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Research Highlights

Highlights

- UK academic biofuel research grant abstracts are compared with wider societal discourse
- The scientific abstracts broadly reflects legitimacy related societal concerns
- We view scientists as involved in institutional change processes
- There remains a case for public deliberation in biofuel research agenda-setting

1 ***Paper for Environmental Science and Policy***

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5 **Scientists as policy actors: a study of the language of biofuel research**

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Scientists as policy actors: a study of the language of biofuel research

Abstract

Theory suggests that the influence of science on policy will be greater when scientific discourse is aligned with the language and meaning of wider social concerns. Seeking to assess whether scientists may be guided by such propositions in a controversial environmental policy arena, we examine the language and content of public-facing, UK scientific research grant abstracts on biofuels for the period 2007-11, comparing these to stakeholder position statements and newspaper articles of the same period. We find that UK scientists have indeed broadly reflected societal concerns about biofuels during this period. However we also find that both science and society have paid less attention to procedural issues. We comment on the implications of the findings for the role of science in environmental policy development.

Keywords

Biofuels; science; discursive institutionalism; institutional change; legitimacy; governance

1. Introduction

Over the last decades, the roles that scientists play in policy making and wider social life have become increasingly varied. Reviewing the science policy studies literature on the diversity of those roles, Hoppe (2005) outlines how at one end of a spectrum we can find scientists providing direct, prescriptive and instrumental decision support and advice for policy practitioners. More moderately, research outputs may have “an indirect and unintended impact on policy through conceptual use, enlightenment, knowledge creep, or research as ideas” (ibid). Scientific findings may also “focus political attention in the shape of new views, innovative problem definitions, and policy alternatives” (ibid). These roles have arguably been further extended by a trend towards new modes of environmental governance, in which societal actors, including scientists, increasingly engage in “private–public co-operation in the solving of societal problems, and new forms of multilevel policy” (Biermann, 2007: 328).

The field of biofuels policy appears to be a prime example of this increasing role of science in policy making, though this role has been far from straightforward. Sometimes the policy changes consequent on new scientific knowledge have been minor, as in the case of the UK delaying the dates by which target biofuel production volumes are met, following the Gallagher Review (Gallagher 2008). Other times, as in the case

1 of indirect land use change, the policy effects of new knowledge have been more significant, with the
2 European Commission in October 2012 publishing a particularly contested proposal for additional
3 safeguards that include indirect land use change (ILUC) factors in reporting (EC, 2012). Fundamentally,
4 underpinning European biofuel policy are assumptions regarding scientific progress towards second and
5 third generation technologies (Levidow and Papaioannou, 2013). Without on-going scientific knowledge
6 production, the proposals of COM(2012) 595 to (inter alia) limit the role of food crops and more strongly
7 incentivise biofuels with no or low indirect land use change emissions, particularly advanced biofuels
8 including algae, straw and wastes, would likely be more difficult to achieve.
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17 Alongside these trends, there have been growing demands for science to be responsive to wider societal
18 concerns, environmental and other. As Lövbrand et al. (2010) observe, rather than viewing scientific
19 endeavour as separate from the logic of democracy (Liberatore and Funtowicz 2003), a large literature on
20 expert democratization within science and technologies studies and post- normal science asks scientific
21 experts to justify their knowledge claims to wider society in addition to their scientific peers (Lövbrand et
22 al., 2010). While evidencing that biofuel scientists are responsive to most, though not all societal concerns
23 in the exemplar policy arena of biofuels, we extend the literature on scientific legitimacy by mobilising a
24 new institutional perspective on scientific activity undertaken with environmental objectives. Specifically,
25 we draw on discourse (ideational) institutionalism and apply arguments by Greenwood et al. (2002) to the
26 example of biofuel science, enabling consideration of the dialectic between the actions of individuals (and
27 actors in general) and social structures. While Palmer (2010) similarly examines UK government policy
28 discourse on biofuels from a discourse institutionalist perspective, here we use the same approach to focus
29 on academic scientists, using mixed methods. Our purpose is not to investigate the most obvious instances
30 of the influence of biofuel science on policy, but rather to examine a much more subtle, dialectic, and
31 indeed less researched mode of policy influence by and on science, and to consider the implications of this
32 for both biofuels policy and for the governance of environmental science more generally.
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48 It is only occasionally that scientists act in policy lobbying roles or as formally instituted policy actors. We
49 view the larger majority of scientists as informal policy actors whose agency arises from their situation
50 within the science-policy nexus. Reflecting the premise of discursive institutionalism (Schmidt 2008; Hay
51 2006), in which discursive factors play a crucial role in institutionalisation and institutional change, we
52 assume that scientists more commonly play a significant role in policy development through the influence
53 of new knowledge and ideas. At the same time, the research questions that science itself pursues are to
54 some extent influenced by their societal context. More precisely we take the view that the influence of
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1 science in institutional and policy change processes is partly a function of the extent to which scientific
2 ideas discursively connect to pre-existing norms, values, beliefs and interests, with stronger connections
3 conferring a higher degree of societal legitimacy. Accordingly, we empirically examine to what extent the
4 language and content of public-facing, scientific texts correspond with textual expressions of legitimacy-
5 related societal concern. The aim is to shed a new institutionalist light on the way in which scientists gain
6 legitimacy for – in this case – various forms of biofuel science. In so doing, we add to literatures on the
7 policy dimensions of science and technology studies and also post normal science, as well as the new
8 institutional literature itself, specifically regarding the role of legitimacy in discursive processes of
9 institutional and policy change.

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18 In terms of the structure of the paper, after detailing the theoretical basis for our study in section two and
19 explaining associated terms, we outline in section three the methods applied to gather empirics with which
20 to discuss the foregoing characterisation of the role of science in policy-related institutionalisation
21 processes. In sections four and five we present these empirics, describing how scientists reflect procedural
22 and consequentially (impact) related societal concerns about biofuels. We then comment on the
23 implications of the findings for the governance of science and wider biofuels policy, not only from a new
24 institutional perspective but also returning to the more dominant prescriptive perspectives (such as post-
25 normal science). In particular, we suggest that the results strengthen the case for direct participation by
26 citizens in over-seeing and informing scientific research agendas, as well as associated policy development.

37 **2. Theoretical context**

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40 While definitions of the term institution are varied and numerous, we understand institutions as consisting
41 of cognitive, normative and regulative structures and activities (*including policies*) that provide stability and
42 meaning to social behaviour (Scott 1995). Institutionalisation we define as “the process whereby things
43 become institutionalized, which, in turn, simply means that things are more or less taken for granted”
44 (Greenwood et al. 2008:15). Mainly we build on the premises of what is referred to as constructivist,
45 ideational or discursive institutionalism, viewing institutions as “codified systems of idea[s] and the
46 practices they sustain” (Hay 2006, 65), “formed as meanings come to be shared and taken for granted”
47 (Maguire and Hardy 2009).

