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Homologies in fields of cultural production. Evidence from the European scientific field

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ABSTRACT

This article suggests a comparative field analytical approach to fields of cultural production. Combining concepts from field analysis and focusing on homology with topic modeling and multiple correspondence analysis, we compare four scientific disciplines and show homological structures along both internal and external principles of differentiation. The empirical analysis suggests that despite major differences between the four disciplines (biology, chemistry, economics, and sociology), they are structured along similar principles. Moreover, cognitive distinctions in certain disciplines can be correlated with institutional properties and symbolic hierarchies. Despite the similarities, the analysis also shows important differences between the four disciplines related to internal organization and their relations to both other scientific disciplines and the field of power. The article shows how topic modeling and multiple correspondence analysis can cross-fertilize to understand how fields of cultural production differentiate and how cultural practices (here scientific knowledge production) relate to social structures (here academic hierarchies and prestige). The method hence allows for comparison between fields of cultural production while retaining a nuanced analysis of specific fields and the practices that constitute them.

1. Introduction

Cultural, moral, and symbolic boundaries and the way they are activated, maintained, and disputed, are of a crucial interest when studying fields of cultural production (Gieryn, 1983; Abbott, 1995; Lamont & Molnar, 2002; Pachucki et al., 2007). The literature on boundaries has proliferated across a wide range of focuses, including music (Lena, 2004; Nowak & Whelan, 2023), art venues (Sasajima, 2022), sports (Allen & Parsons, 2006), and science (Marshall, 2013; Kropp, 2013). Scholarship in cultural sociology focusing on especially symbolic boundaries echoes prior (and up to present) research on symbolic systems and indirect forms of power (Lamont et al., 2015). This approach delves into internal distinctions within classification systems, leveraging insights from Bourdieu's field theory. In fields of cultural production, the *position* of cultural producers, defined by their endowment in various forms of *capital*, is associated with *position-takings* through the sum of their personal dispositions organized through *habitus* (Bourdieu, 1979, p.261). The theoretical relation between these dimensions, or spaces, is expressed through the concept of *homology* (Bourdieu, 1979, p.139).

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Most sociological studies have relied on the concept of homology to describe the articulation between agent's positions and position-takings, hence the relation between subjective and objective structures as the source for action of agents, using geometric data analysis (GDA), mainly through multiple correspondence (Sapiro, 2002; Warczok & Beyer, 2021). Less attention has been paid to the use of homology for comparing *between* fields, which GDA is also designed for (Schmidt-Wellenburg & Lebaron, 2018, p.26). On the one hand, homology may express the interdependence of positions in a field vis-à-vis the field of power (Bourdieu, 1989, p.373). On the other hand, homology may refer more broadly to the observation of similar principles of vision and division across different fields (Bourdieu, 1979, p.547; Bourdieu, 1989, p.384; Sapiro, 2002).

In this article we analyze science as a field of cultural production. This allows us to challenge the concept of boundaries at large, since disciplines are consistently characterized by a dynamic interplay of delineation and transgression (Abbott, 2001; Sugimoto & Weingart, 2015). Especially symbolic boundaries are under scrutiny, through an analysis of science topics in biology, chemistry, economics, and sociology. Empirically, we draw on the projects granted by the European Research Council (ERC). This allows us to compare between these disciplines on a common ground, highly competitive, where struggles to define the symbolic boundaries of disciplines crystalize through the granting of legitimation to specific of research topics.[d] Indeed, knowledge production unfolds within the context of a growing influence of funding agencies, operating at both national and European levels, as pivotal players in research governance (Gläser & Laudel, 2016; Benz & Rossier, 2023). Drawing on scientific abstracts, we map topic spaces to understand how disciplines cognitively structure, and the extent to which homologous principles of vision and division, or *nomos* apply (Bourdieu, 2001, p.103). In addition, we measure the degree to which the dimensions defining these spaces of epistemological position-takings associate with further indicators: disciplinary dimension (measured by ERC panels and journal disciplines) and symbolic dimension (measured by journal ranking, amount of funding and supportive organizations). Symbolic boundaries directly imply a consideration of spaces' relative autonomy, which depicts the entry requirements imposed on newcomers (Bourdieu, 2001, p.101; Elias, 1972) and defines the extent to which the 'sense of the game' vary across disciplines (Gingras, 2012; Bourdieu, 2001, p.103).

