Geography of News

Empirical Studies of German News Media

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ISBN 978-94-6419-778-5

Cover design: Ayse Dincer-Aktas (www.aysedincer.com)

Printing: Gildeprint B.V., Enschede, Nederland

Geography of News

Empirical Studies of German News Media

Geografie van Nieuws

Empirische Studies van Duitse Nieuwsmedia

(met een samenvatting in het Nederlands)

Proefschrift

ter verkrijging van de graad van doctor aan de
Universiteit Utrecht
op gezag van de
rector magnificus, prof.dr. H.R.B.M. Kummeling,
ingevolge het besluit van het college voor promoties
in het openbaar te verdedigen op

vrijdag 12 mei 2023 des ochtends te 10.15 uur

door

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geboren op 17 december 1989
te Yildirim, Turkije

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Acknowledgements

First and foremost, I would like to express my sincere gratitude to my supervisor Tom Broekel. Tom, thank you for getting me started on this journey, for your constant enthusiasm for my work, for providing critical feedback, for challenging me to grow as a researcher, and for frequently reminding me of the importance of taking proper breaks. You have always known if, at a certain point, I needed guidance or autonomy, and you provided me with what I needed the most. During this period, you have been a great mentor to whom I can turn whenever I need advice on my career and whom I can fully trust. Like all PhD journeys, mine also had ups and downs. But if I had to pick one word to describe mine, it would be *fun*. It's always been so much fun working on this project and you can take all the credit for this.

I would also like to extend my deepest gratitude to my promotor Ron Boschma for his invaluable feedback and insight into the final draft of the articles in this dissertation as well as the introduction and conclusion chapters. Each one of our meetings has been a great source of learning for me. I am very thankful to have the opportunity to benefit from his experience and to be inspired by his ideas and thoughts.

I'm extremely grateful to Martijn Smit who made this dissertation possible by accepting to host me as a visiting researcher at Utrecht University six years ago. At that time, I had no idea that this visit would be the start of a new PhD process. Martijn helped me equip myself with the necessary background and skills for economic geography research and showed his support in the early phases of this dissertation.

I'm also extremely grateful to Guido Buenstorf for his unwavering mentorship during the last stage of my PhD, as well as for his profound belief in my work

and abilities. I feel lucky and proud to be a part of his team at the University of Kassel.

During the course of my PhD, I worked at three different universities: Middle East Technical University, Utrecht University, and the University of Kassel. Although I would like to thank all the people in these institutions with whom our paths have crossed and from whom I've learned a lot, to enumerate the entire cast of people who have contributed to my research (directly or indirectly) would amount to writing another book. Still, some people deserve special attention.

I thank all members of the Department of Economics at Middle East Technical University who have contributed immensely to my personal and professional growth during my time as an undergraduate and graduate student. I especially would like to thank Ebru Voyvoda who sparked my interest in economic geography literature in the first place and supported me throughout my studies. I also owe thanks to Fikret Senses, who has always inspired and encouraged me for an academic career. I am deeply sad that he is no longer with us and could not see me finally receiving my degree.

At Middle East Technical University, where I worked as a teaching and research assistant for more than seven years, I was lucky to be surrounded by amazing colleagues. I thank all my former colleagues there for making those years much more enjoyable. I especially thank Aykut Mert Yakut, Zeynep Burcu Cevik, Dilan Aydin, Rengin Meryem Ayhan, Aysenur Ahsen, Beren Demirolmez, Ali Gokhan Karabilgin, Zeki Sengul, and Duygu Celik for their companionship.

I would like to highlight two truly exceptional people, my former colleagues and best friends, Ozgen Ozturk and Hakan Gunes. Since we started our graduate studies, each one of us moved across cities and countries, several times. I cannot even remember when was the last time we saw each other in person. Despite all the changes in our lives and time zone differences, we have held our video calls each and every week. Guys, thank you very much for your friendship, the constant enthusiasm you have shown for my work, reading my drafts countless times, and always being there for me. You are the ones who kept me sane throughout the whole process. I can't wait to celebrate our degrees, together!

During my stay in the Department of Human Geography and Spatial Planning at Utrecht University, I enjoyed the stimulating company of many great people. I would like to thank Andrea Ascani, Andrea Morrison, Paula Prenzel and Pierre Alexandre Balland, for the thought-provoking conversations we had and for their support. I would like to extend my sincere thanks to my paranymphs, Marielle Zill and Mathieu Steijn, for being amazing colleagues and true friends. I am also thankful to Xing Su, Amir Maghssudipour, Prince Guma, Ivonne Elsner, Mathias Koepke, Delphine, Karlijn Sporrel, Valentin Meilinger, Sara McDonald, Marianne de Beer, Nynke Burgers, Karin Snel, Hannah Roberts, and Paulien Hagedoorn for their friendship and for all the fun times we shared in Utrecht.

I would also like to thank my colleagues at the University of Kassel, who not only proved to be great team members but have become my close and dear friends. I thank Anastasiya-Mariya Noha, Francisco Flores, Igor Asanov, Johannes König, Katarina Zigova, Maria Theissen, Matthias Kapa, Merve Kilickan, Pia Schoch, Stefan Büchele and Valon Kadriu for their support and genuine friendship. I also thank Abeer Aziz, Blanca Tena, and Philipp Händel for the moral support they provided.

I would be remiss in not mentioning my dear friends Ayse Dincer, Burak Aktas, and Duygu Tasfiliz who have supported me on this long journey in every way they can. Special thanks to Ayse for designing the cover of this dissertation.

Words cannot express my gratitude to my husband, Ali Özgün, who has been a constant source of love, concern, support, and strength, during good and bad times. Without his endless support and understanding, I wouldn't be able to pursue my dreams.

Last but not least I would like to thank my family. My grandmother Sevim Kayi, grandfather Celal Kayi, and my aunt Melike Kayi gave me a room in their house in Ankara so that I could move out of my hometown and attend one of the best universities in the country there. I am extremely grateful for their unconditional love and support. I thank my sister Aysu Benli for all the joy she brings into my life. Lastly, I am deeply indebted to my parents, Süheyla Benli and Nedim Benli. In a country where even today many girls are out of school, they have always prioritized my and my sister's education, without a moment's hesitation. Anne, baba, teşekkürler!

Table of Contents

Chapter 1

Introduction

1.1 The geographical dimension of media

Two major events of 2016 that arrived through ballot boxes—Brexit and the election of Donald Trump—marked a breakthrough in the politics of the West. Although the economic and social issues that these events involved differed, some determinants of the outcome were similar. The main driver of discontent in both cases was perceived unfairness (Rodrik, 2018; Rodríguez-Pose, 2018), showing that perceptions of the world shape the future, whether or not those perceptions mirror reality. This dissertation studies neither the Brexit decision nor the election of Donald Trump. Rather, it addresses one key factor that influences perceptions of and attitudes toward issues, namely, news media. News media content and news consumption have played a pivotal role in the outcome of these (Watson, 2018; Gavin, 2018; Azari, 2016; Wells et al., 2016, 2020) and many more events. The overarching effects of news media on shaping public opinion are longstanding, and news media coverage of issues, persons, or topics exerts a significant influence on perceptions of the respective matter. This is because in addition to giving information about events, media also usually hint at how we ought to feel and indicate the line of action to take (Lippmann, 1922). Accordingly, the existence of media coverage, the amount of information, and its attributes impact how much importance to attach to the matter, and most importantly, how people understand, remember, and react to it (McCombs and Shaw, 1972; McCombs and Reynolds, 2009; McCombs and Valenzuela, 2020; Coleman and Banning, 2006; Entman, 1993, 2007; Nelson et al., 1997; Iyengar

and Simon, 1993). Of course, the effects do not end with politics. Studies show that news media coverage impacts people's perceived reality in many different contexts, such as their expectations about the economic situation (Goidel and Langley, 1995; Hester and Gibson, 2003), their attitudes toward and adoption patterns for new technologies (Gamson and Modigliani, 1989; Gaskell et al., 1999; Mazur, 2006; Skjølsvold, 2012; Bergek et al., 2008), their acceptance of global warming (Feldman et al., 2012; Bolin and Hamilton, 2018; Gavin, 2018), and even their behavioral responses to a pandemic (Allcott et al., 2020; Ash et al., 2020; Simonov et al., 2020; Bursztyn et al., 2020). Media involvement in almost all facets of our daily lives makes these findings no surprise. Through a newspaper we read, a TV channel we watch, a radio station we monitor, or an application on our smartphones, we expose ourselves daily to mass and social media. Even when we do not do any of these activities or actively reach for the media, the information they disseminate is often inescapable. The issues on the media agenda still find their way to us, usually coming up in daily conversations with friends and colleagues. Accordingly, news media deeply affect the substance of our talk and thought, and how we judge, perceive, and react to issues, which, in turn, affects the political, economic, and social settings in which we live.

No wonder this is not a one-sided relationship. News media organizations are commercial enterprises, i.e., profit-driven companies (Allern, 2002; Herman and Chomsky, 2010) that produce and sell an economic commodity. News is bought, sold, and traded (Kepplinger and Ehmig, 2006); therefore, its content partially depends on the tastes and preferences of the individuals who demand it (Hamilton, 2004). In other words, what the audience wants to hear or read about and how they feel about certain issues impacts what becomes news and the reporting of it.

When we speak of news media, we do not refer to one uniform entity or something identical everywhere. In addition to heterogeneity in the type of news media (e.g., print media, broadcast media), a substantial portion of media heterogeneity is geographical in nature. That is, the available news sources, broadcasting channels, and consumption patterns differ systematically between places (Hutchins, 2004; Carpini et al., 1994; Dou et al., 2006; Young and Dugas, 2012). Geography impacts what becomes news, where, and how, leading to regional differences in individuals' information sets regarding events and matters. Given that the decisions of economic agents are determined by the limits of their

knowledge (Simon, 1955, 1957), geography impacting one's information regarding events and matters is particularly relevant for the literature of economic geography.

Earlier work in the literature acknowledged regional differences in information content, the importance of regional information availability (Pred, 1971; Pred and Törnqvist, 1973), and information flows via news media between regions (Zipf, 1946). Furthermore, several seminal studies touched upon the importance of social processes, such as the exchange of information via mass communication, for the likelihood of novelty creation, adoption, and application (Hagerstrand, 1967, 1966; Cooke et al., 1997; Rogers, 1962) and the role of local information flows for knowledge creation in learning processes (Bathelt et al., 2004; Storper and Venables, 2004). Surprisingly, no direct work appears in the economic geography literature on the role of regional news media, and how they affect and are affected by local economic structures. Media, in general, and regional news media, in particular, are a big part of individuals' information space regarding events, issues, people, or locations. Accordingly, to understand how economic agents' actions lead to the emergence of spatial economic systems at the subnational level, understanding the potential determinants of their decisions -one of which is regional news media- is important.

As the examples of the Brexit vote and the election of Donald Trump showed, the underlying reasons for important decisions that affect the whole nation can be territory-specific and a consequence of local economic developments (Dijkstra et al., 2020; Rodríguez-Pose, 2018; Becker et al., 2017). How the locals perceive regional socioeconomic developments can be of paramount importance and, thus, may require a better understanding of the local narratives and information flows. Focusing on the subnational dimension of news media and the determinants and consequences of news media content can address this aspect. In the pages that follow, I review the literature on the geography of news media with particular attention to the subnational dimension. I show the embeddedness of regional and local news media in the regional economic processes and point out the areas overlooked so far, motivating the research questions this dissertation addresses.

1.1.1 Geography: A determinant of organization of media and media content

Due to limited time and space, the news media cannot cover all events. News value theories in the media-studies literature propose several factors and values (Galtung and Ruge, 1965; Staab, 1990; Harcup and O'neill, 2001) that determine which events the news media cover. Mainly, *newsworthiness* determines the likelihood of a news item's selection for publication (Kepplinger and Ehmig, 2006). News outlets (in the person of their editors and reporters) sort through available events and define what is more important, i.e., newsworthy for their audience (Andrews and Caren, 2010). After the nature and inherent characteristics of the event, such as its unexpectedness or magnitude (Galtung and Ruge, 1965), the main determinant of newsworthiness is the assessment of the event's relevance for the respective audience (Staab, 1990; Allern, 2002; Caple and Bednarek, 2016). The greater the perception of an issue as relevant, the more likely its coverage in the news becomes (Harcup and O'neill, 2017).

Geography plays a key role in this context since significant parts of the differences in judging newsworthiness have roots in geography (Allern, 2002; Boukes and Vliegenthart, 2020). The underlying reason is that an event or issue that is relevant in a particular location may not be so in another. Generally, people have greater interest in things that are close to where they live—local events impact them more than those far away. For example, people would like to know more about an earthquake that happened in the country where they are living than one that happened far away. This is also a major reason why the organization of news media is geographic, i.e., every country has its own national news media. Though national news media do not only cover events happening within their borders, geographic proximity plays an important role. A large body of media studies literature tests the news-flow theory and shows that the visibility of countries in one nation's news media relates to the geographical distance between countries (Rosengren, 1977; Chang et al., 1987; Kim and Barnett, 1996; Wu, 1998; Allern, 2002; Gasher, 2007). Although national news is usually the most consumed type of media content, regional and local news media are critical sources of information, facilitating public discussion and debate, and providing community cohesion around the content they cover (Hess and Waller, 2016; Ewart, 2000). In the regional media context, similar to the national scale, demand again is a key factor shaping the content of the coverage. In that case, events happening regionally or nearby will more likely receive

coverage than those happening in distant places that are less newsworthy for the respective audience. Geographic proximity is particularly relevant in the regional media context. Individuals turn to local and regional media outlets because they demand information about their own regions or the potential impact of events on their region. Many studies confirm that the distance between different regions within a country is negatively related to the value of information, making geographical proximity an important determinant of subnational news flow (Zipf, 1946; Maclean Jr and Pinna, 1958; Peris et al., 2021; Thomas, 2006; Boukes and Vliegenthart, 2020).

How geography impacts news media content is not limited to the existence and frequency of coverage about certain geographies. While proximity helps an event to pass through the first gate (Shoemaker et al., 2007), it is not the sole factor explaining news coverage. Some events that meet other criteria of newsworthiness, making them relevant for the respective audience, get covered even if they do not take place nearby. Differences across geographies impact the relevance of events for the audience and, thus, translate into differences in news content. This perspective is well established at the national level (Shoemaker and Cohen, 2012; Dobek-Ostrowska et al., 2010; Marks et al., 2007; Quandt, 2008), but empirical evidence at the subnational level is rather thin. However, the relationship between regional characteristics (social, economic, political, or geographic) and what the audience finds newsworthy might even be stronger at the subnational level and provide more insights into what becomes news and where. For example, in the context of news in a region where new wind farms are to be erected, a news item related to the experiences of those living next to wind turbines would be very newsworthy. Even if the related news item originates in a faraway location, it is still highly relevant. Many regional characteristics, such as demographics, income and education levels, main economic activities, dominant political leanings, or religion, as well as recent developments in the region, might affect newsworthiness or its absence and drive regional differences in news coverage accordingly. Despite studies showing that news coverage has a distinctive subnational geographic structure, and news content varies across regions (Althaus et al., 2009; Stephens et al., 2009), determinants of this heterogeneity remain mostly unknown and call for empirical investigation.

Geographical heterogeneity in news media is not limited to topics of coverage. Selection of an event for publication ushers in the editing and reporting phase.

Different media outlets hardly report an event in identical ways. A media outlet may highlight one aspect of the event in their reportage, and another outlet can focus on a totally different aspect; one media outlet can hold a positive view about a recent development while another is completely against it. Geography plays a crucial role in this respect as well, impacting the conveyance of information to the audience. Although this applies to almost all events or issues, it becomes easily noticeable in the political context. Media organizations cover issues in a way that conforms with the political views of the newspapers' circulation areas, aligning their slant accordingly (Puglisi and Snyder Jr, 2011; Gentzkow and Shapiro, 2010). More importantly, this holds even within a single media outlet; the slant can vary depending only on the location. News media outlets tailor the information in a way that conforms with their audiences' prior beliefs (Gentzkow and Shapiro, 2006).

This shows how the location of an event impacts the audience the information reaches. Regional characteristics play a role in what is reported, where, and how, by focusing on the processes the demand (or the audience) drives. However, the supply side is also important in explaining geographical differences in media content. To create news content, media organizations need a stable and reliable flow of raw materials, e.g., information regarding events. For this reason, media organizations are in a reciprocal relationship with potential information sources (Herman and Chomsky, 2010). These can be any organization within their reach, such as companies, governments, or associations. Since the public-relations bodies of organizations deliver information regularly, reliably, and containing useful materials (Walters and Walters, 1992; Hong, 2008; Turk, 1986), media organizations make extensive use of them (O'Neill and O'Connor, 2008; Macnamara, 2014; Lewis et al., 2008; Reich, 2010). Accordingly, the characteristics of the organizations to which they are geographically proximate heavily impact the input of news content. For example, in the regional news context, a media outlet in a region where many bank headquarters have located (i.e., a financial hub) is relatively more likely to publish business and financial news items. On the other hand, a tourist-destination region will more likely provide information on hotel occupancy rates, as well as upcoming social and cultural events in the region. Therefore, on both national and regional scales, events happening nearby will more likely receive coverage, and with greater detail, not only because of demand for it but also because the information is

more accessible to journalists. Supply-side determinants of subnational news coverage are yet another area that calls for empirical research.

In addition to the content of coverage, reporting styles are also not purely demand-driven. Media history and cultures impact reporting styles. Differences in news reporting norms and practices at both the national and regional levels significantly affect geographic differences in news coverage (Shoemaker and Cohen, 2012; Quandt, 2008). However, this is another area where subnational research is limited. Other regional news media-related characteristics that might explain differences in the reportage styles across regions are unknown.

All in all, geography is a crucial determinant of the organization of media, and what becomes news, where, and how has a strong geographical dimension. Despite studies hinting at potential differences across regions in terms of news media coverage, how regional characteristics drive these differences is still not well known. Whether different regions within a country receive exposure to heterogeneous sets of news media information (i.e., do they read or hear more about certain other regions or specific topics, and if so, what are the underlying regional characteristics?) remains an open question. This is particularly relevant for economic geography, as differences in regional socioeconomic characteristics will likely translate into differences in news media coverage of related topics. This dissertation aims to fill this gap by understanding the determinants of subnational differences in news media coverage from an economic geography perspective.

1.1.2 Media: A determinant of spatial knowledge and spatial differences in behavior

The above discussion, showing how geography affects media content and organization, touches upon only one direction of the relationship between media and geography. The news media's geographic organization and geography's importance as a determinant of news content mean that an individual's location impacts the information content to which he or she is exposed. That importance derives from the crucial role that the information that news media disseminate may play in shaping the social, political, and economic trajecto-

ries these geographies take, by affecting attitudes toward issues and places.[1] When discussing the mass media effect and its geographical dimension, distinguishing between the information *about* and *across* places -i.e., how media affects people's knowledge *about* different locations and how news content differences *across* regions translate into differences in expectations, beliefs, and perceptions- is useful.

Media content about regions has been addressed by geographers, mainly by focusing on the acquisition of spatial knowledge and the impact of media on the spatial patterning of economic activity. The departure point is how individuals perceive their environment and store spatial information. Early work on cognitive mapping (Downs and Stea, 1973) and environmental cognition (Moore and Golledge, 1976) emphasized the importance of information about relative locations and their attributes for subjective images that people have of places. Information assimilated from physical and social environments arguably constructs each individual's unique subjective representations of reality regarding a place (Burgess and Gold, 1985). These representations,[2] not necessarily identical to reality, contain both locational and attributive information (Garling and Golledge, 2000) regarding geographical areas. They represent individuals' views on what is at a particular location and why they might want to go there (Downs and Stea, 1973). These mental images are not only preference surfaces but also predictors of consequent spatial behavior (Gould and White, 2012). Building upon these theories, many studies show a link between mental representation or images of places, and the actual behavior of economic agents, both at the country (Wilson et al., 2014; Pappu et al., 2007; Hsieh et al., 2004; Laroche et al., 2005) and at the regional level (Meester and Pellenbarg, 2006; Pellenbarg and Kemper, 1997; Lloyd, 1976; Hunt, 1975). Both the quantity and quality of information about locations matter in the formation of spatial

[1] When referring to news media effect, this dissertation refers to any temporary or permanent change in kind, magnitude, or weight in cognition, attitudes, beliefs, affects, and behavior of individuals and formal/informal collections of individuals toward an event, issue, person or location, due to direct or indirect influence following exposure to news, as Potter (2011) defines. Whether mass media exerts a powerful or no impact, and the role played by individual differences in interpretation of media messages have long been discussed in media and communication studies. For a review of mass media effect theories, see Bryant and Finklea (2022); Scheufele and Tewksbury (2007); Potter (2011).

[2] Usually referred to as cognitive maps (Tolman, 1948) or mental maps (Gould and White, 2012).

knowledge (Pred, 1967; Burgess and Gold, 1985). The information can come either directly from personal experience with these locations or indirectly from various alternative sources. One of the most important sources for obtaining spatial information is the media (Griffin, 1999; Appleyard, 1973). Media content conveying information about an event answers the questions of *where* as well as *who, when, how* and *why*. Accordingly, the information about the event also carries information about the location where it took place. Since the event happening at a location is a product of what is in that particular location, media content *about* places reflects their respective characteristics, to some extent.

Media coverage of places creates a hybrid geography, reflecting both spatial and nonspatial characteristics of these places in people's minds (Howe, 2009), and helps individuals to develop generic knowledge of unfamiliar environments (Walmsley, 1982). Many studies show that media initiate, shape, reinforce, and stigmatize the external images of countries (Brewer et al., 2003; Mercille, 2005; Chalip et al., 2003; Baum and Potter, 2008) and cities or other subnational units (Wassenberg, 2004; Gold, 1994; Garcia, 2017; Burgess, 1974; Hastings and Dean, 2003; Devereux et al., 2011). Accordingly, how the media represent places, i.e., their visibility and the content of information *about* them may influence the spatial decisions of economic agents toward these places. Place-branding scholarship shows how frequency and content of media coverage impact economic decisions regarding countries (Foroudi et al., 2016; Dinnie, 2004; van Ham, 2008) and cities (Avraham, 2004, 2000; Dinnie, 2010; Lynch, 1964; Hospers, 2009; Hinnosaar et al., 2021; Boland, 2008). At the subnational level, the influence of media on individuals' perceptions, beliefs, and behavior becomes even more critical. Media plays an important role in the institutionalization of regions, making them meaningful outside of their administrative context (Paasi, 1986; van Gorp and Terlouw, 2017). Furthermore, the news media effect is not limited to external images, i.e., perceptions of outsiders who lack first-hand experiences with respective regions. News media representation of places also impacts internal images, i.e., perceptions of those in the region. Several studies show that media coverage plays a crucial role in the construction of regional identities (Zimmerbauer, 2011; Martin, 2000; Lindgren, 2009; Frisvoll and Rye, 2009). However, we still lack large-scale information on how news media represent places, with what frequency, and in the context of what types of topics.

In addition to the information *about* different geographies, the content of news media coverage *in* different geographies is also important. While the former explains the media's role in shaping perceptions regarding geographies and, thus, influencing spatial behavior, the latter explains how differences in news media content across geographic units translate into differing perceptions, beliefs, and behaviors toward issues. For instance, news media coverage about economic issues demonstrably affects public opinion on economic perceptions and the resulting economic behaviors (Goidel and Langley, 1995; Damstra and Boukes, 2021; Garz, 2018, 2012). More specifically, even after controlling for the actual state of the economy, the frequency, tone, and framing of news coverage of economic issues impact consumer sentiment (Doms and Morin, 2004; De Boef and Kellstedt, 2004; Hollanders and Vliegenthart, 2011), consumer spending (Starr, 2012), inflation expectations (Lamla and Lein, 2014), corporate reputation (Wartick, 1992; Carroll and McCombs, 2003), trading behavior (Li et al., 2014), and stock market prices (Tetlock, 2007). Differences in the information that different news sources disseminate explain differences in economic evaluations (Goidel et al., 2010). In light of the geographic variations in news media content, this suggests that individuals in different geographies may hold differing views regarding issues, depending on the news media coverage to which they have been exposed. Geographic variations in attitudes toward new technologies well illustrate the effect of news media in this respect. Many studies show how differences in news coverage of new technologies across countries have resulted in countries taking different trajectories toward the respective technologies (Gaskell et al., 1999; Skjolsvold, 2012; Negro et al., 2012; Mazur, 2006). The reason is that expectations society holds regarding a technology are fundamental in shaping the development, diffusion, and adoption of the respective technology (Borup et al., 2006; Budde et al., 2012; Geels and Verhees, 2011). Despite ample evidence at the national level, potential variations in news media's content and sentiment with respect to new technologies on a smaller scale (i.e., the subnational level) remain unknown (See e.g., Stephens et al., 2009, for exception). Given the importance of regional scale in stimulating the innovation capability of regions, research on the subnational level would contribute to a better understanding of the relationship between regional news content and related subsequent regional developments. Similar to technology news coverage, we do not know if there exist systematic regional differences in media coverage of many other processes that are critical for regions' economic performance. More importantly, limited research exists on differences in news

exposure at the subnational level and how they affect people's perceptions, behaviors, and subsequent regional developments. One exception is the study of Garz (2018), showing that unemployment news coverage impacts perceptions of the condition of the economy by using German federal state-level data. The findings suggest that regional newspaper content might play an important role in the public perceptions of economic issues. Another exception is the study of Jambrina-Canseco (2023), which shows that geographical differences in newspaper reporting reflect local narratives, and these drive spatial differences in voting behavior. These works substantiate the promise of the regional and local news media in explaining regional differences in perceptions and behaviors. This dissertation aims to address this understudied aspect, i.e., how regional differences in news content translate into differences in perceptions and behaviors across regions.

The effect of regional and local media on social and economic developments is not limited to the content of media coverage, i.e., what the media report *about* a region or *in* a region. The very existence of regional news media, informing their audience about what they consider newsworthy and helping them to occupy a similar information space regarding issues, contributes to producing and maintaining a sense of community (Ewart, 2000; Mathews, 2022). Many studies find that local news media consumption positively relates to the production of social capital, and civic/community/political participation (Kang and Kwak, 2003; McLeod et al., 1996), all important determinants of regional economic development (Paasi, 2003; Raagmaa, 2002). The presence or absence of local media is particularly important for the behavior of economic agents. The probability and magnitude of local trading in financial markets strongly relate to local media coverage (Engelberg and Parsons, 2011). Studies find that local newspapers closing has significant effects on the behavior of firms in the region, such as significantly increased misconduct in firms (Heese et al., 2022), exacerbated agency problems (Kim et al., 2021), and increased toxic emissions (Jiang and Kong, 2021). The effect is not limited to firms; newspaper closures also cause municipal borrowing costs to significantly increase (Gao et al., 2020). Political behavior also closely relates to the existence of local media outlets. Newspaper closings are associated with a decrease in political participation (Magasic and Hess, 2021) and more polarized voting behavior (Darr et al., 2018). These suggest that regional and local media are key institutions

impacting regional social, economic, and political developments, implying the necessity of further research.

All in all, the local and regional media landscape is related to many regional socio-economic characteristics, and this calls for research on the role of regional news media in peculiarities and economic developments at the subnational level. News coverage about regions, i.e., topics with which regions are mentioned in news media, and media's impact on trajectories regions take are among the questions this dissertation aims to address. More empirical research on the subnational dimension of news media would facilitate developing a theoretical framework that explains the relationship between the geographical dimension of news media and regional socioeconomic characteristics. This dissertation also makes an initial step in this direction.

1.1.3 The need for data

The main reason for the limited work on the geographic dimension of media, especially at the subnational level, is data availability. Collecting and analyzing media data is no longer a labor-intensive process, and a growing number of institutions collect and analyze them. However, this does not mean that news media data are easily accessible or available to researchers. First, most of the available news media datasets (e.g., Factiva[3], LexisNexis[4]) are behind a paywall. Second, they have a thematic focus (e.g., financial news). Third and most importantly, they have little or no subnational orientation. Among others, the GDELT project[5] stands out for providing a subnational dimension on events and being open and freely available. This dataset provides detailed information about the events, such as the people and locations involved, and the tone of coverage, by using natural language processing techniques. Although the dataset carries a wealth of information regarding what is happening in different parts of the world and provides it in a systematic manner, this dataset also has shortcomings in analyzing regional media. It does not utilize an extensive number of different news sources nor provide the text of the articles. Most importantly, although the events have a geographic dimension in the dataset, the media outlets do not; i.e., the dataset does not give information about what is published and read *where*. Accordingly, the datasets that provide a substantial

[3] `https://www.dowjones.com/professional/factiva`.
[4] `https://www.lexisnexis.com/ap/academic/form_news_all.asp`.
[5] `https://www.gdeltproject.org`.

view of the subnational dimension of media -i.e., the newsworthy events taking place in specific locations and where these are reported- are still nonexistent. Thus, addressing research questions regarding the regional dimension of news media requires data collection. This constitutes another aim of this dissertation, namely, the establishment of regionalized news-media datasets.

To extract information on media content, focusing on written and news-based media sources is more efficient; these types of media provide information on events encoded in text. Text data is a high-dimensional, rich complement to the more structured kinds of data (Gentzkow et al., 2019) and expresses a vast opportunity to discover previously unknown information. Recent technological developments and improvements in computational methods make it possible to extract information on media content, and automation of tasks in media content analysis allows focusing on a scale far beyond the sample sizes of traditional forms of analysis (Flaounas et al., 2013). Accordingly, print news-media sources and their online outlets provide a great opportunity to investigate the relationship between regional news content and regional characteristics, from an empirical perspective. While local and regional newspapers are not the only form of regional news media, they are the most prevalent form at the regional level (Hutchins, 2004). Regional newspapers typically have a locally concentrated readership that focuses on local events or local aspects of general phenomena (Larcinese et al., 2011). They are also the main drivers of interregional heterogeneity in media exposure, as they usually have differentiated contents for different geographical areas. Thus, this type of media is particularly relevant to addressing questions on the geographical dimension of news media at the subnational level. This dissertation builds such a dataset, consisting of the content of local and regional newspapers and their areas of circulation.

1.2 Research focus and dissertation outline

The preceding discussion shows that despite news media's strong geographical dimension, we still lack information on the determinants and consequences of regional news content. More specifically, despite the fact that the geographical aspect of news media has seen some research interest in media studies and human geography (Jansson and Falkheimer, 2006; Burgess and Gold, 1985), and the economic geography literature acknowledges the importance of local information flows, little published direct work exists on how regional news media

affect the decisions of economic agents, how regional economic characteristics affect news coverage, and how news-media data can provide insights into regional economic structures. This dissertation aims to address this gap, i.e., approach the regional dimension of news media from an economic geography perspective. First, it investigates whether media content referring to events reflects the characteristics of the respective regions, to assess whether news media data can serve as a useful data source for regional studies. Second, it examines how media coverage regarding specific topics aligns with regional socioeconomic characteristics and the attitudes of its audience toward issues. Third, it investigates how subnational heterogeneity in news media reporting translates into systematic variations in related behavioral responses. More specifically, this dissertation aims to address the following research questions.

1. To what extent does the frequency of press (news) releases mentioning regions reflect respective regions' socioeconomic characteristics?

2. How does regional newspaper coverage related to innovation differ across regions and how do the frequency and sentiment of innovation news relate to regional socioeconomic characteristics?

3. Do differences in regional newspaper coverage of COVID-19 translate into regional differences in social-distancing behavior?

The dissertation addresses the research questions empirically for Germany, and accordingly, collected media content data for this country. Strong local and regional newspapers characterize Germany's media landscape (Kretzschmar et al., 2009), and these papers have high circulation and readership numbers (Harnischmacher, 2015; ZMG, 2022; Humprecht and Esser, 2018; Mangold et al., 2017; Krueger and Swatman, 2002; Horz-Ishak and Thomass, 2021), making this country an ideal case for the research questions in focus.

This dissertation contains three main chapters, each focusing on a specific hypothesis formed around the research questions. Chapters 2, 3, and 4 are separate research articles, and Chapter 5 summarizes and reflects on the findings of these studies, points out the contributions to the literature, and identifies remaining challenges for future research. Below, I briefly introduce the aim of each chapter and the analyses I conducted to address the research gap.

1.2.1 Chapter 2: Assessing press releases as a data source for spatial research

As in most social sciences, regional scientists and economic geographers constantly seek to advance their available databases, the better to assess, describe, and explain structural differences at the subnational level. This requires exploiting a range of distinct datasets and complementing standard official datasets with novel data sources. Thanks to technological advances, new datasets appear for almost all quantifiable aspects of human life (Einav and Levin, 2014; Arribas-Bel, 2014). One such novel data source is media content, which provides comparable and representative pictures of socioeconomic activities within regions.

Press or news releases are a type of print media that provide information on new developments and noteworthy events about their issuers. Since these releases frequently include a geographic reference, we argue that they might reflect the characteristics of the regions to which they refer. A company opening a new store, a new play that a theater company is performing, a new exhibition in a museum, a concert a music hall hosts, or a sports game or tournament, all refer to their respective locations. Even with no mention of a specific location, an implied geographical reference characterizes these information flows. Providing information on news from their organizations, press releases implicitly inform about the organization's location. Accordingly, press releases offer several attractive features for spatial research, such as their wide availability, rich textual information that includes aspects that official statistics do not cover, and most importantly, their geolocatability. Despite the recognized value of press releases as a data source (Johnson and Haythornthwaite, 1989; Berger et al., 2020) and several studies indicating their potential value for spatial research (Feldman and Lowe, 2015; von Bloh et al., 2020), the extent to which they contain systematic information for describing socioeconomic structures at the subnational (regional) level remains unknown.

The research article in Chapter 2 addresses this gap, by assessing whether, on an empirical basis, press releases represent a useful data source in this context. More precisely, we argue that regions' socioeconomic structures systematically shape the content of press releases, consequently allowing inferences from using press-release data. We test this argument by assessing the spatial correspondence of information obtained from geolocated press releases in Germany to

that of relevant regions' general characteristics. At the level of 401 districts (NUTS-3 regions), our results confirm that interregional variations in the events that these press releases report correlate well with the regions' general socioeconomic characteristics.

1.2.2 Chapter 3: The geography of innovation and technology news – An empirical study of the German news media

Although innovation and technological progress are crucial ingredients of economic growth (Romer, 1990; Aghion and Howitt, 1990), they may also induce negative social and economic effects. The recent controversy around artificial intelligence (AI) well illustrates this two-sided nature of innovation. While it promises huge potential for future economic growth (Aghion et al., 2018; Goldfarb and Trefler, 2018), some of its implications (such as automation) are also likely to transform the labor market by replacing certain types of workers (Acemoglu and Restrepo, 2019; Frey and Osborne, 2017; Furman and Seamans, 2019), which creates public concern (Fast and Horvitz, 2017). The wider public's attitudes and expectations regarding new technologies matter; they are fundamental factors shaping the institutional structures, which, in turn, affect the development, diffusion, and use of new technologies (Borup et al., 2006; Geels and Verhees, 2011; Budde et al., 2012; Konrad, 2006). News media discourse regarding these technologies partly shapes these expectations (Gaskell et al., 1999; Skjølsvold, 2012; Negro et al., 2012). However, this alignment of news coverage and public perceptions is not one-directional. News media reflect their audiences' preferences and correspond to existing audience views and interests. In this sense, media outlets match their audience's prior beliefs and adapt their slant accordingly (Gentzkow and Shapiro, 2006, 2010; Marks et al., 2007).