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57 Policy-related ideas can occur at different “levels of generality” (Schmidt 2008: 306):
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1. Specific policies or “policy solutions” proposed by policy makers at the foreground.
2. More general programs that underpin the policy ideas and reflect underlying assumptions, organizing principles, definitions of problems and issues to be addressed by policies, as well as norms, methods and instruments to be applied.
3. Background philosophies, "worldviews or Weltanschauung that undergird the policies and programs with organizing ideas, values, and principles of knowledge and society" (ibid: 306).

Schmidt (2008) furthermore distinguishes between two types of ideas:

1. Cognitive ideas, that: “speak to how (first level) policies offer solutions to the problems at hand, how (second level) programs define the problems to be solved and identify the methods by which to solve them, and how both policies and programs mesh with the deeper core of (third level) principles and norms of relevant scientific disciplines or technical practices.”
2. Normative ideas that attach values to political action and serve to legitimate the policies in a program by outlining their resonance with “a deeper core of (third level) principles and norms of public life”.

As Schmidt (2008) hints towards, scientists and research organisations, through direct advice but also through the general creation and communication of new knowledge, are capable of creating both cognitive and normative ideas on all three levels of generality. This begs the question of “why some ideas become policies, programs, and philosophies that dominate political reality while others do not” (Schmidt 2008) or, in other words, why some of the ideas proposed by scientists drive and co-evolve with institutional change, while others do not. For Schmidt (2008: 309), discursive processes help to explain “why certain ideas succeed and others fail”, as ideas are generated, debated, adopted, and changed through discourses (Schmidt 2006). This argument is based on the assumption that it is primarily through texts, ranging from conversational descriptions to more elaborate and widely distributed texts, such as narratives, frames, scripts or scenarios, that information about actions is widely distributed and comes to influence the actions of others (Phillips et al. 2004: 635; Schmidt 2008: 309). Discourses thereby encompass the substantive content, or meaning, of ideas as well as the interactive processes by which these ideas are conveyed. In other words, they include not only what ones says, including a set of ideas bringing new rules, values and practices, but also to whom one says it, how and why (Schmidt 2006: 17; Schmidt 2008). As such, "what makes for a successful discourse, in fact encompasses many of the same things that make for successful ideas: relevance to the issues at hand, adequacy, applicability, appropriateness and resonance. Discourses succeed when speakers address their remarks to the right audiences (specialized or general publics) at the

1 right times in the right ways. Their messages must be both convincing in cognitive terms (justifiable) and
2 persuasive in normative terms (appropriate and/or legitimate)" (Schmidt 2008: 313).
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6 While Schmidt does not provide further detail, Greenwood et al. (2002: 60), referring to Suchman (1995),
7 argue in their model of change that the diffusion of a new idea can only occur if ideas are "compellingly
8 presented as more appropriate than existing practices", either by nesting and aligning them within
9 prevailing normative prescriptions (moral legitimacy) and/or by asserting their functional superiority
10 (pragmatic legitimacy) (ibid). This resonates with arguments within the discursive new institutional
11 literature concerning discourses that are more coherent, i.e. texts that converge in their descriptions and
12 explanations of social reality, that are supported by broader discourses, that are not highly contested by
13 competing discourses, and that are structured, i.e. texts that comprise discourse, draw on one another and
14 on other well-established discourses being more likely to produce institutions. This is because such
15 structured and coherent discourses present a more unified view of some aspect of social reality, which
16 becomes reified and taken for granted (Phillips et al., 2004 and Maguire and Hardy 2009).
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28 A theme that emerges, then, is that of perceived legitimacy and coherent, structured texts as key
29 conditions for achieving acceptance and influence for new ideas. In their seminal work on legitimacy,
30 Greenwood et al. (2002) point towards Suchman (1995: 574), who broadly defines legitimacy as: "a
31 generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate
32 within some socially constructed system of norms, values, beliefs, and definitions". With regard to
33 pragmatic legitimacy, which for Suchman (ibid: 578) rests on "self-interest calculations", one can distinguish
34 between exchange legitimacy (value for particular constituencies), influence legitimacy (related to larger
35 interests, for example in incorporation into decision making structures) and dispositional legitimacy (trust
36 in entities that "have our best interests at heart," that "share our values," or that are "honest,"
37 "trustworthy," "decent," and "wise") (ibid: 578). Moral legitimacy rests on a judgment as to whether an
38 activity "is the right thing to do" and relates to an evaluation of consequences (consequential legitimacy),
39 charismatic characteristics of individuals (personal legitimacy), isolated procedures (procedural legitimacy)
40 and more general recurrent structures (structural legitimacy) (ibid, 579).
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Applying these arguments to our case, we suggest that the extent to which new ideas supportive both of
and by new knowledge created by biofuel scientists achieve wider societal support and become

1 institutionalised is partly a function of how well scientific communication converges with and draws upon
2 well-established (or in other words, in itself coherent and structured) discourse around pragmatic and
3 moral legitimacy-related social concerns. The following section now outlines our empirical examination of
4 these arguments, which takes the form of investigating the degree of linguistic and content
5 correspondence in textual expressions of societal concern and scientific texts written for research
6 proposals.
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10 11 12 13 14 **3. Methods and data**

