by utility functions and lays out an organizational structure so that it is well suited for examining the complexity of cross-border cooperation and coordination that takes place between authorities in the countries and at different hierarchical levels. This allows for a better understanding of where problems arise in the coordination of disaster management procedures. The model is implemented in different layers. Next to the organizational layer, an infrastructure layer allows the simulation of supply routines to provide the affected population with the required

quantities of goods. The model is flexible to be adapted to the geography of each borderland as regional data can be imported and blocked areas can be defined picturing natural barriers of the borderland or broken infrastructure. Moreover, it allows to scale the extent of a disaster by customizing the health state and respective needs of individuals representing the affected population. Several demand patterns are realized by which the population addresses these needs to the organization in charge. In addition, the model allows to measure the coordination effort of spontaneous volunteers via social media which is both a very current and important aspect of disaster management. Thereby, disaster management decisions can be examined at a very high level of complexity. The agent-based study investigates communication in detail so that it allows for several means of communication: direct information exchange in the neighborhood, long-distance communication including the availability of communication media (as those might be disrupted by the disaster) as well as allowing for posts in simulated social media groups. As the borderland is considered, communication models from literature were extended by adding personal characteristics of the sender and receiver of the message that are relevant in this context including their spoken language or trust level. An implementation via agile structure allows to turn on and off all functionality and to combine every pattern with any other so that numerous scenarios specific to the border region of interest can be performed. Results for the examined case studies show that the removal of language barriers and the establishment of trust lead to significantly improved coordination of response capacities. However, the reduction of language barriers was the most effective measure. The strong effects of potential misunderstandings emphasizes the role that language plays in a cross-border context. Thus, disaster response actors of the region should have at least a basic knowledge of the other language. Due to the course of history, reciprocal knowledge was the rule rather than exception in the Upper Rhine region. However, today this aspect no longer comes at *zero cost* and must be specifically promoted. Thereby, it is also important that the actors practice deployment procedures and use of central terms. The coordination is performed by control centers in each country. However, in the cross-border context, these control centers must also coordinate with each other to gain a better overall result for the whole study area. The ability to do so has a high impact on the success of crisis management but it also raises new questions about interoperability of technology, alarm routes, etc. and also about legislation as data protection issues for example to be solved in this field of inter-organizational collaboration. In addition, a network simulation model, which compares the efficiency of hierarchical coordination structures with the direct communication between personal contacts, illustrates well the continued high importance of *grass-root* contacts of a (semi-)private nature. Interestingly, private contacts and coordination via hierarchies are not substitutes but complementary strategies. This also emphasizes the need for high-level policies and low-level policies to go *hand in hand*, as they increase the potential of the other level and thereby could

contribute to a better utilization rate of available capacities. Another important simulation result is that spontaneous volunteers also bring a high potential to the area. In this way, the thesis contributes to borderland resilience by improving strategic planning for disaster response actions from the perspective of authorities. Besides the presented case studies, the model's implementation in a class structure allows for many adaptions and extensions which are interesting to decision-making of stakeholders.

Moreover, as in a disaster the response actors might be overwhelmed so that public involvement in form of self-help capacities of a population are an essential component to improve resilience. Thus, this thesis examines the populations' self-help capacities and their local knowledge in order to provide a holistic planning instrument for borderland disaster response. First of all, from the viewpoint of local responders and decision-makers it is helpful to estimate peoples' self-help capacities. This includes the social bonds among residents, referred to as social capital, as well as their specific willingness to help also across national borders. In order to gain knowledge on these components, an empirical study complements the simulation. As there is no existing framework to measure social capital and willingness to help for a borderland, the thesis presents a novel design as a regional and country-wide comparative approach. The empirical challenge of the presented study, which also requires this special design, lies in the unique feature of border regions that they simultaneously include a comparison between regions (cross-regional comparisons) and a comparison between countries (cross-country comparisons). Based on this, for the first time border area attachment is measured with trust and social capital as proxies. In addition, the respondents' willingness to help across a national border based on Weiners' Motivational Theory of Mutual Help is investigated for the hypothetical scenario of a natural disaster. Both, border area attachment and willingness to help, can be seen as key factors of regional resilience since natural disasters are an increasing threat due to climate change, which requires adaptations on all levels. The methodological highlight is the approach to measure regional social capital which can be applied to basically any border region and provides both policy makers and the citizens themselves with information about people's attitudes toward each other. By applying the study in form of representative telephone interviews for Germany and France in 2019, the database supports decision-making targeted to the local characteristics. Therefore, a NUTS-1 level resolution was taken so that the framework makes it possible to capture the regional identity and is still manageable for a comparison of two entire countries. Including an over-proportional share of respondents living in the French-German border area, the representative study in both countries measures higher levels of cross-regional trust and social capital in the border area compared to regions outside the border area. This evidence hints at an own *identity* of this region. The additional question about (hypothetical) willingness to help showed above all the *hurdles* to be able to call up the positive attitude in the event of a crisis as a cross-border self-help capacity of the citizens. As in the simulation, language is

perceived as particularly important, but the empirical study also shows the ignorance of the conditions in the other country as *inhibitor*. From this, an important policy implication can be derived, namely to harmonize crisis procedures and to establish a higher familiarity with the respective procedures in both countries.