The article hence asks the following questions: to what extent do scientific disciplines share similar principles of vision and division regarding their cognitive configurations? And how do these configurations depend on disciplinary and symbolic dimensions? We understand these specific questions as a starting point and practical illustration for engaging in a discussion and development of a comparative field analytical approach. Building a field theoretical approach for studying and comparing disciplines, we engage in an empirically informed theorization of disciplines and their homologies by analyzing 12 206 ERC funded projects and 200 576 publications associated with these projects. We analyze and compare biology, chemistry, economics and sociology. Methodologically, we combine a scientometric approach to journal classification with a combination of Latent Dirichlet Allocation (LDA) (Blei et al., 2003) and geometric data analysis (Le Roux & Rouanet, 2004) to map spaces of topics (Baier & Gengnagel, 2018; Pareschi & Lusiani, 2020; Kropp & Larsen, 2023). By combining this method with field theory and socio-historical knowledge on sciences, we engage in a theoretical discussion about homologies and symbolic boundaries of disciplines.

The article proceeds as follows. *First*, we theorize fields of cultural production and the specificities of scientific fields. We further reflect on the internal structure of disciplines as well as their relations to other disciplines and to the field of power and emphasize on methodological issues about measurement and metrics. *Second*, we expose our strategy and data. *Third,* in the empirical part, we define disciplines through both journal and article classification that we articulate with ERC native classification schemes and comment on methodological issues. Then, we analyze the spaces of topics of biology, chemistry, economics, and sociology. *Finally*, we draw on our analyses to discuss the challenges in identifying general principles of differentiation across disciplines and the prospects of mapping homological relations in broader fields of cultural production.

2. Fields of cultural production and the specificities of scientific fields

To understand the overarching question of the relation between cultural practice and social structure, we suggest using a field theoretical approach emphasizing the concept of homology. The field of cultural production is a relatively autonomous space embedded within a larger encompassing space, the field of power, which is in turn embedded within a larger encompassing space, the social space (Bourdieu, 2015, p.593). The scientific field, as a subspecies of the field of cultural production, is a field of action in which agents have the power to define the boundaries of the field according to the volume and structure of the capital they possess. Highly significant barriers to entry make it one of the most autonomous fields of cultural production (Bourdieu, 2001). Still, the scientific field is only relatively autonomous, so much so that certain 'worldly' disciplines mostly reproduce the structure of the field of power (Bourdieu, 1984a). Therefore, the question of the autonomy and heteronomy of the scientific field is far from binary and is expressed in multiple and changing ways (Gingras & Gemme, 2006).[e]

In the sociology of science literature, only few references thoroughly engage with understanding the nature of disciplines or suggest

[d] Drawing on ERC granted projects we do not aim at reconstructing entire disciplinary fields including 'all agents and institutions that produce and reproduce science' (Beyer, 2021, p.71). Rather, we engage in addressing homologies through mapping topic spaces. As further developed in the *Methodological approach* section, we employ an innovative methodological strategy mixing topic modeling (Blei et al, 2003) with geometrical data analysis (Le Roux & Rouanet, 2004) to map science topics as symbolic spaces and related them to disciplinary and further symbolic hierarchies (Kropp & Larsen, 2023).

[e] We deliberately set aside the question of the highly variable and ambiguous effects of the internationalization of science on their autonomy (see for instance Bourdieu, 1995, 2023; Heilbron et al., 2017; Gingras, 2002), for they are hardly possible to measure at the topic level through our empirical material.

more conceptual definitions. Whitley (1984) offers an analysis of the differences between scientific fields, building on an organization theoretical framework. He argues that intellectual properties of disciplines such as task uncertainty, mutual dependency, and audience configurations are shaped by the organizational structures of scientific fields. Building on this framework, other researchers have suggested different forms of comparison between scientific disciplines (Andersen, 1996; Gläser et al., 2018). More recently, historians of the social sciences have emphasized the importance of understanding disciplines not solely as fields of knowledge production but also as entities involved in teaching (or the reproduction of the discipline) and the potential societal utilization of disciplinary knowledge (Fleck et al., 2019). The historical approach to the institutionalization of disciplines highlights the shifting conditions and mechanisms of discipline autonomization, echoing more field-oriented analysis of disciplines (Heilbron, 2004). Throughout these discussions runs the insight that disciplines make up fundamental organizational units of the differentiation of modern science and that the institutional and intellectual dimensions are closely connected. Hence, scientific disciplines define career paths and establish hierarchies of recognition distributing the power to reproduce and subvert, albeit it rarely, the inner working of the disciplines. Addressing homologies *between* symbolic structures of disciplines suggests considering them as historical products resulting from their process of autonomization. Any attempt to define a discipline must incorporate a reflection on both its sociological and historical nature, that is, the various struggles over time that have led to its current form.

