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Strategic framing of genome editing in agriculture: an analysis of the debate in Germany in the run-up to the European Court of Justice ruling

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Abstract
New techniques in genome editing have led to a controversial debate about the opportunities and uncertainties they present for agricultural food production and consumption. In July 2018, the Court of Justice of the European Union defined genome editing as a new process of mutagenesis, which implies that the resulting organisms count as genetically modified and are subject, in principle, to the obligations of EU Directive 2001/18/EG. This paper examines how key protagonists from academia, politics, and the economy strategically framed the debate around genome editing in agriculture in Germany prior to its legal classification by the Court of Justice. It is based on an analysis of 96 official statements, including position papers, press releases, and information brochures. Our study reveals eight strategic frames used in the discourse on genome editing and uncovers the strategies used to disconnect from or connect with the previous discourse on green genetic engineering in the 1970s, 1980s and 1990s. Building on competitive framing theory, the study provides explanations for the use and emergence of counter-framing strategies and their success or failure in the debate around genome editing.

Keywords Genome editing · CRISPR · Agricultural biotechnology · European Court of Justice · Strategic framing · Competitive framing theory

Abbreviations

GE	Genome Editing
ECJ	European Court of Justice
NGO	Non-governmental organization
GMO	Genetically modified organisms
CRISPR	Clustered regularly interspaced short palindromic repeats
EC	European Commission

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Introduction

New techniques in genome editing (GE) have led to a controversial debate about the opportunities and uncertainties[1] they present for agricultural food production and consumption (Bartkowski et al. 2018). Proponents of the new techniques argue that, by specifically modifying genetic material, more resistant and productive organisms can be cultivated more cheaply, more easily, and at a faster rate compared to previous genetic engineering methods (Georges and Ray 2017; Huang and Puchta 2019; King et al. 2017). By contrast, opponents point out that the uncertainties associated with GE are not sufficiently known, that it would not fundamentally solve the problems of our current agricultural food system, and that rather, it would shift them elsewhere or even exacerbate them (e.g. Then and Bauer-Panskus 2017).

The controversies around the potentials and uncertainties of novel GE were one of the reasons that the European Court of Justice (ECJ) wanted to create legal clarity around

[1] Following Park and Shapira (2017), we define uncertainty as a situation in which information is not available to the decision-maker and risk as a situation in which the decision outcomes and their probabilities of occurrence are known to the decision-maker.

the status of new mutagenesis methods, which came into force on July 25, 2018. A regulatory approach would limit the prospects of research and development in this area as well as the commercial exploitation of the new technology in Europe (Davison and Ammann 2017; Jones 2015), whereas the non-regulation and non-declaration of GE products would revive the concerns of protagonists about food security and health. Accordingly, in the years prior to the ruling, political, economic, and scientific institutions and non-governmental organizations (NGOs) contributed their positions on GE to the public discourse in an effort to influence the political decision-making process (Bartkowski and Baum 2019; Castellari et al. 2018; Pirscher and Theesfeld 2018). This was also evident in Germany, a country where the debate on genetically modified organisms (GMOs) has always been intense and where the state has used its discretionary powers to create a very strict system for controlling GMO releases based on European legislation.

This study aims to understand how the proponents and opponents of GE regulation strategically framed the GE discourse in the run-up to the ECJ ruling in 2018. It examines the re-framing of frames from the previous discourse on GE, the emergence of new frames, and the competition between individual frames (counter-frames), with the two sides having contributed to the formation of a perception in the political debate on genetic engineering (Dewulf 2013). Building on competitive framing theory, it provides explanations for the use and emergence of frames and the success and failure of the framing strategies used in the GE debate.

The paper is structured as follows. The next section introduces the controversial debate around GE and some background information about the new technological methods in genetic engineering. Following this, we outline the strategic framing and counter-framing theorization, which can be seen as a rich theoretical lens through which to describe the discourse on genetic engineering and the strategies of individual actors in influencing the debate around GE in agriculture. In the methods section, we describe the study context, data collection, and analysis. This is followed by a presentation and discussion of the findings, after which conclusions are drawn.

Background and theory

Genome editing as a controversial regulatory issue

With the help of new molecular biological methods in GE—among which the so-called clustered regularly interspaced short palindromic repeats (CRISPR) and the CRISPR-associated protein (Cas) (CRISPR/Cas) systems are the most widespread—selective changes can be made to the DNA (the carrier of genetic information) of plants, animals, and microorganisms. This is done through a cut at a defined position and the subsequent mutation of a single base or entire base sequences in the DNA introduced by the cell's own repair mechanisms. Since the discovery of CRISPR/Cas by Jennifer Doudna and Emmanuelle Charpentier in 2012, a new tool for genetic modification has become available, which has attracted attention in various fields, such as biology, medicine, and plant breeding (Jinek et al. 2012). In plant breeding, the targeted introduction of mutations into the genome of cultivated plants allows these plants to be modified in such a way that specific breeding objectives, such as yield increase, disease resistance, and improvement of product quality, can be achieved.

A highly controversial discussion has arisen about the potentials and uncertainties associated with these methods, especially the question of whether organisms modified by GE should be defined as "classical breeding" or "genetically modified." Behind this is the question of how the term GMO should be understood, that is, whether it should be defined in terms of the process of product manufacture (process-oriented) or exclusively in terms of the end product (results-oriented). There is a labeling obligation accompanying regulation as genetic engineering calls into question the attractiveness and penetration power of GE, at least in Europe. Due to time-consuming and cost-intensive approval procedures for GMOs, proponents of GE fear that economically strong and scientifically relevant players could withdraw from the European continent. Critics of genetic engineering fear the reverse; that is, in the case of recognition as classical breeding, the precautionary principle will be violated, with the help of which negative ecological and health effects of a new product may be identified before it can be approved for the market. Furthermore, a regulation and labeling obligation would make the successful marketing of such products in Europe more difficult since European, particularly German, consumers are skeptical about genetically engineered products (Spetsidis and Schamel 2001).