Concluding, the thesis contributes to an improved understanding of borderland collaboration as disaster response is becoming an increasingly important challenge in the future. However, disasters do not respect borders so that "establishing a European cross-border mechanism as part of efforts to remove obstacles to cross-border cooperation, including in the area of disaster risk reduction" (Ciambetti 2019) is essential. According to the European Committee of the Regions (ECoR), 37.5% of the European Unions' population live in border areas, comprising 38 internal borders in form of geographical and linguistic barriers (Ciambetti 2019), which outlines the huge potential for improved disaster resilience. As seen in this thesis, there are still obstacles that need to be overcome so that the quantification of the most promising potentials by a holistic framework is a first and foremost attempt.

4.2 Discussion

The objective of this thesis is to derive and quantify success factors for borderland disaster collaboration. Thus, this section is dedicated to discuss the outcome of the thesis with regard to existing literature. Haycock (2007) classifies the following critical success factors

- "factors related to the environment"
- "factors related to process and structure"
- "factors related to resources"
- "factors related to membership characteristics"
- "factors related to purpose"
- "factors related to communication"

in terms of student learning. The author takes these as a basis to guide this section and contemporaneously discusses their application appropriateness in borderland disaster response. Beginning with the factors related to the environment, Haycock (2007) considers them in regard of a history of collaboration and whether there are already existing structures or not. By taking a comparable approach of the two scenarios disabled and enabled borderland collaboration (where the first one does not allow any exchange of resources across the border and the second one allows a perfect exchange by shortest distance without any barrier) this factor clearly could be approved for borderland collaboration by the

agent-based model. Although there is no clear evidence for it in the presented empirical study, literature points out that the higher social capital as measured for the German-French borderland results from historical connectivity. Thus, with regard to borderlands the author adds another success factor, namely transnational attachment. The presented empirical study investigates regional social capital showing significantly higher trust into the neighboring country for people living in the French-German border region compared to people living within the two countries. Having a look at Europe as an broader context, the analysis by Sundell (Redaktion des Katapult Magazins 2021) quantifies regional and national attachment as well as attachment to the European Union. Evaluating the data surveyed within the frame of the 2021 European Quality of Government Index (Charron et al. 2021), it can be seen that most residents within the European Union do not feel a strong attachment to the European Union. Their national or even regional attachment is clearly higher with only one exception, namely the city of Budapest. Having a look at the details of the data, a slightly higher European attachment is measured within the states, that are located at the outer borders of the union as Ireland, Portugal, Lithuania, Poland, Slovakia, Hungary, and Romania. In contrast, a deeper regional attachment is measured at the borderlands between the *inner states* within Europe. Within the whole area of the European Union, the borders are not a static barrier. Instead the movement and exchange of goods across borders is *normal* daily business and it can be questioned whether collaboration across national borders achieved a so strong political and social climate that it is not perceived in peoples' minds anymore. Thus, the European Union as facilitator for all these developments moves into the background and regional attachment becomes present which may include transnational regions. This argument is supported by having a look at Germany and France in the study. Even if the European attachment is not the strongest in absolute terms, a higher value of European attachment is observed for the border region compared to respondents within both countries which shows that the European Union is still present but plays an subordinate role. Pointing directly on the German-French border's impact by asking for the perception of the border in the empirical study of this thesis, there is an overall positive mindset. 13.8% of respondents living in the German-French border area see the border as a very big advantage, 48.6% see it as a clear advantage, 8.5% as a clear disadvantage and only 1.5% see the border as a very big disadvantage. However, still 21.3% claim the border to be neither an advantage nor a disadvantage. In contrast, at the outer borders of the European Union, people are more often confronted with these boundaries and thus, these are more deeply present in their perception. However, as outlined in the state of the art section, the European Union highly invested into regional development by setting up the European Regional Development Fund including large programs "to promote a harmonious economic, social and territorial development of the Union as a whole" so that regional attachment including border regions cautiously can be seen as a success factor.

This success factor is closely connected to the success factor of process and structure which means the existence of roles and policy guidelines that are clear to all members but also allow for flexibility to a certain degree. To examine this success factor, the agent-based model investigated organizational theory comparing the efficiency of information flows by a hierarchical network with a polycentric network of direct contacts between the actors. First, hierarchical networks were examined differing in the number of hierarchy levels. There, a drift to informal requests is observed for an increased number of levels. Furthermore, the number of personal requests increased with the increase of direct contact persons in the polycentric network. However, the hierarchy remained the preferred strategy. This underlines both points, the need of fixed structures but also the flexibility specifically in dynamic situations as success factors. In the presented simulations, the private networks serve as a supplement to the hierarchy. However, in real-world contexts the transitions need to be clarified so that overlaps do not lead to serious problems. Thus, a strategy to react from a global perspective on local imbalances due to additional use of informal contacts is examined. By introducing an alternative way of allocation, these imbalances could be reduced significantly. Moreover, it is useful to have collaboration among all involved actors. In particular, the participation of various actors is tested in the model as it includes a wide range of stakeholders involving spontaneous volunteers as an additional component. Here, it becomes evident that not only the participation of several levels is required, but also there is a need for structures and guidelines. If the coordination structure is perfectly present, the potential of spontaneous volunteers could be used by 38.1% more effectively for the simulated case study. To underline this finding, the empirical study investigates the motivation of people to support those in need by regression over various factors including perceived responsibility, risk perception, or openness towards other cultures. However, the best framework to include them does not apply if there is no willing to help. As there has been no spontaneous volunteering across national borders observed up to date, it is an important point to explore the potential readiness to help. This directly leads over to the next factor as motivation is a precondition to participate and make resources usable.