Following this, we understand scientific disciplines as fields of action bounded by common perceptions and practices about scientific knowledge production, as well as common lines of differentiation and struggle over hierarchies and recognition (Bourdieu, 2001). One important claim in field theory relates to homology between fields, hence the assumption that similar principles of vision and division are present across them, as well as between specific fields and the social space at large (Wacquant, 1989; Bourdieu, 1996; Wang, 2016). Stressing that field theory is a theory of the economy of action implies analyzing disciplines through the practices of scholars, which we address through the content of ERC project abstracts. Taking the activity and not the institutional conditions as a starting point is an appropriate approach for understanding and testing the claim of homology across scientific field and fields of cultural production in general. Following Gorski's (2013, p.328) invitation to develop some new conceptual tools and methodological axioms for possible fruitful futures drawing on Bourdieu's research, we suggest analyzing homologies along three central principles developed from insights from field theory. The *first* principle closely derives from the homology between position-takings and positions, which we operationalize as the degree to which the structure of the topic spaces relates to disciplinary affiliations, thanks to our methodology leveraging LDA and MCA. In addition, we also analyze the extent to which the structure of topics associates with a specific distribution of symbolic resources, namely journals rankings, supportive organizations, and amount of funding. The *second* principle engages with relative autonomy of topic spaces in relation to *the field of power*, i.e., the degree to which the structure of topic spaces may (partly) reflect interests from the bureaucratic, political and economic fields, thereby be imposed principles of vision and division through field intrusion[f] (Schmitz et al., 2017). More concretely, we understand the specific scientific fields under study here as part of a European field of power. Similar to national fields of power, the European field of power is a heteronomous configuration of national and supranational actors and institutions struggling over the principles of domination in European matters, but often with huge effect in national fields (Cohen et al., 2007; Cohen, 2011). The *third* principle engages with relative autonomy of topic spaces in relation to *other fields of cultural production*, namely the degree to which the structure of topics is distorted by principles of neighboring fields (Gorski, 2013, p.330). Empirically, this is measured by identifying the presence of other disciplines or ERC domains that are strongly associated with the topics structuring the topic spaces.

At the institutional level, biology, chemistry, economics, and sociology share common traits, such as specific journals, societies, departments, and curricula. From a socio-historical perspective, however, we expect them to vary in their internal organization as well as in their relations to other disciplines and the field of power. *Biology* has been considered a particularly fragmented discipline, with a long tradition of concurrent epistemologies (Mayr, 1961; Larregue et al., 2020; Benz & Bühlmann, 2024). Biology is also highly stratified (Whitley, 1984), as some agents (molecular biologists) are much more likely to receive economic and symbolic credit than others (evolutionary biologists) (Gingras, 2012). This state of the field is the product of a historical process widely documented in the literature that involves boundary-work of external (political and economic) agencies (Rheinberger, 2010; Wilson, 1994; Morange, 2020). *Chemistry* has been considered as an integrative yet 'plastic discipline' (Louvel, 2015) and has even been depicted as a 'science without a territory' (Bensaude-Vincent & Stengers, 2001). The tension between chemistry as a highly standardized disciplines (Beyer, 2021) and chemistry as a 'tool' that can be appropriated by other fields of research lies at the heart of discipline's socio-historical construction. One example is the importance that organic and physiological chemistry played in the development of molecular biology and the *physico-chemical* approaches to life (Morange, 2020). The boundaries of chemistry are not only blurred towards other disciplines; the discipline also has a long tradition of collaboration with the industrial sector, illustrated by the early institutionalization of applied chemistry already in the nineteenth century (Reinhardt, 2002). *Economics* exemplifies the case of a homogenous scientific discipline with a strong vertical hierarchy at the transnational level (Fourcade, 2006; Korom, 2020). Despite addressing many