Analysis at the national level of media discourse on innovation and new technologies and its relationship with public perceptions (Dudo et al., 2011; Mejía and Kajikawa, 2019) hints at the importance of geography in this context. However, previous research has overlooked the potential variations in news media's content and sentiment, with respect to technologies at the subnational level. Innovation processes are highly localized, requiring a better understanding of variations in the presentation, discussion, and evaluation of new technologies in the news at the regional level. The research article in Chapter 3 addresses

this gap by investigating whether systematic regional variations exist in the news coverage of innovation and technology and identifying their primary determinants (regional characteristics). More precisely, the chapter hypothesizes that variations in frequency and tone of news reporting about new technologies are not random but, rather, reflect systematic structural differences among the regions. Empirically exploring the hypothesis by focusing on German spatial planning regions, we find a strong link between the regional socioeconomic conditions and how newspapers circulating in these places report on innovation and new technologies. Accordingly, this chapter deepens knowledge of the link between news media and conditions for innovation and technology development at the regional level.

1.2.3 Chapter 4: Saved by the news? COVID–19 in German news and its relationship with regional mobility behavior

The unexpected COVID-19 pandemic was a big threat to people's physical, mental, and economic well-being. At the very beginning, people had no idea about the virus, the disease it causes, its consequences, and how to protect themselves. The ambiguity and discomfort that this situation caused increased information-seeking from all available sources. News media, the primary information system available, has been the first place that people saw or heard about the novel coronavirus and learned about the course of the pandemic and how to protect themselves. The COVID-19 pandemic has increased news consumption all over the world (van Aelst et al., 2021; Lemenager et al., 2021; Hölig et al., 2020), and information disseminated via media informed the behavior of their audience. As one would expect, news outlets did not communicate COVID-19 health risks in identical ways. Divergent messages from different media outlets altered audience stay-at-home behavior and consumption patterns (Ash et al., 2020; Simonov et al., 2020; Allcott et al., 2020). Furthermore, different behavioral responses are not limited by the choice of news outlet; the content of information to which one is exposed by the same media outlet also impacts audience perceptions regarding the virus and resulting infection rates (Bursztyn et al., 2020).

There are also substantial spatial variations in the impact of COVID-19 on peoples' lives. Although the role of news media in shaping their audience's health-related behavior is well established, the role played by regional differ-

ences in the consumption of news is still not known. In Chapter 4, we address this gap and investigate the relationship between regional news coverage of COVID-19 and the social-distancing response of their audiences to the pandemic. First, we explore the subnational heterogeneity in the presentation of COVID-19 in the news. Second, we assess whether subnational variations in the frequency and ways in which regional news covers the pandemic translate into spatial variations in social-distancing behavior. Using spatial panel regression models at the level of German districts and weekly observations, we identify a significant, albeit time-variable relationship between COVID-19 news reporting and regional mobility patterns.

The findings suggest that regional news media may have played a role in the spreading of COVID-19, especially at the beginning of the pandemic, as people in locations where the news media covered the virus with a lower frequency and communicated risks in less dramatic ways were less likely to adapt their mobility behavior.

1.3 Concluding remark

A better understanding of regional economic processes entails an understanding of people's behavior, expectations, and perceptions. Despite news media being a crucial channel shaping those, our knowledge on the matter at the subnational level is still very little. The overall aim of this dissertation is to show systematic regional variations in news content and unveil their regional determinants as well as their influence on subsequent socioeconomic developments. Each of the three chapters in this dissertation investigates the bidirectional relationship between the regional dimension of news media and regional social, economic, and behavioral processes, from a different perspective. The findings and their implications enable a deeper and better understanding of subnational heterogeneity in news media reporting from an economic geography perspective, contributing to our knowledge of regions. Finally, in light of the empirical findings, the dissertation offers a broad conceptualization of the relationship between regions and news media, thereby highlighting news as a frequently overlooked factor in economic geography.

Chapter 2

Assessing press releases as a data source for spatial research

Abstract: Describing the distribution and development of socio-economic activities in space is frequently limited due to data availability, as official statistical data sources do not capture all activities, for all geographic scales. Consequently, new and alternative data sources need to be explored in order not to neglect important dimensions of regions' socio-economic structures. This paper presents, discusses, and empirically explores an alternative data source that promises to give detailed and novel insights into regions' socio-economic structures: press releases. While these have been used in the literature, their value for regional research has not been systematically assessed so far. The paper closes this gap by testing if press releases about specific topics provide a good match with the available official statistics on the related socio-economic characteristics, for the German NUTS-3 regions. The empirical analysis confirms that press release content varies systematically between regions, which suggests that they offer substantial potential and might be a useful source for regional studies.

This chapter is a revised version of the publication:
Ozgun, B., & Broekel, T. (2022). Assessing press releases as a data source for spatial research. *REGION*, 9(2), 25-44.

2.1 Introduction

Information on economic activities is at the heart of the empirical literature in economic spatial sciences. Unless researchers collect their own primary data, most contemporary studies rely on official secondary data sources. While the primary data collection requires massive efforts and is simply unfeasible in many situations, the secondary data sources imply that researchers are restricted to looking at socio-economic developments using available data. This may not always give a precise representation of the phenomenon in question. Finding new data sources that capture socio-economic processes in novel ways or from new perspectives is therefore imperative to empirical research.

This imperative motivates the present study, which presents a data source that has seen some applications in the literature yet has not been discussed nor evaluated with respect to its usefulness for spatial economic research at the sub-national level: press releases. A press release is a written statement about a matter that might be of public interest, written by an organization related to the matter. Organizations issue press releases to inform the public about noteworthy news and recent developments. Press releases contain rich and useful textual information covering a wide range of topics in domains like political (e.g., announcements by local administrations), social (e.g., sports and music events), and economic (e.g., updates on new products and firms). Not surprisingly, their value as a data source has been recognized for some time (Johnson and Haythornthwaite, 1989; Berger et al., 2020; von Bloh et al., 2020). However, the extent to which they contain information for describing socio-economic structures at the sub-national (regional) level has not been explored so far. The present paper conducts such an assessment and discusses if press releases represent a useful data source in this context from an empirical basis. More precisely, we argue that the content of press releases is systematically shaped by regions' socio-economic structures, which in consequence allows inferences about the latter by (empirically) observing the first.

We test this argument by assessing the spatial correspondence of information obtained from geo-located press releases of Germany's biggest press release agency to that of regions' general characteristics. At the level of 401 districts (NUTS-3 regions), the study confirms that inter-regional variations in the events reported in these press releases correlate well with the general socio-economic characteristics of regions. For instance, population density, income

level, and touristic potential of regions are clearly reflected in the content of press releases. As there are little to no reasons why this correlation should be systematically different for other and more specific content, our findings substantiate the promise that press releases might be a complementary data source to official statistics in spatial research at the sub-national level, which is likely to capture socio-economic patterns and processes not covered by these. An example of the latter is the study by von Bloh et al. (2020) that uses press releases to capture the entrepreneurial activities and sentiments towards it in regions.

The remainder of the paper is organized as follows. Section 2.2 discusses why press releases might be a valuable data source in spatial sciences. Section 2.3 presents the empirical basis for testing press releases' correspondence to regional characteristics. It outlines the data collection and cleaning process and describes the overall structure of the data set. Section 2.4 discusses the employed empirical set-up of the assessment. Section 2.5 presents the empirical results and discusses the findings. Section 2.6 concludes.

2.2 Press releases: An underutilized data source in spatial studies

In the age of big data, empirical information has been crucial for one's understanding of the world. The analysis of documented and codified facts and narratives is a crucial task in all social sciences independent of the analysis being quantitative or qualitative in nature. Frequently, it is the availability and richness of data that shapes what researchers can investigate and what perspectives they can apply. However, equally true is that all data are "biased" and "incomplete," meaning that each data set only offers a selective and particular view of the world. In sum, high-quality and reliable science requires researchers to utilize and exploit a range of distinct data sets.

This is not any different in spatial sciences, where the interest is frequently to assess, describe, and explain structural differences at the sub-national level, i.e., variations between regions. Doing this requires empirical data that provides comparable and representative pictures of what socioeconomic activities are happening within regions. Unfortunately, researchers are frequently limited to the use of official secondary data sources. While the topics covered by this type of data have been greatly expanded in size and improved in quality,

they still cover only specific portions of spatial socio-economic structures. For instance, information on the average value-added, unemployment, and investments are usually reliable and available in most countries as part of official statistics. They also usually exist for multiple years and at varying spatial scales. In contrast, processes like environmental initiatives, social events, types of sports conducted, etc. are less documented in official statistics (see, e.g., Stuetzer et al., 2018).[1] Yet, such activities are not less relevant. Sport is a major economic factor and this is similarly true for social activities. They both play crucial roles in the emergence and development of social networks and local cultures that facilitate knowledge diffusion, learning, and innovation, which are essential for regions' long-term economic development (Hofstede et al., 2010; Gertler, 2008; Saxenian, 1996). Consequently, it is essential for researchers to seek and explore novel data sources that complement existing ones by either allowing for looking at the same activities and events from an alternative perspective or by capturing aspects completely outside of the scope of official statistics. These may include activities and events that are recent phenomena and hence are not yet captured by such statistics. In this case, it takes unusual approaches and greater efforts by researchers to create empirical information capturing their existence and spatial distribution.

Recent technological developments and improvements in computational methods opened new toolboxes to obtain, structure, and transform data from various alternative sources. Frequently, these sources are not originally intended to be used in this context but provide novel opportunities for spatial research nonetheless (Arribas-Bel, 2014). For example, recent studies show that insights on firms' activities and their spatial interactions can be obtained from website data (Kinne and Axenbeck, 2018; Kinne and Lenz, 2021). Similarly, social media data, such as Twitter, allow researchers to explore topics like well-being and social attitudes. (Mitchell et al., 2013; Lansley and Longley, 2016).

The present paper contributes to the literature by discussing a data source that has been around for a long time, but that has hardly seen any utilization in the spatial sciences: press releases. Press releases issued by companies (Ahern and Sosyura, 2014; Henry, 2008; Dahlin et al., 2006), by political parties (Senninger and Wagner, 2015; Klüver and Sagarzazu, 2016), by local governments (Boussalis et al., 2018), and by health organizations (Park and Reber,

[1] Further limitations and shortcomings of official statistics are discussed in greater length elsewhere (see, e.g., Pérez, 2006; Bean, 2016).

2010) have been valuable information sources for researchers. Although several studies indicated press releases' potential value (Feldman and Lowe, 2015; von Bloh et al., 2020), they have not yet been used on a larger basis in spatial sciences.

Press releases provide important information about their issuers and their activities. In some cases, both the issuer and the event have a spatial dimension. The latter motivates the present paper, as the events reported in press releases may give insight into what is happening in specific locations. In other words, there are good reasons to suspect that information in press releases reflects regional events and activities. Given the great variety of issuers and topics, it is likely that they contain information on socio-economic issues.

Press releases are public statements created by governments, companies, research organizations, and the like, which are delivered to inform the media and targeted audiences. In other words, press releases are *told only to be retold* (Jacobs, 1999). By being one of the most important public relations tools, press releases provide journalists with crucial *raw materials*, as they contain usable information, and are delivered regularly and reliably (Walters and Walters, 1992; Hong, 2008; Turk, 1986; Aronoff, 1976). Accordingly, mass media and these information sources are in a so-called symbiotic relationship, due to reciprocity of interest and economic necessity (Herman and Chomsky, 2010). Not surprisingly, studies show that the reliance of journalists on public relations statements and press releases is extensive (Erjavec, 2005; Lewis et al., 2008; O'Neill and O'Connor, 2008; Reich, 2010; Macnamara, 2014). Crucially, press releases are not news. News is a commodity that is shaped by the dynamics of supply and demand (Hamilton, 2004). Since all events, people, regions, and discussions cannot be covered daily by the news media, all news outlets, e.g., local newspapers, broadcast television networks, or international news agencies, have to make decisions about what to report and what not to. The primary determinant of which events are reported is their newsworthiness (Shoemaker, 2006). Newsworthiness is related to both the inherent characteristics of an event and journalists' assessments (Staab, 1990; Kepplinger and Ehmig, 2006; Galtung and Ruge, 1965; Harcup and O'neill, 2017; Eilders, 2006). From a set of potential newsworthy events, media outlets filter what is perceived to be the most newsworthy for their own audience (Boukes and Vliegenthart, 2020). Even when a story is considered newsworthy, it is not automatically published.

For example, on a slow news day, minor events can become news that wouldn't have been reported on a news-rich day (Gans, 2004).

On the other hand, press releases are subject to just a fraction of this selection process. They do not have to be considered relevant or newsworthy for anyone but the issuer. At least in the short run, it is the issuer's urge to supply information rather than their desire to satisfy demand. Nevertheless, it can be expected that the issuer will invest the efforts of producing a press release only if they expect some demand for it from the press or another kind of audience. In any case, press releases do not go through a similar multi-stage selection, filtering, and editorial processes as news, which is known to induce all sorts of biases (Robinson and Sparkes, 1976; Kariel and Rosenvall, 1984; Chang et al., 1987; Wu, 2003, 2007; Himelboim et al., 2010; Segev, 2015). Consequently, in contrast to news, they are much less subject to these biases built into the journalistic system. However, that doesn't mean that they are unbiased. In many instances, an individual press release is more subjective than a news item that has made it through a more rigorous journalistic process. Crucially, their information content is limited to what the issuer wants to share, and they tend to be written in a positive tone (Maat and de Jong, 2013). Not surprisingly, it is known that for press releases to become news, they need to be rewritten to match the (more objective and rigorous) editorial and stylistic requirements (Walters et al., 1994).

While the subjectivity and a potential positivity bias will translate to the regional level, when press release information is aggregated, at least the degree of subjectivity is likely to "average out" with larger numbers of (heterogeneous) issuers in a location. Indeed, this number will in many cases be larger than the number of news outlets in a region, which frequently are a much smaller and more homogeneous (in terms of education, qualification, and motivation) group, i.e., journalists. Consequently, in many circumstances, and conditional on a large number of issuers, press releases might be a more direct and less-biased information source than news. We also argue that the positivity bias is less of a problem when looking at press releases from a spatial perspective because it would need to have a distinct and systematic inter-regional variance to impact cross-regional analyses. This logic similarly applies to the sentiments of press releases, which are likely to be very positive in general, yet, it is only their inter-regional variance that matters in regional analyses. Nevertheless, they are still subject to specific selection processes implying that they are not

useful information sources in all circumstances. For example, they are less likely to give insights into negative events.

While press releases are different from news, they have a similar potential to identify regional particularities and differences. The heterogeneity of issuers and events they deem to be press release-worthy is substantial. The low effort of writing a press release makes it quite likely that events with a relatively minor level of (social) significance will show up in press releases. The non-restrictiveness of what they can inform about gives more room to heterogeneous events and activities being featured. On top of that, it is their textual nature that gives broader possibilities to extract information. Accordingly, the frequency with which events in specific locations are covered in press releases may give further insights into the observed or unobserved spatial distribution of the underlying events.

The purpose of this study is to unveil the potential of press releases in reflecting regional characteristics based on aggregate numbers of events reported. For this, we adopt a straightforward approach: We expect that specific categories of events found in press releases are related to specific regional characteristics. For instance, events related to economic activities are more likely to occur in regions with plenty of economic actors (banks, insurance); locations attractive to tourists are likely to feature many entertainment events, and so on. Consequently, we seek to assess the empirical fit between the frequency of events of a certain kind reported in press releases in a specific location and general characteristics of the respective regions obtained from official statistics that should relate to them.

2.3 Data

We work with a collection of press releases brought together by the *Presseportal*, a subsidiary of DPA (Deutsche Presse Agentur). DPA is Germany's leading press agency (Kleinsteuber and Thomass, 2007) and the Presseportal is the largest and most popular press release portal in Germany.[2] Their services are used by more than 12,000 organizations, which are represented with their own newsrooms. The portal attracts around 20 million visitors per month (Presseportal, 2021). The agency operates without a clear thematic focus (except for a geographical one on Germany) and provides only minimal professional

[2] `www.presseportal.de`

journalistic editing and selection process. This implies that the press release collection covers a wide variety of topics and events. For example, companies share their financial reports, new product announcements, innovations, new store openings; universities, research institutes, and medical associations share recent findings; local governments share new developments in their regions; local media outlets share recent local events and incidents; sports magazines share information on games and scores; political parties share statements made by their members; cultural venues share upcoming event information. In sum, the portal provides a collection of events and developments which are found worth sharing by their creators. Accordingly, we can expect this data to carry a wealth of up-to-date information on what these organizations do in specific places.

We accessed and downloaded press release data from *Presseportal* for four years (from May 2016 to May 2020). Releases were retrieved daily by using the portal's API service. In total, we downloaded 140, 833 press releases. For all press releases, we recorded the title, full text, date, location, name of the issuing organization, and keywords. While this text data is generally of high quality, several steps were necessary before it could be analyzed.

First, some press releases include TV program information published by TV broadcasters. These releases usually review the content of movies and TV series implying that in most cases, they represent fictional information. Consequently, we removed them from our data.

Second, the location given in the press releases refers to the location of its issuer, which might be distinct from the location of content, i.e., where the event described in the release takes place. For example, a press release about an upcoming play in Hamburg might be assigned to Berlin as the location because the entertainment company issuing the release is located there. In the context of the present paper, we are more interested in where the event takes place. For this reason, we applied a two-step procedure to geo-locate the press release content. In the first step, we identified the names of locations mentioned in the press releases using an adapted string-matching approach based on an extensive list of location names in Germany. Given that the location names in Germany can be a combination of multiple words and some names may refer to multiple locations, we had to develop a sophisticated string-matching approach including intensive cleaning and the use of additional information, to identify

the correct locations. When present in the text, we assigned multiple locations to an individual press release. It implies that press releases are counted multiple times when the press releases are distributed across regions. The multiple counting is reasonable, as multiple locations being named in a press release is most likely due to the underlying event taking place in multiple locations or multiple events being referred to. With this approach, we were able to assign 55,776 press releases to at least one location in Germany. In the second step, we assigned all press releases that did not contain location information, to the location of the issuer, as given in the original database. After the two steps, 99,984 press releases were assigned to one or more locations in Germany.[3] The assigned locations were later aggregated to the NUTS-3 level. More than 80% of all press releases were assigned to just one NUTS-3 region. Figure 2.1 gives a first impression of the spatial distribution of press releases.

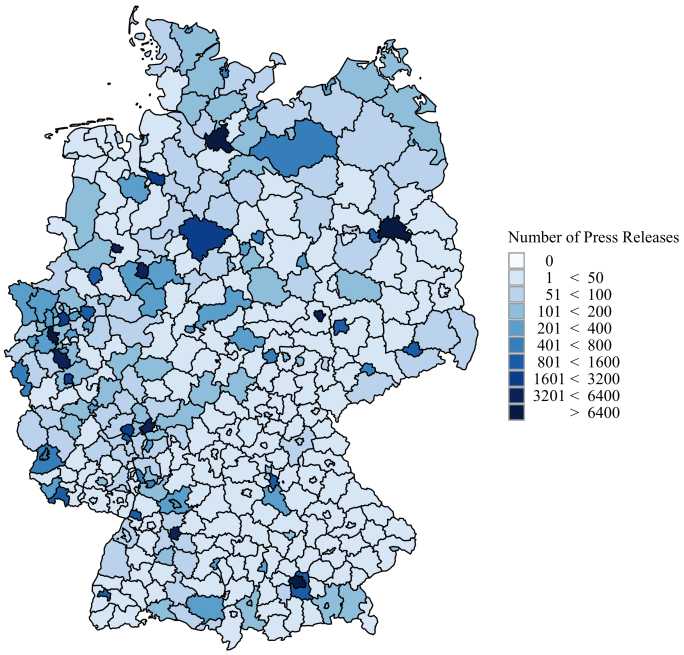


Figure 2.1: Spatial distribution of press releases

[3]The remaining press releases were either issued by organizations outside of Germany or did not contain any location name in Germany. Further details on the geolocation procedure can be found in Appendix A.

The map reveals a strong imbalance in the geographic distribution of press releases. Of 401 districts, only one either had not been covered by press releases, or our approach could not identify any location in the region. 197 districts had been covered in less than fifty press releases, implying that they have been reported about less than once a month, on average. The most frequently covered region was Berlin; it was mentioned 26,559 times. One-third of all press releases referred to four (of 401) regions; namely Berlin, Dusseldorf, Munich, and Hamburg, which are among the most populous German cities. Other regions shown in dark colors on the map are Cologne, Frankfurt, and Stuttgart, which are also among the largest cities in Germany. This observation does not come as a surprise. Districts with a greater population are usually the ones where larger numbers of events are taking place, and where more issuers are located. Other than this, we do not observe any strong spatial pattern such as spatial clustering, or differences between federal states. Spatial autocorrelation also appears to be largely absent.[4]

There were 12,327 distinct organizations issuing press releases. Unfortunately, for these organizations, we do not have background information other than their (often incomplete) names. To get at least some idea about who they are, we manually classified all issuers with more than 100 releases, which in sum contribute about 50% of all press releases. The majority of them are firms (32%), non-profit associations[5] (25%), and newspapers (25%).[6]

Press releases in the data set cover a wide variety of topics. Fortunately, the press release portal associates each press release with one or multiple keywords. In total, there are 283 distinct keywords in the dataset. On average, an article is associated with three keywords. The keywords' frequency distribution is very skewed. One-third of the keywords do not show up in more than ten press releases, i.e., they appear to be very case-specific. In contrast, some keywords are used very frequently, suggesting that the press releases seem to be simultaneously assigned to general and specific keywords. Manual inspection of a randomly selected set of press releases confirmed a good fit between the press releases' content and the assigned keywords. Figure 2.2 shows the frequency

[4] A Moran's I test for spatial autocorrelation confirms this with a test statistic -0.01 and p-value 0.67.

[5] As indicated by an "e.V." being part of their name, which applies to all formally registered non-profit organizations / associations in Germany.

[6] The coverage rate and selection of news articles issued as press releases are unknown at this stage.

of the most common 20 keywords. Clearly, words associated with politics and the economic situation dominate. However, words related to tourism, health, entertainment, and sports themes are also relatively common.

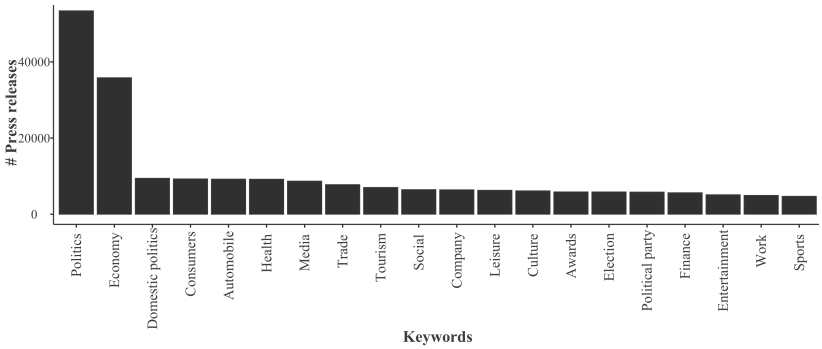


Figure 2.2: Most common keywords and their frequency in press releases

Figure 2.3 visualizes the most frequent keyword for each NUTS-3 region to give an idea about the keywords' distribution in space. Of 283 keywords, 13 turn out dominate in at least one district, with *economy* and *politics* being dominant in 184 and 132 districts, respectively. The distribution of general keywords does not contain insights into inter-regional differences. However, looking at less frequent keywords gives the first impression of a potential fit between press releases' content and regional characteristics. For example, the majority of press releases referring to the city of *Mönchengladbach* are categorized to the keyword *Sports*. This reflects that the city is strongly associated with its soccer team *Borussia Mönchengladbach*, which plays in the Bundesliga. Another illustrative example is *Saarlouis* for which the most frequent keyword is *Automobile*. Correspondingly, the largest employer in this town is the Ford Motor Company's body and assembly facility. These examples show how the portrayal of regions in press releases varies and how significant events and sectors shape the content of press releases linked to these places. In the following, we will explore this link in a more systematic way.[7]

[7]The anonymized version of the dataset is available at: `https://github.com/burcuozgun/grpr`.

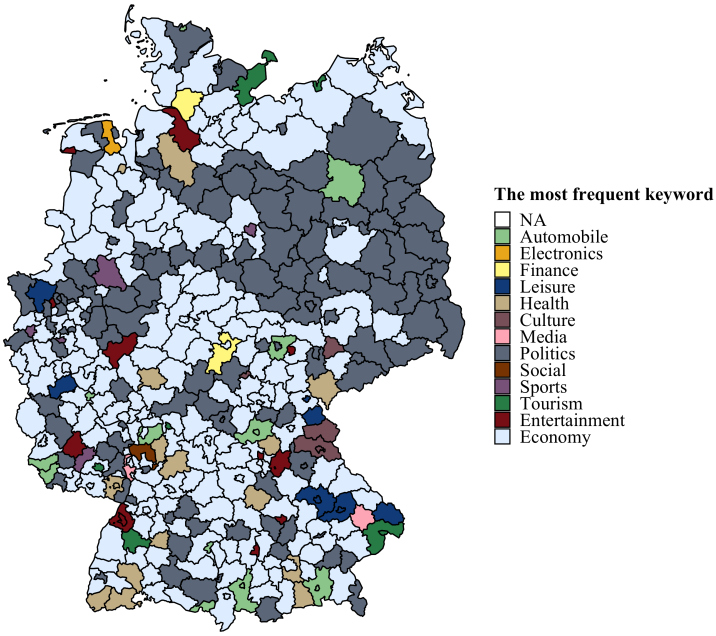


Figure 2.3: The most frequent keyword in each region

2.4 Empirical approach

Our analysis seeks to assess the degree to which the content of press releases corresponds to the socio-economic characteristics of regions. Empirically, we test if regional characteristics explain the frequency with which events are associated with corresponding regions. In our baseline model, the total number of press releases associated with each region, *PRESS*, is the dependent variable, which is related to a set of regional socio-economic factors to assess which of these relate to the quantities of press releases. Afterwards, we estimate four separate models in which the dependent variables correspond to the number of press releases representing specific topics (i.e., keywords). While the set of explanatory variables, i.e., the set of regional socio-economic factors remains the same in each model, it is usually one of them that is contextually most closely related and hence is expected to show the strongest empirical association with the dependent variable.

The size of regions is approximated by their population, which is denoted by *POP*. We capture urbanization with the variable *POPDENS*, which is the num-

ber of resident individuals per square kilometer. The economic success of regions is approximated by the gross domestic product per capita ($GDPC$).[8] All three variables capture the overall frequency with which events take place in regions, in general. That is, larger and more economically successful regions are likely to have more "press-release" worthy events.

A variable that refers to a more specific regional characteristic is tourism ($TOUR$), which shows the touristic attractiveness of regions, measured by the number of overnight stays in tourist facilities per inhabitant. Straightforwardly, we expect the frequency of press releases related to tourism and leisure to be empirically associated with this variable. Peoples' interest in politics is captured by voter turnout in regions ($VOTE$). It is defined as the percentage of eligible voters that participated in the federal elections in 2017.[9] As for tourism, this variable represents a specific set of activities and consequently, should be mirrored by the frequency of political events mentioned in press releases. We also test for correspondence of the intensity of regional innovation activities and these types of events being mentioned in press releases. Innovation activities of regions are approximated by the number of patent applications (PAT).

To isolate the relationship between these socio-economic characteristics and press release frequencies, we consider several control variables. The first one is the categorical variable $EAST$, which has a value of one for regions in former East Germany or zero otherwise. Given the peculiar history of the two parts of Germany, these differences might be reflected in the general practice of using press releases. While we don't have direct evidence, systematic differences in journalistic activities are still known to exist (Haller, 2012) and it is likely that they extend to the practice of press releases.

The German Press Agency (DPA), to which the portal providing the utilized database belongs, has 54 editorial desks distributed across Germany. We suspect that districts in which an editorial desk exists might be over-represented in press releases because they may attract more (local) issuers to utilize the portal's services. In addition, the locations of editorial desks might not be

[8] All data are obtained from the statistical office of the European Union, i.e., Eurostat and *INKAR*, the interactive online atlas of the Federal Institute for Building, Urban Affairs and Spatial Development of Germany (`www.inkar.de`).

[9] Ideally we would like to have a more direct measure of political engagement, like the number of people being members of political parties. However, such data is currently missing.

chosen randomly, but rather be proximate to important press release sources such as political agencies or newspapers. In either case, the existence of editorial desks can cause a potential bias that needs to be controlled for. We include the categorical variable *EDESK*, which is one for districts in which the DPA has an editorial desk or zero otherwise. Lastly, we include the number of press release issuing organizations (*ISSUERS*) to correct for some regions having larger numbers due to more organizations being active issuers. Descriptive statistics of these variables are presented in Tables 2.1 and 2.2.[10] The bivariate correlations are reported in Table 2.4 in the Appendix.

Table 2.1: Descriptive statistics

	PRESS	ISSUERS	POP	POPDEN	GDPC	VOTE	TOUR	PAT
#Obs	401	401	401	401	401	401	398	399
#Null	1	1	0	0	0	0	0	0
#NA	0	0	0	0	0	0	3	2
Min	0	0	34,193	36	0.02	63.10	0.40	0.58
Max	26,881	2,696	3,669,491	4,767.30	0.18	84.10	43.60	824.38
Mean	340.10	71.86	207,398.28	546.39	0.04	75.08	5.48	56.87
Median	49.00	27.00	154,899	200.60	0.03	75.30	3.40	31.28
Std.dev	1632.02	203.06	245,162.41	723.15	0.02	3.80	6.28	82.69

Table 2.2: Descriptive statistics for categorical variables

Variable	Levels	# Obs	%
EAST	1	77	19.2
	0	324	80.8
	All	401	100.0
EDESK	1	54	13.5
	0	347	86.5
	All	401	100.0

Our dependent variable, the number of press releases (in general, or concerning a particular keyword), is a count variable. This suggests the use of general-

[10]The total population count refers to the year 2020; the gross domestic per capita and population density refer to the year 2019; voter turnout is recorded for the federal elections in 2017; and the information on touristic overnight stays is the most recent one available, which is 2015.

ized linear models. Since the variable is characterized by an over-dispersion, we employ a negative binomial distribution.[11] We do not detect any issues of spatial autocorrelation in our models.[12] In the regression analyses, we include all variables representing shares or rates in their original form. Variables measuring absolute numbers are log-transformed to reduce the effect of potential outliers.

We run separate models for different categories of press releases. These categories are selected among the most frequent keywords, based on the availability of secondary data at the district level for which a fit with the keyword can be expected. The subset of press releases related to economic events is given by the dependent variable *ECON*. It denotes the number of press releases assigned to keyword *Economy*. The second category considered is politics (dependent variable: *POL*), for which press releases are considered that are associated with the keyword *Politics*. In both cases, we expect the population variables and income level to show a significant relation. The third subset is the press releases assigned to the keyword *Tourism*, (dependent variable *TOURM*), which is hypothesized to correlate with the touristic attractiveness of regions. The same is true for the fourth subset that comprises press releases associated with the keyword *Leisure*, (dependent variable *LEISR*). We expect districts with a larger population, higher population density, and larger tourist facilities to host a larger number of events and thus be mentioned with leisure-related press releases. Lastly, in the fifth subset, we consider press releases related to technological events. The dependent variable TECH denotes the number of press releases associated with the keyword *Technology*. We expect a larger number of technology-related press releases in regions where gross domestic product per capita and patent applications are higher, as these are commonly associated with the frequency of science and technology events (Balland et al., 2020).[13]

[11] A χ^2 test based on the models' residual deviance indicates the Poisson distribution does not fit. This is further substantiated with a likelihood ratio test for over-dispersion.

[12] Lagrange multiplier test statistic for the error model is 1.820 with a p-value of 0.177 and the test statistic for the spatial autocorrelation model is 0.407 with a p-value of 0.523.

[13] The correlations between the count of press releases in the given categories and regional socio-economic variables are given in Table 2.5 in the Appendix.

2.5 Results and Discussion

The regression results are reported in Table 2.3. Model (1) of Table 2.3 shows our baseline model that relates the total number of press releases to all regional characteristics. Two of our control variables are strong predictors of the number of press releases. Regions where editorial desks of the press agency are located (EDESK) are more likely to appear in press releases. Apparently, they either attract additional press release activities or are in regions where there are more events to report. Since we control for the number of press release issuing organizations (ISSUERS), which also obtains a significantly positive coefficient, EDESK does not capture the presence of many press release issuing organizations. This suggests that editorial desks rather motivate proximate organizations to be more active in this respect. In any case, the findings suggest that the location of editorial desks and the number of press release issuing organizations in the regions as well as the underlying processes need to be taken into consideration when working with press release data in a spatial context.

In addition, we find regions with higher population density, i.e., urban regions, to be mentioned more in press releases. Accordingly, it is urbanization that translates into more events taking place and eventually getting featured in press releases. Crucially, this effect materializes despite the consideration of the number of press release issuers (ISSUERS) and the total population (POP) in the models. It implies that it is not a size, but a (social) density effect that becomes visible in the number of press releases. Although weaker, GDPC also obtains a statistically significant and positive coefficient. It confirms our predictions that more prosperous regions are more likely to host a larger number of events. From this general analysis, it is unclear to what extent, the availability of greater economic resources to initiate and organize events, drives this finding. We must leave this to future research.

We observe a statistically significant and negative relationship between press release frequency and voter turnout (VOTE), which does not meet our expectations, as we expected voter turnout to be positively correlated to the number of political events taking place in a region which should translate into more press releases. As the subsequent analysis will show, this argumentation seems to be far from reality.

In addition to the variables for which we find a statistically significant relationship, it is interesting to note that there do not seem to be significant differences

between former East and West German regions. Accordingly, variations in the frequency of press releases at the sub-national level do not seem to be strongly impacted by the former division of Germany, at least not when controlling for the other variables.

In sum, our baseline model highlights that there is a strong regional imbalance in the frequency of press releases, which is systematically related to regional characteristics, most notably to the number of press release issuing organizations, presence of the editorial desks, and the degree of urbanization. Consequently, these variables should be included in analyses at this level when using press release information.