15 16 *3.1 Case study and exploratory text selection*

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19 A summary of the research process is given in Figure 1.
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24 <Figure 1 A summary of the analytic process>
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30 Examining the correspondence between scientific and wider public discourse first requires that texts are
31 selected for analysis. For this purpose, we first undertook an exploratory phase of identifying ten non-
32 academic stakeholder texts on biofuels, to identify dominant and well established themes for comparison
33 with research grant abstracts (the choice of which is discussed below). Appended <Table A1> lists the
34 stakeholder sources used in the exploratory stage, primarily position statements, defined here as
35 statements setting out some aspect, implicitly or explicitly, of an organisation's position on a biofuel-
36 related theme. A range of publicly available documents was inspected for each stakeholder prior to
37 selection, to select texts informative of stakeholders' dominant and well-established positions on biofuels.
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48 The second stage was to select academic texts on biofuels, for which purpose academic, non-technical
49 grant summaries have been used. Here we assume that the public-facing components of those grant
50 proposals are indicative of the types of ideas associated with the knowledge to be created through the
51 respective projects and their relationship with well-established public legitimacy concerns. For second and
52 third generation biofuels to deliver on UK and European biofuel targets, science must attract investment in
53 those technologies, whether based in academic, commercial or state facilities. In the UK academic system
54 and most others, attracting investment is achieved through successful grant applications. Many grant
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1 proposals present particular ideas of what 'sustainable biofuels' constitute, which we situate on what is
2 termed above the 'programme' level of policy. Some grant proposals make reference to the benefits of
3 particular advanced biofuel technologies, from which we infer that the scientists behind those proposals
4 also view policy support for these technologies favourably. Other grant proposals have a less explicit policy
5 relation, in that they relate to fundamental science without explicit reference to broader implications.
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7 Nonetheless, consistent with discursive institutionalist thinking, we assume that such science still has
8 ideational implications through a wider influence on problem, goal and instrument definitions (programme
9 level) as well as on societal worldviews (philosophy level).
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18 The grant summaries were specifically written for the non-specialist and are part of the assessed grant
19 proposal. Figure 2 provides the description given to academics by the UK Research Councils regarding the
20 purpose of the summaries. This description makes it clear that the summaries are to be written for a public
21 audience, albeit an informed one and with an eye to the funder's requirements (note that public funders
22 also require societal legitimacy to function). As artefacts, the abstracts are therefore assumed to be
23 indicative of both the ideational content of the research and of the language used by scientists to explain
24 and account for that research¹. Sixty five research grant summaries relating to biofuels were available on
25 UK Research Council websites in June 2011. Grant summaries were identified via the keyword search
26 'biofuel' and 'bioenergy', as biofuel is sometimes treated as a sub-set of bioenergy.
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37 < Figure 2: The interpretation of the grant proposal summary given by the Research Councils UK >
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42 The third stage was to obtain a larger sample of UK societal views of biofuels for comparison, for which
43 purpose newspaper media articles were used, specifically those returned by the Nexis search service in
44 terms of UK national newspaper headlines containing the term biofuel(s), for the years 2007-June 2011, the
45 period of the investigation. The date span of the newspaper articles mirrors the date span of the grant
46 abstracts. The use of a searchable newspaper database provided text that could be quantitatively and
47 qualitatively coded. It should be noted that while the content of such articles is coloured by journalists'
48 perceptions (the database also includes business letters), the opinion set is arguably more regulated (via
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57 ¹ While Research Council web managers cannot readily quantify the affiliations of those who actually view their grant
58 databases they did confirm that the abstracts are intended for a non-academic audience (pers. comm.).
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editorial control) and hence with a narrower range than would be found in a broader internet search encompassing blogs, NGO and commercial campaigns, marketing and opinion. Restriction of search returns to articles with biofuel(s) in the headline further constrained the number of articles returned and ensured that the articles have a significant focus on biofuels. The number of articles identified, on a yearly basis, was: for 2007, n=100; for 2008, n=243, for 2009, n=67; for 2010, n=48 and for the first six months of 2011, n=68.

3.2 Analytic methods

With the aim being to explore the responsiveness of academics to prominent moral and pragmatic legitimacy related concerns, the principal method used was content analysis, both quantitative and qualitative (Weber 1990). This involved an iterative approach to coding (Tashakkori and Teddlie 2003), moving between the theoretical and empirical literatures. With a critical realist research approach² and a descriptive and argumentative objective, the coding was closely based on Suchman's (1995) work on legitimacy logics which was also used to categorise themes in the stakeholder documents during the first research phase. Coding and search terms were selected for Nvivo so as to return paragraphs and sentences where corresponding legitimacy-related references occurred. Appended <Table A2> provides more detail on those documents, illustrating the range of opinion, priorities and concerns found among UK actors with an interest in biofuels.

Following Tashakkori and Teddlie (2003), we view the key criterion for methodological choice as the ability of a method to contribute to understanding (i.e. make good quality inferences about) the phenomenon in question. Here, qualitative study enables inferences regarding meaning, while quantitative analysis enables inferences regarding the coherence and structuration, as well as the degree of commonality of discourse.

² Following critical realist arguments, we situate Suchman's work on the transcending level of the 'real', describing what one may refer to as "institutional logics" or "principles of legitimacy" (Leca and Naccache 2006), while situating ideas that shape legitimacy evaluations in terms of these logics at different degrees of taken for grantedness or coherence and structuration on an actual and context-dependent level (Sayer, 2000).

1 As the stakeholder documents showed a clear prevalence of procedural, structural and consequentially
2 (impact) related concerns³, search terms were developed for these two categories (procedural and
3 structural legitimacy were treated as one category). Appended <Table A3> shows the associations made
4 between (a) the selected legitimacy categories, (b) their general form of expression in the texts and (c) the
5 corresponding keyword codes used for qualitative and quantitative analysis (synonyms were also
6 searched). The imbalanced ratio between keywords related to consequential aspects and procedural
7 aspects reflects the imbalance between these two aspects as evidenced in the texts. The general method of
8 inference was repeated in the later stage of qualitative coding.
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17 For the first quantitative phase in which stakeholder position documents were compared with the Research
18 Council abstracts, the keywords were used in a search of the research grant documents using qualitative
19 analysis software, with full sentences also returned so that context and meaning could be checked. In a
20 second phase, this was performed with 500 newspaper articles with 'biofuel' in their headline, to broaden
21 the representation of public discourse on biofuels. During both phases, keyword occurrence was also
22 converted to percentage terms (i.e. normalised) to allow for any unequal length of documents. The
23 references returned in the software searches were visually inspected to ensure meaningful returns. As a
24 further reliability check, manual coding was also undertaken for 25% of the most recent (mid-2011 to 2009)
25 newspaper articles by selecting every fourth article, such that 125 newspaper articles were manually
26 coded. This more recent period was chosen to ensure that relatively contemporary concerns were
27 captured, i.e. as a methodological precaution, though these concerns were also largely referred to in
28 debate dating from 2007.
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42 **4. Results**

43 *4.1 Lexical correspondence*

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45 In the scoping analysis undertaken with the stakeholder documents, the scarcity of process-related
46 keywords relative to consequential-related keywords revealed a general emphasis on consequential
47 (impact-related) dimensions. Differences among the stakeholder sources include: a higher percentage of
48 food-related and process-related (independent audit) keywords in an Action Aid (development NGO)
49 document, plus a lower percentage of renewable-related keywords; a higher level of sustainability
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57 ³ While other themes emerged, the focus, as outlined previously, was on well-established or dominant themes to
58 evaluate structuration and coherence of scientific discourse.
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1 references in a Renewable Energy Association (trade association) document; a higher level of third
2 generation biofuel and yield references in the Greenergy (large biofuel supplier) document; and a higher
3 level of commerce references in the BP (large biofuel supplier) document.
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7 This emphasis on consequentiality is also evident in the documents of the individual research councils, with
8 references to commerce, food, climate change and sustainability exceeding social, process-related and
9 other concerns considerably. Items of note include the strong reference to poverty in NERC summaries, the
10 emphasis on yield in the EPSRC summaries (though all of the summaries have yield-related references) and
11 the references to food in BBSRC and ESRC summaries. The reference to climate change and sustainability
12 rationales is ubiquitous. Figure 3 shows the foregoing and Figure 4 compares the mean percentage
13 occurrence of the keywords in the Research Council summaries and the newspaper articles. Of note here is
14 the quite striking degree of similarity, with exceptions being more frequent reference to food in the
15 newspaper articles and more frequent use of sustainability discourse in the research summaries.
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25 <Figure 3: Legitimacy-related themes in the public summaries of UK Research Council biofuel grants (2007-
26 10) >
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29 <Figure 4: Comparison of legitimacy-related keyword indicators across sources (newspapers and research
30 grant abstracts) >
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37 The prominence of food-related language in the media, reflecting the food-fuel debate, is also evident in
38 Figure 5, which shows the relative occurrence of selected terms in the newspaper articles over the years
39 2007-11. Particularly notable are the 2008 peak, the dominance of food-related discourse and the near-
40 absence of technical terms ('lignocellulosic' being used as an indicator here). Figure 6 shows occurrence in
41 percentage terms without reference to time, but including reference to whether the references to
42 particular topics were presented positively, negatively or in a neutral way.
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51 <Figure 5 Temporal occurrences of the most prominent legitimacy terms in UK national newspaper articles
52 on biofuels>
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55 <Figure 6 Legitimacy-related themes in UK newspaper articles on biofuels 2007-11>
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1 Non parametric Kruskal-Wallis tests <appended Tables A4a-e> show no significant difference ($p=0.433$) in
2 percentage keyword occurrences across *sources* when the Research Councils are aggregated, while visual
3 inspection does show differences in the incidence of different linguistic terms. This adds weight to the case
4 for there being a common set of concerns across sources, but with the range of these concerns being quite
5 particular, specifically impact-related terms being significantly more prevalent than process-related terms.
6 However when the Research Council data is not aggregated, the tests do show a significant differences
7 between the Research Councils and the media article set (at $p=0.05$). These differences arise from ESRC ($p=$
8 0.015) and EPSRC ($p= 0.041$) discourse, while there is no significant difference between keyword incidence
9 in NERC and BBSRC research grant abstracts and the media sample. The same pattern of significant
10 difference is confirmed by additional Mann-Whitney U tests.
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21 *4.2 Thematic content*

