



ELSEVIER

Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

Environmental Innovation and Societal Transitions

journal homepage: www.elsevier.com/locate/eist

Research article

Creating legitimacy for cultured meat in Germany: The role of social cohesion

D. Weckowska^{a,*}, D. Weiss^a, V. Fiala^b, F. Nemeček^c, F. Voss^a, C. Dreher^a^a Freie Universität Berlin, Department of Management, Chair of Innovation Management, Thielallee 73, Berlin, 14195, Germany^b Freie Universität Berlin, Department of Political and Social Science, Otto Suhr Institute of Political Science, Germany^c Goethe-Universität Frankfurt am Main, Faculty of Economics and Business Administration, House of Finance Chair for Personal Finance, Germany

ARTICLE INFO

Keywords:

Technological innovation system
 Legitimacy
 Cultured meat
 Natural language processing
 Social cohesion
 Protein transitions

ABSTRACT

Few studies on legitimization of new technologies were able to provide insights into the longitudinal changes in legitimacy outcomes and the social dynamics that underpin such outcomes. Using a novel mixed-methods approach, combining Natural Language Processing with a qualitative text analysis, and drawing on the concept of social cohesion to investigate the social relations among actors, the study offers new insights into the legitimization of cultured meat in Germany. Using 424 newspaper articles, we identify four topics in the public discourse related to cultured meat and positive average sentiment on each topic over the period 2011–2021. Furthermore, we find the actors, groups, and social relations that shape the observed legitimacy outcomes. The empirical findings are used to develop propositions about the role of social cohesion in legitimacy creation. The study paves the way for future studies on social cohesion dynamics in socio-technical change.

1. Introduction

The urgency of addressing climate change and environmental concerns has led to a large body of scholarly work in the field of sustainability transitions that investigates the transformations towards more sustainable socio-technical systems (Köhler et al., 2019; Loorbach et al., 2017; Markard et al., 2012). In many sectors, such as energy and mobility, successful transitions depend crucially on the emergence and upscaling of new and potentially disruptive technologies. Accordingly, the Technological Innovation Systems (TIS) framework, which we draw on in this study, has emerged as a key analytical concept for investigating socio-technical configurations and processes underpinning development, diffusion and utilisation of technological innovation (Hekkert et al. 2007; Bergek et al. 2008). One key concern of new and disruptive technologies is their "liability of newness" and the associated need to gain legitimacy, which is defined as the alignment of the new technology with formal and informal institutions, including prevailing preferences, understandings, norms, regulations and standards (Bento and Fontes, 2019; Freeman et al., 1983; Markard, 2020). Such alignment plays a vital role in facilitating mobilisation of resources for innovation, driving market demand and adoption, as well as stimulating further knowledge creation and entrepreneurial experimentation (Bergek et al., 2008; Hekkert et al., 2007).

Various TIS studies shed light on legitimacy struggles, focusing either on legitimacy outcomes (Bento and Fontes, 2019; Dehler-Holland et al., 2021; Geels and Verhees, 2011; Isoaho and Markard, 2020; Jansma et al., 2020; Markard et al., 2016; Weiss and Nemeček, 2021) or legitimization processes (Binz et al., 2016; Genus and Iskandarova, 2020; Kishna et al., 2017). However, we found

* Corresponding author.

E-mail address: d.weckowska@fu-berlin.de (D. Weckowska).

<https://doi.org/10.1016/j.eist.2024.100871>

Received 5 April 2023; Received in revised form 15 May 2024; Accepted 10 June 2024

Available online 3 July 2024

2210-4224/© 2024 The Author(s). Published by Elsevier B.V. This is an open access article under the CC BY-NC license (<http://creativecommons.org/licenses/by-nc/4.0/>).

two aspects that, to the best of our knowledge, have not yet been sufficiently addressed. First, there are no methodological approaches that explore longitudinally both the legitimacy outcomes and the underlying social dynamics in the legitimation processes. Second, while scholars provided insights into factors driving actors' actions in (de-)legitimation processes such as firm-specific expectations or expectation-sensitivity of actors (Konrad et al., 2012; Kriechbaum et al., 2021), we still lack a profound understanding of how social relations among actors shape the processes of (de-)legitimation.

To address these gaps, our study proposes a mixed-methods approach that combines quantitative Natural Language Processing (NLP) and qualitative thematic text analysis to examine both the long-term legitimacy outcomes and social relations in the processes (de-)legitimation, which contribute to these outcomes. To unpack the latter, we suggest to examine the social relations among actors engaged in the (de-)legitimation processes through the conceptual lens of social cohesion, which refers to the extent to which people 'cohere' or 'stick' to each other' (Chan et al., 2006, p. 289). They cohere through ideational and cognitive relations (e.g., shared norms, shared values, identity, feelings of belonging) or through social relations (their number and quality), both of which can manifest in actions for common good (e.g., civic and political engagement, solidarity acts) (Schiefer and Van der Noll, 2017). This novel social cohesion-focused perspective can help shed light on the existing and emerging cognitive and social relations, which play a role in the creation of legitimacy (Weckowska et al., 2022).

Our novel methodological and conceptual approach is tested empirically on the case of legitimacy creation for cultured meat in Germany. First, we use natural language processing (NLP) to identify prevalent topics and associated sentiments in 424 newspaper articles published between 2011 and 2021, utilising unsupervised topic modelling and sentiment analysis (Dehler-Holland et al., 2021; Weiss and Nemeček, 2021). Herewith, we map out the dynamics of the aggregated legitimacy outcomes over time. Second, we develop a word dictionary based on the 13 dimensions of social cohesion (Fiala and Jacob, 2023; for details see Appendix C), which we use in combination with the NLP analysis to select 171 papers for a further qualitative text analysis. The inductive, thematic analysis reveals actors, networks and (non-) cohesive social relations, which play a role in creating the legitimacy outcomes identified through the NLP analysis.

The remaining of the paper is structured as follows. Section two reviews the previous literature on outcome-oriented and process-oriented TIS studies on legitimacy. Section three discusses the concept of social cohesion. Section four describes our mixed-method approach. The results are presented in section five and the implications of our study are discussed in section six, along with the study limitations and further research opportunities. The concluding section recaps the key contributions of our study.

2. Outcome-oriented and process-oriented perspectives on legitimacy

Legitimacy of a TIS refers to the degree to which the system is aligned with its surrounding institutional environment, including rules, norms, and regulations. Legitimacy can apply both to the focal technology and the actors within the TIS (Hekkert et al. 2007; Bergek et al. 2008, Bergek 2019). This study focuses on 'technology legitimacy', which focuses specifically on the legitimacy of the focal technology (Markard et al. 2016). It is achieved when the relevant stakeholders, such as consumers, producers, and policymakers, and institutional structures view the technology's attributes as fitting and beneficial. These comprises not only technical performance factors but also industrial and scientific advancements, political regulations, and practices related to the production and use of the focal technology (Rosenbloom et al., 2016). Thereby, TIS legitimacy in this context is considered as the accumulation of more and less legitimate attributes of the technology (Markard et al. 2016).

Past empirical studies have investigated legitimacy dynamics using two main conceptual approaches: one focuses on legitimacy outcomes and their changes over time, while the other is concerned with the underlying processes, that is the activities of actors and their interactions with institutions that create or challenge the legitimacy of a TIS (Binz et al., 2016; Rohe and Chlebna, 2021).

Outcome-orientated legitimacy analyses have been more prominent in the literature (Binz et al., 2016). With the conceptual focus on framing struggles (Geels and Verhees, 2011), collective expectations (Bento and Fontes, 2021; Dehler-Holland et al., 2021; Jansma et al., 2020; Weiss and Nemeček, 2021), discursive struggles (Isoaho and Markard, 2020), or (mis)alignment of the technology with the context institutions, these studies investigate at the macro-level changes in the degree of legitimacy of different entities in a TIS or the whole TIS. Methodologically, most of these studies use time-intensive qualitative analyses of newspapers or (expert) interviews, triangulated with additional sources like reports, statistics, or surveys. A smaller number of studies utilised NLP to examine larger amounts of text data at a lower cost than in the qualitative analyses (Dehler-Holland et al., 2021; Weiss and Nemeček, 2021). These studies map legitimacy changes across long-time periods using media attention and sentiment as indicators for different elements of a socio-technical system around the focal technology. However, they cannot provide a deeper understanding of the actual contents and semantics in the public discourse as the qualitative studies (Weiss, 2022).