Table 2.3: Determinants of visibility in press releases

	PRESS	ECON	POL	TOURM	LEISR	TECH	TECH	TECH
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EDESK	0.851***	0.617***	1.571***	0.002	0.164	-0.443*	-0.456*	-0.456*
	(0.109)	(0.126)	(0.182)	(0.239)	(0.156)	(0.213)	(0.213)	(0.217)
log(ISSUERS)	1.044***	0.950***	1.394***	1.472***	1.120***	0.952***	0.977***	1.029***
	(0.045)	(0.054)	(0.078)	(0.109)	(0.072)	(0.108)	(0.108)	(0.106)
log(POP)	-0.138	0.173	-0.439**	-0.497*	-0.251	0.335	0.193	0.041
	(0.090)	(0.107)	(0.152)	(0.205)	(0.137)	(0.205)	(0.191)	(0.175)
log(POPDEN)	0.132**	0.099*	-0.003	0.133	0.136*	0.119	0.051	0.128
	(0.042)	(0.050)	(0.072)	(0.098)	(0.065)	(0.100)	(0.094)	(0.088)
log(GDPC)	0.304*	0.295*	-0.011	0.321	0.237	0.605*	0.559*	
	(0.124)	(0.145)	(0.209)	(0.279)	(0.185)	(0.257)	(0.255)	
VOTE	-0.031**	-0.010	-0.109***	-0.036	-0.022	0.056*		
	(0.012)	(0.014)	(0.020)	(0.027)	(0.018)	(0.026)		
TOUR	-0.002	-0.016*	-0.016	0.081***	0.025**	-0.006	-0.005	-0.0001
	(0.005)	(0.006)	(0.009)	(0.011)	(0.008)	(0.014)	(0.014)	(0.013)
log(PAT)	0.044	-0.048	0.114	0.086	0.101	0.119	0.287**	0.371***
	(0.057)	(0.068)	(0.096)	(0.132)	(0.089)	(0.137)	(0.110)	(0.104)
EAST	-0.129	-0.343**	-0.067	-0.186	-0.019	0.589**	0.549*	0.465*
	(0.098)	(0.117)	(0.164)	(0.224)	(0.149)	(0.216)	(0.215)	(0.218)
Constant	4.720***	-0.930	10.934***	4.501	1.881	-10.934***	-5.422**	-6.381***
	(1.366)	(1.620)	(2.315)	(3.139)	(2.098)	(3.203)	(1.847)	(1.842)
Observations	396	396	396	396	396	396	396	396
R^2 McFadden	0.208	0.225	0.199	0.172	0.206	0.266	0.262	0.259
R^2(Linear)	0.307	0.312	0.206	0.413	0.446	0.302	0.300	0.298
Max VIF	5.38	5.45	5.46	5.54	5.59	6.01	4.23	3.42
Log Lik.	-1,994.679	-1,536.445	-1,531.040	-1,006.969	-1,059.938	-522.546	-524.914	-527.220
θ	3.122***	2.463***	1.148***	0.733***	1.852***	1.773***	1.753***	1.647***
AIC	4,009.357	3,092.890	3,082.080	2,033.939	2,139.877	1,065.093	1,067.828	1,070.439

Note: Numbers in parentheses are standard errors of coefficients.
*p<0.05; **p<0.01; ***p<0.001

Columns (2) to (6) in Table 2.3 present the findings for the estimations using the frequency of press releases associated with specific keywords as the dependent variable. Other than that, their specifications are identical to that of the baseline model. Note that in these models, the number of press release issuing organizations serves two purposes. First, it controls for inter-regional variation in precisely this number (see discussion above). Second, it accounts for the general tendency of regions to be mentioned in press releases because the variable is highly correlated to the total number of press releases. When including both PRESS and ISSUERS, multicollinearity distorts the estimations ($VIF > 10$). Therefore, we only consider one of the two variables in the models reported here.

The first category of press releases whose spatial distribution is explored is related to the economy (ECON). Besides the control variables discussed above, the model in column (2) shows that economy-related press releases are mostly concentrated in regions with a higher per capita income. While the level of statistical significance is relatively low, it can still be seen as confirmation of our expectations that more economy-related press releases are issued in regions that are economically more successful. The slightly significant and positive relationship with urbanization (POPDEN) adds to this, as more urbanized regions also tend to be more prosperous or at least host a larger number of economic activities. A similar rationale may explain the somewhat stronger significantly negative coefficient of EAST. Given that regions in the Eastern part of the country still lag their Western counterparts in terms of economic prosperity, they appear to be less likely to host economic events that find their expression in press releases. When accounting for inter-regional differences in economic prosperity and urbanization, tourism frequently tends to be over-represented in peripheral and less economically dynamic regions. Consequently, we find a negative relationship between the corresponding variable TOUR and press releases dealing with economic topics. In sum, for this category, our models confirm the idea that press releases' content reflects important economic characteristics of regions. However, while the directions of the coefficients are in full support, a caveat is the relatively low levels of significance of the observed relations.

Our results for politics-related press releases (Model 3) are probably the most surprising. While the control variables are again in line with the expectations and particularly the presence of editorial desks correlates with the spatial dis-

tribution, our core explanatory variable for this set of press releases (VOTE) shows a significantly negative relationship with their frequency. This is opposite to our expectations, as high voter turnout (VOTE) was seen as an indication of democratic engagement and consequently, of the frequency of political events taking place. However, the literature on voter turnout suggests that other determinants, such as labor market conditions, domestic political cleavages, the local age composition, and regional attachment are more important determinants in this context (Fiorino et al., 2019; Henderson and McEwen, 2010). Consequently, our primary indicator might not seem to correlate to the number of political events that took place, which explains our findings for this variable. This is supported by the size of regions (POP) being observed to have a significantly negative relationship with the number of political press releases as well. Less populous regions are usually rather rural, which in Germany tends to correlate with an on average older population. Older populations are politically more interested and might hence induce comparatively more political events to take place in a locality. These are subsequently mentioned in press releases. Clearly, future research will have to work with alternative indicators to assess this relationship more precisely.

In contrast to the findings for political press releases, our findings concerning tourism (Model 4) are in line with our expectations. Regions that host a larger number of tourists per inhabitant are associated with a larger number of tourism-related press releases. Clearly, a stronger touristic orientation implies more touristic events taking place which shapes the press releases associated with that region. Apart from tourism, it is the size of the region that is found to have a slightly significant negative relation with TOURM. Given that tourism matters a lot for smaller and rural regions, this finding strengthens the close link between press releases and touristic activities in the regions.

Model (5) relating the frequency of leisure-related press releases to regional characteristics is basically a mirror of Model (4) concerning tourism. Apparently, the use of the keyword *leisure* is very similar to that of *tourism*, which suggests that they refer to the same overarching category of press releases, which captures touristic and leisure activities.

The last category of press releases of which regional distribution is studied is technology. Here, if we use the same model as for the other categories, we find few and primarily rather weak relations. Technology-related press releases

are positively related to GDP per capita, which is likely to be driven by more technologically active and advanced organizations being in regions with higher levels of economic income. However, the link is not very strong. We also observe a positive relationship with VOTE suggesting that regions with higher voter turnout are more likely to be found in press releases about technologies, for which we do not have an explanation. Crucially, our primary indicator to assess the correspondence between regional characteristics and press releases, the number of patents (PAT), is insignificant. However, the results change when excluding GDPC and VOTE variables. In Models 7 and 8, we remove these variables from the analysis. Now, the number of patents (PAT) obtains a strongly significantly positive coefficient, which is very much in line with our expectations. Consequently, it is the consideration of VOTE and GDPC that "hides" the correspondence of press release information with the intensity of innovation activities in regions.

In addition, the analysis of technology-related press releases highlights the link between press releases and the content of newspapers. The coefficient of EAST is significantly positive, signaling that press releases mentioning regions in East Germany tend to feature information on technologies more frequently than those in the Western part. While in general, innovation activities are still less frequent in the former East than in the Western part, the finding matches that of Ozgun and Broekel (2021), who observe the same positive relationship for the content of (regional) newspapers.

Considering our analysis, we find the assessment of press releases as a source of regional data rather promising. For four out of five studied topic categories, we find a strong correspondence between common indicators of regional characteristics and the content of press releases. In particular, for touristic and leisure activities the link appears to be substantial. The spatial distribution of economic activities also seems to be reflected in the content of press releases. The correspondence of press release content and the intensity of innovation activities (as measured by patents) only becomes observable when not controlling for regions' economic situations and voter turnout. However, it must be pointed out that patents are just one indicator for specific kinds of innovations (those that can be patented) and that NUTS-3 regions (used in our analysis) are generally perceived to be not ideal for capturing their spatial distribution (Brenner and Greif, 2006). Within the framework of the applied approach and data, we did not manage to validate press releases to follow the same spatial

distribution as common statistical indicators in the case of political events. It is likely that our employed indicator is insufficient and hence the finding shouldn't be over-interpreted.

2.6 Conclusion

As in most social sciences, regional scientists and economic geographers are constantly seeking to advance their available databases. Given the fast-changing and complex nature of contemporary developments, standard official datasets may not include the information required to track and analyze these. In the present study, we discussed press releases as an alternative data source in this context. Despite their use in other literature streams, so far, they have been rarely exploited by spatial scientists. Press releases offer a number of attractive features, such as being generally widely available, containing rich textual information that includes aspects frequently not covered by official statistics, and, most importantly, being geo-locatable.

Given these promises of press releases, the aim of this paper was to assess the usefulness of press releases as a data source in spatial economic research from an empirical perspective. We argue that press releases seem to be an attractive data source which, however, requires several crucial aspects to be considered. This includes a certain positivity bias, as organizations are less likely to issue press releases on negative events. A more important aspect from a spatial perspective is that press release information is greatly shaped by the distribution and characteristics of the underlying population of press release issuing organizations. For instance, locations with many organizations active in the sports sector are more likely to show up in press releases on sports. Consequently, press releases will primarily reflect the population of issuing organizations. Yet, this is not always a negative thing, as researchers might be explicitly interested in this population which may otherwise be difficult to be observed. Sticking to the example of sports, for countries in which a comprehensive list of sport-organizations at small geographical units does not exist, press releases with reference to sports activities might give a reasonable approximation of their spatial distribution. Although they cannot be used to infer their absolute number or general importance, identifying regions with comparative strength in these activities is feasible.

To be used in such tasks or similar ones, it is important to know if press releases, when aggregated to the regional level, reflect the socio-economic characteris-

tics of regions. To gain insights into this, we empirically assessed the correspondence of a range of regional characteristics and associated events in press releases. To achieve this, we used a novel data set on press releases published by the German news agency DPA covering all 401 German districts (NUTS-3 regions). The analyses revealed that the overall frequency of press releases and that of specific types of events mentioned therein align reasonably well. In particular, aggregated counts of press releases on touristic activities are strongly correlated to the presence of tourists in regions. A similarly strong link was observed for technology press releases and patents when not controlling for regions' economic prosperity and voter turnout. Although weaker, we also detect a relationship between regional economic development and economy-related press releases. Our analysis was unable to confirm a correspondence between press releases on political topics and political engagement (voter turnout) at the regional level, which we suspect is primarily due to voter turnout not being a good proxy for the number of political events taking place in a region.

In sum, in many instances, regional differences in events and activities seem to be well-presented by press releases. This suggests that press release data might be a useful data source in spatial studies. However, there are important limitations of press release data that apply to all press releases in general and to the specific database used in this study. The latter's relevance in other step-ups depends on how much the data is like the one used in this study. As for the first group of limitations, as pointed out, press releases suffer from a positivity bias and they are shaped by the underlying population of press release issuing organizations. Concerning the latter, the motivations and abilities to produce press releases, as well as the styles thereof, are likely to differ substantially between organizations. So far, it is unknown to what extent these may differ between locations. In addition, press releases are always highly subjective texts, written with a specific purpose, which, unfortunately, is not information to spatial scientists. These may introduce unknown distortions. There is also no information on which events are covered by press releases and which are not. Consequently, as with any other data source, press releases represent incomplete information which must be considered in their interpretation.

As for the data we have used in our study, all these limitations apply. In addition, however, it includes very little information on the issuing organizations. Future research might be able to match these names to register data, to learn more about their areas of activity, size, and type. We also do not know

what fraction of all press releases in a region are covered in the database. For about half of the press releases, no location information was given in the text, which makes assigning them to the correct region in which the event took place very difficult. Even when location information was included, we faced several challenges. For instance, there are still several ambiguous location names. A prominent example is "Essen". It frequently appears in press releases and may refer to, in this case, the city of Essen or to "food" (in German). While manual inspections confirmed a high discriminating power of our geo-location procedure and we are confident about its proper working, there might still be cases in which the location assignment was incorrect. For disambiguation of location names, future studies can use natural language processing tools. In terms of classifying the press releases by topics, we relied on keywords assigned to press releases. Neither do we know who assigned those keywords (either the issuing organization, or the database administrators), nor do we know how reliable they are. Future research may shed light on this by using text classification or clustering techniques. We tried to overcome many of these limitations and in this regard, our empirical study hopefully provides valuable insights for the applied researchers working with press release data and facing similar issues. We also point out a couple of aspects that may help the specification of empirical spatial models based on press release data. For instance, when using their spatial variation, it is essential to consider the location of editorial desks and the number of issuing organizations.

Given the increasing demands for new and rich data sets in regional science, we believe that press releases offer substantial potential and may be very useful in many contexts. For instance, when looking at specific topics, press releases may allow for identifying regional economic specializations that remain hidden in official statistics. Our study is an early step in this direction and might help researchers assess if press releases are useful for their work.

2.7 Appendix

2.7.1 Geo-locating the press releases

To geo-locate the press releases, we rely on the OpenGeo-database, which contains the names and geo-coordinates of more than 12,000 places in Germany (`http://opengeodb.giswiki.org/wiki/OpenGeoDB`). Since German location names can include punctuation and stop words, and some location names are words with other meanings, we cannot apply standard text preprocessing and straightforward string-matching techniques. The procedure we apply is summarized in the following.

1. We remove numbers and all punctuation marks from the text, except for periods, commas, parentheses, and dashes, as these are part of some location names. The punctuation marks that are not removed are standardized into short dashes, i.e., *hypen*, *en dash* and *em dash* all become short dash.

2. We transform the abbreviations in location names to their full words so that they can be matched with the original names. For example, *a.M.* is transformed into *am Main*; *a.d.R.* into *an der Ruhr*; and *St.* into *Sankt*.

3. Although press releases are in German, in some cases, English names of German places are used. We translate these into their German originals. For example, *Munich* is translated into *München* and *Nuremberg* into *Nürnberg*.

4. In German, the first letter of location names are normally in capitals, however, sometimes this is not done when articles and prepositions are part of the name. To differentiate location names from other words, such as verbs, we capitalize all the stop words and prepositions that are used in location names. For example, *an der* becomes *An Der*; *vor der* becomes *Vor Der*. Consequently, all words in location names, if mentioned in the press release, begin with a capital letter. After this step, we clean the corpus by removing words that start with lower case letters. This ensures the removal of verbs, and irrelevant prepositions and articles. This step also decreases the size of text data considerably so that pattern matching becomes feasible.

5. Using string-matching we assign latitude and longitude from the OpenGeodatabase to press releases. In case multiple location names are identified in the text, we assign all locations mentioned to the respective press release.

6. Since some location names in Germany have special letters that do not exist in all alphabets (ä, ö, ü, and ß) and writing the words including these letters by using only the English alphabet is a common practice, we repeat the previous step once more, by replacing the special letters in the list of location names. For example, *ä* is replaced with *ae*; *ß* with *ss* and so on. At the end of these steps, 51,861 press releases are assigned to a location in Germany.

7. In some cases, the places' full names are not mentioned in the press releases. Although this creates ambiguity in terms of text analysis, it is usually clear for readers from the content of the release which location the text refers to. A well-known example of such is *Frankfurt*. There are two prominent locations in Germany containing *Frankfurt* in their names: (*Frankfurt am Main* and *Frankfurt an der Oder*). Hence, a reference to just *Frankfurt* in the text is insufficient to establish a unique match. Lacking any further information to solve this ambiguity, we match in this case the location with the larger population. We assume that it is more likely that the smaller (and lesser known location) is referred with its full name, i.e. *Frankfurt an der Oder*. Manual checks confirm the appropriateness of this assumption. This allows to assign locations to 3,915 additional press releases.

8. In addition to potential location names in the releases' main text, the database offers location information for all press releases for their issuing organization. If a location is mentioned in the article (and it is identified through in the previous steps), we assume that it is a more accurate description of the event's or issue's location than the location of the issuer. However, in the lack of the first, it is still the best available information. Consequently, for all locations where the previous steps didn't result in at least one match, the location of the issuer is used to geo-locate the press releases. For these locations, we primarily use an API access to Google Maps to obtain their geo-locations. At the end of this final stage, 99,984 press releases are assigned to a location in Germany.

2.7.2 Correlation matrix

Table 2.4: Correlation matrix

	PRESS	POP	POPDEN	GDPC	EDESK	VOTE	TOUR	EAST	PAT
POP	0.85***								
POPDEN	0.54***	0.50***							
GDPC	0.21***	0.14**	0.48***						
EDESK	0.39***	0.35***	0.50***	0.30***					
VOTE	0.01	0.09	-0.15*	0.01	-0.06				
TOUR	0.02	-0.03	-0.15*	-0.05	-0.02	0.03			
EAST	0.06	0.01	-0.13*	-0.26***	0.07	-0.45***	0.02		
PAT	0.59***	0.77***	0.49***	0.33***	0.27***	0.32***	-0.07	-0.19**	
ISSUERS	0.92***	0.89***	0.62***	0.25***	0.46***	0.02	0.03	0.04	0.69***

2.7.3 Correlation between press release frequency in selected topics and regional variables

Table 2.5: Correlation between frequency of press releases in economy, politics, tourism, leisure, and technology topics, and regional socio-economic variables

	POP	POPDEN	GDPC	VOTE	TOUR	PAT	EAST
ECON	0.86***	0.56***	0.22***	0.01	0.03	0.63***	0.04
POL	0.72***	0.45***	0.15*	-0.01	-0.01	0.45***	0.08
TOURM	0.82***	0.61***	0.29***	0.01	0.01	0.67***	0.00
LEISR	0.87***	0.61***	0.28***	0.02	0.02	0.67***	0.02
TECH	0.85***	0.55***	0.22***	0.03	0.03	0.71***	0.05

Chapter 3

The geography of innovation and technology news - An empirical study of the German news media

Abstract: Variations in the frequency and tone of news media are the focus of a growing literature. However, to date, empirical investigations have primarily confirmed the existence of such differences at the country level. This paper extends those insights to the subnational level. We provide theoretical arguments and empirical support for systematic regional variations in the frequency and sentiments of news related to innovation and new technologies. These variations reflect regional socio-economic structures. We find that the average newspaper circulating in urban areas features more news on innovation and new technologies than media in more rural areas. Similar findings hold for locations in East Germany and to a certain degree for regions with low unemployment. The sentiments of innovation and new technology news are negatively associated to the unemployment rate, and they tend to be lower in regional newspapers than in national ones. Overall, our results suggest a strong link between the regional socioeconomic conditions and how newspapers circulating in these places report on innovation and new technologies.

This chapter has been published as:
Ozgun, B., & Broekel, T. (2021). The geography of innovation and technology news - An empirical study of the German news media. *Technological Forecasting and Social Change*, 167, 120692.

3.1 Introduction

Innovation is undoubtedly a crucial ingredient of technological and economic growth. However, innovation and technological progress may also induce negative social and economic effects (González-Romá and Hernández, 2016). The discussion of artificial intelligence (AI) nicely illustrates this two-sided nature of innovation (Agrawal et al., 2019; Korinek and Stiglitz, 2017). The sheer unlimited potential of ever-growing mountains of data coupled with breathtaking advances in analytical systems, bear huge potentials for future economic growth and, thus attract the fascination of researchers and businesspeople alike (Aghion et al., 2018; Goldfarb and Trefler, 2018). On the other hand, AI is closely linked to the automation of human tasks and is widely expected to transform and replace the "routine, non-cognitive tasks that have been primarily performed by middle-skilled workers" (Buarque et al., 2019). Consequently, many occupations are in danger of being automated or replaced by AI-based systems (Frey and Osborne, 2017; Acemoglu and Restrepo, 2019, 2020), spurring growing public concerns (Furman and Seamans, 2019; Inhoffen, 2018; Fast and Horvitz, 2017).

How the public thinks about new technologies matters; since it triggers and shapes political debates that eventually translate into concrete policies. In turn, these have the potential to create institutional structures that significantly shape the development, diffusion, application, and ultimately, the socioeconomic benefits that new technologies may unfold (Stone et al., 2016). The scientific literature has long recognized that in this context, the news media play a crucial role, with their substantial influence on public opinion and expectations regarding innovations and new technologies (e.g., Marks et al., 2007; Priest, 1994). This alignment of public opinion and news coverage is not one-directional. Studies show that expectations and citizens' general attitude toward such issues affect their presentation in news media (Watt Jr and van Den Berg, 1978; Gentzkow and Shapiro, 2010). Thus, individuals' perceptions of and attitudes toward innovation are also likely to influence coverage of these issues in the news. Notably, existing studies identify substantial variations between countries in the intensity and sentiments of media coverage of these topics, raising the question of whether such variations occur only at the country level.

In this paper, we argue that while the national level is of unquestioned importance, the subnational (regional) level has been vastly overlooked in this context. Innovation processes are highly localized, with regions' institutional, political, and economic contexts frequently determining the emergence and diffusion of technologies (Cooke et al., 1997; Bednarz and Broekel, 2020). At the same time, news coverage is not uniform across localities, implying that people in different regions are exposed to heterogeneous sets of information and varying evaluations regarding innovations. Consequently, news media may be an important, albeit widely overlooked social institution, that both explains and is explained by heterogeneity in regional attitudes toward innovation and technologies. This paper marks a first step in this direction. We discuss and empirically explore the extent to which regionally circulating news media cover innovation and new technologies differently, in terms of frequency and sentiments. In addition, we explore whether these differences are related to regional socioeconomic conditions.

The empirical study utilizes a newly established source of news information, the *RegNeS* database, which covers the most important national and regional newspapers in Germany. We use a range of text-mining methods to identify and evaluate news on innovation and new technologies in terms of sentiments, and model their geographic distribution with the help of newspaper circulation data.

Our empirical findings at the level of German spatial-planning regions suggest that the average newspaper in urban areas is more likely to report on innovation and new technologies than those in other places. Our results also suggest the existence of an East-West divide: News on new technologies and innovation more frequently appears in newspapers circulating in regions in the former East Germany. A strong negative association exists between sentiments on innovation and new technology news and the unemployment rate in the newspapers' circulation area. Crucially, this result holds, even when controlling for the general sentiments of articles in the newspaper. In sum, our results point toward significant regional variations in the frequency and sentiments to which newspapers expose readers, regarding news on innovation and new technologies. Consequently, looking at such news at a subnational level seems fruitful for gaining a better understanding of the spatial diffusion of new technologies and may represent a distinguishing factor of regional technological systems.

The rest of the paper is organized as follows. Section 3.2 presents the theoretical discussion of the relationship between geography and news on innovation and technologies, particularly focusing on the regional level. Section 3.3 describes the data and our empirical approach. Section 3.4 presents the estimation results, and Section 3.5 concludes by discussing the implications of the findings.

3.2 Motivation and theoretical background

3.2.1 News and public expectations

A central element underlying the relation of news and innovation is expectations. More precisely, expectations are fundamental factors shaping the development, diffusion, and use of new technologies (Konrad, 2006; Borup et al., 2006; Geels and Verhees, 2011; Budde et al., 2012). Expectations usually consist of socio-technological visions describing a future world based on assumptions and empirical observations that translate into a set of scenarios of hopes and fears (Konrad, 2006). Individuals have expectations about the future development and use of specific technologies, about their structures, rules, and regulatory regimes. Expectations regarding innovation and new technologies form and materialize at different levels: micro, meso, and macro. They crucially shape search activities, the selection of technologies and their legitimization (van Lente, 1995).

The role of expectations in technological development is directly linked to the concepts of risk and uncertainty (Berkhout, 2006). First, in an uncertain environment, expectations create coordination mechanisms for economic actors and activities, which can achieve alignment of interests (Alkemade and Suurs, 2012; Eames et al., 2006). Second, many instances of newly emerging technologies do not immediately meet existing markets and commonly lack structural components, such as regulations, infrastructure, user practices, and maintenance networks (Geels, 2002). Due to high degrees of uncertainty in these processes, technologies must attain legitimacy before the creation of such structural components (Bergek et al., 2008; Geels and Verhees, 2011)[1]. New technologies need cognitive legitimacy to attain an institutionalized diffusion of knowledge (Aldrich and Fiol, 1994). Societal embedding is a way of gain-

[1]Bergek et al. (2008) defines legitimization as *the politics of shaping expectations and of defining desirability.*

ing this legitimacy, depending in turn, on societal norms and beliefs (Deuten et al., 1997). Once positive societal expectations have created legitimacy, required components emerge and diffuse (Alkemade and Suurs, 2012; McCormick, 2010), further stimulating the provision of resources, support, and investment in new technologies (Eames et al., 2006; Geels and Verhees, 2011; Borup et al., 2006). Moreover, collective expectations give economic agents a sense of *the way things are going* and, consequently, provide a guide for future research activities (Eames et al., 2006). In sum, collective expectations are part of the social repertoire, integral to the socio-technological landscape (Konrad, 2006) and empirical research confirms that positive expectations are a crucial precondition for successful diffusion of innovation (Geels and Verhees, 2011; Budde et al., 2012).

Although positive expectations held by the wider society may create momentum for policy support and private investments into R&D efforts, sometimes they may harm the very process that they are promoting. A well-known example is the so-called "hype cycles". A hype cycle is a sudden increase in the attention and visibility that a technology gets (van Lente et al., 2013). While a technological hype helps to generate initial interest and promote a technology, it sets high unconscious expectations, hard for most technologies to meet in the short run. If the promises are not fulfilled in the short run, public opinion and attention may quickly turn away, without giving the technology a proper chance for its benefits to materialize (Caulfield, 2004). Hence, hype cycles can lead to overly quick disappointments and consequential withdrawal of support (Bakker, 2010). However, in some cases, the institutionalization processes that such hypes trigger may continue after the hype has ended and keep promoting further diffusion and development of the technology (Ruef and Markard, 2006). Accordingly, the relationship between innovation activities and public expectations is neither straightforward, linear, nor one-sided. On the contrary, it is rather complex and not yet fully understood.

Given the increasing deterioration of the boundaries between science, technology, and society (Gibbons, 1999), what societies expect from emerging technologies is growing in importance, and the expectation becomes increasingly crucial for their future development and application. This raises the question of how such expectations form and what their determinants are.

A range of factors shape public opinion and expectations, with media being among the most crucial. In particular, framing the societal discourse (Konrad, 2006) is essential. As a crucial source of information, visuals, and interpretations of events external to peoples' direct observation (Lippmann, 1922), media have the power to influence the salience of attitudes, and, to certain extents, agenda-setting (McCombs and Shaw, 1972; Hester and Gibson, 2003). In many instances, how the media frame an issue shapes how people understand and remember it. The media also contribute to evaluation of and reaction to those issues (Entman, 1993). By helping people construct meanings and giving them orientation, the influence of media on public opinion is particularly substantial for such complex topics as science and technological development. Generally, people turn to the media to make sense of complexities with which they have little direct experience, for information on which they can rely (Boykoff, 2009; Mast et al., 2005; Zucker, 1978). Consequently, media are an essential element in disseminating science, technology and innovation-related information, opinions, and expectations to the wider public.

Ample evidence supports media coverage shaping public opinion and expectations regarding various technologies. For example, Gamson and Modigliani (1989) show that media discourse has been an essential context for the formation of public opinion on nuclear power since 1945. Another example is the biotechnology debate. In the late 1990s, public opinion on this technology drastically changed, as the public became highly concerned after the extensive media coverage of the cloning of the sheep, Dolly (Petersen, 2001).

In light of this evidence, variations in media presence, coverage, focus, and tone are likely reasons for the spatial variation. Gaskell et al. (1999) and Mazur (2006) highlight that the quantity of news media coverage explains the risk attitude towards and consumption of biotechnology and genetically modified food in different countries, as increased news coverage conveys a sense of hazard and uncertainty. It may also lead to greater awareness of the alleged risks in society. Thus, the influence of media and its spatial variation is important. For instance, Skjølsvold (2012) investigates how the news media of Sweden and Norway have covered and communicated about bioenergy. While news media in Norway focused on technological and economic ambivalence, news media in Sweden promoted optimism and highlight green consumption features. This contributed to the development of different systems of innovation and diffusion patterns in the two countries, with respect to these two technologies. Similarly,

Negro et al. (2012) study the presentation of wind-power technology in the media. They conclude that there was a lack of legitimacy of this technology in Sweden, which, apparently strongly shaped by the negative presentation of the wind power technology in the media.

The relationship between news coverage and spatial variation in perceptions regarding new technologies is not one-directional. As the insights in the literature on mass-media effects suggest, just as media may facilitate a specific agenda, they do not do so independent of their audience. In general, news media must provide for their audiences by reflecting their preferences and corresponding to existing views and interests. In this sense, audiences strongly shape the media's agenda as well (i.e., reverse agenda-setting). Research well establishing that contention, showing that media outlets tend to communicate information in ways that confirm their news consumers' prior beliefs and adapt their slant to the political stance of their readers (Gentzkow and Shapiro, 2006, 2010). Media's effects more strongly reinforce existing opinions than create or alter them (Klapper, 1960). Consequently, the existing salience of a topic to an audience often predicts its frequency and tone of coverage in the media (Watt Jr and van Den Berg, 1978). Put differently, how the press reports an event or issue depends on the target audience. Studies show that this is also true for news coverage of technology-related issues. For example, Marks et al. (2007) find that the existence of a local focus (such as a local incident related to the technology) significantly impacts the news coverage of biotechnology issues, causing countries to differ in their reporting of them. New technologies were also observed to be covered more frequently where there is a greater local significance (Marks et al., 2007). Consequently, we can expect news coverage of innovation and new technologies to vary geographically, because they differ in their relevance to regional societies and, therefore, will be newsworthy to different degrees.

This expected alignment of news media and their audiences is at the center of the present paper, which seeks to assess the degree to which news-media coverage of innovation and new technologies varies systematically in geographical space.

3.2.2 A regional perspective on innovation news

Above, we indicate that many studies analyze national media discourse on innovation and new technologies (Dudo et al., 2011; Mejía and Kajikawa, 2019).

Many of these studies hint at the importance of geography in this context. However, so far, previous research has not adequately addressed the potential variations in news media's content and sentiment with respect to technologies, on a smaller scale, i.e., subnational and regional. An exception is Stephens et al. (2009), who describe substantial variations in the news concerning wind energy, among the U.S. states of Texas, Minnesota, and Massachusetts.

From a theoretical perspective, this observation does not come as a surprise. Foremost, media themselves are regionalized. Besides national television networks and newspapers, there are large numbers of regional and local news broadcasters and outlets. While such news outlets may have some coverage overlap with national and international news, in light of the previous discussion, they generally must adapt to their regional audience, i.e., they select, frame, and present national as well as regional news, in a way that meets the (perceived) regional demand of their customer base. Although individual traits, such as political views and socio-economic status play important roles in one's exposure to news (Price and Zaller, 1993), two individuals who have similar individual traits may be exposed to different sets of news information just because they reside in different locations. Indeed, Althaus et al. (2009) report that news exposure is strongly related to characteristics of the local news market, even after controlling for individual-level variables. The study's results imply that regions vary in their preferences for certain types of news. Multiple studies establish geography's role as an important influence on news exposure and consumption (Bogart, 1989; Webster and Lichty, 1991). In the context of the present study, the existing empirical evidence implies that regional characteristics relate to and shape local news consumption, implying that different patterns of news consumption can be expected to exist in structurally heterogeneous regions such as, e.g., cities and rural locations.

In addition to the consumption of innovation and technology news, the supply will likely be strongly regionalized. Notably, the region- and technology-specific institutional setup of innovation activities (frequently labeled "regional innovation systems") greatly impacts the likelihood of novelty creation, adoption, and application (Cooke et al., 1997). Part of this institutional set-up is the (local) news media, which may act as a facilitator by diffusing information, providing coordination and mobilizing (public) support for novelty implementation and experimentation. By disseminating information on what is happening in a region, news media disseminate opportunities and strengthen collective expecta-

tions (Nordfors, 2004), thereby building interrelations between the involved actors and contributing to connecting relevant stakeholders (Blasini et al., 2013). This also relates to the *local buzz* argument. Accordingly, organizations get exclusive access to localized information flows by being present in specific locations, *by being there* (Bathelt et al., 2004). While localized information flows usually refer to labor mobility, collaboration, and spontaneous interaction, in practice, this also includes local news whose limited range involuntarily excludes actors outside of their respective distribution areas. Notably, this does not imply that these information flows are inaccessible to outsiders, per se. Rather it is about actors being made spontaneously and in an unplanned fashion aware of topics, information, and potential contacts (Broekel and Binder, 2007). Arguments supporting a close link between innovation activities and regional news also appear in the literature on technological transition. Here, demand side, representing a crucial factor in the successful emergence and expansion of new technologies and products, receives particular attention (Geels, 2004). More precisely, the argument is that local demand, in combination with local institutions, is essential in the creation of local market niches that allow new technologies (or products) to grow and evolve until they have reached a developmental stage that gives them a fair chance at non-local markets (Schot and Geels, 2008). This requires a mobilization of early local demand, for which local media besides word-of-mouth communication is essential. Recently, Bednarz and Broekel (2020) empirically confirmed the importance of local demand for the emergence and growth of the German wind-energy industry, even though they do not find that the producers have mobilized this demand.

In sum, we expect regional media to play a crucial role in the information set regarding innovations and new technologies to which individuals are exposed. Moreover, the frequency and content of these information flows are important in the emergence, acceptance, and spatial diffusion of new technologies, at least in the long run. Consequently, better understanding variations in the presentation, discussion, and evaluation of new technologies in the news, at the regional level, is important. This paper is a first step in that direction.

3.2.3 Regional newsworthiness of innovation

The major objective of this paper is to explore regional differences in innovation news coverage. To this end, we aim to understand how an event or issue becomes news in a region, with what frequency and tone, what determines which

event is reported, when and where, in other words, its newsworthiness. Newsworthiness is the likelihood of a news item's selection for publication (Kepplinger and Ehmig, 2006). Media scholars have found that newsworthiness depends on both the nature of the event and the journalistic assessment of the event's relevance to an audience (Staab, 1990; Allern, 2002; Caple and Bednarek, 2016; Eilders, 2006). Kepplinger and Ehmig (2006) disentangle and name these two components of newsworthiness as "news factors" and "news values". News factors are the inherent characteristics of an event, and news values are the judgments about the relevance of the event to the respective audience. News values arise from the fact that news is an economic commodity, and as with all other commodities, its content partly depends on the tastes and preferences of individuals who demand it (Hamilton, 2004). In other words, what people want to hear or read about, and how they feel about certain issues, impact what becomes news in a particular region. In the following, we elaborate on how some news factors and values may generate regional variation in news coverage of innovation and news technology-related events.

One determinant of newsworthiness is *unexpectedness* (Galtung and Ruge, 1965), the surprise element of an event or a discussion, arising from novelty, deviance, or unusualness. Although some events are inherently more unexpected than others, since expectations may vary, unexpectedness also partly depends on the target audience (Bednarek and Caple, 2017). From a regional perspective on innovation news, this suggests that the more unexpected an innovation activity or innovation-related event is in a region, the more likely it will be covered. For instance, von Bloh et al. (2020), argue and support empirically that in highly entrepreneurial regions, founding a new enterprise is a relatively less surprising (and, consequently, less newsworthy) event than it is in regions that hardly experience any positive economic dynamics. Accordingly, this suggests that regions more frequently exposed to innovation and new technology-related events and discussions observe that reporting about them is less likely.

Another determinant is *magnitude*. The intensity or potential impact of events increases the likelihood of news coverage (Harcup and O'neill, 2017; Galtung and Ruge, 1965). This suggests that innovations with a greater (societal) impact are more likely to be presented in the news. Such innovation news is also more likely to emerge in regions with intensive innovation activities, implying generally more innovation events from which to select. Consequently, this effect counters the one previously discussed, since it suggests that in innovation-

intensive regions, more high-impact innovation-events are likely to enter the news system, and the chances of innovation-related news being published may be greater.