It is needless to mention, that an increase of resources led to a proportional decrease in the number of undersupplied victims in the disaster situation. In this regard, it needs to be discussed how to gain supplementary resources. Besides further equipment, also human capital is a crucial factor in disaster response. For example, during the Covid-19 pandemic it is often discussed that not only the number of intensive care unit beds but also the personal being able to care with those patients has to be increased. However, in the cross-border context the exchange of medical goods has been carried out already by professionals so that it is of higher interest, whether there is a readiness to help also within the population rising the self-help capacities of the region. A higher motivation of spontaneous volunteers for example leads to a higher number of resources. It should be outlined that collaboration itself generally comes with costs which are abstracted from in this thesis. This point is

partly reflected by the empirical study uncovering the motivation for volunteers to cross a national border. Results confirmed clearly that the own willingness to help in the neighboring country is lower compared to the welcomeness of foreign helpers from the neighborhood in case the own region would be affected by a disaster. As these values can be expected to be on a similar level based on literature, this result reflects somehow that helpers have the costs in mind in form of need to overcome barriers whereas the costs that others are willing to overcome are clearly appreciated. Asking directly about perceived problems for helping, the main hindering factor are the unknown procedures of disaster response in a borderland. Thus, the simulated coordination framework for spontaneous volunteers providing a leader to assign tasks can help to overcome this barrier, especially in uncertain and dynamic situations. Concluding, not only the addition of resources leads to better outcomes, but also the coordination of them which requires a skilled leadership.

The main investigations of this thesis are in the area of membership characteristics and the interplay of actors with different cultural background as often occurs in a border region. Haycock (2007) mention "mutual respect, understanding, and trust for members and their respective organizations" as success factors but also include that "members see collaboration in their self-interest". These important points are specifically approached in this thesis in both parts, the agent-based model as well as in the empirical study. With regard to trust in organizations of the own and the neighboring country, the model clearly shows that decreasing trust levels lead to additional requests resulting in blocked capacities followed by delays. Consequently, there results a higher number of undersupplied persons. Interestingly, the decreasing curve of undersupplied by increasing perfect request rate (proportion of requests that match trusting sender and receiver) is mirrored S-shaped so that in the lower levels (i.e. less than 45%) and the higher levels (i.e. larger than 85%) an additional increase on trust has less impact compared to the medium levels (between 45% and 85%). Furthermore, the empirical study investigates trust in a cross-regional and cross-country comparative approach for the French and German population. It measures trust towards different groups of people and confirms for all regions that the trust toward people living in their region is higher compared to people living in the neighboring region. The same holds true for the cross-country comparison, i.e. the German respondents in the study admit higher trust towards Germans, similarly the French respondents show higher trust towards French. Interestingly the trust of French people towards Germans was even higher than the trust of Germans towards their fellow citizens, which is a finding that could be replicated from the European Social Survey in 2004. Involving the border area, it can be confirmed that regional trust is significantly higher within the border region compared to the reference regions within both countries. Moreover, this thesis examined other factors in addition to trust comprising social capital based on the variables general willingness to help in the region, social affiliation to the region, group activities performed in the region, and group similarity. This social capital index including the supplementary dimensions

is also highly significant for the border region compared to other regions. In this regard it should be noted, that relationships always have a personal component requiring the individuals willingness to build a trusting relationship. This may be associated with costs in terms of spending time or being ready to travel to the neighboring country. In this sense, collaboration should also be seen as self-interest and finding a balance between formal and informal relationship in this context is very important. Thus, the success factor membership characteristics can be definitely supported with respect to social capital and in particular trust.

The factor "purpose" comprises "clear attainable goals and objectives that are communicated to all partners and can be realistically attained" and a "shared vision" (Haycock 2007). In disaster response, all individual groups have their own expertise and targets, which is of course the way it should be. Nevertheless, when it comes to the coordination of professionals in disaster response and to cope with spontaneous volunteers, it is clear that a common vision helps to assign capacities in an optimal way by complementing expertise and resources. This task is already with the same picture in mind not very easy, but under the hurdles that a border region brings by its nature, harmonization of objectives is even more important. Thus, a "clear attainable goals and objectives that are communicated to all partners and can be realistically attained" (Haycock 2007) brings decisive advantages for disaster resilience. Investigating a shared vision, the empirical study addressed the responsibility for disaster response in both countries. An interesting difference between Germany and France becomes evident with respect to the volunteering aid organizations that are perceived to play a mediating role in Germany but not in France. Apart therefrom, a shared view could be obtained for the disaster management from the populations' perspective. Moreover, also among people living in the border region, a national identity was still measurable with regard to disaster response procedures which may be due to the fact that France is a central state and Germany has a federal system. This could be overcome by building points of contact with qualified leaders assigning tasks as discussed before the largest problem is perceived in not knowing whom to address to help in a neighboring country.