On July 25, 2018, the ECJ finally ruled that organisms obtained by mutagenesis fall under the GMO Directive 2001/18/EC of the European Parliament and must, therefore, be regulated as genetic engineering moving forward. Exceptions to this rule are classical procedures and methods of mutagenesis, since, according to the ECJ's ruling, these have long been considered safe (ECJ 2018). Where exactly the dividing line between new and old mutagenesis procedures is drawn and how this lack of clarity can be dealt with remain unclear in the written justification of the judgement. However, the ECJ clarified that the term GMO is understood to be exclusively process-oriented and that the lack of discernibility of natural and artificial mutations within the end product is, therefore, irrelevant to the definition.

The paper examines the pre-judgment period, which was characterized by a controversial debate in which proponents and opponents of the regulation[2] of GE brought their views into the discourse on the legal classification of GE, both sides vying for interpretive sovereignty. Using the case of Germany, this study analyzes position papers, press releases, and information brochures published by these protagonists in their attempt to influence the public and political opinion-forming process. A useful theoretical lens for analyzing the framing strategies used to influence the policy-making process is provided by strategic framing and competitive framing theory.

Strategic framing and competitive framing theory

The strategic framing perspective recognizes that institutions, organizations, and actors attempt to establish their positions and values in a discourse on generally controversial topics and defend them against competing frames (Matthes and Kohring 2008). It is used as a strategic tool to represent reality, problematize a situation, and, thus, arrive at a desired reaction or interpretation of a topic (Entman 1993). The aim of framing is "to select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation and/or treatment recommendation for the item described" (Entman 1993, p. 56). If a message resonates with the recipient—that is, if it confirms, reinforces, or questions the recipient's opinions—then a strategic frame is considered successful (Benford 1993; Benford and Snow 2000).

Framing research generally offers prospects for developing a capacious and temporal understanding of how a political debate unfolds and how political orientations come to be (Pan and Kosicki 2001, p. 39). For example, Rahn et al. (2017) explained the success of raw milk activists' framing strategies in state legislatures, including consumer choice and food freedom, which tend to resonate more among the public than other frames. Similarly, though drawing on the sociotechnical imaginaries literature, Bain et al. (2020) examined how GE proponents are imagining the potential benefits and uncertainties of corresponding technologies within agriculture in their public statements to the US Food and Drug Administration. These studies do not only reveal how actors attempt to shape perceptions of uncertainties and benefits to ultimately influence regulatory action; they also demonstrate the politics of contested frames. As Gamson (1992, p. 135) put it, "No topic emerges without a counter-topic," that is, the competition between different frames for dominance is never seen to be static but subject to a continuous interplay of action and reaction (Kohring and Matthes 2002; Johnston 2009).

In the competition for dominance, a counter-frame directly addresses the frame it opposes by attempting to invalidate it. "They [social movements] frame, or assign meaning to and interpret, relevant events and conditions in ways that are intended to mobilize potential adherents and constituents, to garner bystander support, and to demobilize antagonists" (Snow and Benford 1988, p. 198). According to the definition of Chong and Druckman (2011), a counter-frame must fulfill the following three criteria: a counter-frame occurs at a time offset from the challenged frame; it represents a fundamentally opposite position to the challenged frame; and it challenges only those frames with greater influence on opinions in the discourse in the past. That counter-frames can undermine the effects of original frames is shown, for example, by Aklin and Urpelainen (2013), who analyzed public support for clean energy in the US and revealed that not only can single frames and arguments trigger support or opposition to clean energy but also that counter-frames can neutralize positive and negative arguments.

Appreciating the relationship between strategic frames and the dynamics of strategic framing suggests that the analysis also pursues the question of the extent to which "old" frames that have been tried and tested in a previous discourse are given new meaning and reframed. In reframing, actors attempt to place existing frames in a new context and, thus, generate a new semantic interpretation of information (Goffman 1974). Goffman (1974) showed that frames that were already successfully established in a discourse were capable of transporting necessary information to recipients in a new context. Such a strategy can also be effective with argumentative repertoires. In his study on organic and genetically modified labeling, Klintman (2002, p. 247) explained how "argumentative cross-overs" into the opponent's type of argumentation can be used to shift argumentation for a closely related issue. Building on this, this study examines a potentially transformative process from the content structure of the pre-existing frames used in the previous discourse on genetic engineering to the frames in the current debate on GE.

A starting point for analyzing and building frames around GE is to look at earlier studies on GMO frames in Germany and internationally and how they have changed since the 1970s (e.g. Durant et al. 1998; Gaskell and Bauer 2001). These studies drew predominantly on media analysis to enhance our understanding of framing processes and the various arguments of proponents and opponents of genetic engineering (e.g. Bonfadelli 2017; Brossard et al. 2007; Görke et al. 2000;

[2] Our analysis does not differentiate between supporters and opponents of GE. Rather, we distinguish between supporters and opponents of regulation through the ECJ. Individual actors have been seeking the regulation of GE, despite seeing the potential of the new technology.

Gschmeidler and Seiringer 2012; Hampel 2012; Hampel et al. 1998; Kohring and Matthes 2002; Matthes and Kohring 2008; Marks et al. 2007; Navarro et al. 2011). More recently, media studies have also turned to the analysis of GE, exploring, for example, the influence of the popular media's framing of a single controversial event regarding CRISPR (Gurev 2017), the definition of CRISPR/Cas and the presentation of its risks and opportunities in the North American popular press (Marcon et al. 2019), and how different metaphors in the German and English press affect public opinion on new genetic engineering methods (Lee 2020).