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23 The large majority of the 40 BBSRC grants returned under a 'biofuel' search term relate directly or indirectly
24 to advancing the fundamental science of (mostly) second and (some) third generation biofuels. Only three
25 have the potential to directly inform an assessment of biofuels: two relate to the environmental and social
26 impact assessment of *Jatropha curcas* production and one relates to N₂O release and pathways associated
27 with intensive crop production. The 13 EPSRC grants returned are more varied, but the largest EPSRC
28 investment was in the Supergen Biomass and Bioenergy consortium, which has primarily (though not
29 wholly) focussed on facilitating the development of bioenergy/biofuels. ESRC funded only two biofuel-
30 related projects in the period examined and both are assessment-focussed: one critically assesses national
31 research priorities on bioenergy and one the political economy of sugar policy change. Some of the 10
32 NERC grants were also assessment-oriented, for example an assessment of biological VOC (volatile organic
33 compound) emissions from land use change that includes biofuel crop production. In short, qualitative
34 inspection does reveal some additional forms of variation between the research councils, but confirmed
35 the emphasis on consequential legitimacy concerns.
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49 Secondly, with regard to the manual newspaper analysis undertaken as an additional check on content, the
50 procedural and consequentially legitimacy-related themes identified in the exploratory stage were
51 consistent with those in the full media sample. The primary concern in the newspaper articles related to
52 the impact of biofuels on food production and availability. In order of descending prevalence, there is a
53 group of articles of approximately equal prominence relating to commercial innovations and activity with a
54 positive tone; positive articles about second and third generation biofuels; articles expressing general
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doubt or opposition to biofuels; relatively neutral descriptions of biofuel debates; and articles expressing negative views about land-take for biofuels. The article themes then continue to gradually decline in prevalence as they refer to concerns about adverse GHG balances and impacts on biodiversity; articles reporting problems with commercial ventures or a negative view of these; neutral articles on aviation as an end use; and articles on adverse impacts on consumers (UK motorists). A small number of articles were also negative about the prospects of second and third generation technologies and specifically argued for a reduction in biofuel targets.

5. Discussion

5.1 Discourse, science and institutional change

The analysis shows substantial variation in keyword occurrences relating to different legitimacy logics (in particular procedural versus consequential), but a lack of significant difference in their incidence by source category, i.e. stakeholder documents, newspaper articles and research council documents. We view this as evidence of societal consensus on the broad scope of concerns regarding biofuel technology and policy, though not an indication of agreement on how to deal with these: the common language indicates a shared emphasis on consequences or impact, but particular positions on these vary considerably (indeed, can be starkly opposed).

At one level, we can infer from this that UK academics as a group (i.e. RCUK-funded scientists) do understand and reflect the scope of wider UK legitimacy related concerns about biofuels. Hence, for example, the fact that the large majority of the 40 BBSRC grants included (representing 62% of the total grant set) relate directly or indirectly to the fundamental science of lignocellulosic and algal biofuels we interpret as a response to societal concern about the limitations of food crop as biofuel feedstocks, the largest concern evident in the newspaper articles. Applying our theoretical frame, we interpret this as scientists seeking alignment with particular, socially-accepted ideas of what 'sustainable' or 'advanced' biofuels constitute. From this perspective, the ways in which the abstracts from the four Research Councils differ reflect the mediating effects of the different research council priorities.

What we have not discussed so far however is the question of consciousness or awareness in this process of alignment. As mentioned above, many grant abstracts embody assumptions about what 'sustainable

1 biofuels' constitute, usually taking this as involving a shift to second or third generation technologies. We
2 infer from this that there is scientific support for policy designs that favour a shift towards the same
3 technologies. What we can't infer, however, is a corresponding and *conscious* policy-related motivation. In
4 practice we would anticipate a range of motivations and levels of policy awareness amongst scientists.
5 Future research, for example in form of in depth interviews with scientists, would provide interesting
6 further insights at this point.
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14 What is more, aligning one's language with the language of wider society (or any target audience) cannot
15 be seen as a guarantor for facilitating institutional change. The new institutional literature, particularly on
16 discourse institutionalism (e.g. Schmidt, 2008) and institutional change (e.g. Greenwood et al., 2002)
17 emphasize that institutional change processes are highly complex social constructions. Here we have
18 focused mainly on what Schmidt refers to as communicating in the right way. But, in our context, the
19 success or failure of a grant proposal is unlikely to hinge solely on the use of particular language or
20 reference to particular themes (though we would hold that this congruence remains very important). We
21 have also not considered in detail Schmidt's questions regarding timing and audience. Regarding the latter,
22 Maguire and Hardy (2009), for example, emphasise that the meanings of particular ideas are not simply
23 passed intact from one text to another. Instead, actors should be viewed as active interpreters of practices
24 whose meaning is, as a result, negotiated in on-going, complex processes (Hardy and Maguire 2008).
25 Hence, individual contributions often have not only intended but also unintended interpretations and
26 consequences. Further research could explore how scientific communications are translated by other
27 actors in a field. In particular, it would be interesting to investigate these processes from the perspective of
28 the grant reviewer, vis a vis their understanding of the legitimization of specific scientific research directions.
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44 *5.2 Prescriptive considerations*