Successful collaboration accounts for effective communication. Haycock (2007) emphasizes the two points of "open and frequent communication" as well as "established informal and formal communication links". Both aspects are investigated in this thesis. Considering language barriers in the communication between the agents, which lead to increased uncertainty in the prioritization of needs, the simulated model results show that an increasing perfect request rate (proportion of requests that match sender and receiver speaking the same language fluently) leads to an exponentially decreasing number of undersupplied. Furthermore, there is a difference between agents speaking the language of the neighboring country directly compared to the scenario where both learn a lingua franca. Thus, the

author adds the need for common language as a success factor in borderland collaboration. As a disaster event is a highly dynamic situation with major need for information, especially for borderlands the investigation in speaking the language of the neighboring country is helpful. For disaster response across borders, the author extends the success factors by interoperability between systems. On the one hand, the technologies supporting the information exchange and harmonization of a situations' current picture (which include for example geographic information systems) need to be aligned so that the exchange of real-time information is possible. On the other hand, usual information transmission technology may fail so that task forces need to come back to traditional communication systems. For example, the commonly used radio is not necessarily a long-distance communication medium so that frequencies need to be adjusted. As this success factor does not only hold for communication systems, it can be categorized within the topic "resources" in general. In fact, the author there already outlines the need of qualified personal as a precondition for the usability of resources. Thus, as the interoperability is also a precondition for the usability of (communication) resources, she would prefer a re-framing of this success factor to "resources and their usability" in the application of the borderland context.

The results show how important a well-functioning cooperation in the border area is, since in an emergency shorter distances are a decisive advantage. However, these can only be used if the collaboration works efficiently. Concluding, success factors are coordination in all dimensions, rapid exchange of precise information and resources for which a common language and trust are required. Moreover, people's attitude as social capital and willingness to help in the borderland are success factors. The author would like to point out that joint planning and the creation of hybrid structures are essential for this. Concluding, by the combination of both methodologies, the agent-based model for inter-organizational collaboration and the empirical study for borderland social capital and willingness to help, the success factors derived by Haycock (2007) in the field of student learning can clearly be proved to be applicable for cross-border disaster collaboration by the approaches in this thesis. The presented framework was validated by experts in the field of risk and crisis management. However, in real-world settings this favorable situation cannot be stated for all borderlands as outlined in the state of the art section because the specific attachment to the region plays an important role. In addition, a disaster is a stressful situation so that planning in advance comprising trust-building relationships is required.

With regard to methodology, the discussion already is presented in the corresponding parts of Chapter 3, which is referred to at this point. It is shown that cross-border cooperation not only offers a direct gain in efficiency, but also lays the foundation for further options and variants of improved crisis management. In the future, technical solutions such as drones or artificial intelligence should continue to be integrated for better practical

implementation of the theoretically determined success factors. The next sections outlines policy recommendations that can be derived from the thesis in detail.

4.3 Policy Recommendations

The results of this study have important practical implications. This thesis addresses various stakeholders. In general, governments could support borderland resilience by creating suitable framework conditions, opportunities and prerequisites so that cross-border cooperation is possible. Moreover, authorities would support this process by developing their communication of the command and control procedures in direction of inter-operability with other systems in order to allow a fast exchange of information (e.g. on available capacities) and the prioritization of medical goods. In addition, disaster response organizations could coordinate their strategic behavior in search and rescue procedures across borders. The population is mainly seen as the target of the resilience measures, but their self-help capacity is essential for a functioning disaster management. For example, during the Covid-19 pandemic, the policy makers were dependent on the population to obey measures containing the infection rates as wearing face masks or social distancing. Therefore, the population should be informed in advance and involved in exercises that align social interaction. Furthermore, the helpfulness and coordination of spontaneous volunteers across borders was examined as a current phenomenon that the disaster response actors need to be aware and address in their risk and crisis communication to prevent uncoordinated actions that arose out of good will, but did not support or still worsen the situation.

The original motivation for this study stems from two research projects, both dealing with cross-border cooperation in the context of risk and crisis management: the Interreg-project SERIOR[1] considering the three-countries' border region between France, Germany and Switzerland and the French-German INCA-project[2]. In both projects, the stakeholder group consisted of researchers and practitioners from the domains of risk management, crisis response and civil protection. In discussions and interviews of the project teams including the author, it has become clear that agencies see a need for an improved co-ordination among disaster response organizations but also for self-help capacities of the citizens in the regions.