GE has also become the subject of strategic framing and perception studies. A growing number of studies have examined the spectrum of public perceptions of GE and its labeling (e.g. Weisberg et al. 2017; Shew et al. 2018; Cui and Shoemaker 2018; Kato-Nitta et al. 2019; Ferrari et al. 2020). Based on interviews with technology-critical European NGOs, Helliwell et al. (2017) pointed out that their opposition to GMOs was mainly driven by skepticism about the strategic framing of the problems and solutions of GE by their opponents and not, as is often wrongly assumed, by emotions and dogmas. The danger of overestimating scientific findings and the resulting loss of public credibility in science due to the media's re-interpretation of strategic frames from scientific press releases was shown by Grochala (2019). Besides these perception-related studies, Doxzen and Henderson's (2020, pp. 869–876) call for scientific communicators to gain interpretive sovereignty through the "opportunity to frame a new CRISPR narrative" before GE "becomes politicized, regulations are solidified, and companies stake their claims" underlines the importance of the strategic framing of the GE discourse. Furthermore, the analysis by Dürnberger (2019) of diverse normative views of the term "nature" in the current protest against GMOs as well as the analysis by Aerni (2018) of the strategic use of the term GMO offer many points of contact with our study. Findings from a comparatively broad study of strategic frames were reported by Bauer and Bogner (2020). Based on several public dialogue events in Europe between 2013 and 2017, Bauer and Bogner concluded that strategic frames, which previously tended to discredit biotechnology, such as ethics, risks, and economics, are losing dominance in favor of a frame on the potential for social progress. We now set out the research design through which our research question is addressed: How have proponents and opponents of GE regulation strategically framed the discourse on GE in the run-up to the ECJ ruling in 2018?

Research design

Context of study

German policy in the 1980s enforced the precautionary principle of risk-aversion in combatting environmental problems such as acid rain, global warming, and pollution in the North Sea (O'Riordan and Jordan 1995). Germany has been a strong driver in enforcing the precautionary principle as a basic principle of European environmental, health, and food safety policy. This environmental policy orientation reflects the fundamental interests of opponents of genetic engineering. Moreover, NGOs such as Greenpeace have always enjoyed a high degree of credibility in German society, influencing public opinion and, thus, indirectly influencing political decision-making processes (Peters and Sawicka 2007). For example, Peter and Sawicka (2007) attribute the fact that no product with a GMO label has been able to establish itself in the German food market so far, thanks to Greenpeace's very effective strategy of publicly condemning and branding food companies and retailers by calling for boycotts of purchases of genetically modified products or publishing shopping guides for food without genetic engineering.

Aretz (2000) prognosticated the decades-long controversy over genetic engineering with strongly polarized camps as rooted in the barely existing involvement of smaller critical groups in the political decision-making process at the start of the negotiations on the legal regulation of genetic engineering. While various interest groups were involved in the legal debates on GMOs in the United States, influential industrial, scientific, and political associations that "shared a positive view of mainstream science" (Peters and Sawicka 2007, p. 63) were said to have played an increasingly privileged role in the legal debate in Germany. The expansion of policy influence over the decades has been viewed with suspicion by NGOs and other GMO opponents and can also be seen as one reason for the highly controversial debate over GMOs in Germany, even by European standards (Aretz 2000; Siebert et al. 2021). This is manifested in, for example, distrust of reports on genetic engineering by the Federal Ministry of Food and Agriculture and the Federal Office of Consumer Protection and Food Safety (Lorch and Then 2008). Overall, with the exception of nuclear energy, no other issue has polarized German society in the last four decades and provoked such controversy as the debate on the application and regulation of green genetic engineering (Peters and Sawicka 2007).

Furthermore, in contrast to the neoliberal notion that "any state intervention is an infringement on liberty" (Brandl and Glenna 2017, p. 630), German policy promotes cooperation and the sharing of ownership and

consumption rights between different economic and scientific biotechnological interest groups. As these collaborations are often based on longstanding relationships that have been "handed down over generations" (Brandl and Glenna 2017, p. 633), they likely also favor the formation of highly influential cartels that have so far stymied democratic debate on innovation (Streeck 2005). However, the regulation of genetic engineering applications under stricter rules in German legislation is due to the fact that scientific research is defined as a nonexclusive and, thus, non-rivalrous good committed to the common good (Brandl and Glenna 2017). Germany, therefore, presents an attractive case for developing a more complete understanding of the strategic framing processes of European legislation on GE.

Data collection

To examine the strategic frameworks articulated in the discourse on GE, two specific actors with opposing views from the areas of politics, science, and business and two from economic/academic associations were selected. The actors' inclusion in the study was based on the heterogeneity of their position on the regulation or deregulation of GE by the ECJ and their access to data.[3] On the pro-regulation side, the actors are Alliance 90/The Greens, the Institute for Independent Impact Assessment of Biotechnology, the seed producer Bingenheimer Saatgut AG, and the Association of Food without Genetic Engineering (VLOG). The opponents of regulation are the Free Democratic Party, the Max Planck Institute for Breeding Research, the seed producer KWS SAAT SE, and the German Association of Biotechnology Industries of the German Chemical Industry Association.

We limited the study to position papers, statements, and press releases as we considered these sources to be the most meaningful in the strategic framing process, and they were also available externally. Beyers et al. (2008) attached particular importance to the publication of position papers to influence the early stages of the legislative processes as they contribute to raising awareness and motivating other actors to participate. As textual data, position papers, statements, and press releases reflect the collective accounts of protagonists and represent a reliable, official, and abundant source. All data used in our study were in German; thus, terms and descriptions that, due to linguistic differences, could not be translated directly into English were dealt with in a reflective manner, and possible differences were highlighted in the course of our study.

The data were collected from the official websites of the selected actors. The period of data analysis began in 2013 (one year after the development of GE) and ended the day before the ECJ ruling (July 24, 2018). As expected, there were very few publications in the first years. The vast majority of position papers, statements, and press releases were published a few months before the judgment, so a temporal distinction between the years was not meaningful. In total, the dataset consisted of 48 press releases, 37 position papers, and 11 information brochures published during this period (n = 96).