While the outcome-oriented studies help us to monitor and explain aggregated legitimacy at the system-level, they tell little about the underlying processes at the micro-level that accumulate to these outcomes (Binz et al., 2016). This has led to a handful of process-oriented analyses employing a combination of interviews and qualitative analysis of secondary sources, such as newspapers, actor-specific reports, websites, and scientific articles (Binz et al., 2016; Genus and Iskandarova, 2020; Kishna et al., 2017). For example, Binz et al. (2016) analyze how legitimacy is actively enacted through actors' institutional work that changes institutional structures, e.g., advocacy, educating, political work, and imagery. Similarly, Genus and Iskandarova (2020) discuss strategies to close legitimacy gaps, including authorisation, rationalization, moral evaluation, and justification through narratives and storylines. Kishna et al. (2017) identify various motives of actors to form alliances for driving legitimation, such as a partners' legitimacy in the market or their social image.

Despite these important contributions, the understanding of technology (de-)legitimation remains limited, arguably for two reasons. Firstly, methods used in past studies didn't connect the micro practices to the important macro-level changes in the aggregate

legitimacy outcomes. Many qualitative micro-level analyses generated much needed insights on legitimation sub-processes, focusing on a limited number of actors, and without the aspiration to account for longitudinal changes in legitimacy outcomes at the aggregated level. A notable exception is [Binz et al. \(2016\)](#), as they also provide a brief depiction of the system-level legitimacy using newspapers, although not in such a comprehensive manner as the outcome-oriented studies using NLP. Our aim is to contribute to the literature by offering a mixed-method approach that allows us to examine the processes that underpin the changes in the legitimacy outcomes at the aggregated levels over long periods of time, by combining the strengths of NLP and qualitative analysis.

Second, the micro-level studies on TIS legitimacy tended to focus on actors and paid relatively little attention to the social relations among them. For instance, some insights into firm-specific expectations, actor-specific sensitivity to changing expectations, and the resonance of certain expectations have been offered by [Konrad et al. \(2012\)](#) and [Kriechbaum et al. \(2021\)](#). Similarly, [Kishna et al. \(2017\)](#) analysed different legitimacy objectives that motivate actors to enter alliances. However, the role of social relations among actors in shaping legitimacy processes is not well addressed, e.g., what social relations play a role in niche-regime struggles and how actors exploit their relations in legitimation or de-legitimation processes. This highlights the need for a broader analytical perspective that can help researchers identify social relations and actors which contribute to creating the aggregate legitimacy outcomes for a TIS. To understand better the role of social relations in (de-)legitimation, this study proposes to look at social cohesion among the involved actors.

3. Social cohesion as lens on social relatedness in (de-)legitimation processes

3.1. The concept of social cohesion

Social cohesion refers to ‘how well people in a society “cohere” or “stick” to each other’ ([Chan et al., 2006](#), p. 289), that is to ‘the quality of collective togetherness’ ([Schiefer and Van der Noll, 2017](#), p. 595). It captures the connectivity between individuals and groups within the society and manifests itself in their attitudes and behaviours. The concept of social cohesion is multi-dimensional and until now there is no common approach to measuring it. Studies distinguish different number of social cohesion dimensions, which - at a more abstract level - can be categorised as ideational or relational ([Schiefer and Van der Noll, 2017](#), [Moody and White, 2003](#), [Janmaat, 2011](#)).¹

Cohesion in ideational aspects means that some actors hold similar values, identities, and cognitive and normative beliefs about the world ([Schiefer and Van der Noll, 2017](#), p. 585) – what is seen as social, political, or economic reality and what actions are seen as appropriate and desirable. Social cohesion, also ideational cohesion, manifests itself in attitudes and behaviours in different life domains (cf. [Berger-Schmitt, 2000](#)). In the past studies it was captured by, for example, identification with a country, perceptions of fairness, perceptions of harmony and conflict, shared values, respect for social rules and norms, perceived legitimacy of institutions) and actions of solidarity ([Avery et al., 2021](#); [Berger-Schmitt, 2000](#); [Botterman et al., 2012](#); [Dickes and Valentova, 2013](#); [Dragolov et al., 2016](#); [Goubin, 2018](#)). In the context of innovation and transformations, ideational cohesion could manifest itself in shared understanding of challenges and problems that need to be solved, shared normative beliefs about appropriateness and desirability of certain institutional, organisational or technological solutions or in solidarity actions, in which actors take responsibility for what they understand as ‘the common good’.

The ‘collective togetherness’ stems not only from cognitive and normative connectivity but also from relations among actors. The relational aspect of social cohesion encompasses ‘the relationships and ties between individuals’ ([Schiefer and Van der Noll, 2017](#), p. 585). Cohesion in relational aspects means that citizens have a relation to one another (horizontal cohesion) or to authorities (vertical social cohesion) that is somehow positive ([Chan et al., 2006](#)). Relational cohesion manifests itself in inter-personal or inter-group attitudes and behaviours. In the past studies, it was captured, for example, by connectivity among individuals or groups, attitudes of tolerance, trust in other people or authorities, and civic/political engagement ([Avery et al., 2021](#); [Berger-Schmitt, 2000](#); [Botterman et al., 2012](#); [Bottoni, 2018](#); [Dickes and Valentova, 2013](#); [Dragolov et al., 2016](#); [Goubin, 2018](#)). The latter is thought to reflect cooperative behaviours of actors in pursuit of common goals. In the context of innovation and transformations, relational cohesion could manifest itself in relations between innovators, society, policy-makers, among other actors, characterised by trust or even joint collective actions for the common goals.

3.2. Social cohesion and (de-)legitimation

It has been argued recently that social cohesion dynamics could shape all key processes in innovation systems ([Weckowska et al., 2022](#)) but empirical examples are missing. Our focus here is only on the influence on the technology (de-)legitimation processes. To bridge the gap between theorising about social cohesion and technology (de-)legitimation, we make two conceptual choices. First, we conceptualise (de-)legitimation through theories on institutional work ([Lawrence and Suddaby, 2006](#)) and institutional entrepreneurship ([Battilana et al., 2009](#)) because we see a connection between ideational cohesion and institutional theories. An institutional perspective on technology legitimation has been adopted, for example, by [Binz et al. \(2016\)](#). Building on their work, we assume that both legitimation and delegitimation are underpinned by institutional work. Second, we juxtapose the relational and ideational dimensions of social cohesion ([Schiefer and Van der Noll, 2017](#)) to identify four types of social relatedness (see [Table 1](#)), which we argue

¹ While some studies also include a distributive dimension, referring to an (un)equal distribution of physical, economic, social, and cultural resources in the society, we consider social (in)equality as a separate phenomenon from social cohesion (see [Schiefer and Van der Noll 2017](#)).

are likely to facilitate different forms of institutional work, leading to different legitimacy outcomes.

Low level of ideational relatedness signifies an existence of multiple institutional orders and opens up an opportunity for institutional change. When ideational cohesion is low or non-existent, that is, when actors have different understanding of the reality and different ideas about what is appropriate and desirable than the mainstream, we expect to observe some form of institutional entrepreneurship, that is, intentional efforts to create new institutions and transform existing ones (Battilana et al., 2009). Indeed, opportunities for institutional entrepreneurship emerge when multiple institutional orders or alternatives are present (Battilana et al., 2009; Clemens and Cook, 1999; Sewell, 1992). For example, under such conditions moral entrepreneurship is likely whereby actors, through their judgements, gradually disassociate the old rules and practices from moral foundations and designate new rules or practices as ‘good’ or ‘desirable’ (Antadze and McGowan, 2017).

One possibility is that actors who reject some aspects of the dominant institutional order have either no personal relation to those following the institutional logic or relate to them negatively (distrust, contempt, lack of solidarity). Under such conditions of low ideational relatedness and low relational relatedness, we would expect to observe institutional entrepreneurship directed towards **institutional transformation**, that is creating new rules and practices to replace the existing ones. Actors driving divergent changes are likely to be outside or at the periphery of the institutional field but could also hold more central positions (Battilana et al., 2009), for example, when they become disillusioned with the practices that they used to perform. Examples of such disruptive institutional work are provided by a study on the rage against the dairy milk regime (Mylan et al. 2019).

Another possibility is that actors experience low ideational relatedness with the mainstream but high relational relatedness. This means they are somehow positively related (e.g., have personal relations, trust) but some normative disagreements are straining their relations. Under such circumstances, we would expect to observe institutional entrepreneurship directed towards **institutional optimization**, that is refining the existing rules and practices, which could help to return to socially cohesive relations. Examples could be advocating for more ethical practices in livestock farming or reduced meat consumption.

In contrast, when actors are ideationally cohesive with the mainstream and thus share the incumbent logic of appropriateness, they are unlikely to engage in institutional work aiming at institutional change. Under such conditions we would rather expect to observe forms of institutional work, which reproduce and sustain the existing institutions.

When actors experience high ideational and relational relatedness, they share the mainstream cognitive and normative beliefs and have harmonious and trustful relations to actors in their reference group. High social cohesion levels make behaviour related to the common good more likely (Deitelhoff et al., 2020). Under such conditions, we expect to observe **institutional maintenance**, which preserves the social order. Institutional work here entails reproduction of old institutions in new social, economic or political reality. For incumbents, it could mean continuing ‘business as usual’ while for newcomers it could be imitation of dominant practices, that is institutional isomorphism (DiMaggio and Powell, 1983). Examples are Dutch producers of meat alternatives who tend to ‘fit and conform’ to the meat regime by largely adopting the dominant production and consumption practices (Hoogstraaten et al. 2023).