The stakeholders admitted that so far there is no objective measure of border area attachment which would be needed for such an assessment. In this regard, this thesis provides a database targeted to local borderland characteristics supporting the decision-makers. Both

[1] www.serior.eu/en/

[2] www.anr.fr/Project-ANR-16-CE92-0011

the importance and the knowledge of the population of their own self-help potential could be addressed by means of risk communication (as done in the European project RiKoSt, which deals with bi-national risk communication strategies for the countries Austria and Italy), involving the population as observers or volunteers in cross-border exercises (as exemplary in the joint German-Danish civil protection exercises such as DANGEREX 2007, DANGERFloodEx 2010 and Emergency Responses without Borders). Well-designed social media campaigns in addition could address the issue, providing the population with timely and correct information as well as clear and straighten action recommendations to prevent the spread of false information which in the worst case attack people from other social or cultural affiliation and minorities.

The results of the agent-based model show a significant improvement if the language of the neighboring country was spoken. Here, modern techniques like artificial intelligence can be helpfully included taking a translator as an example. This need to be customized to the disaster context to translate terms correctly and provide explanation for terms that have another meaning or are used differently in the context. Therefore, in a previous step, guidelines need to be developed that outline these differences and provide explanations for a better understanding of the resulting consequences. In order to be used in different contexts, these tools need various types of applications or variants. For example, a text interpretation is helpful for mails, but also an audio interpretation is needed so that executing forces may use microphones and earphones to get the translation in real-time within a mission. Hereby of course technical details need to be addressed so that these tools do not annoy the user and that they are also applicable for example in noisy environments.

Moreover, the thesis showed that trust reduces misalignment. Therefrom it results that the harmonization of crisis procedures and the establishment of a higher familiarity with the respective procedures in both countries are important consequences. These call for action not only in regard of high-level policy, e.g. EU-level or bilateral agreements, but also on low-level policy based on direct cooperation of regional civil defense organizations. Common training helps to overcome barriers and to get an idea of the other ones' systems and competencies, which can be difficult as there is no adequate translation possible or the adequate position has other tasks and competencies. The establishment of training programs especially on intercultural competencies is required. It also could be an interesting point to exactly reconstruct the setting of one of the case studies in the agent-based model in a *real-world* training exercise. This could not only help to validate the simulated results better but also to extend the competencies.

The analysis in this thesis includes interorganizational collaboration. A fast and precise exchange of up-to-date real-time information to gain a common picture on the situation requires interoperability of systems. However, data protection issues need to be discussed and aligned for all participating nations in advance. Data-protection is a highly relevant

topic also in disaster response as for example seen by the development of the "Corona-Warn-App" in Germany. In addition, it was outlined in this thesis that personal contacts can be useful for fast information exchange among actors in order to provide additional resources within short time periods. Both, the empirical approach and the findings of the established data, are of importance when it comes to an assessment and deeper understanding of border region attachment. As trust and social capital are generally seen as decisive factors for economic development, innovation and growth (Woolcock 1998, Zak and Knack 2001) this also applies to border areas. Vital border regions, which are particularly rich in social capital and social cohesion, can fulfill the function of buffer zones and bridges between two countries. In the same way as a school exchange between young people from two countries helps them to become familiar with the language and the social, political and cultural characteristics of the other country, border regions can contribute to a positive perception of the other country, which ideally will no longer be perceived as inhabitants of an *other country* but of a joint, culturally diverse region. Similarly, Rippl et al. (2010) refer to the importance of bridging-networks, which are open to foreign neighbors. This is all the more likely to be the case the more regularly and naturally the exchange is integrated into the everyday's life of the residents. Hanna et al. (2009) analyze social capital of a focus group of people in British Columbia (Canada) and highlight that a downtown reflects community well-being: "It is important as a place of social intersection and it helps reinforce or build bridging capital. It is the link to the origins of civic society, where the coming together of people creates the cultural and technological creativity that shapes society". In this regard, it is suggested to transform the border-region into *downtown*, i.e. a place where people meet others from both nationalities and provide opportunities for regular exchange. One idea for that would be to make leisure activities in the border region attractive for people from both sides, e.g. setting-up a swimming pool or bowling center with easy accessibility from both sides. In addition, fostering a higher participation in clubs as well as workshops and cultural activities would help to establish a cross-country network of borderland citizens. The use of social media can facilitate cross-country activities (e.g. hikes, shopping tours, teaching excursions) and complement them by easy-access language courses as well as contact and exchange platforms. The second part of this study analyzes the citizens' motivation to help in the neighboring country in the hypothetical context of a natural disaster. These results can be interpreted as empirical proxies for border area resilience, which is an important policy goal as no disaster can be managed without the support of the population. In their official statement on the UN Sendai Framework for Disaster Risk Reduction 2015 – 2030 (United Nations 2015), the European Committee of the Regions articulated their priorities for disaster risk reduction in 2017. With respect to European border regions, it was recommended "to make the residents of the endangered areas aware of the necessity to show solidarity with the residents of the areas prone to disasters" (European Committee of the Regions 2017). However, it is difficult to forecast

how bonds between people evolve during a disaster, which puts a high level of stress on all parties involved. Furthermore, to make the best use of the population's SHC in a disaster context, communication and preparation (e.g. by trainings) are in the foreground. As Lai (2012) highlights, even collaboration among voluntary organizations cannot be easily formed during extreme turbulences and the same holds true for the bond between people within and across regions. Vangen and Huxham (2003) support this view and describe an ideal trust building process in interorganizational collaboration. Hence, there is a high need to understand people's willingness to help in an international context. Pfefferbaum et al. (2013) bring up a framework to strengthen community resilience including intensified interactions among the people but find a very differentiated picture for borderland cohesion, which partly appeared quite fragile. Combining both, direct planning for disasters in border regions, but also to establish and deepen relationships in general, seems to be the most promising approach to make the most efficient use of available resources of the joint region in a disaster situation and thereby to strengthen resilience in a border region.