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46 In the above discussion, we take what can be described as a relativist, managerial and empirical
47 perspective. That is, we do not judge in a prescriptive way, based on some form of overarching ethical
48 framework, what should or should not be done with respect to biofuel policy, or with respect to the
49 organisation of science-policy or science-society relationships. However, one may also take the view that
50 the positions reflected in stakeholder and newspaper texts have empirical substance and merit a scientific
51 and policy response. In the legitimacy literature, the possibility of an empirical basis for and relationship
52 with 'idealistic prescriptive arguments' is acknowledged, for example, by Barker (1990) and Bernstein
53 (2005). Considering our findings from a more prescriptive perspective may thus provide further insights, for
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1 which purpose we can return to our introductory comments relating to demands for scientists to justify
2 their work to a wider audience. Within this more prescriptive tradition, legitimacy is typically considered in
3 relation to democratic qualities (Bernstein 2005), often with a distinction between *input* and *output*
4 legitimacy. While the latter (output legitimacy) can be defined as the ability of subjects of authority to
5 solve a given problem and to fulfil delegated tasks (e.g. Schmidt 2013), input legitimacy tends to be related
6 to responsiveness to societal concerns as a result of participatory processes (Schmidt 2013).
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12 Arguably, such prescriptive concepts of legitimacy of authority have applicability (not only empirically but
13 also ethically) in the area of science in policy, particularly when policy is specifically premised on scientific
14 and technological advance and “where science and technology intersect with the political domain because
15 the issues are of visible relevance to the public” (Collins and Evans 2002: 236). As Nahuis and van Lente
16 (2008) observe, scientific and technological innovation can be regarded, problematically, as to some extent
17 displacing politics in the sense of involving choices that have social consequences, but taking place in
18 contexts in which society is rarely involved directly. Hence several authors have proposed democratic
19 evaluation criteria for scientific and innovation processes (e.g. Rowe et al. 2004, in Nahuis and van Lente
20 2008).
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31 Applying such arguments to our case, the congruence between academic research grants and societal
32 legitimacy concerns may be interpreted as the scientists meeting particular input legitimacy criteria.
33 However, as alluded to above, referring to the same issues is not the same as having a common viewpoint.
34 Indeed despite the lexical similarities, there are a wide range of meanings in the texts, including very starkly
35 opposing meanings. In the context of biofuels, opinions often differ sharply about causes, consequences
36 and appropriate policy prescriptions, despite the same concerns being a shared point of reference.
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43 It is questionable, therefore, whether correspondence between societal and scientific priorities is sufficient
44 in terms of granting, evidencing and guaranteeing input legitimacy for any scientific activity, or whether
45 some form of direct engagement by stakeholders from a range of backgrounds (sectors, affiliations and
46 interests), based on deliberative processes, is merited to achieve greater congruence of meaning. Such an
47 argument would resonate with calls, for example by Schmidt (2013), for what can be referred to as
48 *throughput* legitimacy. According to Schmidt (2013: 14) throughput legitimacy is more process oriented,
49 covering “what goes on in between the input and the output”. In her discussion of the legitimacy of EU
50 governance, Schmidt (2013: 6) includes efficacy, accountability, transparency, inclusiveness and openness
51 to interest intermediation as “mechanisms of throughput legitimacy”.
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1 If issues of legitimacy in general and due process in particular are viewed as normatively grounded, then
2 such prescriptive requests should also apply to scientific activity. In fact, science and technologies studies
3 (STS) theorists have long argued for more authentic public participation in technology innovation research
4 (Sclove 1995). This has been discussed in all senses of the public, from individuals through to civil society
5 and in a variety of settings, not least from technology design through to technology use (Nahuis and van
6 Lente 2010). Calls for more deliberative inclusion and value plurality are also found in arguments for post-
7 normal science (Ravetz 1987).
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12 We, too, take the view that, as much as science may often prefer to view itself as separate to policy, politics
13 and wider institutional processes (cf Hoppe, 2005, on alternative models of science-policy interaction), it is
14 in fact often very much involved in all three and that this calls for effective forms of public oversight. While,
15 in the case of biofuels, affected parties are often physically remote from consumers and policy designers,
16 this should not in principle prevent their engagement.
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25 26 *5.3 Reflections on wider biofuels policy*

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28 In addition to discussing the implications of our findings for the relationships between science and policy,
29 environmental and otherwise, we can also reflect on the implications for biofuel related policies and
30 institutional changes more generally. In particular, our observed emphasis on consequences over processes
31 (within science and beyond) seems to firstly support statements about a societal prevalence of “rational
32 myths *that+ celebrate consequential effectiveness” (Suchman 1995), by which Suchman means the
33 privileging of ends over means. However, as Suchman (1995) argues, it is particularly when issues are highly
34 contentious that there is a need for appropriate procedures, which, in a democratic context (and as
35 highlighted previously), typically concerns issues of participation and inclusiveness. Relatedly, Schmidt
36 (2013) observes in association with EU governance, that while input and output legitimacy may be
37 complementary, i.e. good performance in regard to outputs may to a certain extent make up for
38 shortcomings in regard to input legitimacy, violating procedural throughput criteria can have a major
39 negative impact on public perceptions of legitimacy and can cast a shadow over both input and output
40 legitimacy.
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55 From this we can infer a potential threat for societal support for newly emergent biofuels policy and not
56 just for poorer-performing, first generation technologies. This follows from the large scale of additional
57 demand for agricultural resources that industrial biofuels and bioenergy technologies pose and the
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1 complexity of the policy terrain, where perverse consequences are very possible (Melamu and Von
2 Blottnitz, 2011), as well as the practical difficulties involved in securing consent from those affected by this
3 in countries where procedural rights remain weak (Vermeulen and Cotula 2010). In short, there would
4 seem to be a case for a greater focus on effective, accountable, transparent, inclusive and open processes
5 not only in biofuels science, but also current biofuel policy and institutional design more widely.
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10 11 **6. Conclusions**

12 Science and technology theorists have argued for several decades that there is a need for more
13 responsiveness to public concerns in scientific research and technological development. We have used new
14 institutional theory and quantitative and qualitative content analysis to show that legitimacy-related public
15 and stakeholder concerns are currently reflected in the public-facing science discourse of a controversial
16 area of research and innovation (biofuels). Specifically, we find that a common legitimacy-related discourse
17 on biofuels is shared among academics funded by UK Research Councils, UK stakeholders and public
18 opinion as expressed in newsprint articles. Interpreting this, we have argued that in choosing particular
19 discourse that is consistent with societal legitimacy concerns, scientists are more or less wittingly involved
20 in facilitating closely connected institutional and policy processes, whereby science underpins particular
21 policy directions, incentives and the broader institutional arrangements that support and implement these.
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36 Considering this role of science in discursive institutionalisation processes, alongside an increasing trend
37 towards new modes of governance in which scientists often play formal roles, our findings raise additional
38 (ethical) questions about the case for more direct and deliberative public engagement in science. This case
39 is arguably reinforced by our finding of greater consequential prominence (in the scientific as well as
40 stakeholder and news discourse surveyed) over procedural and equity aspects. This said, there are clear
41 practical, not to say political and institutional difficulties, in enabling more inclusive public oversight of and
42 engagement in the widely dispersed research activity of scientific and technological innovation (Lövbrand
43 et al. 2010). Our discussions raise the question of what forms of deliberation might 'work' in the sense of
44 meeting deliberative process criteria. Moreover, as also observed by Lövbrand et al. 2011: 477) public
45 participation and oversight "requires that theorists are ready to open up their normative commitments to
46 empirical contestation" – in other words to the possibility that more democratised research and innovation
47 processes may actually be ineffective in terms that might include, for example, a reduction in societal
48 objection to a given innovation. The assumption of a social preference to delegate responsibility and
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1 involvement to others should also not go unquestioned: in Europe, citizens are split on the need to be
2 involved in 'decisions about science and technology' (Eurobarometer 2005; in Lövbrand et al., 2011). Hence
3 while our own normative position is that dialogue is generally preferable to no dialogue, we are very aware
4 of the many different types of obstacles to meaningful dialogue in this context. While it might be naïve to
5 suggest that informed public involvement in biofuel science as well as wider policy development, in
6 consumer and producer countries, would have shaped (for example, European) policy in different
7 directions, there remains the view, still largely untested, that broadening involvement in science and policy
8 development generally may lead to more widely accepted (and perhaps better) outcomes.
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Captions and Figure notes