However, when actors experience high ideational relatedness with the mainstream and low relational relatedness, this means that they accept the dominant institutional order and experience conflictual or distrustful relations with some actors, most likely those who propagate change. Under such conditions, we would expect to see **institutional resistance** aiming to discredit the actors who propagate change, delegitimize new practices and prevent institutional change. Resistance activities of incumbent actors in the dairy milk regime provide a recent example showing how niche-oriented activities of incumbents affect institutionalisation of innovation, here plant-based milk (Mylan et al. 2019).

4. Methodology

This section provides a brief description of our methodology, with extensive details available in the appendix. We have adopted a mixed-methods approach to investigate the dynamics of legitimacy creation for cultured meat in Germany, which involves utilising NLP (see Appendix A) along with a subsequent qualitative text analysis (Appendix B) to cover both the outcomes and processes of TIS legitimization.

4.1 NLP analysis

To collect the data, we retrieved 424 German newspaper articles from the Nexis Uni database via an iterative keyword search (Kayser, 2017). Herewith, we cover the period from 2011 to 2021, in which cultured meat has gained significant attention worldwide

Table 1
Framework conceptualising relation between social cohesion and de/legitimation processes.

		Relational cohesion	
		No	Yes
Ideational (normative) cohesion	Yes	Institutional resistance Institutional work delegitimizing new institutions	Institutional maintenance Institutional work maintaining the legitimacy of incumbent institutions
	No	Institutional transformation Institutional work creating new institutions and disrupting/eroding incumbent institutions	Institutional optimization Institutional work undermining the legitimacy of incumbent institutions and refining them

and tens of cultured meat companies were founded (Appendix A: Corpus derivation). Next, the articles were pre-processed following standard NLP procedures like stopword removal and abbreviation normalisation (Appendix A: Pre-processing), before being fed into the framework of Weiss and Nemeček (Weiss and Nemeček, 2021, 2022). The latter uses unsupervised LDA topic modelling (Appendix A: Topic modelling) and sentiment analysis (Appendix A: sentiment analysis) to identify the most prevalent topics discussed in the corpus and their associated sentiment. In turn, each newspaper article is assigned to its probable topic and assigned a sentiment score, ranging from negative (−1) to positive (+1) polarity (Appendix A: Classification). Herewith, we can examine the aggregated level of legitimacy over time, using the media attention towards a certain topic and the associated sentiment: A high or low number of articles with a positive or increasing sentiment indicates an intact or increasing legitimacy, while a high media attention accompanied by negative or decreasing sentiment signals legitimacy struggles (Dehler-Holland et al., 2021; Weiss and Nemeček, 2021). In particular, the overall legitimacy is constituted by various aspects of the TIS, some more legitimate than others. The latter can reveal underlying issues and struggles that may lead to a loss of overall legitimacy for the TIS (Geels and Verhees, 2011; Markard et al., 2016).

4.1. Selection of articles for qualitative analysis

Due to the large number of articles, a NLP-based selection process was required for the qualitative content analysis that followed three criteria. First, articles with a very high probability of covering each topic were selected to enable in-depth analysis of each topic. Second, we selected articles with the most positive and most negative sentiment to understand the changes in legitimacy outcomes overtime (cf. Weiss, 2022; Weiss and Nemeček, 2021).

Third, we aimed to select the articles that could be analysed qualitatively to shed light on the role of social cohesion in legitimisation processes. To achieve this, we first developed a social cohesion dictionary consisting of keywords signifying presence and absence of social cohesion along the 13 dimensions identified by Fiala and Jacob (2023) (See Appendix C: Social cohesion dictionary). Next, a dictionary analysis (Riffe et al. 2014) was conducted to identify the frequency of social cohesion-related words in all articles. This allowed us to identify articles with the highest number of words indicating presence or absence of social cohesion words, which were then selected for the qualitative analysis. We are aware that some of the keywords are less likely to appear in media articles but the dictionary analysis was nonetheless helpful in aiding the selection of articles for the qualitative analysis.

Following the three criteria out of the 424 German newspapers articles about cultured meat published between 2011 and 2021, we selected 171 articles for the in-depth qualitative content analysis. For more details on the selection process see Appendix B.

4.2. Qualitative content analysis

A qualitative content analysis was supported by the software Citavi. First, selected articles were tagged according to a topic, positive/negative sentiment and presence/absence of social cohesion along 13 dimensions (based on NLP and dictionary analysis results). Next, a deductive-inductive coding approach following Mayring (2004) was employed in order to better understand how social cohesion affects legitimacy processes of cultured meat. The analysis was conducted in two major steps.

In the first step the aim was to qualitatively describe the legitimacy outcomes (revealed by the NLP analysis). For this, we used the TIS framework (Bergek et al., 2008, 2015) as a deductive framework and identified passages of text in which an aspect of the cultured meat TIS (e.g., technology, actors, networks, institutions, resources) or its context (e.g., meat sectors, dietary norms) were discussed with particular focus on the legitimacy function. Thus, building on the definition of technology legitimacy provided above, we endeavour to examine all TIS and context structures that potentially influence on legitimacy creation (Markard et al. 2016; Rosenbloom et al. 2016).

Each relevant passage was turned into a 'knowledge item' and linked in Citavi. one of the four topics in Citavi, using the article's topic probability. Subsequently the 'knowledge items' were inductively coded as themes and sub-themes within the topic (e.g., acceptance levels of cultured meat, benefits of cultured meat, etc.). This allowed us to validate the initial topic descriptions and develop more fine-grained descriptions of each topic. The identification of relevant text segments as well as the inductive coding was done by two researchers, resolving any discrepancies in an iterative process.

The aim of the second step was to understand the social cohesion dynamics in legitimacy processes. For this, another deductive-inductive coding was conducted. Two researchers identified text passages that describe the groups of actors or collective actors involved in the legitimisation processes and some form of ideational or relational connectivity among them (e.g., trust, shared norms and values). Each passage was turned into an 'knowledge item' in Citavi, linked to one of the four topics and coded as 'social cohesion-related'. Subsequently the 'knowledge items' were coded in a deductive manner using the framework presented in Table 1 (codes: 'ideationally and relationally cohesive groups', 'ideationally cohesive with low/absent relational cohesion', 'ideational diverse groups but relationally cohesive', and 'ideationally diverse with low/absent relational cohesion'). Lastly, inductive codes were developed to capture the fine differences (e.g., 'Butchers strive to reproduce meat cutting practices in times of challenges' or 'incumbent meat processors, investors and CM researchers and entrepreneurs start working together to reproduce meat market/sales practices for the CM product'. This allowed us to develop the stories about the role of social cohesion in the legitimacy processes.

5. Results

5.1. Deriving the topics discussed in the public discourse

To model the public discourse on cultured meat based on 424 articles, we selected a topic model with four topics and excluding

words that appear in at least 25 articles but no more than 20 % of the corpus. We aimed for relatively good evaluation measures (Coherence: -1.98 , Hellinger: 0.37) and interpretable topic words that have no considerable overlaps or overblown probabilities. The topics labels and key themes are listed in Table 2 and will be elaborated in the following sections. The list of topic words and associated probabilities can be found in Table A1 in the appendix.

The descriptive statistics of the model are given in Table 3 with the number of articles (n), their mean sentiment (mean), and the standard deviation of the mean sentiment (sd). The media attention increased considerably from 11 articles in 2011 to 101 in 2021 and the overall sentiment is positive, oscillating between 0.11 and 0.14 throughout the observed period, what suggests that the cultured meat TIS is generally viewed favourably in public discourse. However, average sentiments vary across different topics and years, ranging from -0.01 to $+0.23$, with a similar range in standard deviations from 0.01 to 0.27 . This variation highlights the complexity of public perceptions and attitudes, indicating that not all aspects of the cultured meat TIS are uniformly accepted or positively regarded. To better illustrate these findings, we offer graphical representations in the next section.

5.2. Modelling the public discourse dynamics between 2011 and 2021

To examine the discourse dynamics over time, we plotted the results of our NLP analysis. Fig. 1 depicts the absolute number of articles for each topic over the examined time period. Overall, despite some fluctuations, we see an increase in media attention for all topics. Considering individual topics, Topic 1 (Trends disrupting meat production) has been the most represented one, followed at some distance by the two topics Topic 2 (Societal changes regarding consumption and cultured meat) and Topic 4 (Market development for cultured meat). In comparison, the Topic 3 (Feasibility and desirability of cultured meat) has received the least attention over the last 10 years. Interestingly, Topic 2 received no articles before 2014. One possible explanation for this could be that consumption of cultured meat was not discussed in media before the presentation of early prototype to the public in the first-ever televised public tasting of cultured meat in 2013.