[f] The field of power is not to be confused with the political field. It is the space of power relations between the different species of capital or, more precisely, between agents who are sufficiently endowed with one of the different species of capital to be able to dominate the corresponding field (Bourdieu, 1994, p.56). Hence, the field of power is the field of struggle for the 'exchange rate' between the different species of capital, which its specific capital being a "capital conferring power over capital" (Bourdieu, 2020, p.34). We do not consider homology to the field of power as a structural homology of positions. Rather, we consider a relation to the field of power when we empirically observe incentives that the field of power proposes or imposes, which case also informs in the varying degree of dependency on it (Bourdieu, 1984a, pp.75-76). Moreover, any absence of structural role of disciplines or symbolic dimension may indicate that the principles of vision and division within a topic space do not (only) rely on struggle for scientific capital but is (at least partly) reflecting a struggle for capital's definition.

topics and objects, the field of economics is not as clustered as biology. Even though it has a strong influence on other social science disciplines, economics is rather isolated from them (Fourcade et al., 2015). At the same time, mathematical modeling and statistical techniques inspired from the natural sciences have been integrated into economics (Fourcade-Gourinchas, 2002). Economists are very central in the field of state expertise, hence many of the field-specific stakes are influenced by the distribution of forms of capital in the field of power (Lebaron, 2001; Maesse et al., 2021; Schmidt-Wellenburg, 2018). Unlike economics, *sociology* is characterized by many concurrent disciplines and related epistemological position-takings, i.e., different in use of methods, concepts and general ideas of science, and relations to society at large (Kropp, 2013; Platt, 2010). Simultaneously, sociology claims to be the most general social science, while it is strongly anchored in national contexts and traditions (Calhoun, 2008; Heilbron, 2004, 2015).

Biology, chemistry, economics, and sociology form four distinct fields in terms of their historical trajectories, internal organization, and relationships with other fields and the social space. Therefore, we anticipate variations in their organizational and cognitive structures. Our purpose is to analyze the extent to which they may also share similar principles of vision and division.

3. Methodological approach

To explore homologies between disciplinary fields, we associate topic modeling with multiple correspondence analysis, which allows us to map topic spaces with an incorporation of supplementary variables. This approach demands careful clarification and detailed information on data gathering and the classification used before interpretation (see Online Appendix A). Defining 'disciplines' lacks consensus, as does hierarchizing terms like 'subdisciplines', 'specialties', or 'research areas' (Sugimoto & Weingart, 2015). While biology, chemistry, economics, and sociology are autonomous disciplinary entities given their historical institutionalization, shared cognitive content, and social practices among scholars, they do not hold the same hierarchical rank in existing taxonomies. Our methodology, leveraging Scopus, utilizes a classification with 27 disciplinary 'major fields', and over 300 'minor fields'. Scopus's 'All Science Journal Classification Codes [ASJC]' identifies three major fields within the biological sciences, further divided into 'minor fields'. Sociology is classified as a minor field under the major field of 'social science'. Economics has a dedicated category named 'Economics, Econometrics and Finance' with fewer 'minor fields' than the biological sciences. Chemical sciences have their categories, but related minor fields such as 'material chemistry' or 'environmental chemistry' exist in various major fields. These classification issues carry significant theoretical, methodological, and empirical implications that are central to this article.

We draw on the open access CORDIS database that lists all ERC projects since 2008. This provides us with an extensive overview of scientific production in the context of a highly competitive access to research fundings and provides information on the projects and related abstracts, amount, and funding organizations. Each project is affiliated to a specific panel defined thematically rather than disciplinarily. This is especially the case for the panels in the social sciences and humanities. Panels such as SH3 The Social world and its Diversity or SH5 Cultures & Cultural Production are not disciplinary exclusive. Therefore, we draw on publications to assess projects' disciplinary affiliations: we identify all articles related to the projects and relative journal discipline, then we attribute a score to each project based on the proportion of articles in biology, chemistry, economics, and sociology journals. For instance, a project with ten publications – six in biology journals, two in chemistry, and two in other disciplines – will get a score of 60 % in biology and 20 % in chemistry.