Figure 1 A summary of the analytic process

Figure 2 The interpretation of the grant proposal summary given by the Research Councils UK

Figure 3 Legitimacy-related themes in the public summaries of UK Research Council biofuel grants (2007-10)

Figure 4 Comparison of legitimacy-related keyword indicators across sources (newspapers and research grant abstracts)

Figure 5 Temporal occurrence of the most prominent legitimacy terms in UK national newspaper articles on biofuels

Figure 6 Legitimacy-related themes in UK newspaper articles on biofuels 2007-11

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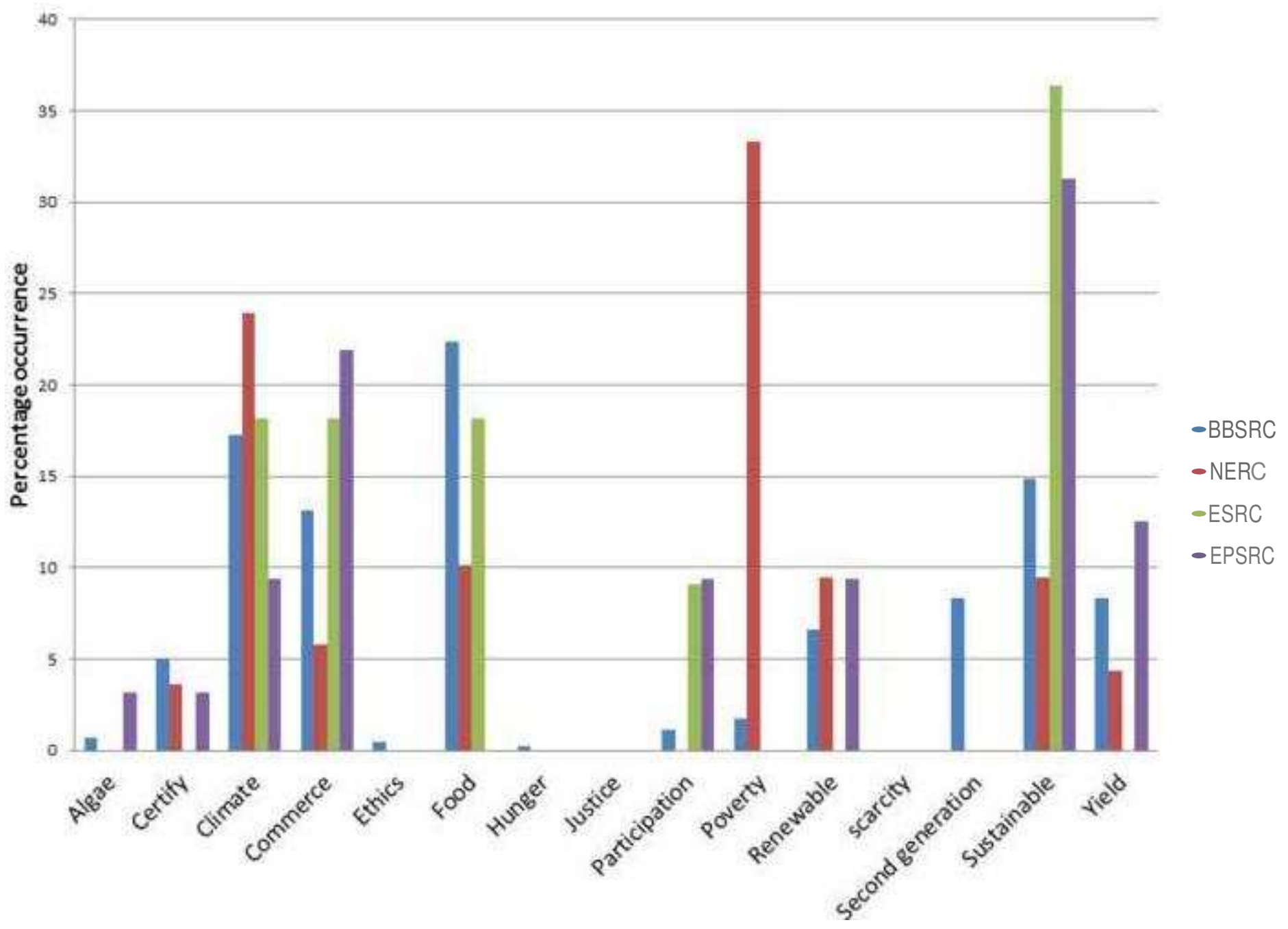
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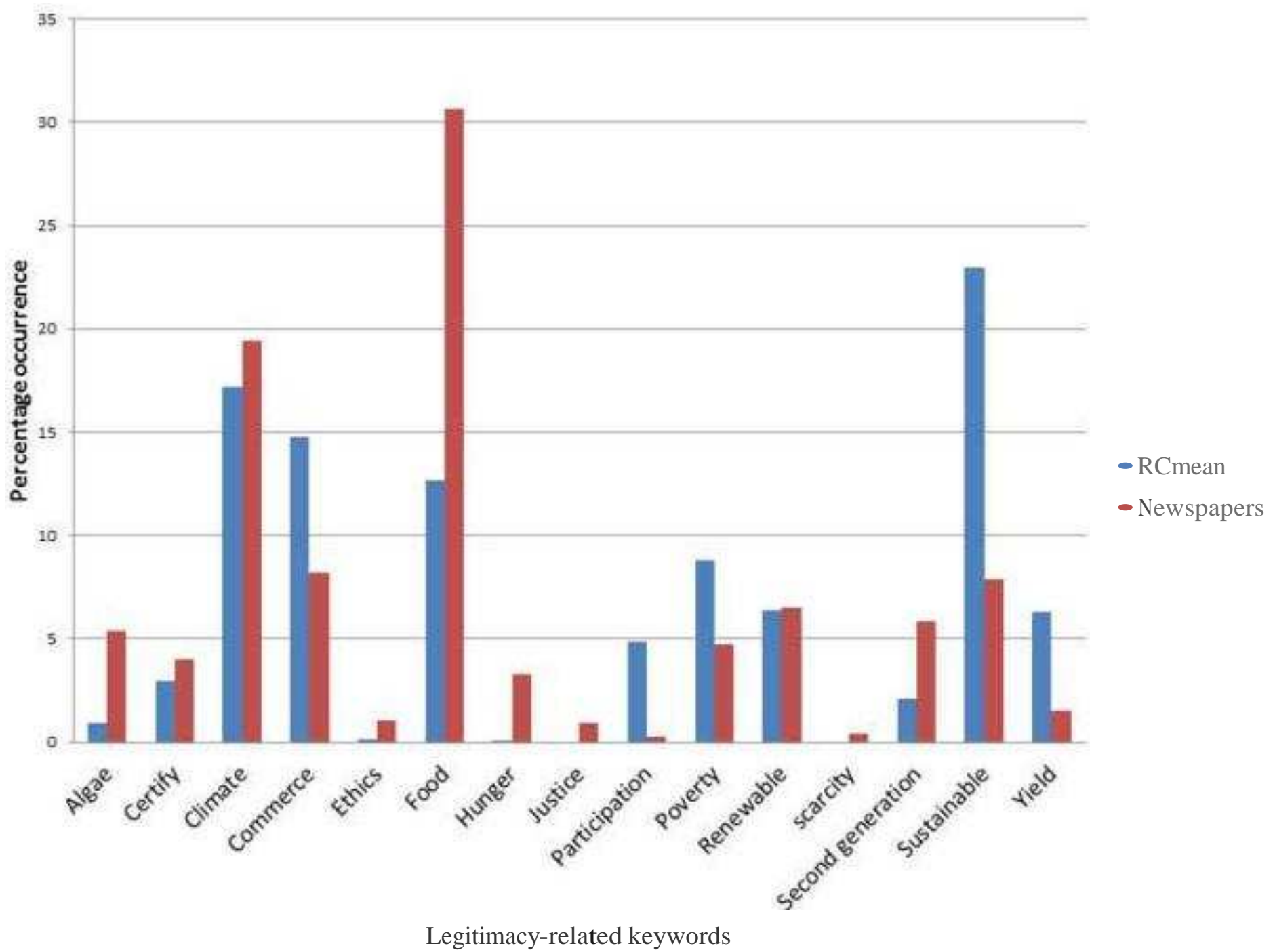
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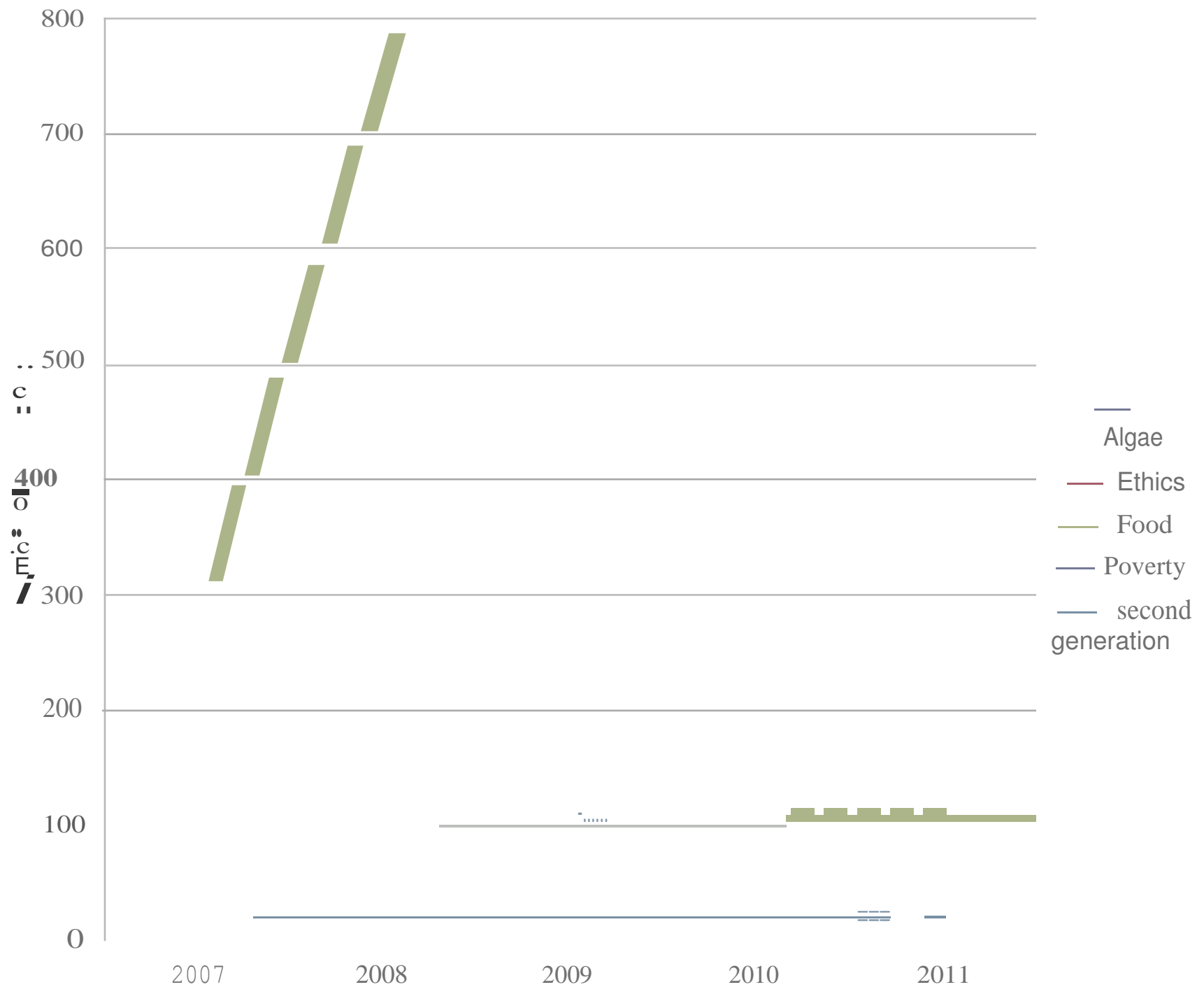