As already indicated by the descriptive statistics, Fig. 2 shows heavily fluctuating sentiments over the observed time period. While the Topic 1 and Topic 4 are rather stable in their sentiment, especially the former, Topic 3 and Topic 2 experience a pronounced uptrend and downtrend, respectively. Nevertheless, we see a comparatively strong sentiment in the most recent year across all topics.

5.3. Qualitative insights into the topics and the role of social cohesion

5.3.1. Topic 1: trends disrupting meat production

5.3.1.1. Topic 1: legitimization outcomes. This topic is about changing norms, values and expectations in relation to food production. The topic revolves around societal trends, which are putting the industrial meat production under pressure and are creating opportunities for radical innovations. Cultured meat is one of the radical innovations and is discussed alongside other alternatives to meat, including plant-based and insect-based meat alternatives, cheese, fish as well as refraining from meat consumption [132; 80; 306].²

Three often mentioned societal trends putting pressure on industrial meat production and at the same time creating opportunities for meat alternatives are: (1) growing importance of environmental protection, (2) ethics of meat production and consumption and (3) acceptance of cultured meat. These concerns are said to be more salient among younger generations and educated women [375; 159; 51].

Environmental Protection. The growing importance of environment-friendly patterns of production is portrayed as a trend that puts pressure on the incumbent meat system. Cultured meat is frequently portrayed as aligned with the ecological sustainability agenda due its resource-efficient production and lower GhG emissions compared to conventional meat [50; 229; 375; 15; 464; 316; 222; 159; 54; 381; 238; 7; 102]. At the same time current patterns of conventional meat production are portrayed as incompatible with environmental sustainability [184; 222; 7].

Ethics. The growing importance of ethical considerations in relation to production of food has been a topic throughout the analysed period [43; 316; 238; 102]. Some claim that cultured meat is aligned with the ethical values of animal welfare [381; 44], while opponents question these claims [632]. The industrial meat production is frequently portrayed as misaligned with the ethical values, however there are also voices defending some forms of animal killing as ethical [343].

Acceptance. Besides its alignment with the ethical and environmental values, cultured meat is further legitimised by the claims of its expected acceptance. Media reports that some scientists in Germany, such as Nick Lin-Hi, expect significant acceptance of cultured meat in the future [50; 187] and that modest acceptance levels are found in recent surveys [229; 582; 186; 227; 148; 399]. The expectations of low acceptance are only occasionally voiced within this topic [679; 223; 381].

5.3.1.2. Topic 1: social cohesion in (De-)Legitimation process. The topic includes no explicit references to social cohesion but the analysis of newspaper articles mentioning social cohesion-related words reveals a number of groups and relations among actors that are intertwined in the legitimization processes.

Our analysis reveals that some groups try to defend the legitimacy of animal killing practices. For example, communities of hunters, which hunt together and socialise, advocate for the view that the practices of animal killing can be respectful and ethical [343]. Given

² The numbers in square brackets refer to the reviewed newspaper articles. See appendix D.

Table 2

Outline of key topics in the public discourse on cultured meat in Germany.

Topic 1: Trends disrupting meat production
societal trends, which are putting the industrial meat production under pressure and are creating opportunities for radical innovations
responses of the incumbent industry actors to these pressures
cultured meat, seen as radical innovation, is discussed alongside other alternatives to meat
Topic 2: Societal changes regarding consumption and cultured meat
changing societal norms, values and expectations in relation to food consumption
the place of cultured meat in the future diets
the policy and industry responses to the societal changes
Topic 3: Feasibility and desirability of cultured meat
technical process of cultured meat production,
technical and market feasibility of cultured meat, its social, ecological, ethical and sensory advantages
investments in cultured meat start-ups
Topic 4: Market development for cultured meat
cultured meat product development, entries in B2B and B2C markets, market regulations
financial viability of conventional meat production
strategic partnerships between the incumbent meat processing/pharma companies and cultured meat entrepreneurs and scientists

Table 3

Descriptive statistics of the cultured meat topic model.

stats	year	Topic 1: Trends disrupting meat production	Topic 2: Societal changes regarding consumption and cultured meat	Topic 3: Feasibility and desirability of cultured meat	Topic 4: Market development for cultured meat	all
n	2011	6.00		2.00	3.00	11.00
mean	2011	0.16		0.11	0.09	0.13
sd	2011	0.27		0.01	0.06	0.20
n	2012	2.00		2.00	2.00	6.00
mean	2012	0.13		0.09	0.11	0.11
sd	2012	0.08		0.01	0.05	0.05
n	2013	18.00		8.00	6.00	32.00
mean	2013	0.03		0.08	0.10	0.06
sd	2013	0.12		0.11	0.18	0.13
n	2014	10.00	4.00		6.00	20.00
mean	2014	0.14	0.23		0.15	0.16
sd	2014	0.12	0.15		0.14	0.13
n	2015	18.00	6.00	1.00	2.00	27.00
mean	2015	0.16	0.24	0.06	0.17	0.18
sd	2015	0.12	0.07		0.04	0.11
n	2016	9.00	2.00	1.00	2.00	14.00
mean	2016	0.15	0.18	0.23	0.10	0.15
sd	2016	0.05	0.13		0.18	0.08
n	2017	13.00	4.00	4.00	1.00	22.00
mean	2017	0.11	0.19	0.12	0.18	0.13
sd	2017	0.07	0.13	0.18		0.11
n	2018	37.00	17.00	20.00	12.00	86.00
mean	2018	0.12	0.09	0.16	0.08	0.12
sd	2018	0.12	0.13	0.08	0.17	0.12
n	2019	24.00	19.00	10.00	10.00	63.00
mean	2019	0.12	0.16	0.18	0.14	0.14
sd	2019	0.10	0.07	0.05	0.15	0.10
n	2020	17.00	9.00	8.00	8.00	42.00
mean	2020	0.11	-0.01	0.23	0.19	0.12
sd	2020	0.06	0.16	0.15	0.08	0.14
n	2021	47.00	22.00	8.00	24.00	101.00
mean	2021	0.12	0.13	0.23	0.16	0.14
sd	2021	0.12	0.13	0.15	0.07	0.12
Total n		201.00	83.00	64.00	76.00	424.00

their acceptance of incumbent practices and close personal relations, it is concluded that the work on maintaining the old institutions takes place under the conditions of ideational and relational cohesion.

Another example shows that incumbent actors work towards preserving old practices of eating meat and delegitimize cultured meat. Specifically, a top German chef is said to promote rejection of cultured meat, which he considers to be 'the wrong way' for the future. He sees himself as a role model for the younger generation of cooks and seems to feel morally obliged to guide them into the 'right' direction [12]. The group of cooks is thought to be ideationally cohesive with the mainstream but distrustful towards the propagators of cultured meat. We conclude that the resistance to new institutions takes place under conditions where ideational

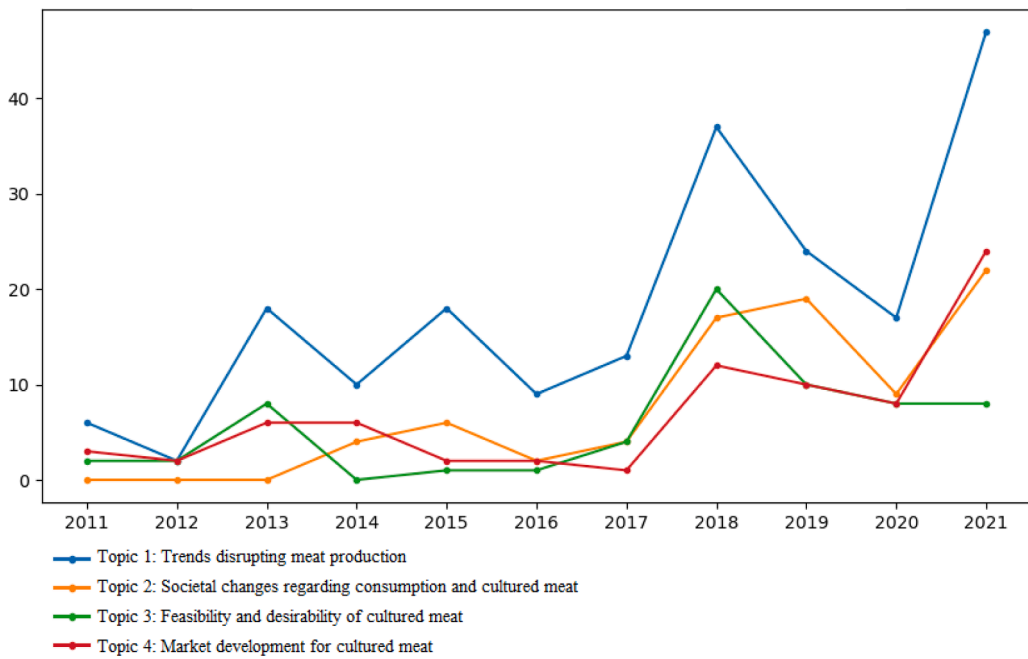


Fig. 1. Volume of articles associated with each topic in the period 2011–2021.