Analytical procedure

To identify and capture the strategic frames, categories and forms of frames were derived from a selection of the data and were then coded and quantified through content analysis (Kohring and Matthes 2002; Akhavan-Majid and Ramaprasad 1998). For the interpretive derivation of the strategic frames in the discourse on GE, the media frames in biotechnology and genetic technology recorded in several analyses (Durant et al. 1998; Hampel et al. 1998; Hampel 2012; Kohring and Matthes 2002; Görke et al. 2000) provided initial points of reference. This was so because of their connection, in terms of content, with the strategic frames, as well as their mutual dependence (Bonfadelli 2017), while being open to newly emerging frames or reframing strategies. The following media frames were chosen from these previous reports on genetic engineering: food security, progress, ethics, Pandora's box, globalization, patenting, and freedom of choice. These frames were selected based on thematic overlaps between the individual framing elements and agricultural issues. In the first step of the analysis, existing frames were deduced from a sample of the data and analyzed according to Entman's (1993) four elements of frames. In the second step, we searched the data set and quantified the elements of the frames that were generated. As we surveyed the data, we also noted and examined elements of counter-frames and evidence of the reframing of existing frames.

As the frequency with which a frame is articulated does not provide sufficient insight into its relevance in the competition for dominance, this study drew conclusions about the relevance of a frame from the analysis of counter-frames. For example, if an actor decided to challenge the argument regarding possible uncertainties about the consequences of GE (Pandora's box) by framing a near-natural technique that is safe, it was coded as a counter-frame in the data analysis. If a Pandora's box frame also challenged the naturalness frame, and this interdependent competition for sovereignty over the interpretation of GE occurred significantly often, we defined this as a counter-frame relationship. This was

[3] For example, compared to the Alliance 90/The Greens and the Free Democrats, only limited information could be generated from the two major German parties, the Christian Democratic Union and the Social Democratic Party, regarding their position on GE regulation.

based on the assumption that the more a frame was taken up by the opposite side, the greater its importance in the competition for control of the narrative.

In order not to analyze our frames and counter-frames in isolation from the legal process that these frames were intended to influence, we will also briefly examine the judgment of the ECJ and the opinion of Advocate General Michal Bobek prior to the judgement vis-à-vis our strategic frames. Since other European or international discourses can also directly or indirectly influence the ruling of the ECJ and the selected actors in our study (in addition to attempting to directly influence European legislation) address society at large in order to indirectly exert political pressure, no direct connections between German discourse and European legislation will be sought here. Rather, we will briefly show which frames of our study were also present at the European legal level and were, thus, transferable to other areas of the discourse on GE.

Results

Structure and frequency of strategic frames

This section presents the results of how the actors strategically framed GE in the run-up to the ECJ ruling. We identified four frames each around the proponents and opponents of the regulation of GE. In almost half of the documents (46.6%), the proponents of regulation framed GE as a Pandora's box, that is, as an uncertain technology. Other strategic frames centered around ecological principles[4] (24%), freedom of choice (16%), and patenting (13.4%). By contrast, GE was framed by the opponents of regulation primarily as scientific progress in which the public should have greater confidence, with regulation being unnecessary (progress, 41.1%). GE was also presented as a way to ensure food security and solve world hunger (food security, 26.1%), as a natural technology (naturalness, 21.6%), and as a way to make science more democratic (democracy, 11.2%). The structure and frequency of these frames are described in greater detail below and summarized in Table 1.

Supporters of regulation

Pandora's box frame The majority of actors, particularly from business and academia, who favored a regulatory approach to GE did so using the Pandora's box frame. In reference to the categorization of unknowns (Gross 2007, p. 751), this frame not only problematized the "knowledge about what is not known" (non-knowledge/negative knowledge) but also the total "lack of any knowledge" (nescience). Therefore, the term "nescience" can be used to describe a worst-case scenario regarding the "prerequisite for a total surprise beyond any type of anticipation" (Gross 2007, p. 751) and with no risk assessment for humans, animals, and the environment. Using examples of possible applications, such as gene drive (a method of accelerating the spread of genetic modification within a population), GE was presented as a genetic engineering method with an unacceptable level of uncertainty and, thus, morally reprehensible. An inadequate technology assessment was blamed on politicians and lobbyists who, for many decades, had consciously used their influence to promote the appointment of persons with an affinity for genetic engineering to important political bodies, thus institutionalizing a friendly atmosphere for such technologies in politics and preventing neutral technology assessments.

Ecological principles frame This frame, which was mobilized particularly strongly by Alliance 90/The Greens, interpreted GE as a threat to the ecological principles of organic associations, whose holistic ecological strategy aimed at feeding humanity was incompatible with the applications of the new biotechnological process. The frame drew on the principles of organic farming, which aimed to preserve the integrity of the genome and cell as a functional unit, secure genetic diversity through high biodiversity, and maintain barriers to cross-cultivation and interaction between plants, living soil, and the climate. The debate on the question of the legality of genetic engineering in agriculture unfolded in unexpectedly open statements by a handful of leading figures in the environmental community who no longer ignored genetic engineering and openly discussed its possibilities (Maurin 2016). In response, the frame's normative basis that genetic engineering was morally reprehensible and incompatible with the foundations of the ecological movement was highlighted, ultimately calling for strong regulation of GE.

Freedom of choice frame This frame saw food labeling as an appropriate means of giving consumers freedom of choice and decision-making with regard to purchasing genetically modified food. However, it was postulated that the labeling obligation could not be upheld if the ECJ did not regulate GE, as genetically modified food without labeling could be produced on and introduced to the European continent. The approach of deregulation, which was presented as morally wrong, could lead to a major loss of acceptance, trust, and credibility, especially in organic farming, among customers. This harm to freedom of choice was caused by the immensely

[4] Because the ethical frame is articulated more strongly in the discourse on red genetic technology, whilst also representing the principle of ecological agriculture, ethical issues are merged with the ecological principles frame in this study.