Relevance is another determinant; the more an issue is perceived as relevant, the more likely is its coverage in the news (Harcup and O'neill, 2017). Consequently, in regions where individuals are more interested in innovation and new technologies, these events are more likely to pass through the journalistic process. The dimensions of *proximity* (geographical and cultural) are a subset of *relevance*, as events occurring close-by tend to be more *relevant* to individuals than those happening far away. Put differently, more geographic or cultural distance between an innovation/technology event and the news outlet decreases the event's newsworthiness (Shoemaker et al., 2007). Proximity is particularly relevant in a regional news context, because the judgment of newsworthiness varies between news outlets (Allern, 2002), and parts of this variation are rooted in geography. Boukes and Vliegenthart (2020) find that domestic stories are over-represented in regional newspapers, compared to other news media types.

In sum, it is the interplay between the supply of innovation-related events in the news system and the demand of the audience for this kind of story, as well as the inherent characteristics of innovation- and new technology- related events and their relevance to the respective audience, that shape the regional coverage of innovation.

How an outlet covers an issue is as important as the frequency of coverage. Thus, the effects above are also likely to shape the sentiments toward innovation and new technologies in the news. We expect that by and large, journalists will seek to comply with existing sentiments among their regional readership, toward innovation, in general, and with respect to specific technologies, in particular. Accordingly, the visibility of innovation and the ways of presenting new technologies in the news media will be a more or less accurate proxy for existing regional public opinion and collective expectations (Fenn and Raskino, 2008; Melton et al., 2016). Nevertheless, we suspect some interference from the journalistic process (e.g., political-sympathies of journalists, events on the national stage), in contrast to the *relevance* effect, might decrease the observable systematic variations at the regional level.

In light of these factors, we aim to investigate if systematic regional variations in the frequency and sentiments of innovation and technology news exist, and to identify their primary determinants (regional characteristics). More precisely, we hypothesize that variations in frequency and tone of news reporting about new technologies are not random, but rather reflect systematic structural differences among the regions. Thus, the study will deepen our knowledge of the link between news media and conditions for innovation and technology development at the regional level.

We empirically explored this hypothesis by focusing on newspapers. We believe that the aforementioned geographical aspect of news exposure can be well understood by looking at regional newspaper readership. While regional newspapers are not the only form of news media, they are the most prevalent form at the regional level (Hutchins, 2004). Regional newspapers are the primary source of regional news and they contribute to defining the norms of their communities, by producing a powerful discourse (Ewart, 2000). Consequently, they are good proxies for regional news media in general.

3.3 Data and empirical approach

3.3.1 Readership shares of newspapers

For the empirical investigation, we needed information on news at the regional level. More precisely, we needed to know what news circulates and what news do inhabitants consume. Unfortunately, most commonly used news databases primarily cover national or international newspapers and provide little information on news at the regional level. Therefore, we used the recently established *Regional News Syndication (RegNeS)* database. This data base provides a daily collection of German-language newspaper headlines and snippets since July 2019. The database covers more than 300 print and online newspapers. As of December 2020, the database consists of more than 6 million unique news entries. The set of newspapers includes regional and national outlets from the German-speaking world (i.e., Germany, Austria, Lichtenstein, Luxembourg, Switzerland).

To simplify data collection and avoid national differences, we exclusively considered newspapers from Germany. Regional newspapers are an essential part of the media landscape and have an extensive readership in Germany (Mangold et al., 2017; Humprecht and Esser, 2018). Newman et al. (2019) report

that weekly usage of a regional or local news media in Germany is 34%, among the highest percentages in Europe. The same report also shows that concerns here about misinformation and disinformation regarding Internet news media are among the lowest, compared to other countries. Consequently, regional news matter in Germany and its outlets are likely to be perceived as trustworthy.

From the *RegNeS* database, we obtained location information on the regional section in which a news article was published. These sections are very heterogeneous. In larger newspapers, many of them almost qualify as independent daughter newspapers, that share specific subsections of the mother newspaper. These joint sections usually cover topics like national and international politics, as well as economic overviews. The remaining parts are readership- and location-specific. In case of smaller newspapers, these sections refer to sets of news that the paper's editorial offices deem relevant to a specific location. Typical examples are reports on local sports results, information on local cultural events, and the like. For smaller, local and regional newspapers, this information is relatively accurate and reflects the locations in which this newspaper holds a significant readership share. In contrast, for larger, multiregional and national newspapers, this information is insufficient to accurately model their spatial distributions of readership, as it primarily reflects regions consisting of one or more federal states in Germany.

Therefore, we enrich this information with actual regional readership data obtained from the German Audit Bureau of Circulation (IVW). This organization records and audits the distribution of advertising media in Germany and covers most (but not all) newspapers in Germany. From this organization, we obtained the number of print and digital subscriptions for each newspaper in its database in each district (NUTS3), per day. This data required processing in multiple steps to become useful in the context of the present study. First, weekly readership was calculated by summing the daily numbers, which allows fairly considering weekday and weekend newspapers, as well as those that are published during both parts of the week. Second, the district-level numbers were aggregated to the level of spatial-planning regions[2] (see the discussion below). Third, the numbers were assigned to the corresponding newspapers in the *RegNeS*-database. For 127 newspapers, a one-to-one matching (based on

[2]Spatial planning regions: Raumordnungsregionen (ROR).

the newspaper's name) between the two databases is possible. We denote the number of subscriptions newspaper n has in region r as $\mathrm{NR}_{n,r}$.

However, this leaves some of the newspapers featured in the *RegNeS*-database unassigned, many of which are smaller local and regional newspapers. To not lose this information, we modeled their shares based on three assumptions.

A) The number of readers of newspapers not included in the IVW-database (IVW) does not systematically vary between planning regions. Hence, the fourth step was, conditional on this, obtaining an estimate of the total number of newspaper readers in region r by summing the corresponding readership information over all newspapers (N) with readers in region r for all $n \in$ IVW.

$$NR_r = \sum_{n \in IVW} NR_{n,r}\,. \tag{3.1}$$

Straightforwardly, we calculated the readership shares (RS) of newspapers with a match in $RegNeS$ and IVW by using

$$RS_{n,r} = \frac{NR_{n,r}}{NR_r} \quad \text{for } n \in IVW \cap RegNeS\,. \tag{3.2}$$

Fifth, this assumption also allows us to calculate the total share of readership that is not accounted for by newspapers with a match in $RegNeS$ and IVW (RS_r^*):

$$RS_r^* = \frac{1 - \sum_n RS_{n,r}}{NR_r} \quad \text{for } n \in IVW \cap RegNeS\,. \tag{3.3}$$

For the sixth step, we assume that B) all readers not reading IVW newspapers, with a match in RegNeS, buy newspapers that are listed in the *RegNeS* database that lack a match in the IVW database. Conditional on this assumption, we can distribute this shares of readers RS_r^* to the set of newspapers included in the $RegNeS$ database, $RS_{n,r}^*$ for $n \in$ RegNeS\IVW. This assumption implies that all newspapers that are part of IVW are somehow included in RegNeS, but for some reason, no match with IVW could be established.

In the third and final assumption, C) all newspapers in the *RegNeS* database with no match in IVW are assumed to hold an equal share of regional readership, i.e.,

$$RS^*_{n,r} = RS^*_{m,r} \quad \text{for all} \quad m, n \in RegNeS \setminus IVW \quad \text{and} \quad n \neq m. \tag{3.4}$$

On the basis of these assumptions, we calculated the readership shares of any newspaper n in the *RegNeS*-database with at least one regional section associated with a location in r, but lacking a match in IVW. It is the share of readership in IVW, not covered by newspapers with a match in *RegNeS* (RS^*_r), divided by the number of such newspapers. In our data, 104 newspapers fall into this category.

$$RS^*_{n,r} = \frac{RS^*_r}{N} \tag{3.5}$$

where $n \in$RegNeS\IVW and N is the total number of newspapers such that $n \in$RegNeS\IVW.

Unfortunately, we lack empirical support for these assumptions. Therefore, we made use of the calculated shares in a very conservative manner, by using them in only two instances. First, all news articles in a newspaper, were assigned to the region in which the newspaper has some readership, i.e., $\text{RS}_{n,r} > 0$ and $\text{RS}^*_{r,n} > 0$. That is, the actual value of the readership share is used in a binary manner, with positive values just seen as an indication of the paper circulating in the region. Second, the shares were used to test the robustness of this allocation procedure, i.e., our estimations were be repeated on subsamples that are identified on the basis of these values.

In total, 231 newspapers were included in this study, with estimated regional readership shares. These newspapers published about 4.3 million news articles within the one year from 01 July 2019 to 30 June 2020. In some instances, the same news article was published by multiple outlets. This might be the case when newspapers share specific sections, or draw from the same pool of articles that national news agencies distribute. Therefore, we assigned a unique identification code to all articles with the same heading and snippet published on the same day. Consequently, the same article was assigned to multiple regions if published by multiple outlets[3].

[3]On average, an individual news article is associated with 1.2 newspapers and 12.8 spatial-planning regions.

Our study crucially depends on the choice of an appropriate spatial unit. Yet, this choice involves a trade-off. On the one hand, when using a very fine-grained spatial delineation, the units of observation are likely too small to correspond to the main circulation areas of newspapers. In this case, these units' socioeconomic characteristics were unlikely to be decisive for newspapers' choices about what to report and how. On the other hand, when the spatial units are too large and greatly exceed newspaper circulation areas, we also might not detect a relation because large portions of these regions are not relevant for the newspaper. Moreover, larger territories imply less spatial information in our empirical models, which reduces the chances of identifying any relation. The last aspect, the lack of spatial variance, rules out using the sixteen federal states in Germany. We are left between three spatial levels for which socioeconomic information is available: the city (10,232), district/NUTS3 (429), and planning region (96) levels. To choose between these three, we calculated the distribution of each newspapers' readers for each of the three levels. Subsequently, for each newspaper, we identified the region with the largest share of readers. Figure 3.1 shows the distribution of these regions' shares, i.e., how many of a newspapers' readers concentrate in a single region for each of the three spatial levels.

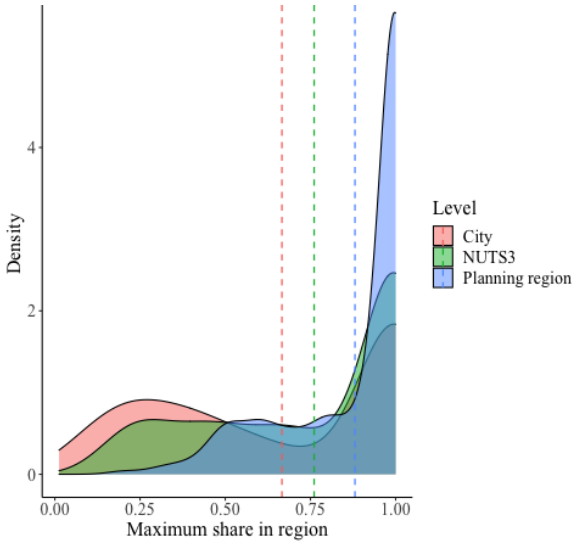


Figure 3.1: Distribution of the largest share of readers in a single region across newspapers

We observe that, for more than 50 % of newspapers (excluding national ones), the vast majority of their readers (almost 90 %) concentrate in just one planning region. Accordingly, for most newspapers, these regions appear to cover almost all of their circulation areas. This share is substantially lower for city-regions (65 %) and NUTS3-regions (75 %). Planning regions also offer sufficient spatial variance with 96 distinct units and therefore, are employed.

3.3.2 News coverage on innovation and new technologies

To identify news articles covering issues of innovation and new technologies, knowledge of topics that the articles cover is crucial. To select relevant articles, we applied a two step-procedure[4]. In the first step, using string-matching algorithms, we identified articles containing at least one of the three keywords on general innovation and new technologies, namely, *technology*, *innovation*, and *science*, very general words that we expected to see in newspaper articles. Added to these were keywords (AI, automation, and robotics) representing specific technologies that were currently diffusing or emerging in Germany. We based their selection on recent debates in the scientific literature regarding technologies with potentially major impacts on society (see, e.g., Acemoglu and Restrepo, 2019, 2018; Furman and Seamans, 2019; Makridakis, 2017). Related keywords for these technologies were *artificial intelligence*, *automation*, and *robot*[5]. Despite our confidence that these search terms gave us a representative picture of news associated with new technologies and innovation, the choice was somewhat arbitrary. Consequently, not all articles were equally relevant, as some containing the word *technology* might not necessarily discuss a new technology or an innovation-related issue. To solve this potential issue, we implemented a second step, using a topic-modeling approach.

We applied the topic-modeling procedure to the set of articles containing any of the above keywords. More precisely, we applied a Latent Dirichlet Allocation (LDA) model. LDA is a probabilistic topic-modeling technique that helps in the automatic discovery of topics (or themes) in a collection of text documents (Blei et al., 2003). It is one of the most prominent methods for topic modeling and is applied in various fields, e.g., medical sciences, software engineering, geography, and political sciences (Jelodar et al., 2019).

[4]Before any text-based analysis, we cleaned the corpus of numbers, punctuation, and stop-words.

[5]The original (stemmed) search strings in German are: *technolog, innovat, wissenschaft, künstlich intelligenz, artifiziell intelligenz, AI, KI, automatisier*, and *robot*.

In the context of the present paper, having supervised the probabilities with which every word appears in a certain topic and the probability with which a news article belongs to a specific category, we eliminated news belonging to irrelevant topics and confirmed our associated topics (innovation/new technologies/specific technologies). That is, by applying topic modeling to the preselected sample of articles and classifying these into subtopics, we assessed the extent to which topics the LDA extracted actually reflected topics in which we were originally interested. For instance, an article may include the keyword "innovation" and hence be selected in the first step. In the second step, the LDA might classify the article into a subtopic clearly focusing on innovation and new technologies, while in another instance, such an article might be classified into a non-innovation-related topic such as "education". Consequently, this procedure minimizes the false-positive error -that is, even while an article contains the word "innovation", among all such articles it might be classified as primarily about education. In this case, it is most likely that the article will be about education with "innovation" being not much more than a side issue. In the following, we exclusively considered articles to be related to innovation and new technologies if they contained any of the above keywords, and LDA classified them as so related. Of course, the minimization of the false-positive comes at the expense of the false-negative error rate. That is, we may not consider all articles related to innovation and new technologies. However, we believe that applying a more conservative approach was more appropriate, given the large number of articles in our database. More details regarding LDA and the topic-modeling procedure appear in 3.6.

At the end of the first step, 23,849 unique news articles were found to include one of our search keywords. At the end of the second step, i.e., topic modeling, we found 20,302 were indeed about innovation and new technology-related events or discussions[6] .

3.3.3 Sentiment analysis

In addition to the variation in the frequency of innovation news reporting, we were interested in potential differences in the sentiments with which they are presented. To obtain a measure of articles' sentiments, we used an auto-

[6]To improve the readability of the paper, we will exclusively refer to "innovation news" and "news on innovation" from now on, which, nonetheless, includes news on new technologies.

mated sentiment analysis tool introduced by Rauh (2018). The tool is built on two widely used German sentiment lexicons, namely, *Sentiment Wortschatz*, and *German Polarity Clues*, developed by Remus et al. (2010) and Waltinger (2010), respectively. Crucially, this tool considers negation. With this approach, we identified the number of positive and negative terms and calculated the sentiment polarity score of each article, by using the following formula:

$$SENT = \frac{\#POS - \#NEG}{\#POS + \#NEG} \tag{3.6}$$

where $\#POS$ and $\#NEG$ denote the total number of positive and negative terms, respectively. The denominator equals the total number of sentiment bearing words.

The distribution of sentiment of the articles appears in Figure 3.2, where the lighter color shows the distribution for all news articles and the darker color for the innovation news (INNOV). Comparing the sentiments towards innovation to the general news sentiment, we see that they mostly receive positive coverage in German news media. Their mean sentiment polarity score is 0.33, whereas the average score of all news is 0.05. Given these results, we infer that news generally bears a neutral sentiment, while innovation and new technologies are indeed (absolutely and relatively) good news in Germany!

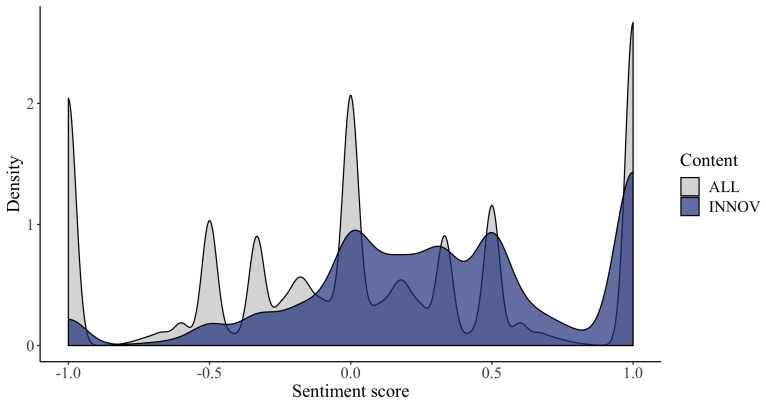


Figure 3.2: Sentiment distribution of innovation news

3.3.4 Regionalizing the news data

Our initial observations are individual news articles. However, newspapers captured in *RegNeS* vary greatly in the number of articles they publish. Moreover, decisions about articles (e.g., content, sentiment, in what regional section in which to publish) are made at the newspaper level. Inversely, readers do not pick what newspaper to read on the basis of an individual article but, rather, by assessing the entire package of articles that newspapers present over a certain time. Consequently, the link between regional characteristics and what is read in a region must be modeled at the newspaper level. Therefore, we aggregated the article-level information at that level. We also must consider that most of the newspapers serve readers in multiple regions, implying that our unit of observation, called *newspaper-regions* in the following, is the combination of newspapers and regions in which they have a positive readership share ($RS_{n,r} > 0$ and $RS^*_{n,r} > 0$; see Section 3.3.1). Accordingly, in our final data, each newspaper appears as many times as there are regions in which it has a positive readership.

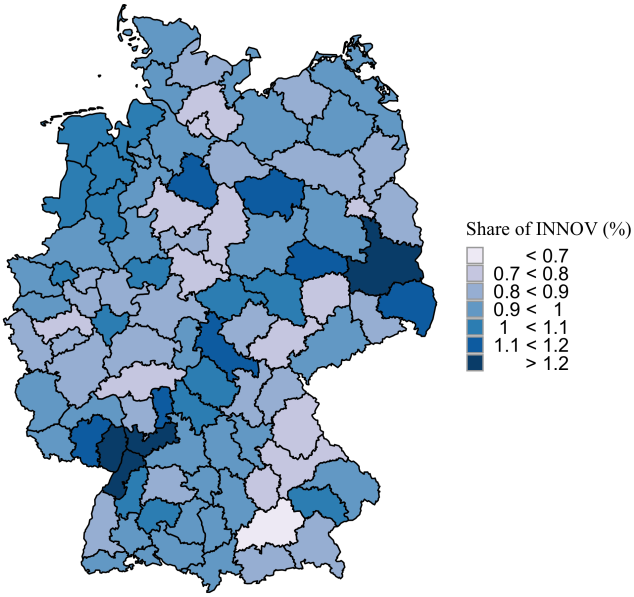


Figure 3.3: Share of innovation news in total news

To capture the variations with which articles in newspaper-regions contain news about innovation, we constructed our first dependent variable, $\text{INNOV}_{n,r}$. The value of $\text{INNOV}_{n,r}$ equals the number of articles that deal with innovation in newspaper n circulating in region r. INNOV is expected to increase with the total number of articles published by the respective newspaper. Therefore, including the total number of news articles published in the respective newspaper-region, $\text{NNEWS}_{n,r}$, in any kind of evaluation is essential.

In Figure 3.3, we illustrate the share of innovation news in total news (INNOV/NNEWS), aggregated at the spatial-planning region level. It can be interpreted as representing the likelihood of reading about innovation when randomly picking up a newspaper circulating in the region. The map provides a first insight into the regional variation in the frequency with which newspapers cover innovation. It reveals a strong imbalance in the share of innovation news coverage, where generally lower shares seem to characterize larger metropolitan regions (Berlin, Hamburg, Munich, Frankfurt).

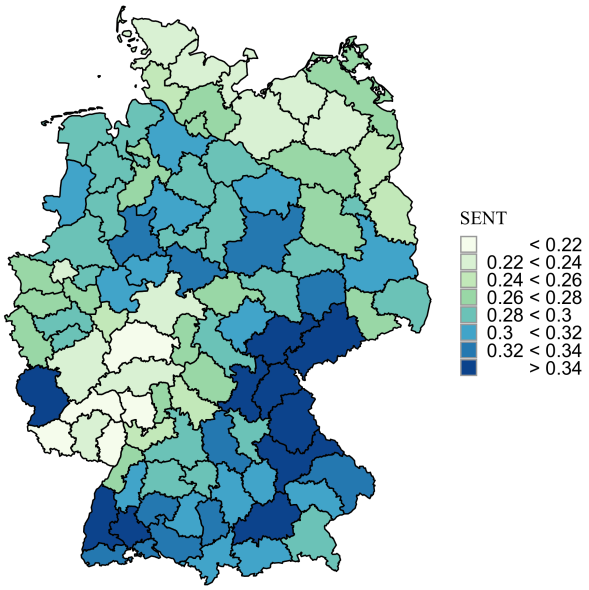


Figure 3.4: Average sentiment of innovation news per planning region

Figure 3.4 represents the sentiments of innovation news ($\text{SENT}_{n,r}$), corresponding to the average sentiment of articles covering innovation and new

technology-related issues in region r. Darker colors correspond to a relatively more positive sentiment towards innovation. As in the case of the frequency of innovation news, we observe a substantial spatial imbalance, which will be explained later. However, in contrast to the previous map, in this case, a clear North-South pattern is visible. Regions in Bavaria and Baden-Wuerttemberg, as well as Thuringia, seem to have newspapers that report these issues more positively.

3.3.5 Regional variables

To investigate if variations in the frequency and tone of innovation news vary systematically with regions' socioeconomic characteristics, we considered a range of variables. We differentiated between urban or rural regions by means of their population density (POPDENS). Urban regions are expected to generate a larger number of "activities" and "events" to report, including more frequent innovation-related events. Accordingly, there is a greater probability that some of them to show up in the news. However, as discussed earlier, what is *newsworthy* is a relative concept, and differences between urban and rural regions might emerge because of innovation news differing in degrees of *unexpectedness*.[7]

The economic development of regions is straightforwardly approximated by the gross domestic product per capita[8] (GDPC). We expect economically more developed regions to generate and their news outlets to report more innovation news. However, that might also trigger a reduction in *unexpectedness* and lower the frequency of innovation news and its sentiments.

In light of the discussion above on some new technologies potentially threatening the demand for human labor, we include the regional unemployment rate (UNEMP) as a potential explanatory factor. Due to the *relevance* effect, we expect more frequent innovation news coverage with a more negative tone in regions with higher unemployment rates.

[7] We also considered the number of patents granted (PATC) per capita, as an indication of the research and development activities. More R&D increases the chances of having more "spectacular" innovations that may find their way into newspapers. However, the variable turned out to be correlated with POPDENS and did not add to the models. Therefore, we dropped it and refrained from reporting the corresponding results at this point. They can be obtained from the authors upon request.

[8] The variable is measured in thousands.

Given the peculiar history of the two parts of Germany, there (still) seem to be systematic differences in journalistic activities (Haller, 2012) and this may potentially impact the judgment of newsworthiness and sentiment of coverage. For this reason, we control for regions belonging to the former East Germany with the dummy variable EAST. The variable takes a value of 1 for the spatial-planning regions that were in the former German Democratic Republic (GDR) and 0 for those remaining.

The regional socioeconomic indicators were obtained from the statistical offices of the German federal states and has been sourced from the INKAR database[9]. We used the most recent data available for each variable (2018). Given the cross-sectional nature of our research and the limited temporal variance of these variables, we are confident that they are a sufficient match of our 2019-2020 news data.

Finally, regions vary in terms of the number of newspapers available, which might impact the likelihood of reading about innovation. Larger numbers of newspapers may bring a certain degree of diversity to regions, with newspapers specializing in different topics, or fierce competition may push newspapers to publish what is found the most newsworthy in the region, making them similar in content. Thus, in order to capture how this diversity impacts innovation news coverage, we include NNP_r, the number of newspapers in region r for all n such that $RS_{n,r} > 0$.

3.3.6 Control variables

Although our dependent variable is at the newspaper-region level, and we are rather interested in its variation; depending on the regional variables, some newspaper-level variables may potentially impact our results. Accordingly, we control for these.

First is the average length of articles that newspapers published. The length might impact the likelihood of detecting search keywords and, thus, might have an impact on the number of innovation news items found. Since the sentiment index depends on the total number of sentiment-bearing words, the total number of words in an article is also likely to have an impact on the assigned sentiment score. The NWORD_n variable is constructed to this end

[9] www.inkar.de.

and it simply shows the average number of words an article contains for each newspaper.

Second, since newspapers significantly vary in their reporting styles, the sentiment conveyed in reporting innovation news also depends on the general tendency of newspapers to frame issues more positively or negatively. To control for newspapers' general sentiment, we construct the control variable NPSENT_n, which represents the average news sentiment (regardless of the topics covered) for each newspaper.

Third, while some newspapers in our data set are regional and local newspapers, some are national, available and with readership in almost all regions. Since journalistic practices might systematically differ between national and regional newspapers, we control for this with the dummy variable, NATIONAL_n. The variable takes the value of 1 for the newspapers with readership share in more than 50 of 96 spatial-planning regions, and 0 otherwise.

Table 3.1: Summary statistics

	# Obs	# NA	Min	Max	Median	Mean	Std.dev
INNOV	2002	0	0.00	1,684.00	114.00	253.34	351.49
NNEWS	2002	0	455.00	116,666.00	23,312.00	29,695.66	24,825.08
SENT	1985	26	-0.50	1.00	0.26	0.29	0.17
POPDEN	96	0	42.00	4,055.00	180.00	335.17	521.37
GDPC	96	0	24.20	65.90	34.75	36.51	8.51
UNEMP	96	0	2.20	10.90	5.25	5.55	2.17
NNP	96	0	11.00	40.00	18.00	20.85	6.39
NWORD	231	0	5.50	435.70	31.90	42.80	59.70
NPSENT	231	0	-0.74	0.52	-0.01	-0.01	0.10

Table 3.2: Summary statistics for categorical variables

	Levels	# Obs	Perc (%)
EAST	1	22	22.92
	0	74	77.08
	All	96	100.00
NATIONAL	1	8	3.46
	0	223	96.54
	All	231	100.00

Table 3.1 and Table 3.2 provide the relevant summary statistics for all variables used in the paper. Correlation of the variables appears in Table 3.7 in the Appendix.

3.3.7 Empirical approach

As pointed out above, the unit of observation is newspaper-regions, i.e., we observe the frequency of newspaper n featuring articles about new technologies and innovation in region r, as well as the sentiments they convey. As newspapers transcend regions, this creates a relatively complex dependency structure among the observations, which renders using standard regression analyses invalid. This becomes obvious in the construction of our dependent variables, which are partly based on newspaper-level information that is the same in all regions in which the newspaper circulates. Put differently, the values associated with newspaper n in region r_i are more likely to be similar to those in r_j than to those held by chance. Such types of problems are common in spatial research, which lends us the methodologies addressing this. More precisely, we use cross-sectional spatial regression approaches and several Lagrange Multiplier (LM) tests (introduced by Anselin et al. (1996) and Anselin (2013), and implemented by Bivand and Piras (2015)) to identify the appropriate models. In all cases, these tests recommend the use of the so-called spatial error model (SEM) (LeSage and Pacey, 2009), which takes the form:

$$y = \beta X + u \quad \text{where} \quad u = \lambda W u + e\,. \tag{3.7}$$

In Equation 3.7, y denotes the dependent variable, X denotes the matrix of explanatory variables, and β is the corresponding vector of coefficients. The disturbance term u is spatially auto-correlated, where λ is the spatial autoregressive parameter and e is the usual independent and identically distributed disturbance. W denotes the spatial weight matrix capturing the spatial dependencies among the observations. Usually, the spatial weight matrix is defined on the basis of geographical neighborhoods or distances, which represent the underlying spatial structures. However, in this study, dependencies arise from the fact that the same newspaper is circulating in multiple regions. Consequently, we construct the weight matrix on this basis. That is, we consider observations (newspaper-regions $r_{n,i}$ and $r_{n,j}$) to be neighbors when newspaper n is circulating in both of them.

$$w_{i,j} = \begin{cases} 1 & , \quad RS_{n,i} > 0 \text{ and } RS_{n,j} > 0 \\ 0 & , \quad otherwise \end{cases} \tag{3.8}$$

In a similar manner, the matrix is row-standardized before being transformed into spatial weights. The LM-tests revealing the presence of this dependency structure in the data confirm the appropriateness of this specification. Notably, our first dependent variable is a count variable ($\text{INNOV}_{n,r}$). Unfortunately, methods for dealing with spatial auto-correlation and count data are not yet sufficiently developed (Glaser, 2017). Consequently, we apply the second-best solution, namely, log-transforming the variable.[10]

3.4 Results and discussion

3.4.1 Regional variation in innovation news coverage

To explore the determinants of regional variation in the frequency with which newspapers cover innovation and new technology-related information, we use INNOV as our dependent variable. It is regressed onto the previously described set of variables using the spatial error model.[11] Table 3.3 shows the according results. In Section 3.3.1, we pointed out that our construction of readership shares that are used to allocate news articles across regions, are based on a number of assumptions. Therefore, we must explore the robustness of our findings, with respect to the specification of this allocation procedure. We do this by repeating our regression analysis for subsamples of our data, defined on the basis of different threshold values of regional readership shares. Newspapers are required to exceed these values before allocating their articles to a region. More precise, in addition to the baseline scenario with no threshold on the readership share, we construct subsamples of the data that include only articles of newspapers that exceed regional readership shares of at least 0.1%, 0.5%, and 1%, respectively. We cannot test for greater thresholds, as the numbers of remaining observations fall considerably. Since increasing the thresholds implies lower chances of newspaper misallocation, we interpret findings that hold in multiple scenarios, as being more reliable and less conditional on the

[10] We also add 1 to the value before the transformation to ensure finite values.

[11] As discussed in Section 3.3.7, the choice of employed spatial model is based on the Lagrange multiplier (LM) diagnostics. Test-statistics and corresponding p-values for each regression appear in 3.6.3.

allocation procedure. However, it turns out that almost all variables with significant coefficients in the baseline scenario remain significant in the other scenarios as well. Consequently, our results appear to be robust, with respect to alterations in the matching of newspapers to regions.

Table 3.3: Frequency of innovation news coverage

	log(INNOV)			
$RS_{n,r}$	> 0	> 0.001	> 0.005	> 0.01
log(POPDEN)	0.058*	0.085*	0.091*	0.116**
	(0.027)	(0.035)	(0.038)	(0.040)
log(UNEMP)	−0.072	−0.199**	−0.184*	−0.116
	(0.057)	(0.077)	(0.082)	(0.090)
log(GDPC)	0.063	−0.205	−0.094	−0.016
	(0.109)	(0.156)	(0.163)	(0.174)
EAST	0.162***	0.195**	0.185**	0.198**
	(0.046)	(0.060)	(0.066)	(0.073)
log(NWORD)	1.153***	1.245***	1.203***	1.174***
	(0.025)	(0.035)	(0.036)	(0.039)
NATIONAL	0.901***	1.068***	0.868***	0.673***
	(0.032)	(0.045)	(0.048)	(0.056)
log(NNP)	−0.128	0.059	0.090	0.019
	(0.073)	(0.073)	(0.060)	(0.061)
log(NNEWS)	1.033***	1.012***	1.019***	1.028***
	(0.013)	(0.019)	(0.021)	(0.022)
Constant	−9.830***	−9.493***	−9.926***	−10.286***
	(0.407)	(0.582)	(0.612)	(0.650)
λ	0.061	−0.047	0.026	−0.006
	(0.046)	(0.056)	(0.055)	(0.059)
Observations	2002	1183	863	679
Max VIF	3.130	3.160	2.970	2.990
Log Likelihood	−1898.674	−1205.481	−792.831	−598.305
AIC (Linear)	3818.998	2431.674	1605.875	1216.619
AIC (Spatial)	3819.348	2432.961	1607.661	1218.609
LR test statistic	1.650	0.713	0.214	0.010
LR test p-value	0.199	0.398	0.644	0.922

Note: *p<0.05; **p<0.01; ***p<0.001

Before looking at the variables representing regional characteristics, the control variables are worth discussing. The variable log(NWORDS) obtains a positive and statistically significant coefficient, confirming our expectations. Innovation news items are more likely to appear in newspapers with longer articles. For similar reasons, log(NNEWS) becomes significantly positive as well; The more

news articles newspapers publish, the more likely it is that some of them will refer to innovation and new technologies. Accordingly, both variables' importance is of a rather technical nature, as they control for "size-effects" or features of the data-collection process.

Insightful results are obtained for NATIONAL. Its coefficients are also significantly positive. Accordingly, national newspapers are more likely to feature articles dealing with innovation and new technologies. This finding most likely reflects the fact that some larger national newspapers have dedicated news sections to technological issues, missing from regional newspapers. For instance, the prominent German newspaper *Frankfurter Allgemeine* has a section called "Technik und Motor" (*Technology and Engine*). However, it may also be due to national newspapers seeking to cover more general newsworthy issues of interest to the whole country.

The first regional variable for which we obtain a significant coefficient in the baseline model and in all threshold-scenarios is population density (POPDEN). Its coefficient is significantly positive suggesting that news articles on innovation are more likely to appear in newspapers circulating in urbanized regions. The explanation for these findings may reside in a generally greater interest among urban readership in topics related to innovation and new technologies, i.e., the relevance of this topic to the urban audience; or in the availability of more unexpected and bigger events in these areas that regional newspapers pick up. Given the substantial concentration of innovation and technological activities in urban regions (Feldman and Audretsch, 1999; Broekel and Brenner, 2011), innovations mostly emerge in cities. Of these innovations, only a few may have a substantial impact on society in general (e.g., "COVID-19 vaccine") and, thus, interest for readers in multiple regions. However, many innovations may be of relatively greater importance to individual regions, either representing success events of local businesses or research institutions, or having noteworthy consequences, such as securing or expanding local employment. Consequently, regions where more such events occur (urban areas), offer a larger pool of newsworthy events to report. According to our results, this also translates into a higher share of innovation news in the newspapers circulating in these places. An alternative to this supply-side (or news factors) argument, is a greater demand for such news in urban areas. Cities tend to have more specialized in high-tech industries and high-skilled jobs (Gomez-Lievano et al., 2018). This creates an audience that is likely to be more interested in news

about innovation. Accordingly, newspapers that seek to appeal to this audience will feature more articles of this kind, in urban areas. This greater exposure to innovation-related news in urban regions will contribute to the formation of a collective expectation generally (Konrad, 2006), and more positive ones in particular. Thus, it paves the way for quicker adoption (Budde et al., 2012), which allocates the early-adopter advantages of innovations to cities.

The second variable with a consistently significant coefficient in all scenarios is EAST, i.e., the indication of a region being located in the territory of the former GDR. The variable's coefficient is positive, highlighting that newspapers circulating in these regions tend to have more innovation news. Interestingly, in contrast to POPDEN, a supply-side explanation seems unlikely to underlie this finding. Even thirty years after the reunification, on average, innovation activities are still not at the level they are in the western part of the country (Gomez-Lievano et al., 2018). Consequently, we can only speculate about factors on the demand side, i.e., the relevance of innovation and new technology related discussions to individuals living in the territory of the former GDR. It might be related to the higher average age of media consumers in East Germany (Gomez-Lievano et al., 2018), or that the history of the GDR, with its stronger focus on technologies and natural science in education, still shaping the perception of and interest in these issues (Gensicke, 1995). This clearly deserves more attention in future research.