This thesis supports borderland collaboration for disaster response in various ways. However, last but not least, the author would like to acknowledge that each disaster is individual and the best reaction plans cannot cover all eventualities. Thus, response needs to stay spontaneous up to a certain degree and see "planning as a process, and above all a process of discovery" (Alexander 2015).

4.4 Outlook

Looking at the upcoming challenges for future disasters in the light of increasing disaster risk due to climate change and attacks - cyber or physically - in particular on critical infrastructure, there will be a rising need on cross-border cooperation. This is also reflected in the strengthening of the European Union's competencies in this area, such as the reformulation of the civil protection mechanism including the expansion of rescEU, which are the European reserve of disaster response capacities and the establishment of an European Civil Protection Knowledge Network with the target to build an integrating force following an all-hazard approach and a central hub with a living memory. The European Union was founded mainly out of economic interests, with disaster control playing a subordinate role, since until then disasters tended to occur locally and on a smaller scale. However, this has changed over time, so that disaster prevention plays an increasingly important role. Through the Treaty of Lisbon in 2009, civil protection became an internal policy of the European Union for the first time. However, the European Union is still seen rather as a supporting and coordinating actor for the national disaster response operations. This changed by the occurrence of the Covid-19 pandemic reaching Europe in spring 2020. "On 27 April [2021], the European Parliament voted for strengthening the European

Union's role in crisis management through a legislative revision of the EU Civil Protection Mechanism. This allows for faster and more effective European solidarity operations in response to large-scale emergencies or disasters that affect several countries at the same time" (European Commission 2021). However, this reformation process surely has not reached an end. Instead, this remains a continuous transformation process of adaptation and development for future hazards, which in general should be scientifically accompanied also in the future.

As in any model, the boundaries of the presented agent-based model needed to be fixed. This model addresses response to disasters and clearly has not the scope to cover the phase of disaster prevention and preparedness which are also important. Another issue that came up by the Covid-19 pandemic is the vulnerability of supply chains. As pointed out, the European Union plans to strengthen its own stock and capacities within rescEU, in particular essentials and medical equipment, to become less dependent on global deliveries as these may become interrupted leading to supply bottlenecks and shortages. However, it could be an interesting approach to also investigate the stability and robustness of supply chains. Instead of *blindly* going back to domestic production and taking a purely national focus, which may result in inefficient procedures doubling capacities and resources that are unused one also should consider the possibility of strengthening the existing structures. Private actors should have an increased interest to make their supply chains more robust and crisis-proofed as they can keep their production and thereby their income. Moreover, this strategy could also be profitable if companies keep up their delivery capability in times where they face low competition. Thus, the states could support to build these robust supply chains due to their positive externality: on one side, the companies already have established global supply chains, so that it is straightforward to keep these instead of building completely new ones and on the other side, intervention measures as border closures could be reconciled so that the state can use the capacities also in disaster situations. Such strategic plannings should be assessed by well-funded scientific analysis with as precise as possible risk assessment and trade-off quantification. In this regard, the model could be extended by additionally considering supply chains, especially those that are in charge to deliver essential goods and services as well as medical equipment. Up to now, the boundaries are set at the disaster scene using the existing facilities. Thinking further - in regard of preparedness and prevention - it also needs to be considered that for a long-term disaster these facilities also would need to be supplied. Thus, it could be an interesting aspect for extension to ensure that the hospitals have enough stock, because as a rule, this procedure is organized by the private sector. If one would extend the model by these actors, the model in addition could support the risk assessment in terms of supply chain disruptions. It is to mention that there are in general advanced in international collaborations as many products are manufactured not only within one country but raw materials, commodities and final products are transported all over the globe

via interconnected routes. However, this could be an interesting form of collaboration to be addressed by the model for the preparedness and preparation phase. The private actors as well could improve their intercultural competencies, trusting supply chains are also important and the public actors could improve their plans against failures. Another point to address by the presented agent-based model might be the costs to establish a collaboration, as this is an important factor, which should not be underestimated. Some parties may have competing or even conflicting targets and interests, which increases the hurdles for collaboration. This aspect in particular gains relevance in the preparedness and prevention phase as especially private companies in these times do have other targets then disaster response. Thus, the dimension of negotiation is an additional point of view that could be pictured in the model in the upcoming future. Even if it does rather not come into play directly in disaster response as the bulk of actors have similar interests to cope with the disaster and to re-establish structures, it is relevant for prevention and preparedness. If one would extend the model by these factors, the model in addition could support the risk assessment, even stronger contribute to a knowledge network and thus, contribute to disaster prevention and preparedness phases.