To construct topic spaces for each discipline, we employ a two-step approach. First, we utilize Multiple Correspondence Analysis (MCA) on a set of topics estimated through Latent Dirichlet Allocation (LDA) (Blei et al., 2003). Topics are defined as 'highly probable words' that are automatically inferred from their co-occurrence in the documents (Blei & Lafferty, 2009, p.72). Using LDA, we represent each document–the ERC projects' abstracts–as a collection of topics. Then, we use MCA to summarize the principal dimensions that explain the distribution of topics and map spaces of epistemological position-taking (Kropp, 2013; Kropp & Larsen, 2023). Subsequently, we assess the association between these dimensions and supplementary variables characterizing ERC projects and related publications. This strategy enables us to evaluate the relationship between documents' positions in the spaces, associated epistemological position-taking (the topics), and further indicators of disciplinary affiliations and endowment in symbolic resources. Furthermore, this approach keeps us vigilant regarding potential limitations in terms of both article and journal-level classification. LDA aligns well with a sociological perspective for classifying and analyzing unstructured text content (DiMaggio et al., 2013; McFarland et al., 2013; Baier & Gengnagel, 2018; Rossier et al., 2023), facilitating the linkage of text and social structure. It employs a relational and descriptive quantitative technique, modeling the probability of specific terms (topics) within a document. LDA treats text as a 'bag of words', disregarding its structural aspects (Blei, 2012; Marshall, 2013). Documents can contain multiple topics, and each term may belong to several topics. As a result, LDA does not yield mutually exclusive categorizations of texts, allowing topics to appear in multiple texts with potential correlations across different texts. Emphasizing non-exclusivity, we not only consider prevalent topics in each text relative to other text groups but also explore correlations between topics based on their co-occurrence. Our primary focus lies in understanding topic relationships, mapping their structure, and positioning documents–the ERC projects–within this structure. We maintain a peripheral focus on delineating topic groups, opting for dimensionality reduction over strict topic partitioning through clustering techniques.

We use supplementary variables to assess the extent to which structuring dimensions of the topic spaces associate with disciplinary affiliations and endowment in symbolic resources. Supplementary variables do not contribute to form MCA axes. They are displayed according to the coordinates of the ERC projects they qualify. To assess the *disciplinary dimension* of the studied MCA axes, we project the following two variables:

- We can systematically examine the association between axes and *panels*, enabling us to evaluate the structural anchorage of topics within the ERC's native institutional classification.

- At the level of journals, we project *journal disciplines* to see the extent to which topics are structured along a disciplinary dimension.

Three additional variables are employed to assess the degree to which topics are organized based on hierarchies according to a *symbolic dimension*:

- *Highest ranked journals* characterize any publications related to the project that have been published in the highest ranked journals according to the CWTS Leiden Ranking (within all journals – sociology, economy, biology, or chemistry – measured with SNIP).
- *Very supportive organization* are the institutions that have contributed most to financing projects. A very supportive organization is one whose sum of all funded projects is in the bottom decile of the total amount distribution (see Online Appendix A).
- Finally, we identified the 10 % *most funded projects* in each discipline, as an indicator of the volume of economic capital (and thus symbolic capital) associated to specific topics, to locate them in the disciplinary space.

4. Empirical part 1: a disciplinary continuum

In this first empirical part, we analyze important morphological aspects of the four disciplines and the interplay between publication practices and institutional manifestations, represented here in the form of funding panels. The analysis brings to light the distinct properties of the four disciplines, emphasizing differences in size, relative autonomy, and openness concerning other disciplines. The analysis underlines the importance of careful empirical construction of the scientific objects when analyzing fields of cultural production. Empirically, we demonstrate variations in the number and distribution of projects in ERC panels based on eleven thresholds ranging from >0 publications to 100 % of publications corresponding to the disciplines. Fig. 1 illustrates how the total number of projects associated with each discipline diminishes as the thresholds increase.

From Fig. 1 we observe that the number of projects is much higher in biology and chemistry than in economics and sociology. Accordingly, the rate of project decline becomes more pronounced as thresholds increase. The number of projects in biology varies from 5 900 at the first threshold to 2 215 at ≥50 %, then to 380 when 100 % of the publications are affiliated to biology journals. For chemistry, these numbers are 4 779 at the first threshold, 1 534 at ≥50 %, and 325 with 100 % of the articles published in chemistry journals. In economics, these numbers vary from 638 to 232 at ≥50 %, then 120 at the last threshold. Finally, the number of projects in sociology decreases from 988 to 196, then to only 55.