Restricting articles to newspapers exceeding a minimum regional readership (RS$>$ 0.001 and RS$>$ 0.005), the coefficient of the rate of unemployment is becoming significantly negative. However, that does not hold for the strictest scenario, a minimum readership share of at least 1%. Accordingly, it can be seen as a weak indication of regions with higher unemployment having lower shares of innovation news in newspapers circulating there. Again, both supply- and demand-side explanations are possible. On the supply side, high unemployment tends to go along with less dynamic economic and technological developments. On the demand side, the local newspaper audience may be less interested in such topics, as there is at least one much more pressing issue - the high unemployment, which leaves less room for news on innovation. Moreover, and somewhat more likely, high unemployment in regions goes hand in hand with lower levels of highly-skilled human capital and high-tech industries. In this sense, high-unemployment may indicate a less technology-interested audience

in general, and these topics are less relevant to the audience that our model picked up.

Together with the previous finding concerning urbanization and its strong correlation to the number of patents (see footnote 7), these observations imply that from a regional perspective, rarity does not drive the newsworthiness of innovations. Unexpectedness is a driver of newsworthiness (Galtung and Ruge, 1965), so the relatively greater rarity of innovation events in rural areas and regions with higher unemployment should have increased the likelihood of their being reported. We observe the opposite: Regions with fewer innovations are not associated with relatively greater newsworthiness or unexpectedness of individual innovation events. In contrast, the finding can be better explained by the *relevance* and *proximity* effect (Harcup and O'neill, 2017; Shoemaker et al., 2007), in regions where innovation more closely relates to or more strongly shapes socioeconomic conditions.

3.4.2 Regional variation in innovation news sentiment

The frequency with which innovations appear in the news is a crucial condition for the general public to learn about them. However, for adoption or, at least gaining legitimacy, their presentation in a positive light is also essential. The aforementioned example of the media presentation of bioenergy in Sweden and Norway leading to different diffusion patterns in each country (Skjølsvold, 2012) highlights this likelihood. Thus, it is important to explore the representation of technological developments and innovations in different regions. A spatial regression model, using SENT as a dependent variable, explores the degree to which sentiments on innovation differ between regions. Table 3.4 presents the corresponding regression results.

As in the previous subsection, a look at the robustness of our results, with respect to specification in the regional allocation procedure, is worthwhile. Given that the models show little sensitivity to alternative specifications, our empirical approach appears to work well when it comes to exploring regional variations in sentiments as well.

The first control variable of interest in this model is NPSENT, i.e., the average sentiment of articles in the focal newspaper. The variable obtains a significantly positive coefficient in the baseline and all other scenarios. This suggests that newspapers that generally have a relatively more positive tone

in their articles show it in news on innovation as well. In itself, this is not surprising. However, it has substantial consequences for the interpretation of the other variables because it implies that we are controlling for newspaper-level effects. Put differently, our findings show the relation between (regional) variables and sentiments on innovation news that go beyond the general tone of newspapers.

Table 3.4: Tone of innovation news coverage

	log(SENT)			
$RS_{n,r}$	> 0	> 0.001	> 0.005	> 0.01
log(POPDEN)	0.007	0.003	0.007	0.002
	(0.004)	(0.005)	(0.006)	(0.007)
log(UNEMP)	-0.030^{***}	-0.029^{*}	-0.029^{*}	-0.029
	(0.009)	(0.011)	(0.014)	(0.017)
log(GDPC)	-0.015	-0.015	-0.029	-0.024
	(0.018)	(0.022)	(0.027)	(0.033)
EAST	0.013	0.013	0.012	0.017
	(0.007)	(0.009)	(0.011)	(0.013)
log(NWORD)	-0.045^{***}	-0.049^{***}	-0.047^{***}	-0.054^{***}
	(0.004)	(0.006)	(0.007)	(0.008)
NATIONAL	0.033^{***}	0.028^{***}	0.050^{***}	0.054^{***}
	(0.006)	(0.008)	(0.010)	(0.012)
log(NNP)	-0.022	-0.019	-0.019	0.004
	(0.012)	(0.011)	(0.010)	(0.012)
log(INNOV)	-0.037^{***}	-0.039^{***}	-0.038^{***}	-0.034^{***}
	(0.002)	(0.002)	(0.003)	(0.004)
log(NPSENT)	0.736^{***}	0.727^{***}	0.820^{***}	0.845^{***}
	(0.028)	(0.037)	(0.046)	(0.054)
Constant	0.690^{***}	0.718^{***}	0.719^{***}	0.686^{***}
	(0.061)	(0.077)	(0.094)	(0.112)
λ	-0.130^{*}	-0.044	-0.120	-0.157^{*}
	(0.057)	(0.057)	(0.064)	(0.069)
Observations	1985	1171	856	672
Max VIF	3.170	3.160	2.970	2.990
Log Likelihood	1748.783	1075.972	746.022	533.993
AIC (Linear)	-3470.071	-2129.323	-1466.319	-1040.538
AIC (Spatial)	-3473.565	-2127.944	-1468.043	-1043.987
LR test statistic	5.494	0.622	3.725	5.449
LR test p-value	0.019	0.430	0.054	0.020

Note: *p<0.05; **p<0.01; ***p<0.001

With respect to other control variables, the models indicate a significantly negative relationship with the length of articles (NWORD), which is primarily

technical, as the number of (sentiment-bearing) words serves as the denominator in our sentiment index and the number of these words tend to increase with the length of articles. The second strongly significantly negative control variable is the number of innovation news items (INNOV) in the respective newspaper. Accordingly, newspapers that report less about innovation, tend to focus on a more positive representation of these topics[12]. In contrast, newspapers with a greater dedication towards this topic seem to take a more critical stand or give more room to less-positive evaluations of innovations and new technologies.

As in the case of innovation news' frequency, we observe significantly positive coefficients for NATIONAL, which substantiates the structural difference between regional and national newspapers. Not only do the latter report more frequently about innovations and new technologies; they also do this in a more positive manner. One potential but purely speculative explanation for this might be that national newspapers rather focus on the overall impact of innovations on societal development. In contrast, regional newspapers' focus on particular regions that may be more concerned about their potential negative (local) consequences. The literature on regional innovation increasingly recognizes that many innovations may actually contribute to the growing spatial inequalities of economic and social status (see for a recent review, see Biggi and Giuliani, 2020). Consequently, innovations might endanger the economic development of many regions, while society, as a whole, benefits from them. Our findings on the difference between national and regional newspapers may reflect this. Again, we have no reliable empirical support for this claim at this stage, which calls for more research on the issue.

With respect to regional variables, we primarily identify the unemployment rate (UNEMP) as having a robust and nearly consistent negative relation with the sentiments of news on innovation. Only in the models with a threshold of 1%, the coefficient remains insignificant at the 0.5 level (though it is significant at the 0.1 level). Accordingly, the interpretation calls for exercising caution, as the result is conditional on considering even relatively small readership shares in the news articles' spatial allocation.

The finding on UNEMP implies that regions with higher levels of unemployment tend to have newspapers in circulation that report relatively more neg-

[12]Note that the newspapers with no innovation news are excluded in this analysis.

atively about innovation and new technologies. It is important to underline that, as Section 3.3.3 shows, news on these issues generally has a positive tone, implying that this is a strictly relative perspective. Nevertheless, this raises the question of why newspapers in regions with higher rates of unemployment report more negatively about innovation and new technologies (and, as shown in the previous section, also less frequently) than regions with lower rates of unemployment? An explanation that fits to this finding is the potential regional variations in the sentiments towards specific technologies. Clearly, many have great potentials to revolutionize our ways of living and promise prosperity (see, e.g., the discussion on AI in Agrawal et al., 2019; Korinek and Stiglitz, 2017). However, these potential benefits are unlikely to spread uniformly geographically. Put differently, only some regions will experience these benefits, while others rather face negative consequences when these technologies become widely adopted. Moreover, most contemporary new and revolutionizing technologies will materialize in regions with the necessary infrastructure and related economic structures in place, e.g., advanced ICT, biotechnology, and industry 4.0 (Iammarino et al., 2019). It seems reasonable that these technologies would also be the ones most discussed in today's newspapers. Given their potential to increase spatial inequality and challenge existing regional economic comparative advantages, for many less-developed regions, these technologies represent a threat rather than bright promises. In this case, we can expect the news media to focus more strongly on such technologies' "dark sides" in regions where their effects are envisioned as rather negative. Our empirical findings seem to support that this might be the case. Yet admittedly, the findings do not provide any direct empirical proof.

To get a somewhat more detailed picture of the matter, we repeat the analysis with a focus on two technologies. They fall into the category of technologies with the potential to boost economic prosperity in some regions that already possess an advanced technological infrastructure and economic basis, namely, AI and automation (Iammarino et al., 2019). On the other hand, they challenge the foundation of many less-advanced regional economies. Section 3.3.2 describes the identification of the corresponding sets of news articles. All variables are the same as in the previous models. The only difference is that the dependent variable log(SENT), for AI and automation exclusively indicates the average sentiment of the news articles that contain the words AI and automation, respectively. The regression results based on the two distinct subsamples

appear in Table 3.5. Interestingly, the results hardly differ from what we obtained for the total set of news on innovation. This is somewhat surprising, given that AI-related and automation-related news only account for 8.5% and 18% of all innovation news, respectively.

Table 3.5: Tone of AI and automation news coverage

	log(SENT)							
	Artificial Intelligence				Automation			
$RS_{n,r}$	> 0	> 0.001	> 0.005	> 0.01	> 0	> 0.001	> 0.005	> 0.01
log(POPDEN)	0.008*	−0.008	−0.011	−0.010	0.027*	0.021	0.034*	0.030
	(0.004)	(0.010)	(0.011	(0.013)	(0.011)	(0.012)	(0.014)	(0.016)
log(UNEMP)	−0.064***	−0.047***	−0.028**	−0.022	−0.036***	−0.035**	−0.036**	−0.042*
	(0.017)	(0.011)	(0.021)	(0.028)	(0.009)	(0.011)	(0.013)	(0.017)
log(GDPC)	−0.008	−0.005	−0.015	−0.002	−0.018	−0.016	−0.026	−0.031
	(0.015)	(0.018)	(0.022)	(0.025)	(0.017)	(0.022)	(0.026)	(0.032)
EAST	0.018**	0.012	0.010	0.012	0.014*	0.019*	0.020	0.026
	(0.006)	(0.007)	(0.009)	(0.010)	(0.007)	(0.009)	(0.011)	(0.013)
log(NWORD)	−0.044***	−0.048***	−0.045***	−0.047***	−0.045***	−0.049***	−0.047***	−0.051***
	(0.004)	(0.005)	(0.005)	(0.006)	(0.004)	(0.005)	(0.006)	(0.008)
NATIONAL	0.019***	0.020**	0.039***	0.043***	0.030***	0.025**	0.046***	0.052***
	(0.005)	(0.007)	(0.008)	(0.010)	(0.006)	(0.008)	(0.010)	(0.012)
log(NNP)	−0.040*	−0.059***	−0.047**	−0.062***	−0.026*	−0.025*	−0.025*	0.000
	(0.023)	(0.020)	(0.019)	(0.021)	(0.011)	(0.011)	(0.010)	(0.012)
log(INNOV)	−0.038***	−0.046***	−0.047***	−0.047***	−0.035***	−0.034***	−0.032***	−0.028***
	(0.002)	(0.002)	(0.003)	(0.004)	(0.002)	(0.002)	(0.003)	(0.004)
log(NPSENT)	0.606***	0.648***	0.747***	0.760***	0.705***	0.739***	0.822***	0.840***
	(0.030)	(0.038)	(0.047)	(0.051)	(0.029)	(0.039)	(0.049)	(0.057)
Constant	0.695***	0.752***	0.738***	0.701***	0.689***	0.707***	0.694***	0.672***
	(0.054)	(0.064)	(0.074)	(0.085)	(0.058)	(0.074)	(0.091)	(0.109)
λ	0.066	−0.078	0.006	−0.104	0.001	0.006	0.062	0.043
	(0.056)	(0.068)	(0.066)	(0.076)	(0.054)	(0.057)	(0.057)	(0.060)
Observations	1581	991	712	553	1892	1118	810	631
Max VIF	3.360	3.130	2.880	2.940	3.240	3.170	2.980	3.010
Log Lik.	1775.918	1192.577	851.087	643.267	1821.544	1092.333	751.058	535.133
AIC (Linear)	−3528.509	−2361.818	−1680.164	−1262.618	−3621.088	−2162.655	−1478.989	−1047.785
AIC (Spatial)	−3527.836	−2361.153	−1678.173	−1262.535	−3619.088	−2160.666	−1478.117	−1046.265
LR test statistic	1.327	1.335	0.009	1.917	0.001	0.011	1.128	0.480
LR test p-value	0.249	0.248	0.924	0.166	0.980	0.915	0.288	0.488

Note: *p<0.05; **p<0.01; ***p<0.001

Besides the control variables, unemployment still obtains a significantly negative coefficient in all specifications. Crucially, it becomes significant in all specifications for automation, while in the case of AI, the coefficient remains insignificant in the most restrictive model requiring at least 1% readership. In any case, these findings clearly show that in regions where the unemployment rate is higher, when reporting about the developments in AI and automation, newspapers focus on the potential threats more than the opportunities these technologies may unfold. This adds to our argument that technologies threat-

ening existing economic advantages are discussed relatively less positively in regions with high unemployment.

The observed relationships between unemployment and sentiments towards innovations and new technologies reinforces the arguments concerning frequency: High *relevance* of innovations for the regional audience that originates in an urban, technology-driven economy accompanies an audience interested in a positive presentation of such topics and newspapers satisfying this demand. Crucially, since such news not only appears with greater frequency but also in a more positive fashion, newspapers are likely contributing strongly to the building of positive collective expectations (Konrad, 2006; Budde et al., 2012). Consequently, newspapers seem to facilitate innovation diffusion, which particularly works to the benefit of already well-developed regions. Also, this example of a link between regional socio-economic structures and (regional) news, supports the view that newspaper data gives approximate insights into local public opinions and attitudes (see also, Fenn and Raskino, 2008; Melton et al., 2016).

Two further results are worth pointing out. EAST is positively significant in the case of AI and automation in the baseline models. This suggests a tendency toward somewhat more positive presentations of both technologies in the eastern part of Germany. Besides confirming the (still) existing structural differences between the two parts of Germany, we interpret this finding as newspapers in East Germany reflecting a more positive attitude toward these technologies. We also find a weak indication (i.e., coefficient of POPDEN being significantly positive at the 0.5 level in the baseline models) that sentiments of AI- and automation-related news are more positive in urban regions. A potential explanation might be that the impacts of automation on employment are expected to be lower in cities (Frank et al., 2018). Accordingly, in these places, people might feel less threatened by automation, and news outlets might be less inclined to cover specifically negative aspects or they focus on these technologies' positive side.

3.5 Implications and conclusion

Aggregate expectations play an important role in the development, diffusion, and use of new technologies. The frequency of exposure to innovation- and new technology-related information and the tone of the presentation are crucial for the formation of collective expectations and public opinion. One important

channel by which information and opinions about innovation are diffused is the news media. They have a strong geographical dimension, and this may have substantial consequences, in the sense that the heterogeneity in the media reporting is likely to translate into unequal exposure and, thus, differing opinions. Studies widely confirm this at the national level, showing that media differ between countries in frequency and tone of coverage about innovation and new technologies.

The present paper adds to this literature with a complementary study at the subnational (regional) level. More precisely, we argue that so far, much of this literature neglects the realization that innovation processes and technological diffusion are at least as much a subnational process as a national one. In addition, most of the media are also strongly organized at the subnational level. With few nationwide outlets, regional and local newspapers strongly shape the newspaper landscape in many countries. The present paper links this regional dimension of the news media to that of innovation (diffusion) processes, by exploring whether there is a significant variation in the frequency and sentiments of innovation news at the subnational level. Thus, the paper not only addresses an issue hardly addressed until now, but it also brings together two literature streams (the geography of media and the geography of innovation studies) that are (still) relatively loosely connected.

To address this research gap, our empirical study employs a novel data set on national and regional news in Germany, recently established *RegNeS* database. This database covers headlines and snippets of more than 300 news sources from the German-speaking world. Within this data, we identified innovation news, by employing string matching algorithms and topic modeling. Their sentiments are quantified using the polarity classification tool developed by Rauh (2018). The data has further been enriched by information on newspapers' spatial circulation, which allows for approximating where news articles are most likely read.

Our results highlight that newspapers circulating in urban areas are more likely to feature news on innovation, implying more frequent exposure of readers to such information. We also identify notable differences between East and West Germany; news on innovation appears more frequently in newspapers in regions located in the territory of the former GDR. Some weaker evidence of a difference between the two parts of the country are also observed with

respect to the sentiments with which such news are presented. On average, AI- and automation-related news tends to be written in a more positive tone in East, than in West Germany. Given that the reunification of the country did take place more than 30 years ago, these are somewhat surprising findings, which clearly call for more research in the future. Our study also hints at that the frequency and sentiments of innovation news are negatively associated with the levels of regional unemployment. Newspapers circulating in regions with less favorable labor markets appear to feature fewer articles on this topic, and if they do feature them, it has a relatively less-positive tone. A potential explanation for this finding is that many contemporary technologies (e.g., AI and automation) represent further severe threats (Frey and Osborne, 2017; Acemoglu and Restrepo, 2019) to the regions that are already economically weaker. This may lead to less-positive sentiments and generally less interest in these types of technologies, which carry into the editorial rooms of regional newspapers.

Our analyses show that newspaper coverage of innovation related events and discussions systematically varies across regions. This is likely to be explained by what is frequently referred to as *reverse agenda setting theory* (Watt Jr and van Den Berg, 1978), i.e., prominence of news stories about innovation is driven by the already existing interest on the issue by the regional newspapers' readership. In turn, this relates to the regional factors considered. Accordingly, our study adds to prior research findings that the characteristics of regional news markets affect the news (Althaus et al., 2009) and that regional news media's tone reflects existing beliefs and attitudes of their consumers (Gentzkow and Shapiro, 2006). We show that regional socio-economic characteristics explain the available information set about certain topics in each region. For instance, relatively more-negative (or less-positive) sentiment regarding innovation news coverage in regions with higher unemployment rates, demonstrates this alignment of news media's attitude and regional macroeconomic indicators. It suggests that, in particular, the *relevance* and *proximity* effect drive the alignment between news and regional characteristics.

Yet, our study does not deliver causal empirical evidence. Theoretically, processes such as newspapers' having the power of agenda-setting (McCombs and Shaw, 1972) may fuel a reverse relationship. In addition, more omitted variables (e.g., newspaper ownership) might play a role in this setting. Nevertheless, given the rather fundamental and time-invariant nature of the considered

regional characteristics, as well as the usually unemotional and politically cold discussions surrounding most innovations, there is hardly any support for such interpretation.

Our findings appear against the backdrop of some empirical limitations. Our data exclusively feature regional and national newspapers, ignoring other news outlets that might be of even greater relevance, such as tech-magazines, radio shows, and TV programs. We also concentrate on a single country (Germany). The employed data is limited to only headlines and text snippets. Adding to this is its cross-sectional nature, implying that specific events and short-term trends may affect some of our findings. Collecting long-term news information and having access to full-text news archives are the obvious solutions to these limitations, for future research.

Admittedly, our study is also limited in its ability to disentangle and identify the mechanisms underlying our findings. However, it clearly confirms the existence of substantial and systematic heterogeneity in the presentation of innovation and new technologies at the subnational (regional) level. It also shows that this heterogeneity is related to the fundamental regional socioeconomic characteristics, implying that the news media does not stand apart from the general spatial organization of countries. In this sense, it raises the question of whether and to what extent the general path-dependent development of regions shapes the news and may contribute to it. Consequently, regarding the specific set of news in the focus of the present paper, looking at news at the subnational level appears to be a fruitful avenue for gaining a better understanding of technologies' spatial diffusion, in general, and for the development of regional innovation systems, in particular.

Keeping the limitations of the study in mind, our study suggests some implications. For instance, our observation of innovation news being relatively more frequent and positive in urban areas might contribute to the easier adoption and diffusion of new technologies in such places, in the long run. Consequently, this difference might be one factor fueling the increasing concentration of innovation activities in urban areas (Balland et al., 2020). Similarly, more negative news on innovation in regions with weaker economic developments, e.g., higher unemployment, may severely reduce public expectations and sentiments in this context. It can reinforce a non-supportive or even absent innovative culture, which further lowers local aspirations to positively engage with technological

change and entrepreneurial activities (on the latter aspect, see von Bloh et al., 2020). In this case, the discussion of the local news media may occur in the context of regional innovation policies. However, this requires a better understanding of the geographical dimension of the news media and how this shapes and is shaped by other socioeconomic spatial structures.

3.6 Appendix

3.6.1 Topic modeling

To find the optimal number of topics to identify by the LDA, we relied on the metrics developed by Griffiths and Steyvers (2004); Cao et al. (2009); Deveaud et al. (2014) and Arun et al. (2010).[13] In our case, they suggest to consider between 50 and 70 topics. Qualitative assessments of the results suggest 60 topics to deliver the most coherent and meaningful groupings. On this basis, the LDA parameters were estimated using Gibbs sampling (Grün and Hornik, 2011). The outcome of the topic modeling is that each document is assigned to a topic, and each topic is described by terms with varying probabilities. We relied on qualitative (manual) assessment to identify those topics most likely to relate to innovation and new technologies. Table 3.6 shows a section of the obtained term-topic matrix. The topics in bold are examples of the ones we considered to be of relevant in the context of the paper. In total, of the 60 topics, we classified 50 as being related to innovation and new technologies.

Table 3.6: The most common 5 terms within each topic

1	**fahrzeug**	**technologi**	**eautos**	**elektromobilitat**	**zukunft**
2	klimawandel	weltweit	thunberg	global	klimaschutz
3	unternehm	impfstoff	biontech	curevac	corona
4	**digital**	**automatisier**	**technologi**	**zukunft**	**wirtschaft**
5	spiel	sport	fussball	team	saison
...	...	...	...	...	...
56	**autonom**	**fahr**	**bus**	**fahrend**	**automatisiert**
57	cdu	spd	bundesregier	grun	polit
58	**startup**	**unternehm**	**innovation**	**wirtschaft**	**investor**
59	**robot**	**international**	**iss**	**humanoid**	**raumstation**
60	**innovation**	**kunstlich**	**intelligenz**	**technologiezentrum**	**eroffnet**

[13] Implemented in the *ldatuning* R-package.

3.6.2 Correlation table

Correlation of the variables used in the regressions appears in Table 3.7.

Table 3.7: Correlation matrix

	POPDEN	GDPC	UNEMP	EAST	NNP	NNEWS	INNOV	SHARE	NWORD	NATIONAL	SENT
GDPC	0.35***										
UNEMP	0.37***	-0.38***									
EAST	0.07*	-0.46***	0.46***								
NNP	0.58***	0.51***	0.17***	-0.28***							
NNEWS	-0.02	0.00	-0.05*	-0.03	-0.07**						
INNOV	-0.03	-0.03	-0.03	0.02	-0.09***	0.29***					
SHARE	-0.03	-0.03	0.00	0.00	-0.04	-0.06*	0.81***				
NWORD	-0.01	0.00	-0.01	-0.06**	0.04	-0.17***	0.10***	0.50***			
NATIONAL	-0.10***	-0.11***	-0.01	0.08**	-0.20***	0.18***	0.34***	0.23***	-0.21***		
SENT	-0.02	0.03	-0.08**	0.00	-0.04	-0.10***	-0.32***	-0.28***	-0.10***	-0.19***	
NPSENT	-0.03	0.04	-0.10***	-0.08**	0.02	-0.01	0.01	0.05	0.16***	-0.40***	0.47***

*p<0.05; **p<0.01; ***p<0.001

3.6.3 Lagrange multiplier diagnostics for spatial dependence

Table 3.8 shows the LM test results for each regression analysis. Of all models, the spatial error model seems to be the most appropriate.

Table 3.8: LM test results

		RLMerr		RLMlag	
	$RS_{n,r}$	test-statistic	p-value	test-statistic	p-value
log(INNOV)					
	> 0	87.737	0.000	0.054	0.815
	> 0.001	71.176	0.000	0.759	0.383
	> 0.005	70.866	0.000	0.083	0.773
	> 0.01	58.926	0.000	0.584	0.445
log(SENT)					
	> 0	22.118	0.000	0.153	0.695
	> 0.001	23.627	0.000	0.063	0.802
	> 0.005	27.465	0.000	1.293	0.256
	> 0.01	3.073	0.008	3.506	0.061
AI log(SENT)					
	> 0	12.771	0.001	0.802	0.371
	> 0.001	6.213	0.013	0.488	0.485
	> 0.005	8.789	0.003	0.032	0.858
	> 0.01	12.723	0.000	0.428	0.513
Automation log(SENT)					
	> 0	14.711	0.000	0.024	0.869
	> 0.001	5.885	0.015	0.006	0.938
	> 0.005	4.114	0.042	0.078	0.779
	> 0.01	14.771	0.000	4.850	0.076

Chapter 4

Saved by the news? COVID-19 in German news and its relationship with regional mobility behavior

Abstract: There are substantial differences across regions regarding COVID-19 infections and deaths, which are partly explained by differences in practicing social distancing. In this paper we argue that the portrayal of COVID-19 in regional media might be an important factor in explaining regional differences in social distancing. By using mobility as a proxy, and analysing data on regional news coverage in Germany, we investigate empirically whether the geographical heterogeneity in COVID-19-related news reporting has translated into spatial variations in social distancing. Our results confirm that the frequency of and the element of fear in COVID-19 news have a significant, albeit time-varying, relationship with social distancing.

This chapter has been published as:
Ozgun, B., & Broekel, T. (2022). Saved by the news? COVID-19 in German news and its relationship with regional mobility behaviour. *Regional Studies*.

4.1 Introduction

The coronavirus, COVID-19, has quickly become a global pandemic with seemingly inescapable consequences on daily life. Since its first appearance, COVID-19 has infected more than 600 million people. There is no doubt that both the disease and the measures taken against it changed the established patterns of people's daily lives suddenly and drastically. However, the response to the pandemic has not been the same everywhere. In some places, people changed their lives substantially, while in others, they reacted rather modestly, and the determinants of such spatial variations are not fully clear. The present paper argues and empirically tests whether the presentation of COVID-19 in news media contributes to this spatial heterogeneity.

COVID-19 brought uncertainty to people's lives, which induced a strong demand for information regarding the virus and everything related to it. In most cases, people turn to the news media to update their knowledge of the disease and inform their behavioural responses. In many instances, the first information source from which people learned about the existence of the disease has been the news media. However, news media outlets are rarely identical in terms of selection and reporting of issues, and this is not any different for COVID-19-related news. Crucially, news reporting and consumption have a strong geographical dimension at the subnational level (Althaus et al., 2009; Bogart, 1989; Ozgun and Broekel, 2021).

In this paper we first explore the subnational heterogeneity in COVID-19-related news coverage. Second, we assess if subnational variations in the frequency and tone of news coverage of the pandemic translate into spatial variations in peoples' pandemic-related behaviour. As several studies confirm the important role of news information on health behaviour (Simonov et al., 2020; Bursztyn et al., 2020; Ash et al., 2020), our study focuses on the mobility of individuals as an observable expression of social distancing behaviour. Using spatial panel regression models at the level of German districts and weekly observations, we identify a significant albeit time-varying relationship between COVID-19 news reporting and regional mobility patterns. In regions where COVID-19 was covered more frequently and presented in more fearful ways during the pandemic's early stage, we observe larger drops in weekly mobility. This negative relationship, however, becomes a positive one during 'the good times', that is, at low points of infection numbers in summer and when the

first vaccines became available. Given that mobility is a critical determinant of COVID-19 infections and deaths (Glaeser et al., 2020; Nouvellet et al., 2021; Alessandretti, 2021), our study suggests that regional news media has played a role in the spreading of COVID-19, especially at the beginning of the pandemic. People in locations where the news media covered the virus with a lower frequency and communicated its risks in less dramatic ways were less likely to adapt their mobility behaviour.

The remainder of the paper is organized as follows. Section 4.2 reviews the related literature and develops the research hypotheses. The used data sources are described in Section 4.3. Section 4.4 introduces the employed empirical approach and the results are presented and discussed in Section 4.5. Section 4.6 concludes the paper.

4.2 The link between news media and health behavior

Although the COVID-19 pandemic was a global threat, there have been substantial differences across regions in the extent to which they were affected by the pandemic (White and Hébert-Dufresne, 2020; Bosa et al., 2021; Hoekman et al., 2020; Roelofs et al., 2022). Many studies show that preventive practices, such as social distancing, have been one of the main determinants of regional differences in the number of infections and deaths (Badr et al., 2020; Glaeser et al., 2020; Carteni et al., 2020; Engle et al., 2020; Nouvellet et al., 2021; Hadjidemetriou et al., 2020). Although national and regional policies including lock-downs and stay-at-home orders had significant impacts on social distancing behaviour, that is, on reducing the mobility of individuals (Courtemanche et al., 2020; Dave et al., 2021; Gupta et al., 2021; Bialek et al., 2020), compliance with orders and voluntary social distancing, that is, individual choices, have been identified to have played a more important role (Goolsbee and Syverson, 2021; Eckert and Mikosch, 2020). That raises the question of what factors explain these differences. The literature on spatial differences in social distancing and accordingly infection rates, identifies a number of regional factors to have been decisive including population density (Allcott et al., 2020; Ehlert, 2021; Desmet and Wacziarg, 2021; Engle et al., 2020; Bialek et al., 2020), income level (Chiou and Tucker, 2020; Maiti et al., 2021; Desmet and Wacziarg, 2021), age composition (Bialek et al., 2020; Engle et al., 2020; Desmet and Wacziarg, 2021; Ehlert, 2021), political leanings (Engle et al., 2020; Desmet and Wacziarg, 2021; Painter and Qiu, 2021; Barrios and Hochberg, 2020), and

share of foreigners and ethnicity (Egorov et al., 2021; Benitez et al., 2020; Maiti et al., 2021).

The media coverage of COVID-19 is argued to be another important factor affecting individuals' social distancing decisions. Individuals' dependence on media clearly intensifies during times of crises or uncertainty (Ball-Rokeach and DeFleur, 1976; Ball-Rokeach, 1985) since perceived risks garner attention (Burns and Slovic, 2013). It is confirmed that crisis situations such as natural disasters, terrorist attacks and political turmoil are associated with increased news consumption (Lowrey, 2004; Althaus, 2002; Westlund and Ghersetti, 2015). The COVID-19 outbreak is undoubtedly a significant crisis that suddenly challenged established patterns of daily life. In particular, at its beginning, billions of people had no idea about the potential magnitude of the upcoming crisis, how it would impact them individually and, most importantly, how they could adapt their behaviour to protect themselves. In line with what has been observed for other crises, the COVID-19 pandemic also led to an increase in information-seeking and news consumption all around the world (Bento et al., 2020; Lemenager et al., 2021; van Aelst et al., 2021; Hölig et al., 2020).

The well-established influence of news media on people's perceptions and the importance they attach to issues (McCombs and Shaw, 1972; Hester and Gibson, 2003) emerges from the frequency of coverage, the tone and the framing (Entman, 1993; Doms and Morin, 2004; Booth, 1970; Bursztyn and Cantoni, 2016; Hollanders and Vliegenthart, 2011). Crucially, this influence also alters risk perceptions (Pidgeon et al., 2003). For instance, the frequency of media coverage tends to increase the sense of hazard and leads to changes in associated behaviours (Mazur, 1984; Gaskell et al., 1999; Mazur, 2006; Bauer, 2005; Holman et al., 2014). Given the magnitude, severity of health risks and uncertainty regarding COVID-19, it can be expected that the presentation of COVID-19 in news media has a substantial impact on how people adapt their health behaviour related to this new and highly dynamic threat. Several recent studies provide empirical support for this assumption. For example, by focusing on the time dimension, Ophir et al. (2021) identify that the framing of COVID-19 news has been associated with changes in peoples' mobility.

Of course, the news media is not one uniform entity but rather is comprised of a large set of various outlets. Even in the case of a global pandemic, news

outlets select different events to report about, emphasize varying aspects, or express different stances and attitudes towards issues. These differences across news sources (primarily based on the political leaning of the news outlets) explain their audiences' health-related behaviours, including their compliance with stay-at-home orders and their purchasing of goods necessary for protection (Jamieson and Albarracin, 2020; Andersen, 2020; Simonov et al., 2020; Ash et al., 2020). Bursztyn et al. (2020) even find that consuming particular shows within the same network, that communicate COVID-19-related risks in distinct ways, translates into variations in their audiences' COVID-19 infection rates. However, the extent to which differences in COVID-19-related reporting explain the spatial pattern of behavioural reactions to the pandemic and, ultimately to its spatial diffusion, is still unknown. This knowledge gap motivates the present paper.

A substantial portion of heterogeneity within news media is geographical in nature. That is, the available news sources, broadcasting channels and consumption patterns differ systematically between places (Hutchins, 2004; Carpini et al., 1994; Dou et al., 2006; Young and Dugas, 2012). As a consequence, even individuals with similar individual traits and news preferences can be exposed to distinct sets of news information as well as the presentation thereof, only because they reside in different locations (Althaus et al., 2009; Bogart, 1989; Ozgun and Broekel, 2021). This applies to health-related news as well (Powell et al., 2016). Despite large geographical variations in COVID-19 exposure and responses as well as the easily observable heterogeneity in pandemic reporting across news outlets, little is known about the extent of subnational variations in the news presentation of COVID–19.[1] These arguments and research gap lead to our first hypothesis.

Hypothesis 1: There exists substantial regional heterogeneity in news media reporting on COVID–19.

The existence of systematic subnational heterogeneity in COVID-19 reporting becomes relevant when it results in systematic variations in peoples' behavioural responses to the pandemic. In light of the findings of previous studies, our second hypothesis is related to behavioural responses. We focus on social

[1] Although at a larger geographical scale, Liu et al. (2021) take an initial step towards this direction. By investigating the first month of the pandemic, authors find that media coverage is associated with a reduction in the number of COVID–19 cases.

distancing as a health-related behaviour because it is adaptable and can be empirically captured with the help of a proxy.

Hypothesis 2: Regional heterogeneity in news media reporting on COVID–19 translates into regional variations in social distancing.

We expect people to adapt their social distancing behaviour in ways that reduce the risks associated with COVID-19 more strongly in regions where the news media reports COVID-19 more frequently and in a more alarming fashion than in regions where this is less the case. However, the effects of news media on health-related behaviour, for example, social distancing, might not be as straightforward as the hypothesis suggests. Increased media coverage of a risk does not always lead to behavioural changes. While the news media is frequently a trigger of abstract worries and risks, studies show that these do not necessarily translate into actions (Hawkes et al., 2009). For instance, when media over-dramatize issues, trust in the media declines, which lays the ground for counterproductive behaviours such as a higher reluctance to be vaccinated (Elledge et al., 2008; Taha et al., 2013). In addition to too little or too much coverage, contradictory and confusing news distorts the public's perceptions of health risks (Taha et al., 2014). While it can be expected that such over- and undershooting, as well as contradictory information, mediate the impact of the news media on behaviour, they also imply that news media's influence is time-variant and fact-specific. The news media effect is greater when topics are new and people cannot rely on their own experiences (Zucker, 1978). This occurred during the beginning of the pandemic when individuals' knowledge about and experiences with the coronavirus were very limited. As, unfortunately, first-hand experiences gradually increased, the reliance on news as a crucial information source is likely to have decreased. Consequently, it can be expected that the relationship between news reporting and behavioural responses weakened over the course of the COVID-19 pandemic. Our third hypothesis reflects this progression:

Hypothesis 3: The influence of news media on social distancing diminishes over time.