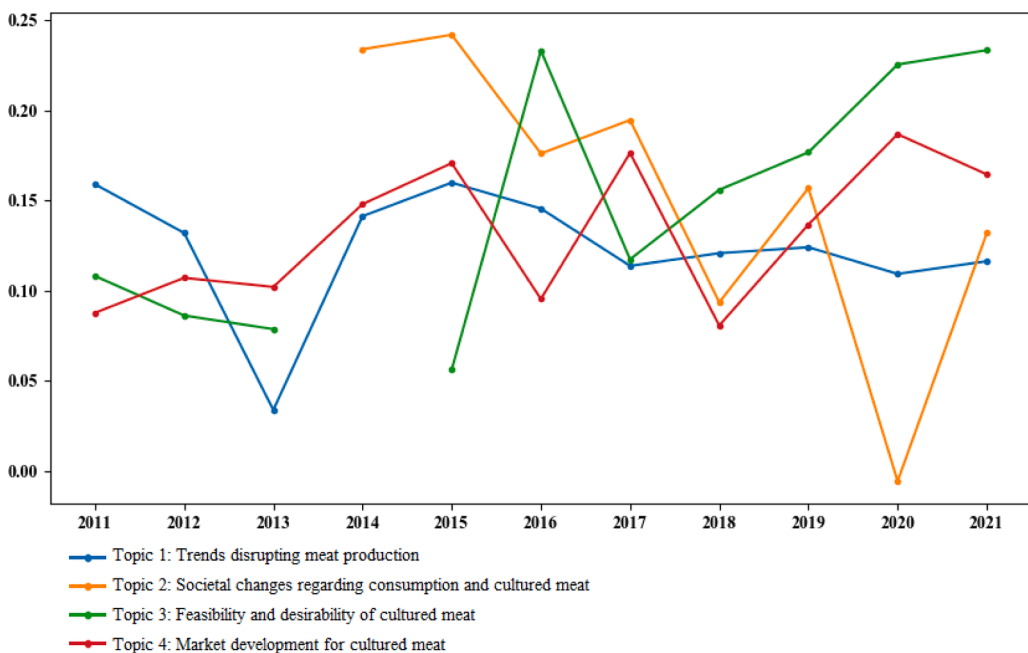


Fig. 2. Mean sentiment score for each topic in the period 2011–2021.

cohesion is present and relational cohesion is absent.

We also find stories indicating that some incumbents work towards refining the institutions related to meat production. For example, in response to the growing importance of environmental sustainability of food production, the German Butchers Association are reported to put social pressures on the ‘black sheep’ to respond to the ‘green agenda’ and change their practices. While this indicates some lack of ideational cohesion among the butchers, they also can be described as relationally cohesive as they help each other in times of crisis [346]. It is concluded that the institutional work focused on refining old practices and institutions - i.e., institutional optimization - takes place under the conditions where the actors depart ideationally from the mainstream but are socially related with actors following the mainstream logic.

Furthermore, we identify examples where actors delegitimize industrial meat production. This can be illustrated by the political protests, so called 'Schweinstall Aktion', against the sales of unethically produced meat and lack of transparency about unethical practices in the meat industry [185]. The relation between activists and animal farmers seems to be characterised by lack of ideational cohesion (different values & norms) and relational cohesion (distrust, intolerance) - under this social condition, we observe attempts to destroy old institutions and create new ones, that is, institutional transformation. No groups of cultured meat actors were found to shape the discourse on the acceptability, ethics and environmental sustainability of cultured meat.

5.3.2. Topic 2: societal changes regarding consumption and cultured meat

5.3.2.1. *Topic 2: legitimation outcome.* This topic is about changing societal norms, values and expectations in relation to food consumption, the place of meat as well as cultured meat and other alternatives in the future diets, as well as the policy and industry responses to the changing dietary norms.

The drop in average sentiment observed in 2016 relates to the discussion of possible future food habits, which was stimulated by the results of the Nestle-funded study 'Wie is(s)t Deutschland 2030?' ('How i(eat)s Germany in 2030?'). Among other things, the study assessed perceptions of five future scenarios [608]. The future scenario including cultured meat, along with pill-based food and insects, was reported to be little shocking and to be seen as realistic [230]. Some claimed on this basis that in Germany cultured meat is seen as part of the future [608], some argued that cultured meat is part of a positive future scenario, in which consumers value health and sustainability [603] while others called cultured meat the 'scenario of absurd' [425].

Cultured meat is portrayed positively by some professors working at German universities who postulate that cultured meat tastes like natural meat, is healthy, has a gentler production process than meat [61], and will replace industrial meat production in the near future because it will have low prices and ethical advantages [102]. Alongside the positive coverage, there is also negative coverage about consumption of cultured meat, reflected in the drops in the average sentiment in 2018 and 2020.

Specifically, in 2018 cultured meat seems to have been caught in the negative discussion of meat alternatives. For example, a publicly funded organisation, namely New Zealand Airline, is criticised in German media for supporting consumption of 'artificial meat' [318, 379] instead of national meat products. Although the articles are about plant-based meat alternatives, they use the expression 'artificial meat', which is commonly used for cultured meat in German media. In 2020 we observe that the legitimacy of cultured meat is further undermined through reports about the low public acceptance of consumption of the 'artificially produced meat' in Germany [278, 219]. Doubts are expressed about the validity of the claimed contributions of cultured meat to food security and its production is considered risky and alienating people from food production.

5.3.2.2. *Topic 2: social cohesion in (de-)legitimation process.* The topic includes no explicit references to social cohesion but interesting insights into relations between actors are revealed through the qualitative analysis of articles mentioning social cohesion-related words.

Our analysis reveals that environmentally and regionally-minded consumers contribute to maintaining legitimacy of meat consumption. For example, the butchers are reported to benefit from trustful relations with the local communities and the regionalisation trend [173]. The personal relations and interpersonal trust indicate presence of relational cohesion whereas the shared norms about meat consumptions indicate some ideational cohesion. As in Section 4.3.1.2, we conclude that the work on maintaining the old institutions takes place under the conditions of ideational and relational cohesion.

We also find that some consumers drive the erosion of meat consumption norms. As "eating is becoming a question of world view and social prestige", people with different socio-demographic backgrounds hold different views on food, follow different food-related norms and exhibit different food-related behaviour [230]. Flexitarianism is portrayed as an example of changing norms and consumption behaviours, which could aid the emergence of markets for cultured meat [86]. The discrepancies in norms and practices indicate the lack of ideational cohesion among the consumers. This condition seems to be conducive to institutional transformation where old consumption norms are eroded and new ones are created.

Furthermore, we identify failed attempts to create new institutions for meat consumption. The German Green Party pushed for reduced meat consumption in the proposal of the Veggie Day and according to media reports this contributed to the loss of voters' trust in the party and their lost election in 2017 [104]. The media reports that society is divided regarding the legitimacy of state interventions in stimulating more environmentally friendly consumption patterns, indicating a strain in the government-society relations and an absence of ideational cohesion. The lack of vertical ideational social cohesion, among the political proponents of transitions and the public seems to obstruct the institutional change, which would encourage new consumption patterns.

In contrast, state interventions that maintain the meat consumption practices are portrayed as welcome. For example, the regulatory changes, which aim to fix the food safety issues in the incumbent meat production system and enable continuation of the current consumption patterns are portrayed as legitimate and rebuilding the institutional trust between the public and the government. The "Beef Labelling Surveillance Task Transfer Act" is said to have improved food safety and protected public health after the BSE crisis [565]. This example illustrates relations between the government and the society characterised by strained ideational cohesion (appropriateness of old regulations is questioned) but intact relational cohesion (overall trust in government). As in Section 4.3.1.2, we conclude that the refinement of old practices and institutions takes place under the conditions of absent ideational cohesion and present relational cohesion. The building of acceptance for cultured meat appears to be caught into the existing divisions within the society, where food consumption practices are more cohesive within groups than across groups.

5.3.3. Topic 3: feasibility and desirability of cultured meat

5.3.3.1. *Topic 3: legitimization outcome.* This topic includes discussions about the technical process of cultured meat production, technical and market feasibility of cultured meat, its social, ecological, ethical and sensory advantages as well as investments in cultured meat start-ups.