Beyond these marked differences in the number of projects, the variation in thresholds also implies different panel composition. Fig. 2 shows for each threshold the share (in%) of projects affiliated to panels corresponding to the discipline and to other panels. For instance, we calculate the share of projects recorded in biology panels according to each threshold for publications in biology journals. Absolute numbers and the distribution of the supplementary variables are displayed in Online Appendix B.

Looking at the panel distribution, we observe important differences across disciplines. Many projects with publications in biology or chemistry journals are recorded in other panels than biology and chemistry panels. The share of these other panels decreases from about 60 % at the first threshold (all projects that have published at least one article in biology/chemistry journals) to about 40 % at the threshold of ≥50 %. This share then slightly decreases to increase again at the two last thresholds. From these observations, biology and chemistry show similar patterns despite their diverging degree of autonomy. Hence, chemistry, qualified as a 'science without territory' (Bensaude-Vincent & Stengers, 2001), does appear as open as the very hierarchical and more autonomous biological science.

Economics and sociology show different behaviors. From a threshold of ≥40 %, almost 90 % of the projects that publish in economics journals are recorded in the economic panel. This share then remains remarkably stable until the last threshold. This observation directly echoes the very high autonomy of this disciplinary field (Fourcade et al., 2015): economics influences other social sciences disciplines but does not integrate them for publication in disciplinary journals. In contrast, other panels are more likely to publish in sociology journals. Their share decreases from about 40 % at the first threshold to about 20 % at the threshold of ≥50 % and increases again to about 30 % when 100 % of articles are published in sociology journals. This leads to two interpretations: like in biology and chemistry, it is relatively likely that some other disciplines publish in sociology journals without being themselves recorded in sociology-related panels. However, as panels are not discipline-related for the social sciences and humanities, these other panels are likely to be recorded in other SHS panels.

In support of this interpretation, table 1 displays the share of projects according to the type of panels they are recorded in. We focus on the threshold of >50 %, which we also later use to construct the space of topics.[8]

The projects with a threshold of >50 % publications in biology journals are 56.5 % to be recorded in one of the five biology panels. The other panels involved are mainly related to health and medical sciences: LS4 Physiology in Health, Disease & Ageing (5.5 %), LS5 Neuroscience & Disorders of the Nervous Systems (4.8 %), LS6 Immunity, Infection and Immunotherapy (5.4 %) and LS7 Prevention, Diagnostic & Treatment of Human Diseases (5.5 %). In addition, 5.5 % of the projects are affiliated to the Proof of Concept (PoC) panel, aimed at enhancing commercial orientation, however with no indication on discipline. Projects affiliated to chemistry journals are 49.5 % to be affiliated to one of the two chemistry panels. The other panels involved relate in priority to PE8 Products & Processes

[8] The reasons for choosing a threshold of >50% are twofold. *First*, we assume that the publication of more than the half of articles in journals related to a discipline is an analytically fair indicator for being assigned to the discipline in question. *Second*, we empirically observe that the share of 'other panels' is at its lowest around this threshold. A higher threshold carries a risk of dropping off a significant number of relatively interdisciplinary projects. Higher thresholds also include few projects, and certainly too few publications, making the results unreliable. Conversely, a lower threshold may lead to an over-representation of other panels, making it difficult to interpret and compare topic spaces.