The three hypotheses are tested by using information on German regions' exposure to COVID-19, COVID-19-related news reporting in (regional) newspapers, and by using mobility as a proxy of social distancing behaviour.

4.3 Data and variables

4.3.1 Units and time of observation

The empirical analysis focuses on Germany, as we have access to high-quality information on individuals' mobility and regional news coverage. The period under consideration ranges from the beginning of March 2020 to the end of February 2022, which captures the early phase of the COVID pandemic in Germany (albeit not the very first infections in January 2020) and the subsequent development.

Ideally, analyses on COVID-19-related behaviour and news media exposure would take place at the level of individuals. However, since this information is not available, we opt for a second-best approach and conduct the analysis at the regional level. The unit of observations is the 401 German NUTS-3 regions (districts), the smallest available spatial entity for which comprehensive data on mobility and news are available. Another aggregation is done in the time dimension. While the mobility and news information is available for individual days, we aggregate it to weekly averages since there is an unknown time lag between news exposure and mobility response, and there is significant heterogeneity in the COVID-19 testing and, accordingly, infection data, and in mobility patterns between the weekends and weekdays (Edsberg Møllgaard et al., 2021; Christidis et al., 2021). Weeks are defined as calendar weeks: 1–5 January 2020 is the first week, 6–12 January 2020 is the second, and so on.

Figure 4.1 shows the weekly number of new infections divided by the population. Each point corresponds to a district for the given week and dates indicate the first day of the given week. According to the Robert Koch Institute[2], the first wave started around the 10^{th} calendar week of 2020, i.e., at the beginning of March 2020, and ended around mid-May 2020. Following the first wave, there was a so-called interim period, during the summer, with few and mild cases (Schilling et al., 2021). The second wave was from the beginning of October 2020 until mid-February 2021, which was immediately followed by a third wave that ended in June 2021. After a summer plateau in mid-August

[2]The Robert Koch Institute (RKI) is Germany's central scientific institution in the field of biomedicine and one of the most important bodies for the safeguarding of public health.

2021, the fourth wave, also known as the Delta wave, started. Immediately after the fourth wave, at the end of 2021, the fifth wave, the Omicron wave, started.[3]

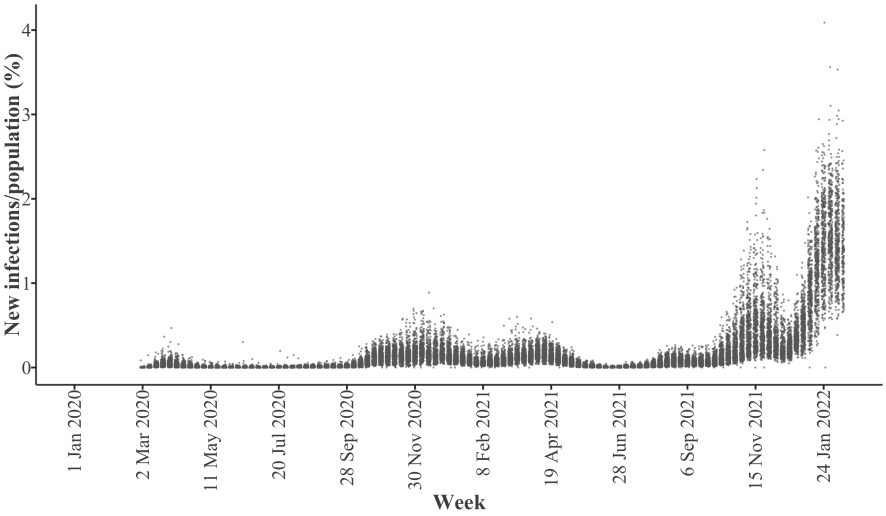


Figure 4.1: Share of population newly infected with COVID–19 in Germany, data taken from the Corona Data Platform

4.3.2 Mobility as an indicator of social distancing

As highlighted above, we focus on social distancing as a health-related behaviour, because it is highly likely to be affected by news reporting about COVID-19 and is empirically observable. Several studies find and confirm that mobility, as a proxy for social distancing, is strongly related to infections and deaths (Glaeser et al., 2020; Carteni et al., 2020; Nouvellet et al., 2021). We follow the established practice and utilize the mobility indicator provided by the German Federal Statistical Office (Statistisches Bundesamt).[4] It is based on mobile network data, which are widely used to detect mobility patterns of individuals (Bwambale et al., 2019; Oliver et al., 2020; Pullano et al., 2020).

[3]Information on pandemic waves is taken from the epidemiological bulletin of RKI: `https://www.rki.de/DE/Content/Infekt/EpidBull/Archiv/2022/Ausgaben/10_22.pdf?__blob=publicationFile`.

[4]For further details about data collection, see: `https://www.destatis.de/DE/Service/EXDAT/Datensaetze/mobilitaetsindikatoren-mobilfunkdaten.html`.

The indicator denotes the change in the total number of mobile devices within a region carrying out a movement, that is, switching from one radio cell to another, within a day, by comparing it with the same working day in 2019.[5] Crucially, the statistical office adjusts the indicator for public holidays.[6]

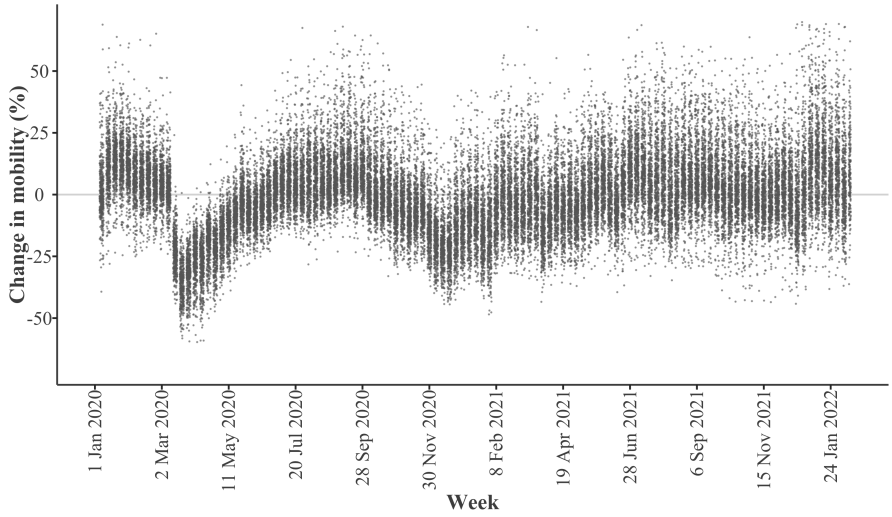


Figure 4.2: Weekly mobility change compared to 2019

Figure 4.2 shows the average weekly mobility change in German districts from the beginning of January 2020 to the end of February 2022. The first waves of the pandemic are clearly visible in Figure 4.2, with significant drops in mobility. However, Figure 4.2 also shows that although individuals' mobility behavior always responded to the changes in the COVID–19 situation, the magnitude of response has diminished over time. While the number of confirmed cases is a lot higher in the last wave, the average change in mobility response is around zero.

[5]Note that mobile phone data also have several shortcomings related to population sampling and market share of operators providing the data. However, since we do not have access to metadata due to privacy concerns, we are not able to assess and report potential issues here. The mobility indicator also does not differentiate between the distances traveled. Although not all movements indicate the same level of contact rate, mobility data is still the best proxy we have for social distancing.

[6]Public holidays refer to both national holidays and state-level religious holidays.

4.3.3 Regional COVID–19 News

To explore to what extent the portrayal of COVID-19 in regional news explains behavioural responses in the form of decreased mobility, we construct a set of variables reflecting this dimension at the regional level. While the consumption of national newspapers shows considerable geographical variations, local and regional news, as well as regional sections of national newspapers, are the main drivers of interregional heterogeneity in news exposure. They, therefore, stand in the foreground of the subsequent analysis. In Germany, regional newspapers are an essential part of news consumption (Mangold et al., 2017; Humprecht and Esser, 2018; Newman et al., 2019; Hölig et al., 2020). Studies and surveys show that local and regional newspapers and their online offerings have been very important in informing the population in Germany during the pandemic (Maurer and Gutenberg, 2021), and general trust for media about COVID–19 information was about 85% (Viehmann et al., 2020). This importance of and reliance upon regional news media makes Germany an ideal case for testing the hypotheses in this study.

We obtain information on newspapers at the regional level from the RegNeS database. RegNeS provides a daily collection of news headlines and snippets of most newspapers circulating in Germany that are presented on newspapers' websites. Crucially, it differentiates between national and subnational sections as well as versions of national newspapers implying that portions of their content can also be associated with specific localities. The cleaning and geo-locating procedure of news items are outlined in Appendix 4.7.1.

To identify news items related to COVID-19, we use a rule-based classification method and pattern matching. More precisely, after pre-processing the text data, we identify news articles that contain words related to COVID-19 in the title or snippet. The list of search terms are: *COVID–19, coronavirus, Sars-Cov-2, pandemic, quarantine, lockdown, and virus-mutation.*[7]

[7]The exact search terms in German are: COVID–19, corona, SarsCov2, pandemie, quarantäne, ausgangssperre, virusmutation. Clearly, this list does not capture all news about COVID–19. For example, news stories with the phrase *vaccination center* almost exclusively refer to facilities for COVID–19 vaccine injections, however, the text might not mention the word COVID–19. Identifying all of those cases would introduce a lot of subjectivity and potentially many false-positive results. We, therefore, stick to the rather conservative approach, requiring any of the key tokens above to appear in the text.

The first variable constructed on the news information is the share of COVID news (*COVID_NEWS*). This variable is first constructed at the newspaper level implying that for each newspaper (or its regional section), the share of COVID-related news articles is calculated. Secondly, the average of this figure across all newspapers associated with a region is computed. The idea behind this method of calculation is that people usually read just one newspaper, so they are exposed to all articles dealing with COVID-19 featured in one newspaper and their combined (average) characteristics will determine the impact on the readers' mobility behaviour. Lacking precise readership information on all newspapers, we are limited to assigning equal weights to all of them when aggregating this variable at the regional level. Consequently, the variable represents the average share of COVID-related news in newspapers read in a specific region.

Figure 4.3 shows *COVID_NEWS*, for each week and for all districts. The first COVID–19-related news in the RegNeS database appears on January 9, 2020, the day on which the World Health Organization published an online statement on a cluster of pneumonia cases in Wuhan, China.[8] Following this initial appearance, the virus was featured only in a few news articles. With the first announced case in Germany on 27 January 2020, attention for the topic increased and COVID–19-related news articles went up to 10% of all news before the share decreased again. In March 2020, news coverage of COVID–19 surged, which coincided with the first COVID–19-related deaths being reported in Germany, and with the World Health Organization declaring COVID–19 a pandemic on March 11.[9] At the end of March 2020, almost 60% of all news articles published in Germany were mentioning COVID–19 in one way or another. Although the temporal development of media attention generally matches the ups and downs of COVID–19 case numbers in the country, news coverage has never reached these levels in the subsequent waves. This shows that the newsworthiness of COVID–19 was mostly determined by the *unexpectedness*, and to some extent by the *magnitude* of the threat. Note that the observed patterns in our dataset are in line with Maurer and Gutenberg (2021), who show that

[8] See: https://www.who.int/china/news/detail/09-01-2020-who-statement-regarding-cluster-of-pneumoniacases-in-wuhan-china.

[9] See: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020.

the peak of media coverage was in the first wave, although the infection rate was much more dramatic in the later waves.

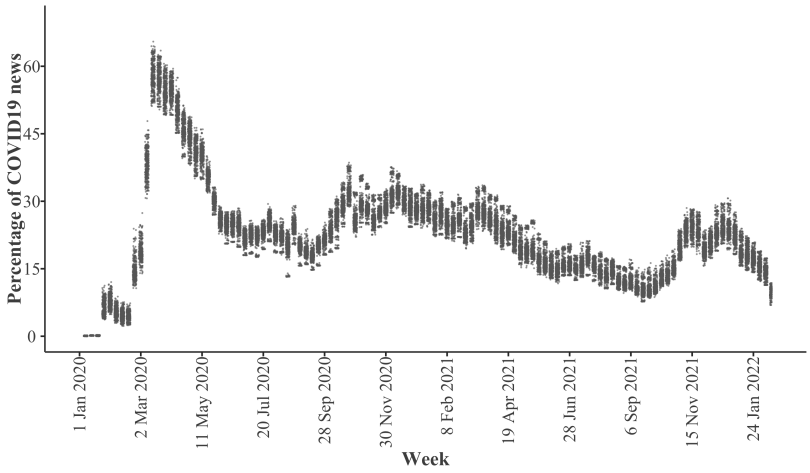


Figure 4.3: Weekly percentage of COVID–19 news

In addition to the intensity of reporting, we are interested in the ways COVID-19 is presented. Ideally, one can assign a sentiment polarity index to each piece of news, based on a sentiment lexicon. However, available sentiment dictionaries do not fit the specific needs of analysis for COVID-19 news since the list of sentiment-bearing words and their weights are misleading in this context.[10] We therefore rely on an emotions lexicon, i.e., NRC[11], which associates words with basic emotions such as *anger, fear, anticipation, trust, surprise, sadness, joy,* and *disgust* (Mohammad and Turney, 2013) and has been used to identify sentiments in text documents (Mohammad et al., 2013; Bose et al., 2019). Since the health risks conveyed by news articles have the most potential to influence

[10]German sentiment dictionaries developed for general purpose or political texts fail to assign coherent sentiment scores to COVID–19-related texts. For example, the word *positive* has a positive association in all sentiment dictionaries (see e.g., Rauh, 2018; Remus et al., 2010), while in the context of COVID–19, the word is usually used for *testing positive* which is definitely not a positive development, on the contrary, a negative one. Since this and many other sentiment-bearing words predominantly imply the opposite sentiment in the COVID–19 context, conducting a sentiment analysis based on lexicons that are not specifically designed for COVID–19 generates not only useless but also misleading results.

[11]National Research Council Canada.

peoples' related behaviour, of these basic emotions, we use *fear*, to assess the degree to which newspapers covered COVID–19 in a dramatic way.[12]

To represent the degree of *fear* expressed in an article about COVID–19, we use the share of its words with a fear association in it, that is, it is the total number of fear-associated words divided by the total number of words. Figure 4.4 shows the average share of fear words in the COVID–19 news. Aside from the sharp increase before the beginning of the pandemic, and an increase at the peak of the fourth wave, we see only a modest decreasing trend over the observed time period. This implies that on average, news articles reporting about COVID-19 used more or less the same wording in terms of inducing fear, and the fear element in news articles decreased over the course of the pandemic. For our analysis, this rather time-invariant character of the variable is positive, as it allows assessing interregional variations in this dimension with less concern about overall time trends. On this basis, we construct the region-level variable, the share of fear words in COVID-19 news (*COVID_FEAR*) in the same way as the *COVID_NEWS*, that is, by first calculating the average at the newspaper level, before averaging it across all newspapers appearing in a region.

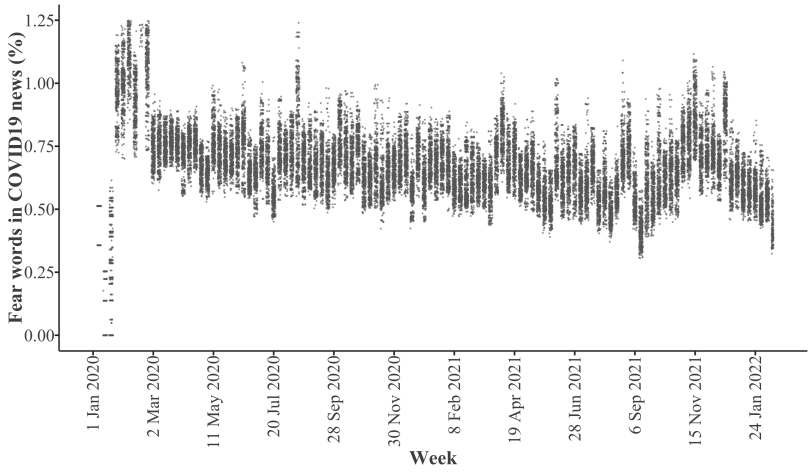


Figure 4.4: Weekly percentage of fear words in COVID–19 news

[12]In the lexicon, there are 1454 fear-associated German words. Some examples that frequently show up in COVID–19-related news articles are (translated in English): *alarming, fatal, collapse, contagious, dead, harm, infectious, quarantine, risky, threatening, unsafe, worrying.*

Crucially, newspapers are known to have certain writing styles. Consequently, articles published by one newspaper (in different regions), are likely to be more similar in this dimension than articles published by different newspapers. To account for this, we construct a variable that represents the average fear element in all non-COVID-related news items published by a newspaper and average this across all newspapers in a region (*NONCOVID_FEAR*).

4.3.4 Non-news related control variables

The two news-based variables are our main explanatory variables whose influence on mobility we seek to identify. This requires a set of controls (in addition to the *NONCOVID_FEAR*), to isolate news variables' effects from potentially confounding factors. The most important control variable in this respect is the number of COVID–19 cases, which we obtain from the Corona Data Platform database.[13] The variable *NEW_INFECT* denotes the sum of newly reported COVID–19 cases per week in a district divided by the district's population.

Another potential influence on mobility behaviour is weather conditions. Studies show that mobility is closely related to temperature and precipitation (Cools et al., 2010; Keay and Simmonds, 2005; Spinney and Millward, 2011). We consider two weather variables to account for this: the average temperature (*TEMP*) and precipitation height (*PREC*) for each calendar week and district. The data collection process is outlined in Appendix 4.7.2.

School holidays are another factor impacting the mobility of individuals. In Germany, school holidays are set by each federal state administration. Both the timing and the number of vacation days vary across states. To control for this, we include a school holiday binary variable(*H_DAY*) indicating if at least two days in a week were school holidays or not. Given that our dependent variable, *MOBIL*, already accounts for public holidays, each of which lasts for one or two days only, this variable is intended to capture regional differences in mobility and news reporting during school holidays.

[13]Corona Datenplattform is commissioned by the German Federal Ministry for Economic Affairs and Energy and collects daily COVID–19 statistics at the district level. See: `https://www.corona-datenplattform.de`.

4.4 Empirical approach

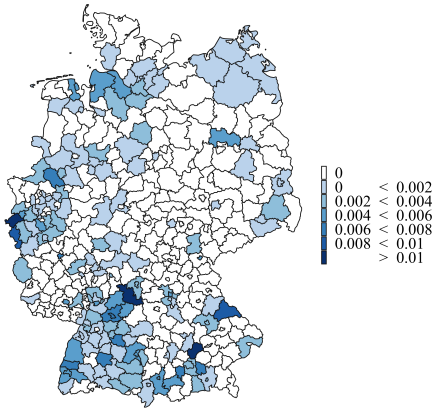
In total, our data include observations for 103 calendar weeks (from March 1, 2020 to February 28, 2022) and for 400 German NUTS–3 regions.[14] Summary statistics for the variables are given in Table 4.1.

Table 4.1: Summary statistics

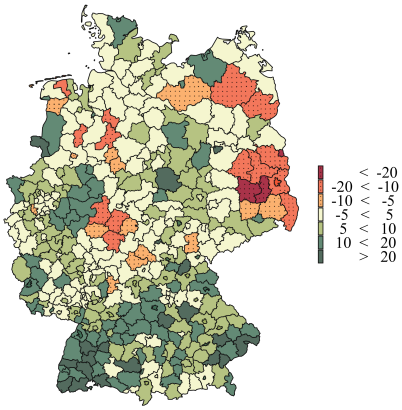
	Obs.	**Min**	**Max**	**Median**	**Mean**	**Std.dev**
MOBIL	41,200	−59.701	90.511	−1.570	−1.220	16.229
NEW_INFECT	41,200	0	4.089	0.054	0.169	0.347
COVID_NEWS	41,200	6.937	65.487	22.973	24.175	10.085
COVID_FEAR	41,200	0.306	1.283	0.663	0.665	0.112
NONCOVID_FEAR	41,200	0.583	1.401	0.926	0.931	0.097
TEMP	41,200	−13.286	25.814	9.521	9.929	6.584
PREC	41,200	0	28.250	1.314	2.042	2.278

The spatial variation in the core variables is illustrated by Figure 4.5 for the first week of the pandemic in Germany (10^{th} calendar week of 2020). At this time, 241 regions did not have any confirmed COVID–19 cases. The clustering of cases in the southern and western regions is clearly visible. Interestingly, changes in mobility during the same week do not show the same pattern (Figure 4.5b); regions in which mobility dropped the most are those with few or no cases at all. The share of COVID–19 news does not seem to correlate with the number of cases either (Figure 4.5c); regions with larger shares are not the ones with higher infection rates. In contrast, the share of fear-bearing words seems to correlate with the number of new cases. However, these are just cross-sectional correlations at one moment in time, which do not qualify for statistical inference. Nevertheless, these highlight that the behavioural response may not be a one-to-one reaction to regional COVID-19 cases, which prompts the question of whether variations in news reporting about the pandemic act as a mediator.

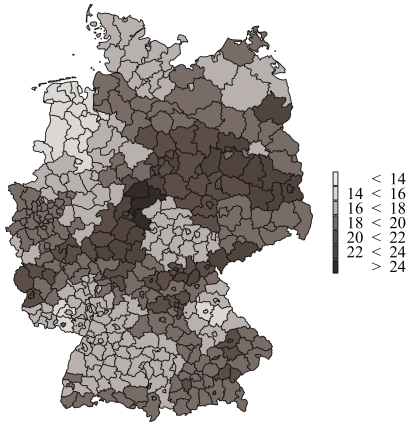
[14] We exclude the observations before the 10^{th} calendar week as we do not have infection numbers at the district level before that. Also, infection data is not available for the DEG0N region from August 2021 onward, so this region is removed from the analysis.



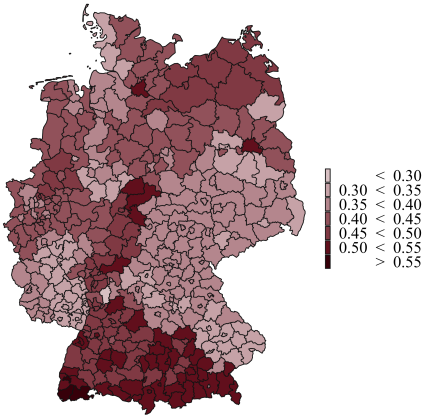
(a) *NEW_INFECT*



(b) *MOBIL*



(c) *COVID_NEWS*



(d) *COVID_FEAR*

Figure 4.5: Spatial distribution of selected variables on the 10^{th} calendar week of 2020

Figure 4.5c and Figure 4.5d supports Hypothesis 1, as we see substantial differences in the frequency and ways of presenting COVID–19 in regional news at this moment in time. Clearly, some regions experience larger than average exposure to COVID–19 news, while others are below average. In addition, *COVID_NEWS* and *COVID_FEAR* are clustered in space indicating

that substantial parts of this variation emerge from differences in reporting between newspapers as their distribution areas frequently cross district boundaries.

As shown in Section 4.3.1, the pandemic came in waves, which are also reflected in news reporting. Recent studies show that the determinants of the spread of COVID-19 varied in different phases of the pandemic (Roelofs et al., 2022). This implies that, with each new wave and growing scientific and experience-based insights, peoples' perceptions and behavioural reactions to the pandemic might have also changed. In other words, the relationship between news reporting on COVID-19 and changes in mobility are unlikely to be time-invariant. We take this into account by splitting our data set (103 weeks $\times$ 400 regions) into subsamples of three months each. Subsequently, we run individual analyses for each three-month subsample that is overlapping with the previous one by two months. In each of the 22 regressions, change in mobility (*MOBIL*) constitutes the dependent variable. We exploit the panel structure of the data to control for time-invariant unobserved factors by including region-specific fixed effects. Potential week-specific global events are accounted for by time (week) fixed effects.[15]

Our spatial units of observations are rather small, implying that our observations are likely characterized by spatial dependencies.[16] We, therefore, use spatial panel regression including the spatial lag of the dependent variable and a spatial error component (See e.g., Anselin et al., 2008). The spatial weight matrix is constructed on a binary basis, that is, based on whether districts share a border or not.[17] Accordingly, our framework is a spatial panel regression model with two-way fixed effects.[18]

4.5 Results and discussion

Our first hypothesis (Hypothesis 1) concerning the existence of significant regional heterogeneity in COVID-19-related news reporting is tested with a simple two-way fixed effects (region and week) panel regression. The dependent variable is the share of COVID-related news that is related to the number of

[15] Accordingly, what we aim to capture is the global associations between news exposure and social distancing by taking local variations into account.

[16] For the Lagrange multiplier test results, see Appendix 4.7.3.

[17] Note that the spatial weight matrix is row standardized.

[18] Estimations are done with *splm* library of *R* (Millo and Piras, 2012).

confirmed new COVID-19 cases, which is theoretically its primary determinant. Nevertheless, we find the regional-fixed effects to be statistically significant. A similar outcome is observed when doing the same estimations with the share of fear words in COVID news as the dependent variable, which is related to the number of cases and to the share of COVID-related news.[19] Consequently, there is additional systematic variance in both variables besides the reported COVID-19 cases at the regional level, which confirms our hypothesis.

Before we present the detailed results for the other two hypotheses, Figure 4.6 gives a first impression of the bivariate relationship between *COVID_NEWS* and *MOBIL* pooled over all periods. As both variables do not follow the same time trend (see Figures 4.1 and 4.2), the figure illustrates the existence of a negative relationship between the intensity of news reporting about COVID-19 and mobility, which motivates the following analysis.

Figure 4.7 illustrates the results of 22 spatial panel regressions with each regression representing a specific three-month period: the first one includes all weeks in March, April, May 2020; the second includes all weeks in April, May, June 2020, and so forth. The figure features the coefficients of explanatory variables and their 99% coefficient intervals.[20]

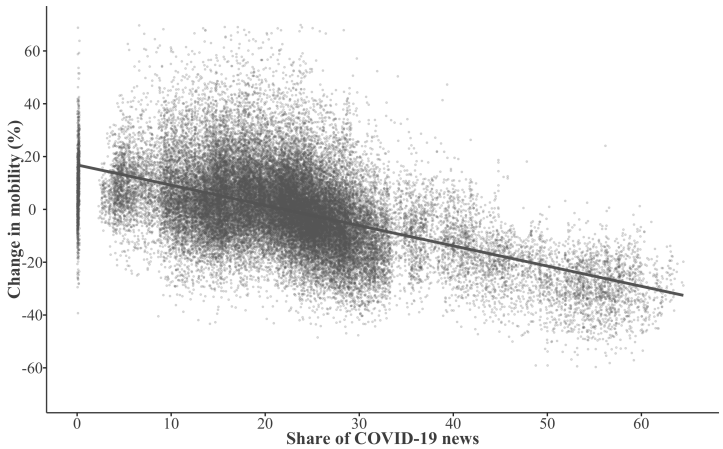
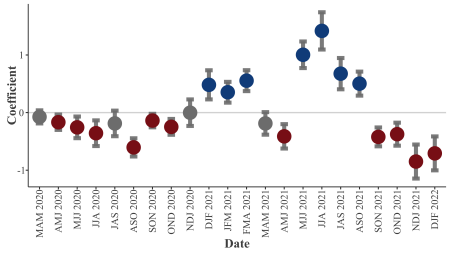


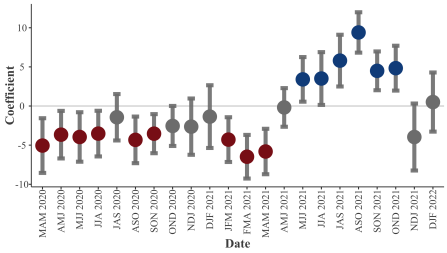
Figure 4.6: COVID–19 news frequency and change in mobility

[19]F-statistic for *COVID_NEWS* and *COVID_FEAR* are 1.2163***, and 7.2163***, respectively.

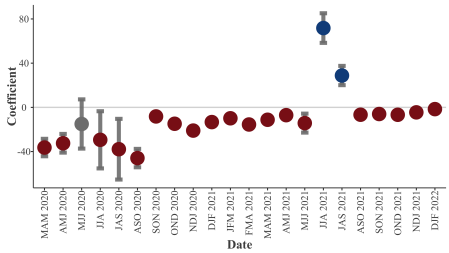
[20]Results are also provided in a table in the Appendix 4.7.4.



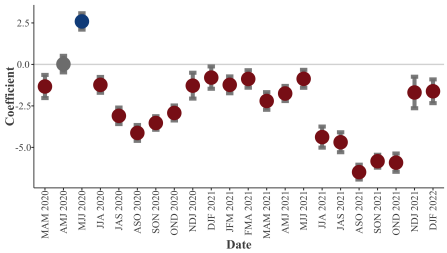
(a) *COVID_NEWS*



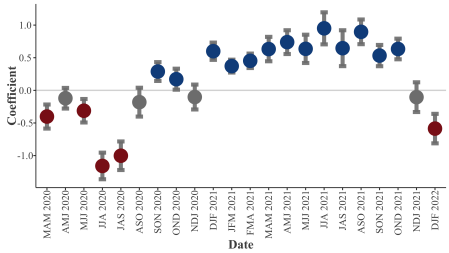
(b) *COVID_FEAR*



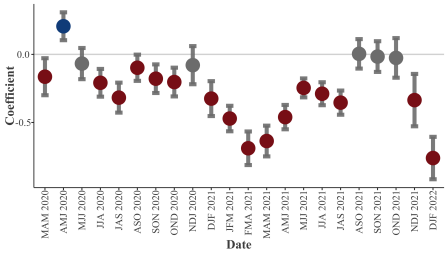
(c) *NEW_INFECT*



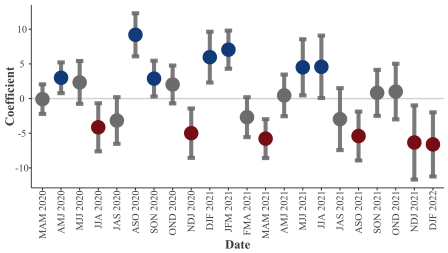
(d) *H_DAY*



(e) *TEMP*



(f) *PREC*



(g) *NONCOVID_FEAR*

Figure 4.7: Spatial panel regression results

The coefficient of *COVID_NEWS* is negative and mostly statistically significant for all periods from the beginning of the pandemic until November, December 2020 and January 2021 (Figure 4.7a). Hence, in the first 10 months of the pandemic, regions where newspapers covered COVID-19 more frequently experienced larger decreases in mobility. This provides clear empirical support for our second hypothesis (Hypothesis 2): a more intensive presentation of COVID-19 in the (regional) news makes people become less mobile to avoid exposure to potential COVID-19 sources. The figure also adds support for news media's effect not being constant over time, that is, Hypothesis 3. At the beginning of December 2020, the direction of the relationship reverses: the frequency of news coverage becomes positively related to mobility implying that more news about the virus translates into higher mobility levels. We suspect that this reversal is driven by the reporting about the arrival of effective COVID-19 vaccines. In November and December 2020, the share of vaccination news drastically increased and changed the content of the COVID-19-related news in a positive way (See Figure 4.8 in Appendix 4.7.5). The anticipation of vaccines is associated with less willingness to keep up social distancing (Andersson et al., 2021), which is confirmed by our results. The new information about the availability of vaccines in December 2020 is likely to have convinced people of the pandemic's approaching end. In anticipation of this, people in regions where COVID-19 was covered more frequently show higher levels of mobility in anticipation of this, that is, low levels of social distancing. This pattern remains intact until the third wave starts around March 2021 when the relationship's direction flips again, which coincides with a fading optimism in the vaccines putting an end to the pandemic. In addition, it was around this time when the third wave peaked, which had severe consequences for people's lives. Consequently, the coefficient of the share of COVID-19 news in the April, May, June 2021 period is significantly negative. With the ending of the third wave and the generally positive developments during the summer plateau (rapidly increasing vaccination rates and fewer infections), the relationship between COVID-19 news coverage and mobility turns statistically significant and positive again. We suspect that people had learned from previous experiences and anticipated that the pandemic was not over yet. Consequently, they heavily used this window of opportunity to compensate for their lower mobility in the prior months. Very much in support of this explanation is the effect suddenly wearing off with the beginning of the fourth wave and new virus mutations

looming on the horizon. The statistically significant and negative coefficient of the share of COVID-19 news in the most recent periods reflects this.

In sum, our findings on the share of COVID-19 news support our Hypothesis 2 and partly Hypothesis 3. In addition, they highlight that the relationship between news and mobility behaviour is complex and difficult to assess when looking at one dimension of news such as the frequency of reporting about a topic alone. Therefore, the second perspective, the emotionality of reporting (here with a focus on the fear emotion) complements the previous analysis. Figure 4.7b shows the coefficients obtained for *COVID_FEAR*.[21]

The negative and mostly statistically significant coefficient of *COVID_ FEAR* during the first three waves of the pandemic support the above reasoning: higher levels of the fear element in COVID-19 news articles negatively related to mobility from the beginning of the pandemic until the end of the third wave. That is people in regions where the news media communicated the risks regarding COVID-19 in a more fearful way, decreased their mobility to a larger degree. The findings also support the argument that the positive relationship between the frequency of news and mobility during the second wave was related to the content of news being relatively more positive, which is likely due to reporting about effective vaccines.

Starting with the plateauing of infection numbers in the summer of 2021 and during the fourth wave, we obtain some counter-intuitive results that to a degree resemble some of which are observed for the frequency of COVID-19 coverage as well: A more fearful reporting is associated with higher levels of mobility. As the fifth wave started (the Omicron variant phase) and Germany reported unprecedented high numbers of COVID-19 infections, the positive relationship between the fear element in the COVID-19 news and mobility vanished again. Most likely, this changing relationship reflects a potential temporal mismatch between the intensity of a threat (i.e., as expressed in current infection rates) and its representation in the media. During the good times of the pandemic (e.g., interim periods), higher levels of the fear emotion in the news media are understood as a signal that bad times are still ahead (e.g., the next wave). In anticipation, people reacted by increasing their mobility – they seized the

[21] We also include a control for the general tendency of newspapers to use such words in the respective region and week (*NONCOVID_FEAR*), so that the variable captures to what extent the fear element in COVID–19 news articles diverge from the newspaper's general reporting style.

opportunity while they still could. Another explanation is that misalignment of what (and how) is reported in the news media and actual infection numbers translated into people perceiving the media as over-dramatizing issues. Consequently, they reacted opposite from what is expected based on the news. The latter process has been observed by Taha et al. (2014) for the H1N1 outbreak. Our research adds suggestive evidence as far as the coefficient of the fear emotion becomes negative, although insignificant, when the fifth wave started and the infection numbers became much more threatening. In any case, our results for the share of fear words add further evidence for the impact of regional news on social distancing behaviour (Hypothesis 2) and that this impact is not time-invariant (Hypothesis 3). As for the frequency analysis, the relationship is time-invariant and complex in nature. Crucially, it is troubled by a so far unidentified and most likely time-variant time lag between the news and people's behavioural responses. In addition, an analysis at the regional level, such as ours, doesn't allow for considering the heterogeneity of individuals' experiences and what is reported on an aggregated level in the news.