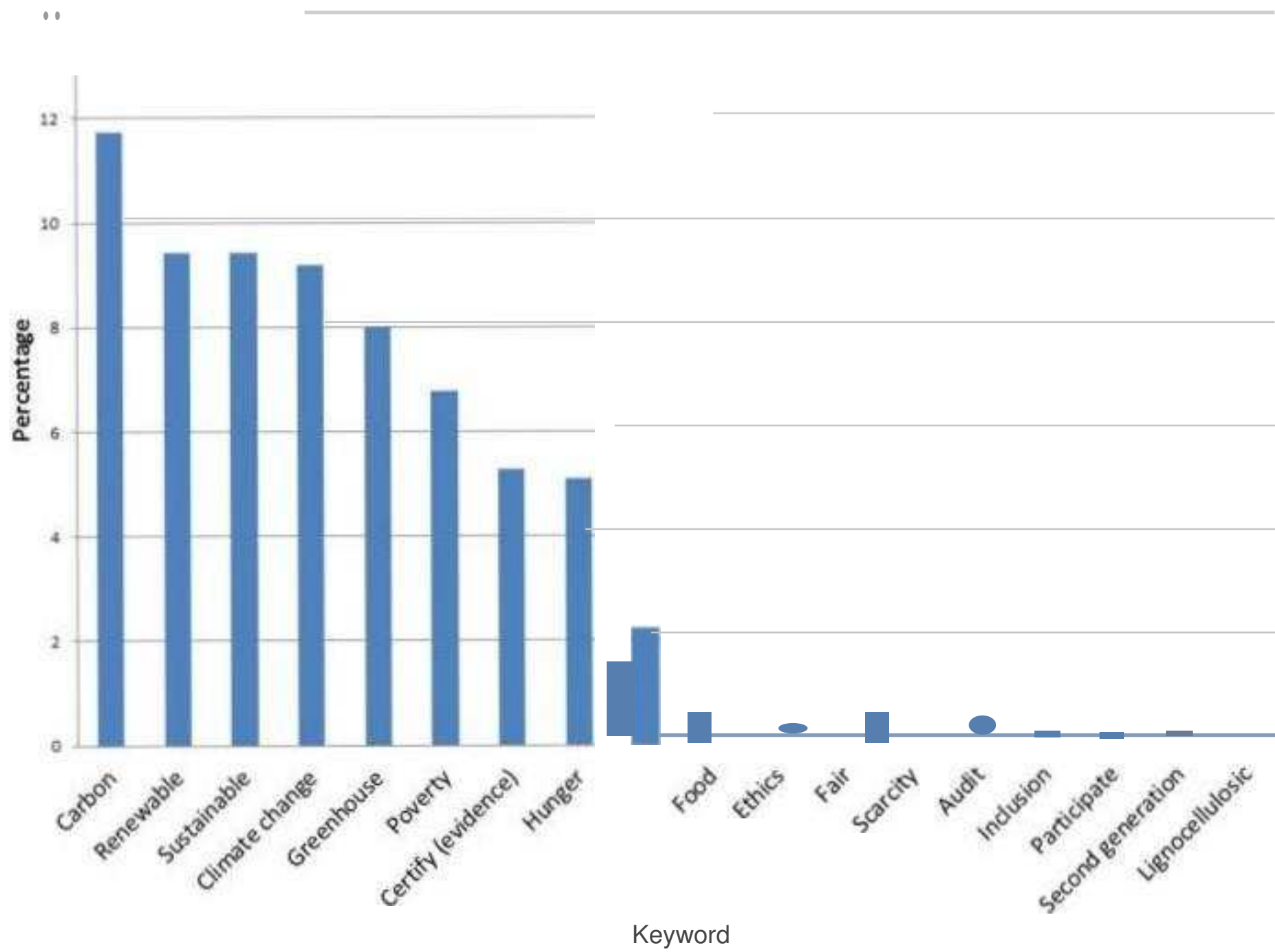
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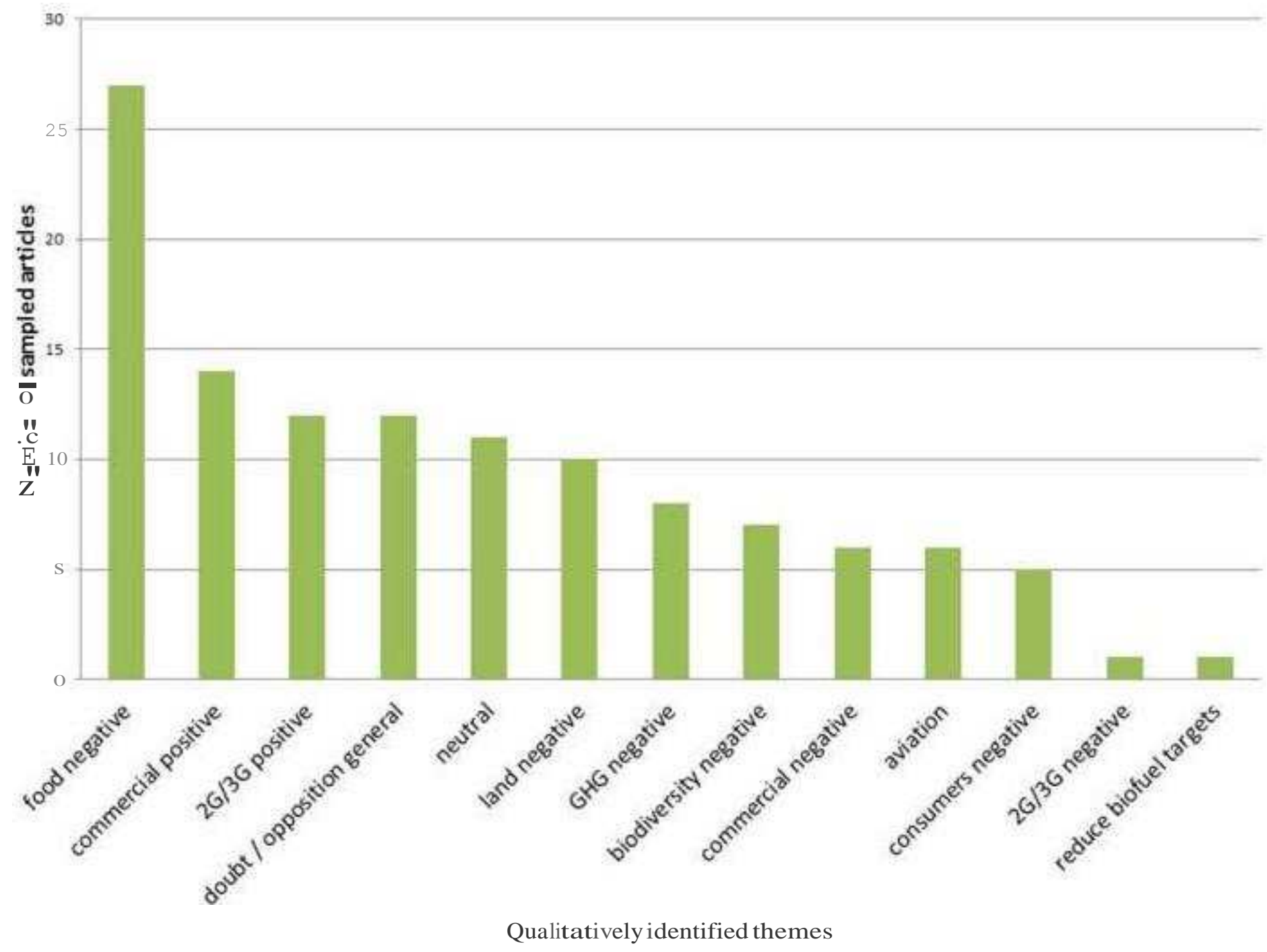


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