Social benefits of cultured meat are claimed to include its potential to satisfy growing global demand for meat [48], its contribution to healthy diets [48] and reduction of global hunger [312]. These claims are based on expert opinions e.g., of Mark Post, the scientist and entrepreneur, whose team was the first in the world to present the prototype of cultured meat in a public tasting event in 2013 [312; 48]. Cultured meat entrepreneurs are reported to see ethical benefits in the production of cultured meat as, according to them, it can take place without any harm to animals [190; 48; 648; 155]. The media coverage on the ecological desirability of cultured meat is varied. Ecological benefits, such as reduced use of energy, water, land and GhG emissions are advocated by some scientists, founders of cultured meat start-ups [190; 48; 648; 302], and venture capitalists investing in cultured meat [478]. More critical articles refer to a study published by the Karlsruhe Institute of Technology and question if cultured meat's theoretical assumptions underpinning the ecological claims will be verified in practice [155; 648].

The comments on technical feasibility are also mixed. While some articles celebrate the technological milestones, such as the first cultured burger patty [302; 155] and advances in production of cultured steaks [302], others point out that it will take years until mass production at reasonable cost is possible [312; 259; 155]. The perceptions of market feasibility are rather positive. For example, significant demand for cultured meat is expected by some cultured meat entrepreneurs [312; 48] and senior figures in the meat industry [648; 478]. Other cultured meat entrepreneurs stress however that the price needs to be reduced and the use of bovine serum avoided for the markets to emerge [155]. The sensory experience of eating cultured meat was first expected to be negative [190; 312] but with time more positive expectations are reported [648].

Besides the social desirability and technical feasibility, the legitimacy is also created through reports about attractiveness of cultured meat to investors. Widely reported are investments abroad, including investments of German meat processing firms and pharmaceutical firms in cultured meat start-ups abroad [259; 302; 648; 155; 478].

5.3.3.2. *Topic 3: social cohesion in (de-)legitimation process.* The topic includes no explicit references to social cohesion and virtually no references to any dimensions of social cohesion. We find no evidence that groups or collective actors are involved in legitimization of feasibility and desirability of cultured meat. The media reporters and scientists seem to carry out the institutional work in isolation. One possible reason for this is high competition in the emerging field of cultured meat, which prevents emergence of cohesive groups and the technical nature of Topic 3, which excludes actors without technical expertise from this discourse.

5.3.4. Topic 4: market development for cultured meat

5.3.4.1. *Topic 4: legitimization outcome.* The predominant theme centres on the development of a market for cultured meat. In contrast to Topic 3, it places a greater emphasis on business aspects rather than technical aspects. In the early 2010s, investments in research on cultured meat were accompanied by comments about a long way to market [334, 217, 279] and low market readiness [279, 287]. In the late 2010s, emerging market opportunity was discussed: the declining turnover in the German meat industry in 2018 and the growing turnover of incumbent meat producers from their plant-based meat alternative products [118]. In early 2020s, there are many positive reports about market development, including the first worldwide market entry of cultured meat in 2020 in Singapore [597] and other planned market entries in the near future [73, 291, 555], cultured media products on the market [597], ongoing product developments [555], and decreasing production costs, which are seen as a key obstacle to market formation [282; 597]. Media reports advancements in production techniques that are expected to facilitate market development, including the development of a growth medium that lowers production costs and enable scale-up [597], cultivation of meat without genetic modification, which improves market acceptance [555] and 3D printing techniques for cultured meat that enable better textured products [126].

While the market-focused discussions tend to be positive, occasional negative opinions also appear. In 2016, for example, arguments are made to reduce or forbid 'artificial meat substitutes' or label them as 'laboratory meat' [84] and in 2018 cultured meat is portrayed as unnatural and unnecessary, as demand for food is seen to be well met and ecological meat production is seen as a better alternative [615].

An important sub-theme is about the emerging strategic partnerships between the incumbent meat processing/pharmaceutical companies and culture meat entrepreneurs and scientists, which are supposed to facilitate the scale-up and market entries. Examples include a partnership between the Technical University Darmstadt, Merck and the Tufts University focused on the development of bioreactors for a large-scale production of cultured meat [126; 282] and a partnership between the meat processing firm PHW and Supermeat start-up for the product development and market introduction [118].

5.3.4.2. *Topic 4: social cohesion in (de-)legitimation process.* We find an example illustrating how incumbent actors - namely butchers - maintain the legitimacy of meat production under the changing market conditions. The members of the Bavarian Butchers' Association, one of the 15 German guild associations for butchers, help each other, share knowledge and engage politically in their common interest. The group jointly tackles business problems, such as staff shortages, through e.g. training of new generations and reproduction of meat cutting practices and tries to sustain the viability of the incumbent production patterns [128]. Given their relations, some shared values, mutual help and collective political engagement of the butchers, it is concluded that the work on maintaining the old

practices and institutions takes place under the conditions of ideational and relational cohesion.

We also find that incumbents (meat processing [73, 118], and pharmaceutical companies [118, 126,282]) form relations with cultured meat developers to help preserve their business models and hence the institutional order. The above-mentioned partnerships signify emerging relational and ideational connectivity among these actors as they seem to share the market logic and the vision for future production of animal proteins. The conditions of ideational and relational cohesion seem conducive to knowledge production, which (if successful) could allow meat processing and pharmaceutical companies to reproduce their business practices in the future.

6. Discussion

6.1. NLP-based legitimacy analysis of cultured meat in Germany

Similar to [Dehler-Holland et al. \(2021\)](#) and [Weiss and Nemeček \(2021\)](#), our study exploits NLP-tools to map the aggregated legitimacy dynamics, providing new empirical insights into the legitimacy of cultured meat in Germany over the period 2011–2021. Given its high media attention and strong sentiment throughout the years, Topic 1 can be said to dominate the public discourse, while Topics 3 and 4 also contribute positively but to a lesser extent. Conversely, worsening sentiment associated with Topic 2 undermines the legitimacy of cultured meat in Germany, potentially affecting its development.

Based on the content of each topic, our results suggest that the legitimacy outcome is intertwined with struggles of the prevailing regime, i.e., adaptation efforts of meat sector incumbents to rising sustainability concerns and changing consumer preferences. Thus, our analysis indicates that the legitimization of cultured meat TIS is still in its initial stages and is heavily reliant on changes in the broader context ([Markard, 2020](#)). This is a similar observation to that made in the early years of biogas ([Markard et al., 2016](#)) and potable water reuse ([Binz et al., 2016](#)).

6.2. Mixed-method approach for studying TIS legitimization

Our novel mixed-method approach allowed us to observe interesting associations between the legitimacy outcome and social dynamics of the legitimization process. First, we observe that topics with fairly stable sentiment are associated with many socially cohesive relations, such as Topic 1 and Topic 4. For Topic 1 this coincides with the presence of socially cohesive groups from the regime that act for stability and continuity of the incumbent food system and delegitimizing of the emerging TIS. Likewise, Topic 4 is associated with cohesive regime groups but also by emerging cohesive relations between cultured meat and regime actors. The presence of such groups seems to be mediated by the institutional structures in the incumbent system.

Second, we observe that the worsening sentiment in Topic 2 is associated with social relations that appear to be ideationally non-cohesive. The discourse in this topic revolves also around strains in relations between citizens who value the status quo of dietary habits and political actors who are promoting change. Moreover, there seems to be a weakening of societal social cohesion that is conducive to the emergence of groups embracing change. They are however unconnected with mainstream ideals and have little power to influence discourse.

Third, for Topic 3 we observe that strengthening of a positive sentiment can take place in absence of socially cohesive collective actions. This corresponds with individual advocates generating excitement around the niche, as well as some emerging groups of scientists and entrepreneurs supporting cultured meat. We find no institutionalised groups or dedicated networks contributing to these legitimacy outcomes.

Overall, the combination of outcome-orientation and process-orientation indicates that the media attention and sentiment correspond with the presence or absence of socially cohesive groups from both the cultured meat TIS and the established regime. We observe that significant changes in the sentiment on a topic are accompanied by either strain on existing social and ideational relations. This insight resonates with [Binz et al. \(2016\)](#), who observe institutional work aimed at actor relations and public support during phases when a TIS is contested in the public discourse. Similarly, [Kishna et al. \(2017\)](#) and [Genus and Iskandarova \(2020\)](#) emphasise efforts to build new relationships between actors. Interestingly, we observe that positive sentiment and media attention of a topic can emerge absent of associated socially cohesive groups. Related to literature on technology hypes, this phenomenon could be propelled by significant events such as substantial investments into technology startups or press releases of successful prototypes by companies that are picked-up and disseminated by journalists through mass-media ([Dedehayir and Steinert, 2016](#); [Geels and Verhees, 2011](#); [Kriechbaum et al., 2021](#)). This illustrates that our approach is capable of capturing the multifaceted aspects of legitimization processes.