The global Covid-19 pandemic underlines the relevance of borderland studies for disasters as it provides insights into the significance of national borders, the perception of national borders and the respective reactions of the population. Looking exemplary at the German-French study region, there are some interesting observations to mention. Despite the border was closed for the general public, with respect to operational crisis response there has been an official cooperation of emergency medicine units bringing victims from the highly affected Alsace region in France to different hospitals in Germany, which – at least partly - relaxed the distress in French hospitals (Wiegel 2020). On the side of the citizens, there have been different reactions observable. On the one hand, French people have experienced hostility by Germans that culminated in thrown stones on ambulances bringing French victims. On the other hand, on June 15^{th}, 2020, the day the French-German border was re-opened, it came to spontaneous celebrations of citizens living in the French-German border area and the same could be seen at the German-Polish border, too. Both observations within a very short period of time, signals of hostility and friendship, show the strong emotional impact and quite extreme and erratic reactions of parts of the citizens with respect to the neighboring country during times of stress. Border regions must probably always live with this permanent tension between potential and gulf. This thesis should help to identify, measure and understand at least the more stable component of this potential and to use it for the benefit of resilient societies, regardless of which nations. In addition, cooperation mechanisms were explored, which in the future will hopefully help to manage disasters on a common basis and avoid border closures. Nevertheless, future research could shed more light on the inherent complexity and structure of a borderland. As Helliwell and Putnam (1995) find, there are different levels of social capital in North

and South Italy, a deeper analysis of regional differences would support a detailed picture and context. It might be a difference between borderlands that are closely connected and those that have a separating structure like a mountain area or a river with only a few bridges across. In addition, it would be interesting to extend the empirical study to other border areas inside (e.g. the remaining external borders of Germany and France) and outside the European Union and compare this with the presented results. As two countries from Western Europe with similar language family and religious tradition are analyzed, the transfer of this approach could require a control of cultural differences. Here, the concepts of *Cultural Capital* (Throsby 1999), *Cultural Intelligence* (Ang et al. 2007) and *Global Citizenship* (Reysen and Katzarska-Miller 2013, Fattori et al. 2015) might provide helpful insights. In this context, the concept of cosmopolitanism as "an approach to culture that focuses [...] on changes among forms" and thus "much more concerned with the solution of risk management problems" (Earle and Cvetkovich 1997) could gain in importance. In times of emerging nationalism, Europe-skepticism, and populism oriented towards segregation and xenophobia, these objectives are of great influence not only in terms of crisis resilience.

A Appendix

Gender, age, education, and ownRegion were given by the sampling procedure.

Description of the coupled region given after the first question: For respondents living in the border area: "we assume the coupled region in the following to consist of the Upper-Rhine region including South Palatinate and Alsace". For respondents in Germany: "we assume the coupled region in the following to consist of your state and the neighboring state that you mentioned". For respondents in France: "we assume the coupled region in the following to consist of your region and the neighboring region that you mentioned".

Description of the assumed hypothetical disaster given before asking about WTH in neighboring region and country: "Now, please imagine that the [neighboring region/neighboring country] was hit by a severe natural disaster (similar to a hurricane in the USA). The state of emergency already lasts for a week and has meanwhile led to a lack of of essential goods. In addition to the help provided by civil protection agencies and voluntary aid organizations, volunteers from the population are needed."

Variable	Question	Scale
Neighboring Region	First of all, please tell me the neighboring ["Bundesland" in Germany and "Région" in France] that you can reach most quickly from your place of residence.	16 states of Germany, 13 regions of France
General WTH	How would you rate the general WTH of the people in your coupled region? Is the general WTH very high, rather high, rather low or very low?	4 point likert scale: very high, rather high, rather low, very low
Social Affiliation	Do you feel social affiliation with the coupled region in which you live, all in all very much, rather much, rather less or not at all?	4 point likert scale: very much, rather much, rather less, not at all
Group Activities	How often do you actively participate in joint activities with several people, such as sports clubs, art or cultural communities, in your coupled region? Do you do this once a week, several times a week, several times a month or less often?	4 point likert scale: several times a week, once a week, several times a month, less then seveal times a month
Group Member Similarity	Members of a group may differ for example in age, religion, education, or political attitudes. Are the members in the groups in which you actively participate overall very similar, rather similar, rather different, or very different in comparison to you?	4 point likert scale: very similar, rather similar, rather different, very different
Risk Attitude	How do you rate yourself personally? How risky are you in general? Are you very willing to take risks, rather willing to take risks, rather not willing to take risks or not willing to take risks at all?	4 point likert scale: very willing to take risks, rather willing to take risks, rather not willing to take risks, not willing to take risks at all