Table 1 Overview of the strategic frames in the German discourse on genome editing in agriculture

	Frame	Fre-quency*	Definition of problem	Moral evaluation	Causes ascribed	Action recommended
Supporters of regulation (Number of statements / n = 63)	Pandora's box	46.6%	Given the unknown uncertainties, there is a fear of "opening the floodgates"; uncertainty as a predicted threat, warnings of catastrophe	negative	Consequences of GE for the environment are not assessable	Regulation of GE as a minimum goal to prevent a catastrophe for man and nature. GE represents a high risk for the environment and should therefore be regulated
	Ecological principles	24%	GE is not compatible with the principles of ecological agriculture	negative	Ecological guidelines forbid the use of GMO	Organisms created through GE should be regulated and labelled as GMO. The precautionary principle should be upheld
	Freedom of choice	16%	Insufficient labelling of GMO products harms consumers' freedom of choice	negative	Supporters of genetic technology have a strong lobby in the food industry	To safeguard consumers' freedom of choice, organisms created through GE should be regulated
	Patents	13.4%	Monopolization of the seed market; patents obstruct small and mid-size cultivators from profiting from innovations	negative	Global players use patents to gain a monopoly over the seed market	Patenting of plants should be forbidden, and GE should be regulated
Opponents of regulation (Number of statements / n = 33)	Progress	41.1%	Lack of public trust in scientific insights and loss of innovative and competitive potential within the global economy	positive	Debates are ideological rather than scientific; the European legal system is old-fashioned in a globalized world with interconnected trade	Definitions of GMOs should be brought into line with scientific progress; deregulation to ensure scientific freedom in Germany and Europe
	Food security	26.1%	Insufficient global availability, accessibility, exploitation, and stability of food	positive	Growing population, climate change, and increasing resistance	Deregulation and allowing the cultivation of productive and resistant organisms
	Naturalness	21.6%	The processes of GE are identical to those of nature and, therefore, represent a comparatively small risk	positive	A mutation induced by GE cannot, in retrospect, be distinguished from a natural mutation	GE does not differ from traditional approaches to mutagenesis and should be deregulated
	Democracy	11.2%	Insufficient opportunities for lay people/the public to take part in scientific discussions and shape them	positive	Laboratories/experts have a monopoly over knowledge	Deregulation should free science from the corset of established academia

*Percentage distribution between the proponents and opponents of regulation based on position papers, press releases, and information brochures of relevant actors in the discourse on GE in agriculture

powerful genetic engineering lobby, which has great interest in promoting the sale of genetically altered products without labeling. To ensure that genetic engineering is subject to all testing, authorization, and labeling requirements, the frame of freedom of choice was mobilized by opponents to demand the regulation of new biotechnological methods.

Patenting frame In the agricultural discourse on GE, the patenting frame was used by the opponents of regulation to point to the danger of seed market concentration by global corporations. If individual nuclei of manipulated plants are patented by global players in the seed market, small to medium-sized cultivation enterprises could be at a competitive disadvantage. In particular, if genetic engineering processes are patented, there may be a threat of further monopolization of knowledge (Brinegar et al. 2017), through which large seed companies will further expand, and the market will become even more concentrated. This problem was due to the fact that GE proponents expected substantial financial gains, leading them to file a large number of patents. A further criticism was the general possibility of patenting plants, genes, and methods of cultivation. With the call for the regulation of GE by the ECJ, there was hope that, at least on the European continent, the existing concentration of the seed market would not become even more entrenched.

Opponents of regulation

Progress frame In the discourse on GE in agriculture, the selected opponents of regulation highlighted, in most cases, insufficient public trust in scientific progress. This reasoning provided a strategic frame often used by critics of regulation (Max Planck Society 2019). In this study, the progress frame, expressed particularly strongly by scientific and economic actors, criticized the debate for being overly emotional. Through the regulation of GE in Europe, it has been argued that major research institutes and companies with strong market positions would relocate to countries with more liberal legislation on biotechnology. This would result in Europe's loss of innovation and competitiveness in the global biotechnology market. A fundamental hostility toward research from politics and society would lead to the regulation discussion not being based on scientific findings but on an "ecological" ideology. The actors' efforts at thwarting regulation were described as a struggle over the ideological foundations of science.

Food security frame This frame focused on the problem of insufficient global availability of and access to food, in particular, staples. Climate change is seen as part of the cause of inadequate food security, leading to droughts that impede productive harvests. Further, plants for food production have become more resistant to pesticides, so global food security has not yet been achieved. Therefore, GE is seen as beneficial and morally indispensable as it offers an opportunity to cultivate the resistant or productive organisms that we need in a comparatively quick, cheap, and easy way. So that GE could be applied in Europe without a complicated approval process, food security concerns were addressed in arguments against regulation.

Naturalness frame This frame presented interventions into genetic material by GE as natural or identical to nature. It used a somewhat "romantic" image of nature, one existing in the imagination of the German public, to present mutations occurring in nature as supposedly low-risk. Although, in the United States, for example, the experience of continental colonization tended toward a perception of nature as wilderness that had to be conquered and cultivated (Ott et al. 1999; Nash 2001), in Germany, a comparatively late and rapid industrialization and urbanization resulted in a contradictory image of nature, one that "had already been saturated with symbolic meanings by the Romantics" (Goodbody 2007, p. 5). Consequently, the historical definition of nature in Western Europe, especially in Germany, partly explains why German attitudes toward GE are generally negative. Based on this understanding of nature, interventions into genetic material through GE are also considered low-risk. The naturalness frame was used by opponents of regulation to demand that the risk assessment of GMOs focus on the end product (result-oriented) and not on the production process (process-oriented). The rationale for privileging the final product in the constitution of the law is that a mutation induced by GE does not currently appear to be distinguishable from a natural mutation. By contrast, proponents of regulation would like to tie legal assessments to the process of production. As a recommendation for action, therefore, the naturalness frame advocated deregulation of GE and called for the existing law on genetic engineering to be adapted to the current state of knowledge.

Democracy frame The comparatively fast, cost-effective, and simple cultivation of resistant and productive organisms was used as an argument for a more democratic governance of science. The democracy frame pointed out that, if regulated, small and medium-sized cultivators, as well as the public, would be excluded from new scientific knowledge about GE. It was argued that the technology assessment accompanying the regulation of GE would only be affordable to well-off individuals, companies, and institutions. In contrast to the patenting frame, which also denounced seed market concentration, the democracy frame argued against the regulation of GE so as to enable access to small players to the new technology, thereby counteracting the market power of large corporations. The democracy frame also used the imagery of "do it yourself" biologists who conducted

garage experiments with "CRISPR starter kits" (Campbell 2019) and portrayed this as an act of the democratization of scientific knowledge.