6.3. Social cohesion as a novel perspective on TIS legitimacy creation

The study contributes to the emerging discussion on the role of social cohesion in the (de)legitimation of socio-technical change. While a recent study shows that social cohesion can facilitate trust in new technology, and consequently its acceptance and diffusion ([Kamide, 2021](#)), our study reveals that the relation between social cohesion and technological change is much more complex. On the basis of our findings, we are able to validate a few propositions about the role of social cohesion in legitimization presented in our framework (see [Table 4](#)).

We find that under the conditions of ideational relatedness to the mainstream, actors engage in reproducing practices and norms of the dominant institutional field and hence prolong the legitimacy of the incumbent modes of production and consumption ('institutional maintenance') or they resist institutional change by delegitimizing potentially disruptive innovations ('institutional resistance'). Conversely, under conditions of ideational dissent with the mainstream, actors drive institutional change by refining existing

institutions ('institutional optimisation') or creating new ones in place of the old ones ('institutional transformation').

The observed instances of institutional transformation were performed by individual actors (e.g. scientists and entrepreneurs) and collective actors (e.g. green party, activist groups), which aligns with the well-established notions of individual/heroic entrepreneurs and collective institutional entrepreneurship (Garud et al., 2007; Battilana et al., 2009). All identified instances of institutional entrepreneurship are directed towards eroding incumbent institutions and creating new ones instead but the actors pursue various goals and their efforts are not coordinated. This resonates with the observation made by Hoogstraaten et al. (2020) that institutional entrepreneurship can be characterised by dispersed collective agency.

For the proposed here notion of 'institutional optimization' we find examples of institutional entrepreneurship in a highly institutionalised field (meat production) carried out by incumbent collective actors, who have high status and a central social position within the institutional field. This is in line with the observation of Battilana et al. (2009) that central actors can engage in institutional entrepreneurship. Our study suggests that such forms of institutional work are directed at refining old practices or adding new practices that align and complement the existing ones.

Overall, our findings suggests that a breakdown in social cohesion is conducive to legitimising change and hence for socio-technical transitions. However, given the exploratory nature of our study, these propositions need to be validated in future studies

7. Conclusions

Legitimacy is an essential aspect for the emergence and broad adoption of new technologies. It helps to mobilize resources for innovation activities within a TIS and gathers support from key stakeholders. The aim of our study was to examine the legitimation process of a new technology, specifically cultured meat, by taking the outcome-oriented perspective and the process-oriented perspective, aided by the concepts of social cohesion.

In this light, our study contributes to the literature on TIS legitimacy in three ways. First, we make an empirical contribution by revealing the overtime dynamics in the aggregate legitimacy of cultured meat in Germany, specifically about the four topics in the public discourse in which cultured meat is discussed alongside conventional meat and transformational changes in the agri-food system. Second, the study introduces a novel mixed-method approach, which, unlike previous studies, enables us to investigate both long-term legitimacy outcomes and the underlying social dynamic during early stages of a TIS development. Third, on the conceptual level the study represents the first step in integrating social cohesion as a structured means to analyse TIS legitimation processes, gives insights into how social cohesion among actors creates the social conditions for legitimation and delegitimation processes.

Nevertheless, study is subject to some limitations. First, we acknowledge the possibility that our findings are influenced by the specific database, article types, and keywords we used. Therefore, in order to ensure the validity of our insights, future research should broaden its scope by exploring various combinations of keywords and sources such as social media, industry associations, scientific studies, and political stakeholders. Second, the NLP approach, like any automated text analysis method, is vulnerable to errors stemming from imprecise sentiment scores or topic assignments. These errors can arise from complexities such as sarcasm, intricate negations, or multiple topics within a single article (Lane et al., 2019). To address such challenges, more sophisticated approaches can be employed (e.g., O'Hare et al., 2009, Xianghua et al., 2013, Hain et al., 2023). However, it's crucial to weigh the benefits of improved accuracy against the costs of reduced flexibility, as more advanced necessitate expensive training data and domain expertise (Weiss and Nemeček, 2021). Third, our research utilizes a qualitative text analysis based on an inductive categorization. While this approach enables us to gain a deeper understanding of the nuances and complexities within our data without predefined outcomes, it also poses challenges to generalising the results. Thus, we only assert the analytical generalizability of this study (cf. Binz et al., 2016). Relatedly, our results do not claim causal effects between the observed legitimacy outcomes on the aggregated level and the corresponding social cohesion patterns on the actor-level. Therefore, future research should build on our approach and extend the analysis to establish cause-and-effect mechanisms.

Last but not least, this research offers only the first step towards unpacking the role of social cohesion dynamics in development and diffusion of technological innovation. Further research is necessary to examine how ideational and relational social cohesion shapes other system-building processes in a TIS.

CRedit authorship contribution statement

D. Weckowska: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Supervision. **D. Weiss:** Methodology, Formal analysis, Software, Data curation, Visualization, Writing – original draft, Writing – review & editing. **V. Fiala:** Formal analysis, Writing – review & editing. **F. Nemeček:** Methodology, Formal analysis, Software. **F. Voss:** Investigation. **C. Dreher:** Funding acquisition, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Weckowska D., Weiss D., Fiala, V., Voss, F., Dreher, C. reports financial support was provided by Berlin University Alliance, grant number 111_MC_SocCoh_5.

Table 4
Summary of findings from qualitative analysis.

Topic	Actors	Story	Cohesion	(De-)Legitimation
1	Communities of hunters	Present the killing of animals as respectful and ethical, thus defending the existing norms and values shared by the community	Ideational & relational relatedness	Institutional maintenances
2	Meat producers and consumers	Trustful relations between regionally-minded consumers and local butchers perpetuate the production and consumption of high-quality regional meat products.		
4	Meat processors and cultured meat start-ups	Larger, incumbent meat processing firms form relations with cultured meat developers to preserve their overall business model. They jointly maintain the dominant market logic.		
4	Butchers Association	Members of butcher association jointly tackle business problems under changing market conditions.		
1	Butchers Association	Calling out "black sheep" among butchers who do not make their production practices more sustainable to the detriment of the butchers' community as a whole.	Relational relatedness but not ideational	Institutional optimisation
2	Government - society	The German government took action to increase meat safety and quality to enable the continuation of the current meat production system and restore trust.		
1	top German chef and his fellow chefs	Top chef advocates that the chef community should reject cultured meat in favour of existing culinary practices and norms (such as the value of high-quality conventional meat).	Ideational relatedness but no relational	Institutional resistance
2	Green Party – voters	The German Green Party tried to introduce a "veggie day". (The creation of the new institution failed due opposition from many parts of society → institutional resistance).	No ideational and relation relatedness	Institutional transformation
1	Protesters and meat producers	Strong protests against certain types of industrial meat production (Schweine-stall-aktion) with the aim of destroying old institutions.		
2	Consumers	Consumers are driving the erosion of meat consumption norms, as different dietary habits (such as veganism or flexitarianism) become a means of differentiating themselves from the mainstream.		

Data availability

Data will be made available on request.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.eist.2024.100871](https://doi.org/10.1016/j.eist.2024.100871).

References

- Antadze, N., McGowan, K.A., 2017. Moral entrepreneurship: thinking and acting at the landscape level to foster sustainability transitions. *Environ. Innov. Soc. Transit.* 25, 1–13.
- Avery, E.E., Hermsen, J.M., Kuhl, D.C., 2021. Toward a better understanding of perceptions of neighborhood social cohesion in rural and urban places. *Soc. Indic. Res.* 157, 523–541.
- Battilana, J., Leca, B., Boxenbaum, E., 2009. 2 How actors change institutions: towards a theory of institutional entrepreneurship. *Acad. Manag. Annals* 3, 65–107.
- Bento, N., Fontes, M., 2019. Emergence of floating offshore wind energy: technology and industry. *Renewable Sustain. Energy Rev.* 99, 66–82.
- Bento, N., Fontes, M., 2021. Legitimacy and guidance in upscaling energy technology innovations.
- Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., Rickne, A., 2008. Analyzing the functional dynamics of technological innovation systems: a scheme of analysis. *Res. Policy.* 37, 407–429.
- Berger-Schmitt, R., 2000. Social Cohesion As an Aspect of the Quality of societies: Concept and Measurement. ZUMA Mannheim.
- Binz, C., Harris-Lovett, S., Kiparsky, M., Sedlak, D.L., Truffer, B., 2016. The thorny road to technology legitimation—Institutional work for potable water reuse in California. *Technol. Forecast. Soc. Change* 103, 249–263.
- Botterman, S., Hooghe, M., Reeskens, T., 2012. One size fits all? An empirical study into the multidimensionality of social cohesion indicators in Belgian local communities. *Urban Studies* 49, 185–202.
- Bottoni, G., 2018. A multilevel measurement model of social cohesion. *Soc. Indic. Res.* 136, 835–857.
- Chan, J., To, H.-P., Chan, E., 2006. Reconsidering social cohesion: developing a definition and analytical framework for empirical research. *Soc. Indic. Res.* 75, 273–302.
- Clemens, E.S., Cook, J.M., 1999. Politics and Institutionalism: explaining Durability and Change. *Annu Rev. Sociol.* 25, 441–466.
- Dedehayir, O., Steinert, M., 2016. The hype cycle model: a review and future directions. *Technol. Forecast. Soc. Change* 108, 28–41.
- Dehler-Holland, J., Okoh, M., Keles, D., 2021. The legitimacy of wind power in Germany. Working Paper Series Prod. Energy.
- Dickes, P., Valentova, M., 2013. Construction, validation and application of the measurement of social cohesion in 47 European countries and regions. *Soc. Indic. Res.* 113, 827–846.
- DiMaggio, P.J., Powell, W.W., 1983. The iron cage revisited: institutional isomorphism and collective rationality in organizational fields. *Am. Sociol. Rev.* 147–160.
- Deitelhoff, N., Groh-Samberg, O., Middell, M., Schmelzle, C., 2020. Gesellschaftlicher Zusammenhalt – Umrisse eines Forschungsprogramms. In: Deitelhoff, N., Groh-Samberg, O., Middell, M.E. (Eds.), *Gesellschaftlicher Zusammenhalt. Ein interdisziplinärer Dialog*, Campus, Frankfurt/New York.