Trust Own Region	In the following I would like to list a number of people. Please tell me in each case whether you have very great, rather great, little or no trust in them? Residents in your region	4 point likert scale: very great, rather great, little trust, no trust
Trust Neighboring Region	In the following I would like to list a number of people. Please tell me in each case whether you have very great, rather great, little or no trust in them? Residents in your neighboring region	4 point likert scale: very great, rather great, little trust, no trust
Trust Germans	In the following I would like to list a number of people. Please tell me in each case whether you have very great, rather great, little or no trust in them? Residents in Germany in general	4 point likert scale: very great, rather great, little trust, no trust
Trust French	In the following I would like to list a number of people. Please tell me in each case whether you have very great, rather great, little or no trust in them? Residents in France in general	4 point likert scale: very great, rather great, little trust, no trust
Responsibility	In your opinion, who is mainly responsible for supplying the population in your region in the event of natural disasters, such as severe floods or damage caused by severe storms? Is this the state, i.e. police, professional fire brigade, military? Are these voluntary aid organizations, such as the volunteer fire brigade, Johanniter or the Red Cross, or should the population be able to take care of themselves?	3 item scale: state, volunteers, citizens

Confidence Citizen	Please tell me whether you agree with the following statement completely, rather, rather not or not at all? In the event of a serious natural disaster, the population in your region can make adequate provision for itself without professional emergency services, for example by drawing on crisis supplies or through neighborly help.	4 point likert scale: agree completely, agree rather, agree rather not, agree not at all
Confidence Government	Please tell me whether you agree with the following statement completely, rather, rather not or not at all? Professional emergency services can provide adequate care for the population in your region.	4 point likert scale: agree completely, agree rather, agree rather not, agree not at all
Evaluation Of The Border	[Filter: Only respondents from the border area were asked this question] In general terms, how do you assess the close distance to France in terms of coping with a possible natural disaster? Do you see the proximity to France as a very big advantage, a big advantage, a big disadvantage or a very big disadvantage?	4 point likert scale: very big advantage, a big advantage, a big disadvantage, a very big disadvantage
WTH Neighboring Region	Would you go to the affected area to support the helpers on site? Would you do so in any case, more likely, more unlikely, or not at all?	4 point likert scale: in any case, more likely, more unlikely, not at all
WTH Neighboring Country	If the same natural disaster would hit the neighboring country of Germany, which is the fastest to reach from your place of residence. Would you travel to the affected neighboring country to support the helpers on the spot?	4 point likert scale: in any case, more likely, more unlikely, not at all

Difficulties	Regardless of whether you would help in a specific case or not. I will now read to you possible difficulties that could arise if you were to help in Germany's neighboring country. Please tell me for each aspect whether it would apply to you personally or not.	6 item scale: The distance to the neighboring country is too far for me, I cannot communicate in the neighboring country, The culture of the neighboring country is not familiar to me, The procedures of crisis management with regard to responsible authorities and response teams are unknown to me, I would be afraid of violating the laws of the neighboring country out of ignorance when helping, I would not know whom to turn to for help
Welcomeness To Helpers	Assuming that the natural disaster would affect your state and that volunteers from the closest neighboring country of Germany would come to help. Do you think that these helpers from the neighboring country would generally be very welcome, rather welcome, rather not welcome or not welcome at all?	4 point likert scale: very welcome, rather welcome, rather not welcome, not welcome at all
Openness	There are different ways to get in contact with people from other countries and cultures. I will now read you about the different possibilities. Please tell me for each aspect whether it applies to you or not.	5 item scale: I work in another country or have regular exchanges with international colleagues, I have relatives or friends from another country, I regularly go on holiday to other countries, I do voluntary work for people abroad or for foreigners in Germany, I regularly use literature or media from another country

Provided Help	Have you yourself ever helped to cope with a natural disaster, e.g. severe flooding or severe storms, for example by direct help on site or by donating money or commodities?	yes/no question
Type Of Help	I will now read to you various ways in which one could help. Please tell me for each statement whether it applies to you or not.	5 item scale: I have donated money or commodities, I have helped spontaneously on site (e.g. filling sandbags, etc.), I have compiled data and information with the help of social media, I have helped as a volunteer member (e.g. with the Red Cross or other aid organizations), I am professionally active in civil protection (e.g. fire brigade, THW, etc.)
Experience	Have you ever been directly affected by the effects of a natural disaster yourself, so that help was needed from outside?	yes/no question

Received Help By Citizen	In the following I will name a number of people. Please tell me in each case whether you found the help of these people at that time very helpful, rather, rather not helpful or not helpful at all? Private persons (e.g. family, neighbors, friends)	4 point likert scale: very helpful,rather helpful, raher not helpful, not at all helpful
Received Help By Volunteers	In the following I will name a number of people. Please tell me in each case whether you found the help of these people at that time very helpful, rather, rather not helpful or not helpful at all? voluntary aid organizations (e.g. Johanniter, Red Cross or others)	4 point likert scale: very helpful,rather helpful, raher not helpful, not at all helpful
Received Help By Government	In the following I will name a number of people. Please tell me in each case whether you found the help of these people at that time very helpful, rather, rather not helpful or not helpful at all? Governmental help (e.g. police, firefighter, military)	4 point likert scale: very helpful,rather helpful, rather not helpful, not at all helpful

Table A.1: Variables, Questions and Scales

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