Relationships between frames

The findings on the relationships between the frames are presented in two steps. First, the frames used in the run-up to the ECJ ruling on GE are compared with past framing of GMOs. We then explore the counter-framing strategies regarding GE, which the protagonists used to address the frames of the other side.

Frames of GMOs and GE

A general and less surprising observation was the difference in the two discourses before and after the discovery of CRISPR/Cas. The frames previously expressed in the discourse on genetic engineering articulated a multitude of options for action, such as "public accountability" (Hampel et al. 1998) or the avoidance of "cloning as moral risk" in the discourse about the cloned sheep Dolly at the end of the 1990s (Kohring and Matthes 2002). However, the discourse on GE mainly concentrated on the question of regulation, particularly the judgement of the ECJ. Although there was a common emphasis in both discourses on the various potentials, risks, and uncertainties of genetic technologies, the frames for the discourse on GE seem to have been reframed to focus on jurisdiction.

While some frames continued to occur (notably progress, food security, Pandora's box, patenting, freedom of choice, and ecological principles), the findings also reveal changes between the media frames in the previous discourse on genetic engineering and the strategic frames articulated in the new discourse on GE in agriculture. Looking at the use of individual frames, it is striking that the most frequently articulated frame by the proponents of regulation was that of the Pandora's box, which was not the most prominent in earlier analyses of media frames on genetic engineering. In the past, a more general public responsibility frame was consistently dominant, while the Pandora's box frame appeared with a lower (and even decreasing) frequency, overall, less than 10% between 1973 and 1996 (Hampel et al. 1998). In the discourse on GE, it was somewhat reactivated to support the framing of GE as a technology with too many uncertainties. By contrast, the dominance of the progress frame in the opponents' narratives of GE tied in with the earlier discourse on GMOs and research on media frames. While it was used as a "central organizing idea" to provide meaning to an "unfolding strip of events" (Gamson and Modigliani 1987, p. 143) in the previous discourse on GMOs, it appeared as a more aggressive, provocative, and exaggerated frame in the GE discourse.

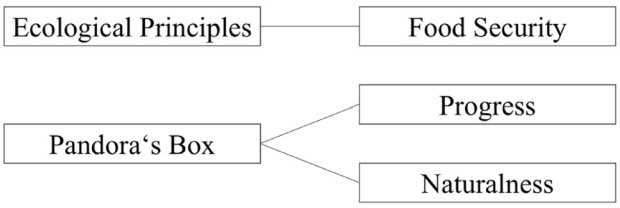

Fig. 1 Counter-frames of genome editing in agriculture

Furthermore, we observed two new anti-regulation frames (naturalness and democracy), which had previously played no relevant role. While naturalness issues had previously emerged through an underrepresented naturalness frame or as partially related to the ecological principles frame used by critics of genetic engineering methods, we observed that, thematically, the current naturalness frame was very much tailored to the discussion on GE and (de-) regulation and could, therefore, be considered as specific to the GE discourse. The same logic could be applied to the democracy frame, which presented GE as an opportunity for a more democratic form of science because it would enable the rapid, inexpensive, and simple cultivation of more resistant or productive organisms. Both frames focused on GE, and there appeared to be greater difficulty in transferring them to other discourses compared to other strategic frames in the GE discourse. They were also exclusively created by anti-regulation opponents, who acted as frame sponsors in the GE discourse.

Counter-frames in the discourse on GE

In the competition for interpretive sovereignty over the legal assessment of GE, three main relationships could be observed between the strategic frames used by the proponents and opponents (Fig. 1). The frame encapsulating GE as contributing to global food security was usually countered by the proponents of regulation with the frame of ecological principles. Recognizing the problem of insufficient food security, the proponents of regulation argued that the use of GE did not solve this problem but, rather, exacerbated it. As a counter-proposal, they called for greater food sovereignty by promoting inter alia organic farming based on ecological principles. In return, the food security frame denied that organic farming could make a significant contribution to securing an adequate food supply for the growing world population.

With regard to the frame most frequently used by the proponents of GE regulation (Pandora's box), two counter-frames were observed. First, the warning that the use of GE in agriculture posed uncertainty competed with the view that there was a lack of public trust in scientific results (progress). The progress frame claimed that the supporters of

regulation had a conservative attitude toward scientific progress and were guided by dogmas and ideologies. However, the opponents of regulation were accused of placing blind faith in scientific progress without sufficiently addressing the uncertainties. As these were the two most frequently articulated frames in the debate, one could assume that they were the two most relevant strategic frames, indicating a primary line of conflict in the discourse on the regulation of GE.

Second, while the Pandora's box frame painted the idea of unpredictability, another counter-framing strategy of the opponents of regulation was to characterize GE as a natural technique, thereby relativizing uncertainties as assessable risks. Between the two frames, there was intense debate about the extent to which GE crosses the line between classic mutagenesis and genetic engineering. The distinction between a natural and an artificially created mutation was a central point of conflict in the GE discourse, leading to a fundamental discussion of the definition of nature and naturalness. It is important to note that the frame of naturalness was almost exclusively articulated in the context of the Pandora's box frame and, therefore, seemed to exist exclusively as a counter-frame. This means that, for the critics of regulation, the naturalness frame had a comparatively high relevance in the competition for interpretive sovereignty over GE.

Frames in the ECJ ruling

Before the ECJ delivered its ruling on the regulation of GE on 25 July 2018, ECJ Advocate General Michal Bobek published his opinion on 18 January 2018, which provided a general indication of the pending judgment (Bobek 2018). In his argument that organisms obtained by mutagenesis should, in principle, be exempt from the strict rules of the European Genetic Engineering Act (Directive 2001/18/EC) and that GE should, therefore, not be regulated, there were references to the progress frame. That there were no other references to frames besides the progress frame, which also argued against the Pandora's box frame, may also be due to the formal language of the official document. To the surprise of many stakeholders, the ECJ decided to regulate GE and opted not to follow the recommendation of the advocate general. The ECJ's judgement predominantly referenced the Pandora's box frame as well as the naturalness and ecological principles frames, though it did not directly challenge other frames.