Figures 4.7c–4.7g report the findings for the control variables. As expected, Figure 4.7c confirms that the percentage of the population infected with COVID-19 is negatively related to weekly mobility change except for two periods during the summer plateau of 2021 when the coefficient becomes positive. This is the period when vaccination surged and restrictions were lifted. However, a warning regarding a possible next wave was made. Increasing infection rates during this period (albeit at low levels) might have signalled to people that they should enjoy their mobility while they still can before the next wave starts. Thereby, the perception of a "window of opportunity" seems to have emerged. The coefficient of H_DAY is almost always negative (and significant), with the exception of one (summer) period in 2020. In a common manner, higher temperatures and lower rainfall are associated with higher mobility in the majority of our regressions (Figures 4.7f and 4.7e).[22] In sum, the control variables show the expected relations and thereby add confidence to the specification of the models. To further reduce the potential of our results being driven by misspecification, we present the results for two alternative specifications. In the first, we consider the effects of partial lock-downs and in the second, we apply a looser definition

[22]We refrain from interpreting the coefficients of $NONCOVID\_FEAR$, since we define COVID–19 news in a very conservative manner. Consequently, this variable may still be shaped by COVID–19 news. The variable is primarily designed to isolate the true effects of fear word usage in COVID–19 news.

of which news are about COVID-19 (see Appendix 4.7.6). The results confirm the findings of the baseline model.

In summary, our findings contribute to the literature on how the communication of health risks in the context of the COVID-19 pandemic via the news media shapes changes in social distancing behaviour at the regional level, something that has not been explored so far (Andersen, 2020; Simonov et al., 2020; Ash et al., 2020; Bursztyn et al., 2020). The study shows that regional heterogeneity in news reporting explains differences in social distancing across regions (Hypothesis 2), except for those times during the pandemic when the overall situation appeared less threatening. The latter point underlines the time-varying influence of news, which is mediated by the situation during different phases of the pandemic (Hypothesis 3).

4.6 Conclusion

Although the COVID-19 pandemic was (and at the time of writing, remains) a global threat, its effects were not only specific to countries but also differed between regions (White and Hébert-Dufresne, 2020; Bosa et al., 2021; Hoekman et al., 2020). Preventive measure practices such as social distancing have been shown to be the main determinants of differences in infection and death rates across regions (Badr et al., 2020; Glaeser et al., 2020; Carteni et al., 2020; Engle et al., 2020; Nouvellet et al., 2021; Hadjidemetriou et al., 2020), and regional differences in social distancing are shown to be related to various factors including population density, income level, age composition, political leanings, etc. (Desmet and Wacziarg, 2021; Ehlert, 2021; Engle et al., 2020; Bialek et al., 2020; Barrios and Hochberg, 2020). Yet, the precise spatial diffusion of the pandemic is not fully understood and the present paper argues that the news media's reporting about it is a missing piece in the explanation. While existing research supports this view with studies comparing the situation in one country over time or comparing the audiences of different news organizations, there were hardly any insights into the subnational dimension. That is, does the regional heterogeneity in the ways COVID-19 is presented in the media impact peoples' behavioural reactions, resulting in differences in the pandemics' spatial diffusion, was still unknown. The present paper addresses this question and explores how regional variations in COVID-19 coverage relate to peoples' social distancing decisions as expressed by their mobility behaviour.

Empirically, we investigated whether regional differences in the mobility responses to the pandemic can be explained by variations in the frequency and tone of COVID-19-related news in Germany. Changes in mobility behaviour have been approximated with mobile phone data and information on the news has been extracted from the RegNeS database. By estimating a range of spatial panel regression models, we find that regions where media covered COVID-19 more frequently and in more fearful ways experienced higher drops in mobility at the beginning of the pandemic. Crucially, we observed these relations to be time-variant with their effects being conditional on the general COVID-19 situation. That is, while the link was found to be negative at the beginning of the pandemic and during the times of high rates of infection, it was insignificant or even positive when the infection rates were low and when the first vaccines arrived. Accordingly, our results suggest that news media's effect on behaviour is largest when their content (and tone) fits the situation as perceived by individuals. This conclusion is consistent with previous studies arguing that news exposure is more likely to reinforce actual experiences than completely change or create new perceptions (Klapper, 1960; Miller and Krosnick, 1996; Newton, 2006). In any case, our results provide further evidence that the news media plays a role in the spatial diffusion of the COVID-19 pandemic by shaping compliance with social distancing behaviour (Andersen, 2020; Simonov et al., 2020; Ash et al., 2020; Bursztyn et al., 2020).

Our study has some limitations. Although the frequency and fear intensity of COVID-19 news give insights into how the news media communicates the risks related to the disease, we do not know the exact content of these news articles. Since the pandemic affects almost all parts of daily lives, news articles are likely to address a wide range of aspects related to COVID-19. For example, news can be about local cases or the national situation; they can contain announcements of event cancellations or re-openings; they may present new vaccines or new virus variants. Consequently, by using purely quantitative measures, our study just scratches the surface of what news articles contain, which gives a clear direction for future research. Another limitation concerns our focus on just one type of media, namely newspapers. There are some indications of COVID-19 having reduced print media consumption (Mihelj et al., 2021; Newman et al., 2021; Hölig et al., 2020). Individuals who used to read newspapers might have switched to online news outlets during this time. Social media may also have become a substantial substitute in this context. Future studies with

access to other data sources should therefore consider this and shed additional light on the relative importance of different news channels and outlets. Another limitation is the unknown time-lag structure between news consumption and individual response. The aggregation in this study implies a relationship between weekly news exposure and subsequent behavioural change. Although alternative specifications (not reported here) and tested time lags ranging from one day up to one week, did not provide more conclusive results than the ones presented here, the nature of the temporal relationship between news exposure and behaviour is not based on empirical grounds. Lastly, while the employed news database establishes a link between news data and the area of their most likely readership, it doesn't contain any information on the location of the events reported. This creates a discrepancy between how close the event, for example, the health threat of COVID-19, is to a news article's readership. As our results suggest, considering this appears to be crucial for identifying the effect of news at the regional level. Notwithstanding these limitations, our study contributes to the growing literature stream on exploring variations in news and its effects at the subnational level. Crucially, it highlights that this frequently overlooked (spatial) dimension of news matters and that it seems to have considerable implications for understanding socio-economic processes and (spatial) heterogeneity in developments.

4.7 Appendix

4.7.1 Geolocating the news

The link between news articles and regions is established by two types of information. For about half of the newspapers, RegNeS has obtained data on readership shares from the German Audit Bureau of Circulation (IVW). This organization collects information on the number of print and digital subscriptions for most newspapers in each district. For the other half, regionalization is done on the basis of information provided by newspapers on their targeted geographical areas. That is, almost all newspapers organize their news articles according to geographical areas for which they are believed to be of relevance. Some of these articles are assigned to multiple locations while others are exclusive to specific locations. RegNeS utilizes this information in combination with the readership shares to assign news articles to regions in the following way: If a newspaper featuring an article has a positive readership share in a NUTS3 region, the article is assigned to that region. If no readership information is available, RegNeS relies on the location extracted from the newspaper's website for which this article was featured. Since newspapers that are linked to almost all regions in Germany (truly national newspapers) and that do not have dedicated regional sections do not add to regional variation, they are excluded from the analysis. We exclude all newspapers that are associated with more than 50 % of the regions in our sample. Note that although some newspapers might be read by more people in a district compared to other available newspapers, all newspapers circulating in a district are considered equal in the analysis.[23] Accordingly, the COVID–19 news exposure in this study should be seen as the probability of being exposed to COVID–19-related information, picking a newspaper randomly, among the newspapers circulating in the region.

After the cleaning and geolocation process of the news articles, there are 9,083,623 unique news articles, from January 1, 2020 to February 28, 2022. The dataset covers 224 different newspapers of which 46 circulates in only one NUTS3 region. Each news item in the dataset is assigned a unique ID based on the title and first few sentences so that no double counting can occur at the newspaper level. However, when a news article is published by multiple newspapers in the region (for example, when provided by a press agency), we

[23] For further details regarding the geolocation of news articles and calculation of readership shares, see Ozgun and Broekel (2021).

take this information into account as this increases the likelihood of people in a region coming across that news article.

4.7.2 Data on temperature and precipitation

Data on weather-related variables are obtained from the climate data center (CDC) of Germany's national meteorological service, DWD.[24] Temperature and precipitation variables are constructed on the basis of weather station observations; the daily observations are obtained on precipitation height and mean temperature at the station level. Based on the geographical coordinates of the weather stations, regional weekly averages of all observations falling into their area are calculated. For daily precipitation, there are 5,599 weather stations. Of 401 districts, 70 have a single station, 277 have more than one, and 54 have none. For daily temperature, there are 1,106 weather stations and of 401 districts, 183 have one, 108 have multiple stations, and 110 have none. If a district has no weather station within its borders, the observations of the closest weather station are assigned to the district.

4.7.3 Spatial diagnostics

Tables 4.2 show the results of Lagrange multiplier tests (Anselin et al., 1996) for spatial dependence. Note that the within transformation is applied to the baseline model before the tests are performed. In the tables, *LML* and *LME* refer to LM test statistics for spatial lag dependence and error dependence, respectively. *RLML* and *RLME* are the locally robust test statistics for spatial lag, allowing for a spatial error; and for error, allowing for a spatial lag, respectively. As seen in the tables, although spatial dependence structure differs from one analysis period to another, the vast majority of the periods are characterized by spatial lag and error dependence. Accordingly, we use spatial panel regression including the spatial lag of the dependent variable and a spatial error component.

[24]The Deutscher Wetterdienst. Accessed on 2 March 2022 at `https://cdc.dwd.de/portal/`.

Table 4.2: Spatial diagnostics

	MAM2020	AMJ2020	MJJ2020	JJA2020	JAS2020	ASO2020	SON2020	OND2020	NDJ2020	DJF2021	JFM2021
LML	2089.94***	2034.81***	1529.47***	1747.37***	2017.58***	2667.18***	2894.05***	2919.87***	1724.60***	1510.97***	1438.13***
LME	2092.18***	2027.11***	1496.13***	1736.96***	2017.08***	2712.97***	2863.22***	2896.61***	1733.68***	1496.95***	1361.47***
RLML	0.28	7.83**	44.78***	10.65**	7.98**	1.16	37.05***	27.84***	0.04	14.48***	86.55***
RLME	2.53	0.13	11.43***	0.24	7.49**	46.94***	6.21*	4.58*	9.12**	0.46	9.89**

	FMA2021	MAM2021	AMJ2021	MJJ2021	JJA2021	JAS2021	ASO2021	SON2021	OND2021	NDJ2021	DJF2022
LML	1867.27***	1743.17***	1670.94***	2999.06***	3510.97***	3223.64***	1629.86***	911.20***	868.69***	1639.62***	1778.12***
LME	1755.3***	1737.87***	1668.69***	2949.72***	3533.96***	3242.55***	1694.80***	939.39***	876.38***	1618.91***	1740.06***
RLML	115.32***	17.33***	10.22**	49.62***	14.5***	8.87**	0.41	0.19	2.21	20.73***	40.6***
RLME	3.35	12.02***	7.97**	0.28	37.48***	27.77***	65.34***	28.38***	9.91**	0.01	2.55

Note: *p<0.05; **p<0.01; ***p<0.001

4.7.4 Regression results for the baseline model

Tables 4.3, 4.4, 4.5, and 4.6 show the results of the baseline model. Numbers in the parentheses depict 99% confidence intervals.

Table 4.3: Regression results 1

	Dependent variable: *MOBIL*				
	MAM 2020	AMJ 2020	MJJ 2020	JJA 2020	JAS 2020
COVID_NEWS	−0.074	−0.167	−0.256	−0.358	−0.188
	[−0.188; 0.039]	[−0.300; −0.034]	[−0.444; −0.068]	[−0.581; −0.135]	[−0.410; 0.034]
COVID_FEAR	−5.054	−3.661	−3.956	−3.525	−1.438
	[−8.548; −1.560]	[−6.700; −0.622]	[−7.119; −0.794]	[−6.443; −0.607]	[−4.402; 1.527]
NEW_INFECT	−36.362	−32.493	−15.043	−29.370	−37.859
	[−44.257; −28.467]	[−40.946; −24.040]	[−37.321; 7.236]	[−55.239; −3.501]	[−65.320; −10.398]
TEMP	−0.401	−0.121	−0.312	−1.159	−1.002
	[−0.586; −0.217]	[−0.279; 0.037]	[−0.492; −0.133]	[−1.362; −0.955]	[−1.221; −0.783]
PREC	−0.164	0.206	−0.068	−0.209	−0.318
	[−0.300; −0.028]	[0.104; 0.309]	[−0.182; 0.047]	[−0.310; −0.107]	[−0.428; −0.208]
H_DAY	−1.331	0.018	2.590	−1.233	−3.098
	[−2.029; −0.633]	[−0.481; 0.517]	[2.097; 3.083]	[−1.709; −0.756]	[−3.596; −2.600]
NONCOVID_FEAR	−0.079	2.999	2.333	−4.142	−3.164
	[−2.215; 2.057]	[0.779; 5.220]	[−0.753; 5.420]	[−7.611; −0.674]	[−6.527; 0.199]
λ	-0.356^{***}	-0.41^{***}	−0.113	0.17^{*}	0.075
ρ	0.405^{***}	0.424^{***}	0.104	−0.148	−0.018
Observations	5200	5200	5200	5200	5200

Table 4.4: Regression results 2

	Dependent variable: *MOBIL*				
	ASO 2020	SON 2020	OND 2020	NDJ 2020	DJF 2021
COVID_NEWS	−0.604	−0.138	−0.248	−0.002	0.482
	[−0.762; −0.446]	[−0.255; −0.021]	[−0.385; −0.110]	[−0.232; 0.229]	[0.229; 0.735]
COVID_FEAR	−4.326	−3.533	−2.547	−2.636	−1.354
	[−7.304; −1.348]	[−6.030; −1.036]	[−5.104; 0.010]	[−6.233; 0.960]	[−5.363; 2.655]
NEW_INFECT	−45.897	−8.205	−14.834	−21.015	−13.318
	[−54.221; −37.572]	[−11.771; −4.639]	[−17.259; −12.409]	[−23.960; −18.071]	[−16.589; −10.047]
TEMP	−0.181	0.288	0.171	−0.102	0.600
	[−0.402; 0.040]	[0.144; 0.433]	[0.010; 0.332]	[−0.293; 0.088]	[0.467; 0.732]
PREC	−0.098	−0.178	−0.203	−0.079	−0.325
	[−0.194; −0.002]	[−0.283; −0.073]	[−0.309; −0.098]	[−0.219; 0.061]	[−0.453; −0.197]
emphH_DAY	−4.129	−3.531	−2.927	−1.281	−0.794
	[−4.607; −3.652]	[−3.939; −3.122]	[−3.379; −2.475]	[−2.060; −0.501]	[−1.467; −0.122]
NONCOVID_FEAR	9.196	2.879	2.031	−4.989	5.972
	[6.091; 12.301]	[0.300; 5.458]	[−0.701; 4.763]	[−8.551; −1.427]	[2.308; 9.637]
λ	−0.042	-0.288^{***}	-0.325^{***}	0.055	−0.006
ρ	0.109	0.292^{***}	0.337^{***}	−0.009	0.029
Observations	5200	5600	5200	5200	5200

Table 4.5: Regression results 3

	Dependent variable: *MOBIL*					
	JFM 2021	FMA 2021	MAM 2021	AMJ 2021	MJJ 2021	JJA 2021
COVID_NEWS	0.353	0.554	−0.188	−0.412	1.004	1.418
	[0.173; 0.534]	[0.373; 0.736]	[−0.383; 0.008]	[−0.624; −0.201]	[0.773; 1.234]	[1.095; 1.742]
COVID_FEAR	−4.292	−6.480	−5.814	−0.182	3.404	3.513
	[−7.152; −1.433]	[−9.269; −3.692]	[−8.717; −2.910]	[−2.650; 2.287]	[0.554; 6.254]	[0.140; 6.886]
NEW_INFECT	−9.880	−15.502	−11.220	−7.061	−14.257	71.751
	[−12.718; −7.043]	[−18.924; −12.079]	[−14.715; −7.725]	[−10.779; −3.344]	[−22.837; −5.677]	[58.350; 85.152]
TEMP	0.372	0.453	0.633	0.739	0.636	0.950
	[0.273; 0.470]	[0.342; 0.564]	[0.446; 0.820]	[0.556; 0.921]	[0.420; 0.853]	[0.705; 1.196]
PREC	−0.471	−0.689	−0.636	−0.460	−0.246	−0.289
	[−0.564; −0.377]	[−0.812; −0.566]	[−0.749; −0.523]	[−0.550; −0.371]	[−0.316; −0.176]	[−0.373; −0.205]
H_DAY	−1.231	−0.877	−2.204	−1.752	−0.868	−4.381
	[−1.739; −0.723]	[−1.403; −0.350]	[−2.735; −1.673]	[−2.208; −1.296]	[−1.409; −0.327]	[−5.016; −3.745]
NONCOVID_FEAR	7.052	−2.684	−5.778	0.456	4.509	4.581
	[4.303; 9.801]	[−5.560; 0.193]	[−8.582; −2.974]	[−2.550; 3.461]	[0.467; 8.551]	[0.080; 9.081]
λ	−0.003	−0.093	0.316***	0.397***	0.468***	0.349***
ρ	−0.033	0.089	−0.324***	−0.423***	−0.503***	−0.343***
Observations	4800	5200	5200	5200	5200	5200

Table 4.6: Regression results 4

	Dependent variable: *MOBIL*					
	JAS 2021	ASO 2021	SON 2021	OND 2021	NDJ 2021	DJF 2022
COVID_NEWS	0.676	0.503	−0.422	−0.375	−0.850	−0.708
	[0.405; 0.947]	[0.295; 0.711]	[−0.585; −0.258]	[−0.574; −0.175]	[−1.145; −0.554]	[−1.002; −0.413]
COVID_FEAR	5.802	9.401	4.496	4.837	−3.961	0.506
	[2.497; 9.107]	[6.821; 11.982]	[2.018; 6.974]	[1.972; 7.703]	[−8.242; 0.319]	[−3.273; 4.285]
NEW_INFECT	28.809	−6.660	−6.019	−6.706	−4.520	−1.586
	[20.098; 37.521]	[−10.403; −2.917]	[−7.026; −5.011]	[−7.774; −5.639]	[−5.536; −3.504]	[−2.287; −0.885]
TEMP	0.646	0.897	0.533	0.634	−0.104	−0.586
	[0.371; 0.921]	[0.708; 1.086]	[0.370; 0.696]	[0.476; 0.792]	[−0.332; 0.124]	[−0.812; −0.360]
PREC	−0.354	0.004	−0.016	−0.026	−0.336	−0.761
	[−0.443; −0.266]	[−0.104; 0.112]	[−0.129; 0.097]	[−0.171; 0.119]	[−0.528; −0.144]	[−0.917; −0.605]
H_DAY	−4.691	−6.491	−5.835	−5.921	−1.692	−1.619
	[−5.292; −4.089]	[−6.939; −6.043]	[−6.224; −5.445]	[−6.472; −5.370]	[−2.642; −0.742]	[−2.334; −0.903]
NONCOVID_FEAR	−2.963	−5.401	0.824	1.012	−6.331	−6.610
	[−7.430; 1.503]	[−8.926; −1.875]	[−2.494; 4.142]	[−2.998; 5.022]	[−11.677; −0.985]	[−11.237; −1.983]
λ	0.31***	−0.01	−0.032	0.046	−0.193*	0.28***
ρ	−0.285***	0.04	0.09	−0.01	0.237**	−0.281***
Observations	5600	5200	5200	5200	5200	5200

4.7.5 Share of vaccination news

Figure 4.8 shows the share of COVID–19-related news that refer to vaccination. We identify vaccination-related news using a pattern matching approach with the pattern *vaccine* while excluding news related to non-COVID vaccines (e.g., influenza). The exact (German) patterns used are *impfung, impfen, impfstoff, impfzentrum*. We exclude patterns in which *impf* is preceded by any of the following strings: *grippe, influenza, malaria, masern, polio, pocken, staupe,*

krebs, zecke, schweinepest. News about vaccines was below 2% in all COVID–19-related news until November 2020. On 9 November 2020, Pfizer-BioNTech announced that their vaccine candidate against COVID–19 achieved success in a first phase 3 study.[25] In December 2020, many countries gave emergency-use authorization to Pfizer-BioNTech, and shortly after, the Moderna vaccine received approval as well. During the same month, in Germany, the first vaccination doses were given to a select group of people. The introduction of vaccines meant that COVID–19 lost some of its threat, implying different mobility responses. In addition, it changed the discussions in the news, which became increasingly centered around vaccination and everything related to it. By January 2021, more than 20% of all COVID–19-related news already included the mentioning of vaccines and this figure has remained at high levels since.

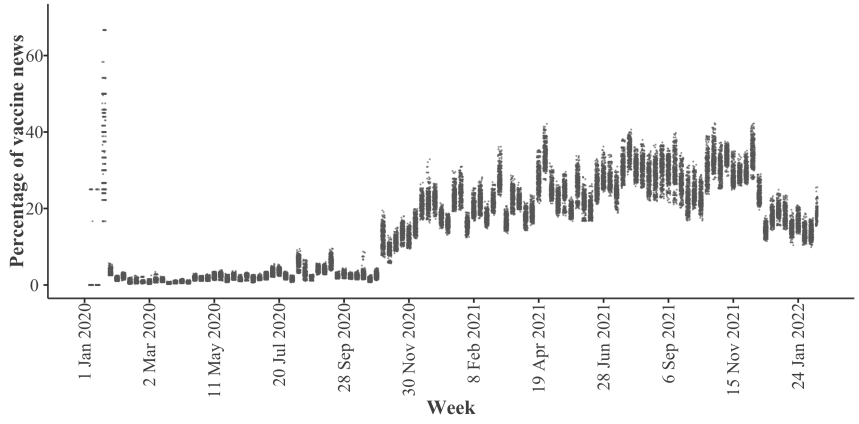


Figure 4.8: Weekly share of vaccination news in COVID–19-related news

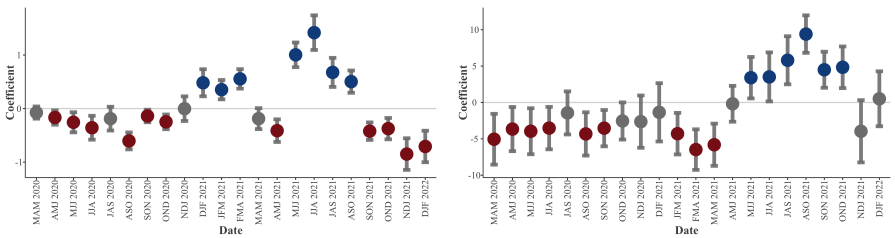
4.7.6 Results for alternative specifications

In the following, we assess the validity of our results under different model specifications. The specifications are analogous to our baseline, except for the given deviation in each case. We only show the results for the focal explanatory variables, i.e., the share of COVID–19 news and share of fear-associated words

[25] See: `https://www.pfizer.com/news/press-release/press-release-detail/pfizer-and-biontech\-announce-vaccine-candidate-against`.

in COVID–19 news, but all of the variables in our baseline are also controlled for and full regression result tables are available upon request.

In Germany, restrictions are subject to a rule, based on the number of new infections per 100,000 inhabitants, in each municipality. The seven-day incidence rate being above or below certain thresholds such as 35, 50, 100, and 165 specifies which activities are allowed and which are not. Incidence rate 100, for example, is a significant threshold which is called *emergency break*. In the event this threshold is reached, all leisure facilities close, restaurants can only offer takeaways, shops can only offer click-and-collect service, and accommodation in tourist facilities is not allowed. Accordingly, this specific number of new infections is expected to limit the mobility of individuals significantly. Similarly, if the incidence rate exceeds 165, schools and similar education and training facilities are not allowed to offer in-classroom teaching, which means a further reduction in mobility. Since the incidence rate is a function of the weekly number of COVID–19 infections which we already control for, including both measures causes multicollinearity. This is why we do not include this incidence rate variable in our baseline model. In this specification, we drop the new COVID–19 infections and, in addition to the other controls in the baseline, we include a dummy variable based on the incidence rate that takes 5 different values: *below 35*, *between 35 and 50*, *between 50 and 100*, *between 100 and 165*, and *above 165*.

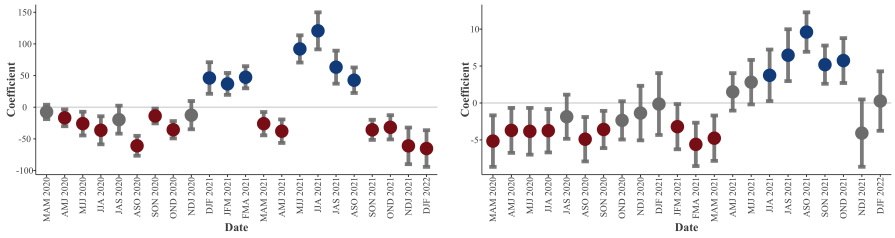


(a) *COVID_NEWS* (b) *COVID_FEAR*

Figure 4.9: Spatial panel regression results: Restrictions are controlled for by including the thresholds of incidence rate, instead of the number of confirmed cases

Figure 4.9 shows the coefficients of news-related explanatory variables when the specific intervals for the incidence rate are controlled. The coefficients only slightly change and the statistical significance of results stays the same in all regressions, accordingly, our results hold under this specification as well.

Figure 4.10 shows the results for the case when COVID–19 news are defined in a more general manner. In our baseline, news articles categorized under COVID–19 were only the ones explicitly mentioning the name of the virus and the disease. In the following case, we also include COVID–19 vaccine-related news, which does not necessarily mention COVID–19 but mentions phrases such as *vaccination center* so that we know for sure the news article is about COVID–19, although it does not explicitly mention it. The coefficients of frequency and fear intensity of COVID–19 news are nearly identical to our baseline results, showing that the results are not sensitive to the exact choice of search terms used in pattern matching.



(a) *COVID_NEWS* (b) *COVID_FEAR*

Figure 4.10: Spatial panel regression results: A more general COVID–19 news definition

Chapter 5

Conclusion

5.1 Main empirical findings

News media are involved in almost all facets of our daily lives and have overarching effects on our perceptions of and reactions to issues. However, media are not uniform across locations; media content and consumption patterns differ systematically across regions. This implies that individuals' information sets regarding events and, accordingly, their attitudes toward issues may differ depending on their location. Consequently, identifying the determinants and implications of subnational heterogeneity in news coverage is key to understanding regional peculiarities and developments.

Although various streams of literature have touched upon the subnational dimension of news media and its importance, they have mostly overlooked its relationship to economic activities. Deeply embedded in regional socioeconomic structures, regional and local news media are likely to be crucial institutions that both shape the behavior of economic agents and are shaped by regional economic conditions and developments. However, our knowledge on this matter is limited by how little work exists on the structure of these relationships, which motivated this dissertation.

The overall objective of this dissertation was to investigate the bidirectional relationship between (regional) news and regions' socioeconomic characteristics and developments. Each chapter addressed one of three distinct relationships in the complex regional news system: the potential that media data offer for

looking into regional peculiarities, the alignment of regional news media coverage with the socioeconomic characteristics of the regions it serves, and the effect of information that news media disseminate on differences in people's behavior across regions. Next, I summarize the main findings of this dissertation and discuss several central implications for future research.

5.1.1 To what extent does the frequency of press (news) releases mentioning regions reflect respective regions' socioeconomic characteristics?

Chapter 2 showed that the overall frequency of press releases and specific types of events aligns well with the characteristics of the respective regions they serve. By utilizing the novel *German Regionalized Press Releases Database*, which consists of geolocated press releases in Germany, we counted the frequency of press releases about specific topics in German districts (NUTS-3 regions). Empirically, we tested if regional characteristics explain the frequency with which events are associated with corresponding regions. We found that the total number of press releases strongly correlates with the existence of the media agency's editorial desks, population density, and the number of issuers. We also found that the number of press releases on tourist and leisure activities strongly correlates with the presence of tourists in regions, and technology-related press releases show up more in regions where per capita income is higher, and a larger number of patents are issued (when not controlling for regions' economic prosperity). Though weaker, we also detected a relationship between regional economic development and economy-related press releases. We failed to confirm a correspondence between press releases on political topics and political engagement (voter turnout) at the regional level, which we suspect is primarily due to voter turnout not being a good proxy for the number of political matters taking place in the relevant regions. Overall, our findings showed that regions' socioeconomic structures systematically shaped the content of press releases. The findings highlight the link between regional characteristics and their news media portrayal, suggesting that looking at specific topics in media outputs support identifying regional economic specializations.

5.1.2 How does regional newspaper coverage related to innovation differ across regions and how do the frequency and sentiment of innovation news relate to regional socioeconomic characteristics?

Chapter 3 showed systematic differences in the coverage of innovation and news items relating to new technology, and regions' socioeconomic characteristics can explain these differences across regions. Using the newly established *RegNeS* database, we identified innovation news by employing pattern matching and topic modeling, and we assigned each news item a sentiment polarity score. The empirical analysis of the German spatial-planning regions showed that newspapers circulating in urban areas are more likely to report on innovation, implying more frequent reader exposure to such information. We also identified notable differences between East and West Germany; innovation news appears more frequently in the newspapers of regions in the former GDR. We also found that newspapers in the two parts of the country differ in terms of sentiments with which they present such news. Newspapers circulating in the former East cover innovation in a more positive tone. The most important finding of the analysis is that the frequency and sentiments of innovation news are negatively associated with the levels of regional unemployment. Newspapers circulating in regions with less favorable labor markets feature fewer articles on innovation and new technologies and use a more negative (or less positive) tone. In sum, Chapter 3 showed that newspaper coverage of innovation-related events and discussions systematically varies across regions, which the already existing interest in these issues in the newspapers' circulation areas is likely to drive.

5.1.3 Do differences in regional newspaper coverage of the COVID–19 translate into regional differences in social distancing behavior?

Chapter 4 showed that regional differences in news media portrayals of COVID-19 explain regional differences in mobility in response to the pandemic. By using the *RegNeS* database, we first identified the frequency of COVID-19 news and fear elements in COVID-19-related news coverage in Germany. Then, we used these to explain regional social-distancing behavior, proxied by mobility patterns. Using a range of spatial panel regression models, we found that more

intensive reporting about the COVID-19 pandemic translated into decreasing mobility in the corresponding area. Similarly, we found a negative relationship between the use of fear-emotion words and regional mobility changes in certain phases of the pandemic. Crucially, we observed these relations to be time-variable with their effects conditional on the general COVID-19 situation in the country. That is, while the link was robust at the beginning of the pandemic, it became more erratic over time. In particular, the relationship between the intensity of COVID-19 news coverage and mobility turned positive following the announcements of successful vaccines, which we do not observe in the fear-intensity of COVID-19 news, showing that the news coverage turned particularly positive during that period, leading to increased mobility. During the interim period between two waves at the beginning of Summer 2022, we observed a positive relationship between news frequency and sentiment; when the pandemic felt like it was ending, and infection numbers were low, increased and dramatic news coverage on COVID-19 was associated with increased mobility. Most likely, news media content acted as a signal of a future wave and caused individuals to be more mobile while they still could before it became too risky. With the emergence of a new variant of the virus, the relationship between news coverage and mobility turned negative again. Overall, the results showed that subnational differences in news reporting, even in the context of a global health crisis, and that the frequency and tone of coverage explain regional differences in behavioral responses to the pandemic.

5.2 Implications

The three research articles in this dissertation contributed to a better understanding of subnational heterogeneity in media reporting, showing that regional differences in media content both explain and are explained by regional socioeconomic characteristics. Before moving to a more detailed discussion of the implications of the findings, we highlight three main points. First, the distribution and characteristics of events and organizations in the regions shape press release content regarding the regions, which are crucial inputs in news production. Second, systematic regional variations in the frequency and sentiments of news related to specific topics reflect regional socioeconomic structures. Third, reportage differences between regional media outlets explain regional differences in related behaviors. These findings substantiate the potential that news media data offer for economic geography scholarship. Next, I discuss the impli-

cations of the findings and make an initial step toward the conceptualization of the relationship between regional economic activities and news coverage.

5.2.1 News media data for spatial research

Empirical research usually restricts researchers to the use of official secondary data sources. Although the topics this type of data covers have greatly expanded in size and improved in quality, they still cover only specific portions of spatial socioeconomic structures. Yet, activities that official data sources do not cover are not necessarily irrelevant; on the contrary, they might be playing crucial roles in regional development. Accordingly, though not originally intended for research purposes, exploring new data sources might allow us to approach regional economic peculiarities from new angles. This dissertation suggested that news-media data represent one such data source that might contribute to a better understanding of regional socioeconomic developments.

One of the main contributions of this dissertation is the establishment of two news-media-related datasets, each with a spatial dimension. The first is a collection of press releases retrieved via daily web-scraping with a public API key since May 2016, from Germany's largest press-release portal (*Presseportal*, a subsidiary of German Press Agency). Different organizations issue these press releases, including firms, nonprofit associations, media organizations, local government bodies, and institutions. They cover a wide variety of topics and events that their creators found worth sharing. To obtain the location of these events, using text-mining techniques, we extracted the German location names from the main body of the articles. After aggregating the locations at the NUTS-3 level, the constructed database, i.e., *German Regionalized Press Releases Database* provides the full text of more than 250,000 press releases and to which region the content of each press release refers, along with the date, keywords, and information on the issuing organization. A part of the German Regionalized Press Releases Database[1] is made publicly available, and can be freely downloaded from its GitHub repository[2]. The second dataset, *Regional News Syndication (RegNeS)*, is a daily collection of news headlines and snippets from newspapers with an online presence, circulating in Germany. The

[1]The publicly available version of the dataset covers the period from 10 May 2016 to 31 May 2020. The number of press releases for each keyword is aggregated at the NUTS-3 level. The press release and organization IDs are anonymized.

[2]`https://github.com/burcuozgun/grpr`.

news snippets were retrieved via daily web scraping. The database covers local and regional as well as national newspapers. Most importantly, subnational sections of national newspapers are differentiated, meaning that some portions of national newspaper content can be associated with specific localities. We obtained the information on the circulation areas of these newspapers—i.e., regions in which each newspaper has readers—from the German Audit Bureau of Circulation (IVW), the institution that records and audits the distribution of all advertising media in Germany. Since we have the circulation information on small geographical scales, depending on the task on hand, we can aggregate distribution areas at different levels such as NUTS-3. In addition to making it possible to address the research questions regarding the regional determinants and consequences of news coverage, the establishment of these two datasets allowed us to assess the correspondence between news-media data and regional characteristics.