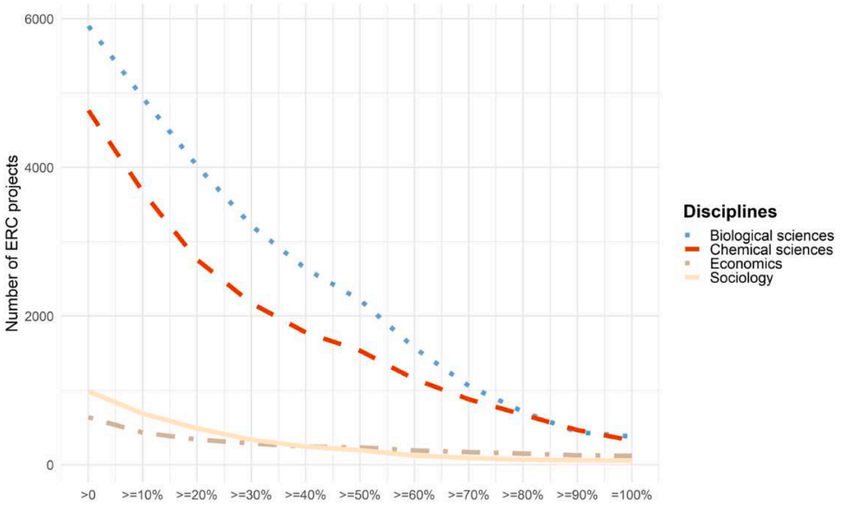

Fig. 1. Total number of projects.

Engineering (12.6 %), to PE10 Earth System Science (6.8 %), and to PE3 Condensed Matter Physics (4.7 %). Moreover, 9.3 % of the projects are affiliated to the Proofs of Concept (PoC) panel. In economics, 87.5 % of the projects are affiliated with economics panel, which is a much higher score than biology and chemistry. SH2 Institutions, Governance & Legal Systems and SH3 The Social World and Its Diversity count for an aggregated figure of 8.2 %, and other panels for only 4.3 %. Finally, sociology-related projects are 74 % to be affiliated with panels SH2 Institutions, Governance & Legal Systems or SH3 The Social World and Its Diversity. The most represented other panels are SH5 Cultures & Cultural Production (8.2 %) and SH6 The Study of the Human Past (7.7 %).

The distribution of panels strengthens the interpretation of biology and chemistry journals as permeable to other disciplines, making these disciplines less autonomous as theoretically expected. In biology, this openness appears to be mostly directed towards neighboring disciplines (Chen et al., 2015). Chemistry seems to include more distant disciplines more readily, such as earth sciences and various types of engineering. Economics appears as autonomous and institutionalized. In contrast, we find projects publishing in sociological journals among many panels. This indicates both the very general scope of sociology, but also its inability to institutionalize its specific scientific gaze. To further the analysis of the homologies between the four disciplinary fields, we focus in the next empirical part on modeling spaces of topics.

5. Empirical part 2: structures in the space of topics

In this second empirical part, we analyze the four spaces of topics. We combine the description of principal dimensions (or axes) that structure each field with the distribution of supplementary variables referring to journal disciplines, panels, highest ranked journals, very supportive organization, and most funded projects. The degree of association between topics and disciplines and/or symbolic resources guides our interpretation of the homology between position-takings and positions, as well as the extent to which the principles of vision and divisions that structure these symbolic spaces are either disciplinary-based, or heteronomous with other disciplinary fields and/or the field of power. We consider interpreting the two principal axes of every four spaces. Online Appendix C displays needed MCA metrics together with the list of the most contributing topics.

5.1. Biology

The first axis in biology (Fig. 3) represents field-specific principle of differentiation, by distinguishing between ‘functions’, ‘cell’, and ‘regulation’ on the left and ‘ecosystems’, ‘ecology’ and ‘evolution’ on the right. The three most contributing topics on the left side are ‘protein.bind.domain’, ‘rna.transcription.rnas’, and ‘cell.stem.niche’. On the right side, the three most contributing topics are ‘carbon.forest.biodiversity’, ‘community.species.diversity’, and ‘change.global.ecosystem’. These two poles clearly refer to two epistemologies that have historically structured the biological sciences into two competing groups: functional biologists on the left and evolutionary biologists on the right (Mayr, 1961). These are not two institutionalized disciplines *per se* but a very strong principle of distinction that determines research objects, methods, and the scale (micro versus macro). When projecting panels as supplementary variables, we observe that LS1 Molecules of Life: Biological Mechanisms, Structures and Functions and LS3 Cellular, Developmental and Regenerative Biology are displayed on the left side of the space, while LS8 Environmental Biology, Ecology and Evolution is displayed on the right. The projection of publications offers similar results (see Online Appendix D). From the projection of panels and publications, we assume that the first axis is institutionally anchored in disciplinary distinctions, therefore reflects a high degree of homology between position-takings and disciplinary positions. Moreover, this axis also has a symbolic dimension as we observe that projects that publish in highest ranked journals are clearly displayed on the left side of the space. This, again, is consistent with the literature that stresses that functional biologists benefit from higher symbolic recognition than evolutionary biologists (Gingras, 2012;