Discussion

Our analysis suggests that the lack of knowledge about the outcome of the imminent ECJ ruling was used by actors in the German discourse on genetic engineering in agriculture to make significant changes to their strategic communication. This applies, in particular, to those who already had a rather positive attitude toward genetic engineering in the past. The ECJ ruling was handed down only a few years after the first scientific discovery and development of GE. Therefore, all actors were under time pressure to strengthen and establish their position in the competition over interpretive sovereignty. While all the frames in question made recommendations for the outcome of the ECJ ruling, they differed in terms of their position on the possible outcome of the ruling and the problem and cause underlying their recommendation. Our study reveals that the proponents of regulation made special efforts to tie their frames to the previous genetic engineering discourse, while the opponents of regulation articulated new frames, presumably to resolve the previous battle lines of the old discourse in their favor.

In the competition for interpretive dominance over GE, the Pandora's box frame was challenged by two counter-frames (naturalness and progress), which could mean that it was seen by the opponents of regulation as the greatest threat in the competition for interpretive sovereignty over GE. Moreover, this was also the most frequently used frame by the proponents of regulation. Chong and Druckman (2013) pointed to the necessity of a multi-frame strategy in the encounter with opposing frames. They maintained that, unified frame strategies cannot be successful because respondents with strong and weak attitudes to a topic react differently to a frame: "the best counter-framing strategy is contingent on the nature of audiences" (Chong and Druckman 2013, p. 1). In our study, the naturalness frame seemed to address a rather uninformed audience through soft language, while the progress frame appeared to target informed individuals who were in favor of regulating GE. To achieve sovereignty over the framing of the discourse on GE, two different groups were mobilized against the Pandora's box frame. In 2018, the ECJ was in favor of regulating GE; that is, the efforts of the supporters of GE had not (yet) proven to be successful. However, Chong and Druckman (2013) highlighted that the impact of a frame that tends to address people with weak opinions only unfolds through its long-term and repeated articulation. Therefore, it is possible that the effectiveness of the naturalness frame was not sufficiently developed in the short period leading to the 2018 decision and could not stand up to the previously successful argumentation structure of GE opponents. Opponents used previously successful frames that could more easily be taken up to become effective.

It is reasonable to assume that the naturalness frame could gain more traction in the further course of the German and European debate on GE than it did in the opinion of Advocate General Michal Bobek and the ECJ ruling. Although this is difficult to assess at this stage, the ongoing debate on GE shows that this frame continues to be mobilized (e.g.

Rose et al. 2020). In September 2019, the European Council, under the influence of neutral scientific opinions, instructed the European Commission (EC) to review "how to ensure compliance with Directive 2001/18/EC when products obtained with new mutagenesis techniques cannot be distinguished, using current methods, from products resulting from natural mutation" (Council 2019, p. 1). This suggests an increasing affirmation and institutionalization of the naturalness frame. In April 2021, the EC published a study referencing the European Food Safety Authority (EFSA et al. 2021), in which it was pointed out that "similar products with similar risk profiles can be obtained by conventional breeding techniques, certain genome editing techniques and cisgenesis" (EC 2021, p. 59). Therefore, that it "may not be justified to apply different levels of regulatory oversight to similar products with similar levels of risk" (EC 2021, p. 59) also confirms our assumption of the naturalness frame gaining influence and further demonstrates that the discourse on GE regulation did not end with the 2018 ruling. A comparative study based on the post-judgment period could provide more information in this respect.

One could assume that the image of being in "harmony with nature" and the theme of naturalness were exclusively instrumentalized by the proponents of GE regulation. However, our findings show that this theme was hijacked and transformed by critics of regulation, who have adopted and mobilized it to their advantage. Similarly, opponents of regulation have pointed to the potential for democratizing the scientific system by framing GE as a supposedly simple and cheap application (democracy frame), countering the impression that GE would bring about a concentration of the seed market (patenting). Although the content of both new strategic frames appear to be similar at first glance, the differences become apparent when the individual frame elements are analyzed according to Entman (1993). Thus, the two new strategic frames (democracy/naturalness) seem to seek proximity, in terms of content, to the prominent frames (patenting/Pandora's box) of their opponents in the competition for interpretive sovereignty. However, in doing so, they offer a different solution. Overall, it seems that the new frames sought to avert an image of imbalanced market power, exaggerated pursuit of profit, and short-term action. To some extent, it can be assumed that critics of regulation did try this strategy in recent decades with the food security frame, which had substantive proximity to the ecological principles frame. However, while the food security frame can be applied to any genetic engineering method, two new frames emerged in the GE discourse that integrate the specific technical characteristics of GE into the argumentation. It may be that actors who have opposed genetic engineering for decades tend to describe the two new frames as a hybrid of contradictory arguments and, therefore, do not accept them.

Food security and ecological principles represent two of the competing strategic frames, which, even before the discovery of GE, sought to challenge each other in the discourse on genetic engineering in agriculture and, therefore, could fall back on proven argumentation strategies (Fairbairn 2012; Hospes 2014). As both frames tend to address people with strong opinions from the opposing side, one might want to speak of a hardening of the fronts.

Overall, the frames identified in this study reflect recent findings from framing studies in Germany (BfR 2017a; Helliwell et al. 2017) based on interviews with civil society and NGOs. Elements of frames such as Pandora's box, ecological principles, freedom of choice, patenting, progress, and food security are reflected in all studies on the discourse of GE. The focus of studies on respondents belonging to groups that tend to reject genetic engineering might explain the lack of frames used by opponents of regulation (naturalness and democracy). Our findings also shed light on the relationship between strategic frames and frames of GMOs from media framing studies. While similar frames have been used in discussions on genetic engineering methods since the 1970s (e.g. food safety, Pandora's box, progress, or patenting), the two new frames (naturalness and democracy) seem to be tailored to the discourse on the regulation of GE. Here, but also in frames such as progress, there is the impression that critics of regulation are particularly interested in using the new frames to discuss technical issues, whereby, for example, the repeated references to and discussion of mutations could be interpreted as an attempt to make the discussion about GE a boundary object to negotiate or initiate a soft meaning of the technology (Metze 2017).