- Dragolov, G., Ignác, Z.S., Lorenz, J., Delhey, J., Boehnke, K., Unzicker, K., 2016. Social Cohesion in the Western world: What holds Societies together: Insights from the Social Cohesion Radar. Springer.
- Freeman, J., Carroll, G.R., Hannan, M.T., 1983. The liability of newness: age dependence in organizational death rates. *Am. Sociol. Rev.* 692–710.
- Fiala, V., Jacob, K. 2023. IFST - social cohesion indicator guidelines a starting point for measuring social cohesion in food systems. IFST Discussion Papers. Berlin. Available at: www-ifst-berlin.de.
- Geels, F.W., Verhees, B., 2011. Cultural legitimacy and framing struggles in innovation journeys: a cultural-performative perspective and a case study of Dutch nuclear energy (1945–1986). *Technol. Forecast. Soc. Change* 78, 910–930.
- Genus, A., Iskandarova, M., 2020. Transforming the energy system? Technology and organisational legitimacy and the institutionalisation of community renewable energy. *Renewable Sustainable Energy Rev.* 125, 109795.
- Goubin, S., 2018. Is inequality a latent construct? An assessment of economic inequality indicators and their relation with social cohesion in Europe. *Soc. Indic. Res.* 136, 21–40.
- Garud, R., Hardy, C., Maguire, S., 2007. Institutional entrepreneurship as embedded agency: an introduction to the special issue. *Organ. Stud.* 28 (7), 957–969.
- Hain, D., Jurowetzki, R., Lee, S., Zhou, Y., 2023. Machine learning and artificial intelligence for science, technology, innovation mapping and forecasting: review, synthesis, and applications. *Scientometrics*. 1–8.
- Hekkert, M.P., Suurs, R.A.A., Negro, S.O., Kuhlmann, S., Smits, R.E.H.M., 2007. Functions of innovation systems: a new approach for analysing technological change. *Technol. Forecast. Soc. Change* 74, 413–432.
- Hoogstraaten, M.J., Frenken, K., Boon, W.P., 2020. The Study of Institutional Entrepreneurship and Its Implications For Transition Studies, 36. *Environmental Innovation and Societal Transitions*, pp. 114–136.
- Hoogstraaten, M.J., Frenken, K., Vaskelainen, T., & Boon, W.P. (2023). Replacing meat, an easy feat? The role of strategic categorizing in the rise of meat substitutes. *Environmental Innovation and Societal Transitions*, 47, 100703.
- Isoaho, K., Markard, J., 2020. The politics of technology decline: discursive struggles over coal phase-out in the UK. *Rev. Policy Res.* 37, 342–368.
- Jansma, S.R., Gosselt, J.F., Kuipers, K., de Jong, M.D., 2020. Technology legitimization in the public discourse: applying the pillars of legitimacy on GM food. *Technol. Anal. Strateg. Manage* 32, 195–207.
- Kamide, H., 2021. The effect of social cohesion on interest, usefulness, and ease of use of a driving assistance system in older adults. *Int. J. Environ. Res. Public Health* 18, 11412.
- Kayser, V., 2017. Comparing public and scientific discourse in the context of innovation systems. *Technol. Forecast. Soc. Change* 115, 348–357.
- Kishna, M., Niesten, E., Negro, S., Hekkert, M.P., 2017. The role of alliances in creating legitimacy of sustainable technologies: a study on the field of bio-plastics. *J. Clean. Prod.* 155, 7–16.
- Köhler, J., Geels, F.W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., Alkemade, F., Avelino, F., Bergeck, A., Boons, F., 2019. An agenda for sustainability transitions research: state of the art and future directions. *Environ. Innov. Soc. Transit.* 31, 1–32.
- Konrad, K., Markard, J., Ruef, A., Truffer, B., 2012. Strategic responses to fuel cell hype and disappointment. *Technol. Forecast. Soc. Change* 79, 1084–1098.
- Kriechbaum, M., Posch, A., Hauswiesner, A., 2021. Hype cycles during socio-technical transitions: the dynamics of collective expectations about renewable energy in Germany. *Res. Policy*. 50, 104262.
- Lane, H., Hapke, H.C., Hapke, H., 2019. *Natural Language Processing in Action: Understanding, Analyzing, and Generating Text With Python*. Manning Publications Company, New York, NY, USA.
- Lawrence, T.B., Suddaby, R., 2006. Institutions and institutional works. Eds.. In: Clegg, C., Hardy, T.B., Lawrence, W.Nord (Eds.), *The Sage Handbook of Organizational Studies*. Sage Publications, London, pp. 215–254.
- Loorbach, D., Frantzeskaki, N., Avelino, F., 2017. Sustainability transitions research: transforming science and practice for societal change. *Annu Rev. Environ. Resour.* 42, 599–626.
- Markard, J., 2020. The life cycle of technological innovation systems. *Technol. Forecast. Soc. Change* 153, 119407.
- Markard, J., Raven, R., Truffer, B., 2012. Sustainability transitions: an emerging field of research and its prospects. *Res. Policy*. 41, 955–967.
- Markard, J., Wirth, S., Truffer, B., 2016. Institutional dynamics and technology legitimacy - a framework and a case study on biogas technology. *Res. Policy*. 45, 330–344.
- Mayring, P., 2004. Qualitative content analysis. *Companion Qual. Res.* 1 159–176.
- Mylan, J., Morris, C., Beech, E., Geels, F.W., 2019. Rage Against the regime: Niche-regime interactions in the Societal Embedding of Plant-Based Milk, 31. *Environmental Innovation and Societal Transitions*, pp. 233–247.
- O'Hare, N., Davy, M., Bermingham, A., Ferguson, P., Sheridan, P., Gurrin, C., Smeaton, A.F., 2009. Topic-dependent sentiment analysis of financial blogs. In: *Proceedings of the 1st international CIKM workshop on Topic-sentiment analysis for mass opinion*. Association for Computing Machinery, New York, NY, USA, pp. 9–16.
- Rohe, S., Chlebna, C., 2021. A spatial perspective on the legitimacy of a technological innovation system: regional differences in onshore wind energy. *Energy Policy* 151, 112193.
- Rosenbloom, D., Berton, H., Meadowcroft, J., 2016. Framing the sun: a discursive approach to understanding multi-dimensional interactions within socio-technical transitions through the case of solar electricity in Ontario, Canada. *Res. Policy* 45, 1275–1290.
- Schiefer, D., Van der Noll, J., 2017. The essentials of social cohesion: a literature review. *Soc. Indic. Res.* 132, 579–603.
- Sewell, W.H., 1992. A theory of structure: duality, agency, and transformation. *Am. J. Sociol.* 98, 1–29.
- Weckowska, D., Barnickel, C., Feindt, P., Dreher, C., 2022. Towards a framework for inclusive food systems transitions. In: *13th International Sustainability Transitions Conference*. Online.
- Weiss, D., 2022. *Technological innovation systems: a critical review of quantitative methods*. Copernicus Institute of Sustainable Development, EU-SPRI 2022 Conference, Utrecht University, Netherlands.
- Weiss, D., Nemeček, F., 2021. A text-based monitoring tool for the legitimacy and guidance of technological innovation systems. *Technol. Soc.* 66, 101686.
- Weiss, D., Nemeček, F., 2022. A media-based innovation indicator: examining declining technological innovation systems. *Environ. Innov. Soc. Transit.* 43, 289–319.
- Xianghua, F., Guo, L., Yanyan, G., Zhiqiang, W., 2013. Multi-aspect sentiment analysis for Chinese online social reviews based on topic modeling and HowNet lexicon. *Knowl. Based. Syst.* 37, 186–195.