Our findings in Chapter 2 regarding the correspondence between the press release content *about* regions and characteristics of the respective regions contribute to the literature on the value of new data sources and automated textual analysis, for a better understanding of economic processes, firms, and regions (Berger et al., 2020; Feldman and Lowe, 2015; Arribas-Bel, 2014; Crampton et al., 2013; Meijers and Peris, 2019). Press release content reflects regional characteristics and developments well in the location of the issuer or the event, at small geographical levels. Press release data is also advantageous in terms of timeliness, informing about activities, events, or developments immediately after they happen or even before, if the news release is an announcement. The good fit that Chapter 2 reported implies that when looking at specific topics, press releases (or news media data in general) may allow for identifying regional economic specializations. For instance, for countries where data are not available on certain activities, such as environmental initiatives, social events or gatherings, or types of sports, these might be approximated by the use of press release data. Given the importance of such activities for the emergence and development of social networks and local cultures that facilitate knowledge diffusion, learning, and innovation, which are essential for regions' long-term economic developments (Hofstede et al., 2010; Gertler, 2008; Saxenian, 1996), capturing these indicators at small geographic units can contribute to our knowledge regarding regions. Although the absolute number of events, ac-

tivities, or developments does not necessarily imply general importance, using the data for identifying comparative strength is feasible.

Chapter 2 also contributes to the media studies literature, as it uses a *place name counting* technique to identify the intensity of information regarding places. Supporting the findings in the geography of media literature at the subnational level (Walmsley, 1980; Blotevogel, 1984), we find systematic differences in the frequency of media coverage of regions. These differences among press releases imply that the so-called *spatial bias* does not necessarily occur in the newsroom, but also exists at the input level. Our results show that larger or economically more prosperous regions' media coverage partly originates in the higher number of events, due to the larger number of organizations making these events or developments possible. Building upon the quantity of information flows framework, this dissertation also utilizes the content of information regarding regions. Chapter 2 shows that certain characteristics and types of organizations located in the regions determine the content that prompts the mention of certain regions. Media outlets make extensive use of press release content (O'Neill and O'Connor, 2008; Macnamara, 2014; Lewis et al., 2008; Reich, 2010), and our results imply that to convey information about an event or development, news stories represent what a visitor will find, what kind of activities are taking place, and what is new in a particular location. This is relevant due to the crucial role media play in the perceptions of regions and in explaining spatial behaviors (Gold, 1994; Avraham, 2000; Boland, 2008; Burgess, 1974). Also, from an economic geography perspective, news media and other communication systems are arguably at the root of the mechanisms that make relationships between regions and economic growth possible. Pred and Törnqvist (1973) and Zipf (1946) argue that any movement or flow (commodity, capital, or human) taking place requires the transmission of knowledge. People need information regarding regions and their respective economic opportunities or risks, which available communication systems such as news media usually disseminate. Regions' appearance in each other's news media (Peris et al., 2021) and the topics with which these regions are associated become a part of people's information space regarding those regions. As the descriptive analysis of topics in Chapter 2 shows, some sectors or types of activities might dominate the outlook of regions, shaping their images. These representations are key in explaining perceptions of regions and resulting spatial behavior.

Although not the main focus of Chapters 3 and 4, the findings of these research articles, showing the alignment between news media content and regional characteristics, attitudes, and behaviors, also show that the information on what becomes news and what is read in different geographies is crucial for our understanding of information flows, collective expectations, and attitudes at subnational scales.

Despite being a novel and attractive data source, drawing inferences on regional characteristics from news data, in general, and press release data, in particular, require caution. First, in the context of press releases, one should bear in mind that the organizations themselves write these, and often they are not objective pieces and may consist of subjective statements. Accordingly, although they inform about the events taking place or matters that relate to a place, the actual content of information should not be over-interpreted. Second, the information news media disseminate is an economic commodity whose content both supply and demand dynamics determine. Accordingly, when using news media data to understand regional characteristics, one should be aware that the availability of events or audiences' willingness to hear about those alone does not solely determine the information referring to places. Third, although press releases and newspaper articles are a good starting point to get an idea of what is said *about* regions, visibility of subnational units in other types of media (legacy media or social media) is also important for understanding regional activities, as well as regions' external images.

This dissertation took an early step in assessing the value of news media data for regional studies that I hope may guide future researchers toward the opportunities and challenges this type of data carries.

5.2.2 Alignment of regional media content and audience

Another contribution of this dissertation was showing that in terms of topics covered and their presentation by news media, systematic differences exist across regions. By focusing on the media portrayal of innovation and new technologies, Chapter 3 showed the alignment between regional news media content and audience characteristics. The chapter's findings have several important implications. The representation of new technologies can potentially influence the future of focal technologies by reinforcing attitudes and supporting or hindering their development.

For example, AI and automation are contemporary emerging technologies that news media extensively discuss. They pose potential threats to employment, especially in certain occupations (Acemoglu and Restrepo, 2019; Frey and Osborne, 2017). Worth noting in this regard is our finding that in regions where unemployment is higher, innovation and new technologies coverage is less frequent and with relatively more negative sentiment. This is likely to originate from the demand side of the news-making process. The audience in regions already having less favorable labor market conditions might perceive these new technologies more negatively due to their possible negative impacts on the unemployment rate. This is important because news media coverage of new technologies does impact attitudes toward the respective technologies (Gaskell et al., 1999; Skjolsvold, 2012; Negro et al., 2012; Mazur, 2006). Moreover, attitudes, beliefs, and collective expectations regarding new technologies are important determinants of their later development, adoption, and diffusion patterns (Budde et al., 2012; Borup et al., 2006; Geels and Verhees, 2011). Innovation processes and technological diffusion are subnational processes at least as much as they are national ones. Accordingly, our results show that subnational differences in news coverage aligning with the audience suggest that the lack of news coverage of these topics in some regions might cause individuals to be unfamiliar with certain technologies. More importantly, negative news coverage might constantly reinforce negative perceptions and expectations regarding these technologies. As a result, a lack of interest or negative perceptions may make the development, adoption, and diffusion of these technologies less likely in certain regions, due to the information content that news coverage exposes. At the end of the day, diffusion of innovation is a function of communication, as Hagerstrand (1966) articulated; one cannot adopt an innovation unless one has first seen it, heard of it, or read about it (p.27). Considering the willingness to adopt another precondition of innovation adoption, the findings of Chapter 3 imply that the amount of news coverage and the media sentiment toward innovation may play a role in its diffusion patterns.

By showing that regional socioeconomic characteristics explain the available information set about innovation and new technologies in each region, Chapter 3 not only addresses an issue hardly addressed until now but also brings together two loosely connected literature streams, i.e., the geography of media and the geography of innovation studies.

5.2.3 Regional news media effect

Although the COVID-19 pandemic was a global threat, regions differed both in the extent to which the pandemic affected them and in terms of infection and mortality rates (White and Hébert-Dufresne, 2020; Messner and Payson, 2020; Bosa et al., 2021; Hoekman et al., 2020; Azzolina et al., 2020). Individual choices played a great role in reducing the speed of the spread (Goolsbee and Syverson, 2021). Although the crucial role that news media played in influencing individuals' preventive practices and, accordingly, infection rates (Simonov et al., 2020; Andersen, 2020; Ash et al., 2020; Bursztyn et al., 2020) is established, our knowledge of potential differences in the portrayal of COVID-19 across subnational units was still nonexistent. This dissertation contributed to the knowledge of news media's effect on health behavior from a geographical perspective, showing that differences in news exposure explain subnational differences in social-distancing behavior.

The findings of Chapter 4 have important implications, in terms of the relationship between news media and the regions they serve. In some regions, regional news outlets might have protected their audience by covering COVID-19 more frequently and in a more alarming fashion. Similarly, people in locations where the news media downplayed the risks of COVID-19 by covering it less frequently and in less dramatic ways were less likely to adapt their mobility behavior and, hence, might have put themselves and others in greater danger of getting the disease. If regional news media coverage explains differences in behavioral responses, even on a health-related topic—a topic on which vast agreement existed regarding the ways to protect oneself and others—in more complex or controversial topics, news media might be a crucial, albeit overlooked factor that explains regional differences in behaviors and attitudes toward issues. This suggests that discussing how the spatial structures of the economy stem from the behaviors of economic agents calls for taking into account the content of communication flows to which individuals are exposed.

The findings of Chapter 4, indicating a time-variable relationship between regional news coverage and individuals' social-distancing behavior, also have implications regarding the dependency between media and regional audiences. The news media effect taking the expected direction and magnitude at the beginning of the pandemic and during its most uncertain times, i.e., when a new variant emerged, suggests that the news media effect intensifies during times

of ambiguity when the public's information need is greater. This aligns with mass-media dependency theory, namely, the dependency between the media and their audience rises when a relatively high degree of change is present in a society (Ball-Rokeach and DeFleur, 1976). Confirming this theory at the sub-national level, findings of Chapter 4 imply that when public knowledge on a matter is very limited, or society is going through a change related to an event or issue, how these matters are covered in local and regional media particularly influences individuals' opinions of them. Similarly, when no such information is needed in a particular context, the effect of regional news media coverage might be limited or nonexistent.

5.2.4 Policy Implications

When it comes to media, deriving policy implications is a complex task, due to the principle of media freedom. Since the articles in this dissertation focus on the content of media, i.e., the frequency with which the media cover different topics and the tone of the coverage, none of the chapters explicitly included policy as a subject of study. Still, the results of this dissertation have several policy implications, outside of the media content and the behavior of media systems.

In the context of COVID-19, many studies find that social media have disseminated misinformation, fake news, and conspiracy theories, (Ahmed et al., 2020; Kouzy et al., 2020; Srivastava et al., 2020; Zarocostas, 2020) and these beliefs are associated with undesired health-related behavior, such as noncompliance with government precautionary regulations and less willingness to undergo testing and vaccination (Freeman et al., 2022; Salali and Uysal, 2020). On the other hand, traditional newspapers were associated with much less misinformation than other news channels, such as social media (Bridgman et al., 2020; Dhanani and Franz, 2020; Hölig et al., 2020). In this respect, by demonstrating how regional and local media coverage regarding COVID-19 affected the mobility of their audience, Chapter 4 shows the importance of access to information these regional outlets disseminate. This supports the argument that local news media can be considered a merit good, consumption of which we should encourage. With decreasing subscription numbers and declining advertisement revenues, many local and regional media outlets are struggling to survive (Nielsen, 2015; Olsen et al., 2020; Olsen and Solvoll, 2018; Alpert and Keach, 2020; Siles and Boczkowski, 2012), and this necessitates immediate action. Positioning local

and regional news media as merit goods would justify regulatory support and efforts to ensure the sustainability of local journalism (Ali, 2016).

Chapter 2 findings, regarding the existence of regional editorial offices of a national press agency acting as a determinant of press release frequency, also show the importance of local outlets for the regions' visibility. Our results imply that these outlets manage to attract more organizations to report about their activities, increasing the possibility that regional and national news items feature regions. Organizations themselves write press releases that usually cover and emphasize positive developments, so increased news coverage will likely benefit regions. Furthermore, the number of editorial offices or media outlets may also impact the diversity of topics with which regions are associated and contribute positively to regional images.

The results of Chapter 3, showing the alignment between regional news media content and tone and the characteristics of the audience they serve, imply that regional and local news media outlets are embedded in local cultures. Accordingly, government support for local and regional news outlets without compromising the freedom of the press is important. Regional news media not only report on a specific geographic area or people living there but also events, developments, and issues from a local angle (Hess and Waller, 2016).

All in all, the findings in this dissertation emphasize the vital informational function of regional and local news media. Combining these findings with those of studies that show the negative political, economic, and social effects of not having local and regional media outlets (Miller, 2018; Matherly and Greenwood, 2021; Gulyas, 2021; Gao et al., 2020) suggests the need for policies to ensure the sustainability of local news production.

5.2.5 Theoretical framework

The findings of this dissertation and their implications showed that news media are integral parts of the societal dimension of the regions they serve. The activities taking place in the region determine the news content they produce, and their coverage influences those upcoming by affecting economic agents' behaviors. This section provides a broad conceptualization of the regional dimension of news media and its relation to economic activities. The conceptualization utilizes several theories from media studies, such as news value theory, mass media effect theories, media dependency theory, and news flow theory. Figure

5.1 summarizes the region-internal news process, for a better understanding of drivers and effects of news coverage *in* regions.

Figure 5.1: Regional dimension of news media: News coverage *in* regions

Figure 5.1 shows the regional embeddedness of news media, from the perspective of an arbitrary region. All economic activities and developments, all political and social events—in short, everything that happens in the region—contribute to the supply of potential news items as *inputs*. Similarly, all events, issues, and developments happening within the region and everywhere else that might be of importance for the region also contribute to the news supply. News media organizations (national, regional, and local) are regional institutions, bound by the region's *media culture and norms*, as well as their journalistic and reporting practices, judging the newsworthiness of each item for their audience. A news item's *selection* for publication is a function of regional characteristics, as the news media organizations would like to meet the demand of their audience—i.e., they would pick the most relevant matters and events. Once the selection occurs, editors and journalists also make decisions about how to *report* on the matter, defining the attitude toward it and its salience. Again, the demand side, i.e., *characteristics of the audience*, plays a role in this process. Reporting in regional news media or regional sections of national news media might be tailored to align with the audience's prior perceptions of the matter. The importance of the demand side in news coverage does not necessarily dominate the supply side. Inherent characteristics or the novelty of

the events also impact what becomes news and ways of covering it, regardless of the audience's prior interest in or perceptions of the matter. As a result of this complex selection and reporting process, newsworthy events and developments that took place within the region or in other places nonetheless relevant to the region appear in media that circulate in the region. Depending on the news consumption patterns, some events and matters, alongside their salience, tone, and framing, become a part of the information space of the news audience in the region. What they hear or read about contributes to their understanding, expectations, attitudes, and behaviors regarding the events. Note that news media information complements the audience's own experiences with the issues. Accordingly, for issues of which individuals have no prior knowledge, news media information might be crucial as it is usually the only available source. An important determinant of the news media's *effect* on regional economic activity is the dependency structure between media, audience, and society. As Ball-Rokeach and DeFleur (1976) argue, the causal effect of media can only occur in a media-dependent society. The sociocultural system, the centrality of media information, and many other factors can influence this dependency structure. As the recent pandemic has also shown, exogenous events changing information needs also impact the dependency on media. Thus, the more individuals depend on media for specific information content, the more central news information becomes (Littlejohn and Foss, 2009). Accordingly, the news media effect that Figure 5.1 shows might be very strong or null, might challenge the prior beliefs of the audience or reinforce them, depending on many factors regarding the event and the region. All in all, regions shape the events that the news media will cover, and news media coverage of events shapes regions' subsequent events and developments.

Figure 5.1 approaches the embeddedness of subnational news media in the regions from only one perspective: news coverage in regions. Yet, understanding the drivers and influence of news coverage *about* regions is equally important, which Figure 5.2 illustrates. The supply of events in a region is not only relevant to its residents. Depending on the characteristics of and developments in other regions, events happening in a region can become a part of news coverage in other regions as well, via national or regional news media. Again, depending on the inherent characteristics of the focal event, as well as the existing beliefs and attitudes of the audience, news media organizations make the decisions on the events to cover, the frequency, tone, and framing of coverage.

The representation of an event with reference to a region contributes to the image of the respective region in other locations. Especially if audiences' experience with the mentioned region is nonexistent or limited, what they hear or read about a region in news media will likely be all they know about certain locations. As the literature on mental maps suggests, these images on people's minds (not necessarily identical to reality) contain both locational and attributive information regarding geographical areas (Gould and White, 2012; Tolman, 1948; Garling and Golledge, 2000; Downs and Stea, 1973) that may impact the future attitudes and behavior of economic agents, as well as their economic decisions regarding these locations (Meester and Pellenbarg, 2006; Pellenbarg and Kemper, 1997; Lloyd, 1976; Hunt, 1975).

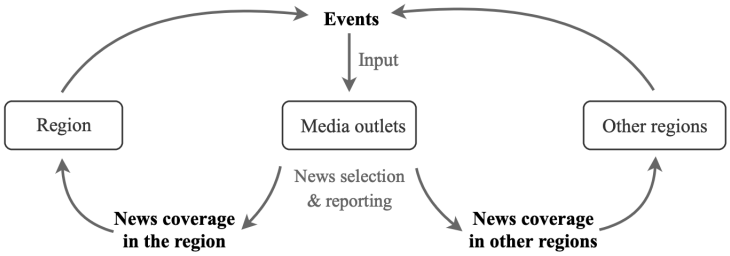


Figure 5.2: Regional dimension of news media: News coverage *about* regions

This conceptualization shows that the information flows disseminated via news media are not one-way but, rather, interactive messages, both affecting and being affected by regional audiences' attitudes and regional socioeconomic structures. News media has a strong regional dimension, and news coverage and regional economic activities have a complex bi-directional relationship. Since news media is a crucial channel shaping economic agents' perceptions, expectations, and behavior, from an evolutionary economic geography perspective, understanding subnational differences in news content and news consumption may help to explain the micro behavior of economic agents and why certain processes develop in some regions and not in others.

According to Simon (1955, 1957), when making decisions, economic agents neither possess all the necessary information nor have the perfect ability to process

all of the available information. Thus, the limits of decision-makers' knowledge and ability are the bounds of economic decision-making. Extending this idea to economic geography, Pred (1967, 1973) argue that the amount of information available to the decision-maker and the ability to use that information are two fundamental dimensions of locational decision-making. Furthermore, information circulation is inseparable from human spatial interaction, and newspapers are a crucial source of information in making events of distant origin locally available (Pred, 1977; Pred and Törnqvist, 1973; Zipf, 1946). Although newspapers are not the only information source or communication channel, information disseminated via news media is still crucial in individuals' perceptions regarding matters and locations. This dissertation showed that geography impacts what becomes news, where, and how, leading to regional differences in individuals' information sets. Following the behavioral approach, this implies that news media information might have an impact on households' and firms' economic decisions, including locational ones. Accordingly, the information content that the decision-makers possess via news media might be an important but overlooked factor in the evolution of unevenly distributed economic activities in space.

How new regional growth paths emerge has been one of economic geography's most important questions (Neffke et al., 2011; Hassink et al., 2019; Boschma and Martin, 2010). Path creation helps to explain the emergence and growth of new economic activities in regions and to shape geographies of economic development and transformation (Martin and Sunley, 2006; Boschma and Martin, 2010; MacKinnon et al., 2019). In addition to firm-based variables, many non-firm economic actors and institutions play crucial roles in these processes (Binz et al., 2016; Dawley, 2014). For a new development, such as the implementation or diffusion of a new technology, to take place in a region requires legitimization among broad sets of societal actors. Legitimacy creation relates to the expectations and beliefs of these actors, e.g., the wider public, policymakers, and financial institutions, to mobilize the necessary resources and form a market (Borup et al., 2006; Geels and Verhees, 2011; Njøs et al., 2020; Steen and Hansen, 2018). Mutual expectations of economic actors, i.e., conventions, shape the attitudes and behaviors, as they are implicit rules of what to do in specific situations (Sunley, 2011). For this reason, collective expectations (or conventions) have generative power in path creation processes (Steen, 2016). They may impact the development of a new economic activity positively, by fa-

cilitating the adoption and diffusion, or they may have detrimental effects and become an obstacle to new path development (Borup et al., 2006; Steen and Hansen, 2018; Hassink et al., 2019). Similarly, policy decisions emerge out of a complex interplay of many actors across different levels (Uyarra, 2010), and in light of the interpretation of available information, preferences and beliefs regarding issues are crucial parts of this process (Slembeck, 1997).

Studies show that media largely shape collective expectations; media content to which economic actors are exposed can alter or strengthen attitudes toward and stimulate further action on a product, innovation, or industry (Geels, 2014; Sjøtun, 2019). This dissertation provided empirical evidence on significant subnational differences, in both the quantity of news information and media sentiment toward issues, and on the fact that regional differences in news coverage explain differences in behavioral responses. Accordingly, the findings of this dissertation imply that regional differences in news content and consumption might play a role in how and where new economic activities emerge and develop over time, through expectations channel. Positive and frequent news coverage about a potential development in a region might help economic actors to have positive expectations for the respective activity, reducing uncertainty, facilitating the adoption and market formation, and providing support for policy action. Therefore, news media might contribute to regional path creation and development that determine broader patterns of regional economic structures. This also relates to the local buzz argument (Bathelt et al., 2004; Storper and Venables, 2004); news media create a regional information space for economic actors, allowing them to have similar information, expectations, and attitudes toward issues.

The discussion on the role of collective expectations, social conventions, norms, and the like, in enabling regions to learn and adapt to changes and in path creation and development, also relates to the institutional approach in economic geography (Rodríguez-Pose and Storper, 2006; Morgan, 1997). The importance of institutional infrastructure for innovation activities in particular (Cooke et al., 1997; Howells, 1999; Doloreux, 2002; Amin, 2001) and regional economic development in general (Rodríguez-Pose, 2013; Uyarra, 2010; Gertler, 2010) is well-established. By arguing that regional news media help the creation of mutual expectations (conventions) in a community, shape the patterns of economic action, and provide cohesion among the regional economic actors,

this dissertation positions news media as a part of the regional institutional setup.

Notably, the relationship between institutions and economic development is not necessarily unidirectional (Glaeser et al., 2004). This is the case for news media as well; regional organization of news media and news content in or about regions is not an exogenous process. This dissertation showed that activities in a region both influence are influenced by news coverage. This causal interdependence, i.e., the bi-directional causality between news coverage and regional economic structures, suggests that they are co-evolving (Murmann, 2003; Schamp, 2010; Gong and Hassink, 2019).

Lacking a clear and dedicated theoretical framework for the interaction between economic agents and regional information space that media create, this subsection made a step toward connecting the regional dimension of news media to economic geography, utilizing theories in media-studies, human-geography, and economic-geography literatures. I hope that this conceptual framework attracts more direct work on the relationship between communication systems and regional economic structures.

5.3 Concluding remarks and directions for future research

Each of the three research articles in this dissertation touched upon a different aspect of the regional dimension of news media, focusing on news releases and newspaper content regarding specific matters. These studies showed that regional news media are strongly embedded in the regions they serve and, yet, they are a widely overlooked aspect when investigating regional phenomena. Accordingly, while this dissertation made an initial step toward figuring out how economic geography as a research field can benefit from and contribute to the understanding of the regional dimension of news media, several limitations apply to all three chapters of this dissertation, and some relevant questions remain open.

First, although this dissertation revealed formerly unknown aspects of the relationship between regional news coverage and the behavior of the audience, this relationship still requires further investigation. Ideally, research on the impact of news information on individuals' behavior should be approached at the individual level. Lacking data on the news content each individual was exposed to, their behavioral responses to this information, and other potential deter-

minants that might affect their behaviors, this dissertation opted for a second best and focused on the smallest geographic scale possible, i.e., NUTS-3 level. As data becomes available at the individual level, future studies can enhance our understanding of the impact of news media on the behavior of individuals and the rationale behind these behavioral responses.

Second is the changing demand and supply structure of the news markets. Print newspaper consumption has been declining for a long time (Peiser, 2000; Heimlich, 2012; Newman et al., 2021). Although COVID-19 induced an increase in online news consumption (Lemenager et al., 2021; van Aelst et al., 2021), in general, news media are now competing with other attractive media bundles and digital platforms (Hölig et al., 2019). Since legacy media are still an important source of news (Horz-Ishak and Thomass, 2021), the current declining trend is a concern for future research. Furthermore, there are also structural changes on the supply side of the media markets, both within nations and globally, one of which is the increasing market concentration (Winseck, 2008). If the current trend continues, a small number of publishers is likely to dominate news outlets. This is important since media ownership consolidation leads to a decrease in source and content diversity. News outlets owned by the same organization are more likely to publish news of similar scope, focus, and diversity (Baum and Zhukov, 2019; Vogler et al., 2020; Hendrickx and van Remoortere, 2022). As the developments following Elon Musk's purchase of Twitter Inc. have also recently shown, ownership of media outlets (legacy or social media) can have significant consequences for how and which information is available to individuals. Therefore, future research should also focus on how the structure of the news media market is changing and what it means for regional and local information content.

Third is the geographical scope of the research. The specific focus of all studies in this dissertation was Germany, an ideal case for the research questions in focus, but it is also a special case. Germany's news consumption is higher than that of many other countries, and strong local and regional newspapers characterize the country's print media landscape (Kretzschmar et al., 2009), with every city, town, and region still having at least one local newspaper (Harnischmacher, 2015). Also, German audiences attach greater importance to regional news than most other countries, which high circulation and readership numbers also show (Harnischmacher, 2015; ZMG, 2022; Humprecht and Esser, 2018; Mangold et al., 2017; Krueger and Swatman, 2002; Hölig et al.,

2019). In addition to regional and local newspapers deeply embedded in the media landscape, national newspapers usually supplement their content with a local section, often a separate paper tailored to the respective distribution area. Furthermore, in Germany, the level of general trust in news is among the highest in Europe, and concerns about misinformation are among the lowest (Hölig et al., 2020; Newman et al., 2021). Accordingly, the findings of this dissertation may not necessarily apply to other countries identically. This limitation applies to three dimensions. First, journalistic norms, values, and reporting practices can vary across countries. Second, country-specific characteristics, such as culture, might affect to some extent what the audience finds newsworthy. Third, local and regional news consumption and the importance attached to them may not be as high in other countries as in Germany. However, since our study does not make any assumptions about the journalistic and audience structures, potential cross-country differences in these areas do not affect the generalizability of the results. If a country has only a little heterogeneity in news content, and consumption at the subnational level or news readership is particularly low, then the magnitude of the effects, i.e., the extent to which regional news coverage explains regional differences in behavior and regional characteristics affect regional media coverage might differ from what this dissertation finds. Future research can address these concerns. Collecting data on local and regional news content and readership for other countries would be a natural step forward from this dissertation and may deepen our understanding of the regional aspect of news content and consumption.

In addition to these points, relevant questions are still open for future research to take up. How are discussions on economic risks and opportunities regarding regions shaped? How do local and regional news content, i.e., the frequency, tone, and framing of coverage, influence subnational location choices of economic agents (e.g., entrepreneurs, investors, labor)? Does media content have a role in the emergence and growth of technological niches at the subnational level? To what extent does local news discourse inform about the openness or resistance toward socioeconomic transformations? All in all, a need for direct work on subnational differences in news content and consumption persists, as well as representations of regions from an economic geography perspective.

Notwithstanding the limitations outlined above, this dissertation was an attempt to bring the geographical aspect of news media to the attention of eco-

nomic geography scholarship and provide novel insights into the differences in news coverage across regions as well as their determinants and consequences. The findings and their implications contribute not only to economic geography literature, but also to the relevant discussions in the innovation studies, media studies, and human geography literatures. I hope that this dissertation will provide a useful reference for scholars aiming to study this promising area of research.

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Nederlandse Samenvatting

Een beter begrip van regionale economische processen biedt inzicht in het gedrag, de verwachtingen en de percepties van mensen. Hoewel nieuwsmedia een cruciaal instrument zijn om die vorm te geven, is onze kennis hiervan op subnationaal niveau nog beperkt. Weliswaar wordt in verschillende literatuurstromingen kort ingegaan op de subnationale dimensie van nieuwsmedia en het belang ervan. Toch heeft dit aspect met betrekking tot economische activiteiten veel minder aandacht gekregen. Het algemene doel van dit proefschrift is drieledig: aandacht vestigen op dit onderwerp, inzicht verschaffen in systematische regionale verschillen in de inhoud van nieuwsberichten, en regionale determinanten en de invloed ervan op de gedragingen van economische actoren blootleggen. De drie belangrijkste hoofdstukken behandelen elk een relatie in het complexe systeem van regionaal nieuws. Er wordt op drie aspecten ingegaan. Ten eerste de mogelijkheden die mediagegevens bieden om regionale bijzonderheden te onderzoeken. Ten tweede de afstemming van berichtgeving in de regionale media met de sociaaleconomische kenmerken van de respectieve regio's. Ten derde de vraag hoe regionale nieuwsberichten verschillen in gedrag van mensen in verschillende regio's verklaren.

In hoofdstuk 2 wordt betoogd dat de inhoud van persberichten systematisch wordt vormgegeven door de sociaaleconomische structuur van de regio, wat weer gevolgtrekkingen toelaat op basis van de gegevens van persberichten. Dit wordt getoetst aan de hand van een reeks persberichten in Duitsland en door de ruimtelijke overeenstemming van informatie in persberichten te toetsen aan die van de algemene kenmerken van de regio's. De empirische analyse op het niveau van de 401 Duitse districten (NUTS-3-regio's) laat zien dat de algehele frequentie van persberichten en die van specifieke soorten genoemde gebeurtenissen goed aansluiten bij de kenmerken van de respectieve regio's. Er bestaat

met name een sterke correlatie tussen het totale aantal persberichten en het feit dat een mediabureau over een redactie beschikt, de bevolkingsdichtheid en het aantal uitgevers. Daarnaast is er een sterke correlatie tussen het aantal persberichten over toeristische en vrijetijdsactiviteiten en de aanwezigheid van toeristen in een regio; bovendien verschijnen technologiegerelateerde persberichten vaker in regio's met een hoger inkomen per hoofd van de bevolking en waar meer octrooien worden verleend (als niet gecontroleerd wordt voor de economische welvaart van regio's). Tussen regionale economische ontwikkeling en economiegerelateerde persberichten is een – zwak – verband gevonden. Uit de resultaten van het onderzoek blijkt dat de inhoud van persberichten systematisch wordt bepaald door de sociaaleconomische structuur van een regio. De overeenstemming tussen de inhoud van regiogebonden persberichten en de kenmerken van de respectieve regio's draagt bij aan de literatuur over de waarde van mediagerelateerde gegevensbronnen en geautomatiseerde tekstanalyse; dit verschaft een beter begrip van economische processen, bedrijven en regio's. Een goede afstemming tussen de inhoud van persberichten en regionale sociaaleconomische kenmerken houdt in dat als we kijken naar specifieke onderwerpen, persberichten of nieuwsmediagegevens in het algemeen, het mogelijk kan zijn om regionale economische specialisaties aan te wijzen die in traditionele secundaire gegevens verborgen blijven.

Hoofdstuk 3 kijkt naar de relatie tussen sociaaleconomische kenmerken en berichtgeving op regionaal niveau door zich te richten op krantenartikelen, die in vergelijking met persberichten een objectiever en relevanter nieuwsaanbod bevatten. Nauwkeuriger gezegd: onderzocht wordt hoe de berichtgeving in regionale kranten over innovatie verschilt tussen regio's en hoe de frequentie en de inkleuring of toon van nieuws over innovatie zich verhouden tot regionale sociaaleconomische kenmerken. De belangrijkste hypothese is dat verschillen in de frequentie en toon van nieuwsberichten over nieuwe technologieën niet willekeurig zijn, maar een afspiegeling zijn van systematische structurele verschillen tussen de regio's. Door de inhoud van in Duitsland uitgegeven regionale kranten te verzamelen en een empirische analyse van de ruimtelijke ordening van Duitse regio's uit te voeren, is gebleken dat kranten die in stedelijke gebieden verschijnen eerder over innovatie berichten, wat betekent dat lezers vaker aan die informatie worden blootgesteld. Ook zijn er opmerkelijke verschillen geconstateerd tussen Oost- en West-Duitsland; nieuws over innovatie verschijnt vaker in kranten van de regio's in de voormalige DDR. Kranten in Oost- en

West-Duitsland verschillen ook wat betreft de toon waarop dit nieuws wordt gepresenteerd; kranten in de voormalige DDR hanteren een positievere toon in hun berichtgeving over innovatie. De belangrijkste uitkomst van de analyse is dat de frequentie en de toon van innovatienieuws negatief samenhangen met de regionale werkloosheidsgraad. Kranten die verschijnen in regio's met een minder gunstige arbeidsmarkt bevatten minder artikelen over innovatie en nieuwe technologieën en die zijn bovendien vaak negatiever (of minder positief) van toon. Samenvattend laat dit hoofdstuk zien dat de berichtgeving in kranten over innovatiegerelateerde gebeurtenissen en discussies verschilt per regio, wat de regionale sociaaleconomische kenmerken systematisch weerspiegelt.

Hoofdstuk 4 onderzoekt of verschillen in de regionale berichtgeving betreffende de coronacrisis zich vertalen in regionale verschillen in 'social distancing' (beperking van sociale contacten). Door mobiliteit te gebruiken als maatstaf voor social distancing en door gebruik te maken van ruimtelijke paneldata-regressiemodellen op het niveau van Duitse districten alsmede wekelijkse observaties, is een significante – tijdsafhankelijke – relatie tussen berichtgeving over de Covid-19-pandemie en regionale mobiliteitspatronen vastgesteld. Intensievere berichtgeving over de coronapandemie blijkt zich te vertalen in afnemende mobiliteit in het desbetreffende gebied. Ook blijkt er een negatieve samenhang te bestaan tussen het gebruik van woorden die angst(gevoelens) uitdrukken en de verandering in regionale mobiliteit in bepaalde fasen van de pandemie. Cruciaal is dat deze relaties tijdsafhankelijk zijn en dat het effect ervan afhankelijk is van de algemene coronasituatie in Duitsland. Dat wil zeggen: hoewel het verband aan het begin van de pandemie robuust is, verandert dit in de loop van de tijd. Met name de relatie tussen de intensiteit van de (corona)berichtgeving en mobiliteit wordt positief als bekend wordt gemaakt dat een vaccin succesvol is. Dat dit niet zichtbaar is in de angst-intensiteit van coronagerelateerd nieuws, toont aan dat de berichtgeving gedurende die periode zeer positief wordt en leidt tot een toename van de mobiliteit. In de periode tussen twee besmettingsgolven aan het begin van zomer 2022 is een positieve relatie zichtbaar voor zowel de frequentie als de toon van de berichtgeving; als de pandemie ten einde lijkt te komen en het aantal besmettingen laag is, is er een verband tussen meer (ingrijpend) coronanieuws en toegenomen mobiliteit. De resultaten laten in het algemeen zien dat regionale nieuwsmedia een belangrijke factor zijn die gedragsverschillen op subnationaal niveau verklaart.

Naast het opbouwen van twee nieuwsmedia-gerelateerde datasets met een ruimtelijke dimensie heeft dit proefschrift bijgedragen aan een beter begrip van de subnationale verscheidenheid in mediaberichtgeving. Het laat zien dat regionale verschillen in media-inhoud een verklaring zijn voor regionale sociaaleconomische kenmerken én hierdoor verklaard worden. Ten eerste blijkt dat de inhoud van persberichten met betrekking tot regio's – een cruciale input voor nieuwsproductie – wordt bepaald door de verspreiding en kenmerken van gebeurtenissen en organisaties in een regio. Ten tweede blijkt dat systematische regionale verschillen in de frequentie en toon van nieuwsberichten over specifieke onderwerpen de regionale sociaaleconomische structuur weerspiegelen. Ten derde blijken verschillen in berichtgeving tussen regionale media de regionale verschillen in bijbehorende gedragingen te verklaren. Deze uitkomsten vormen een onderbouwing van de mogelijkheden die nieuwsmedia bieden voor de economisch-geografische wetenschap. Daarmee kan dit proefschrift als uitgangspunt en referentiekader dienen voor wetenschappers die dit veelbelovende onderzoeksgebied willen bestuderen.

Curriculum Vitae

Burcu Özgün was born on 17 December 1989, in Yildirim, Bursa, Türkiye. She holds Bachelor's (2012) and Master's (2014) degrees in Economics from the Middle East Technical University in Ankara, where she also worked as a research and teaching assistant from 2012 to 2020. During this period, in the 2017-2018 academic year, she has been a visiting researcher at Utrecht University in the Department of Human Geography and Spatial Planning. Soon after this visiting period, in December 2018, she became an external Ph.D. candidate in Economic Geography at Utrecht University. Since June 2021, she works as a research and teaching fellow at the University of Kassel, in the Economic Policy, Innovation, and Entrepreneurship research group. She has four academic publications, three of which are parts of her dissertation.

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