For this reason, the success of the communication strategy of anti-regulation actors in the future will depend on the extent to which the new frames succeed in reducing the complexity of genetic engineering to a level that resonates with the perceived reality of recipients without dissociating it from scientific knowledge. By contrast, the communication strategy of the proponents of regulation will likely be successful only if their frames from the previous genetic engineering discourse can also be effectively transferred to the debate on GE. This was the case in the short term, but all articulated frames will have to prove themselves in future competitions for interpretive sovereignty over new genetic engineering methods.

The extent of the influence of the identified strategic frames on the GE discourse and the regulation by the ECJ, therefore, remains open for the time being. Since the impact of a frame can be independent of the approval or rejection of a recipient and, thus, diffuse and difficult to capture, research on the effects of strategic and media frames on recipient frames has been underrepresented thus far: "For example, even if one disagrees completely with a frame's assertion that welfare is unacceptable because the poor are lazy and

irresponsible, the frame may still make salient one's beliefs about the poor, positive, or negative" (Nelson et al. 1997, p. 228). By showing that the entrenched attitudes and behaviors of recipients are unlikely to be influenced by strategic framing unless it is deliberately incorporated into broad-based campaigns, Fesenfeld et al. (2021) also exposed the general limitations of strategic framing. However, by using "political rhetoric to shape a legislative debate in their favour," interest groups "strategically highlight some aspects of a proposal while neglecting others in order to direct collective attention to their preferred policy option" (Klüver et al. 2015, p. 495). Even if there are indications that the critics of GE regulation are trying adopt new communication strategies to increase public acceptance of genetic engineering, the debate preceding the ECJ ruling seemed to have been "fought out" between an underrepresented part of the interested public and semi-professional to professional experts. The fact that, according to the Federal Institute for Risk Assessment, only 14% of German consumers had heard of GE (BfR 2017b) and consequently played only a subordinate role in the "scientifically and legally oriented debate" (BfR 2017a, p. 5) speaks in favor of this view.

The analysis of recipient frames, defined by Entman (1993, p. 53) as "mentally stored clusters of ideas that guide individuals' processing of information," could follow experimental online survey designs such as those used by Rahn et al. (2017) and Mutz (2011). While our research results only allow conclusions to be drawn about the number of articulated strategic frames and counter-frame relationships, experimental surveys can also test the response of the rather uninformed public to the strategic frames of the actors in the discourse and the media frames. On the basis of this study's findings, for example, the question can be posed as to the extent of the success of the strategy of the critics of regulation in challenging the Pandora's box frame with the two frames of naturalness and progress. Although this study showed that, in the German discourse on GE, the naturalness frame emerged in the run-up to the ruling in order to break through previous thought patterns with the help of softer language, it could not contribute to preventing regulation by the ECJ at the European level. From the analysis of the opinion of Advocate General Michal Bobek and the judgment of the ECJ, conclusions can be drawn that the Pandora's box and progress frames, in particular, have found their way into the final legal assessment of GE. However, the fact that the majority of the frames identified did not form part of either document could be attributed to their formal nature. Nevertheless, this assumption should not obscure the fact that, within the German discourse, the debate on the regulation of GE can be regarded as a key event, permanently changing the structure of the ongoing debate.

Future research could also examine the extent to which the boundaries between the proponents and opponents of genetic engineering have changed as a result of the discussion around GE (Siebert et al. 2018) and the extent to which this has affected the articulated frames and counter-frames of the actors involved in the discourse. An analysis of the Green Party in Germany could be particularly interesting in this context. Individuals at the state and federal levels have begun criticizing the current position on GE, calling on other members of the Green Party to take a closer look at the opportunities of GE and rethink whether certain new technologies could contribute to food security. However, driven by the debate on a new basic program with the goal of future governmental responsibility, official statements endorsing the previous rejectionist position of the Green Party on genetic engineering appeared mainly after the ECJ ruling. The incipient opening or debate in a party characterized by a clearly negative and unified position on genetic engineering could perhaps mean that counter-framing strategies are beginning to take effect.

Conclusion

As two new strategic frames emerged, and existing frames were strategically reframed to foster a desired outcome in the pending ECJ judgment, the debate on GE can be considered a key event in the German discourse on green genetic engineering. In comparison to the previous genetic engineering discourse, the content of the frames was differentiated according to the methods of GE. The ECJ judgement seems to have enabled the process of forming new frames and, in a short period, accelerated them in the competition for sovereignty over interpretation. The ECJ's decision to regulate GE can be interpreted as an indication that the new frames have not yet been able to gain traction in the European legislature. The fact that the naturalness frame, in particular, was increasingly used in official documents, as in the study of the EC, may be a sign that the critics of regulation will continue to rely on this frame in the competition for sovereignty over the interpretation of GE at the European level. Critics of the regulation of GE attempted to strategically change the discourse on GE in their favor by creating new frames, while the proponents of regulation tended to rely more on frames that had proved successful in the competition for sovereignty over interpretation in recent decades. In the further course of the GE discourse, for example, the discussion on the reform of European genetic engineering law with regard to the differentiated regulation of GE organisms, it will be interesting to see the extent to which the ECJ judgment and the study by the EC will be accompanied by further changes in framing strategies. That the reactions of the actors in Germany to the EC study were not long in coming and ranged from complete misunderstanding to complete approval indicates a continuing dynamic discourse on

GE, with actors strategically adapting and developing their frames to align with current events in the ongoing contest for interpretive sovereignty. Beyond that, only in retrospect will it become clear the extent to which the regulation of the new biotechnological findings, which is determined by the European constellations of laws and institutional framework conditions, has contributed to increasing social welfare.

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