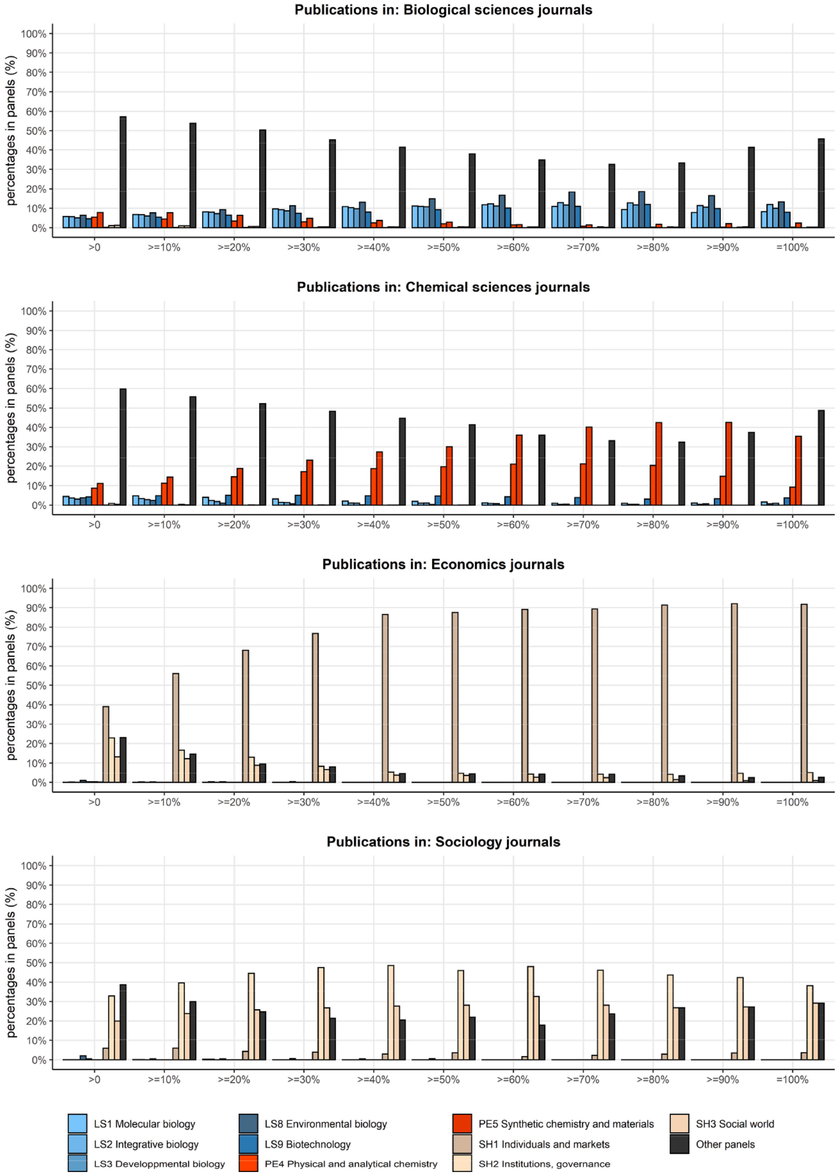

Fig. 2. Share of projects according to the thresholds and the ERC panels.

Table 1
Distribution of panels in the disciplines at the threshold of >50 % (in%).

	Panels: Biology (%)	Panels: Chemistry (%)	Panels: Economics (%)	Panels: Sociology (%)	Other panels (%)
Biology (n = 2 215)	56.5	4.8	0.05	0.4	38.3
Chemistry (n = 1 534)	8.9	49.7	0	0.07	41.4
Economics (n = 232)	0	0	87.5	8.2	4.3
Sociology (n = 196)	0.5	0	3.6	74.0	21.9

Morange, 2020).

The second axis represents a difference in the orientation of research topics based upon the autonomy of biology in relation to other disciplinary fields. It distinguishes between 'clinical', 'technology', and 'product' at the top and 'gene', 'adaptation', and 'evolution' at the bottom. The three most contributing topics at the top are 'material.cost.develop', 'engineer.base.technology', and 'image.resolution.device', which clearly relate to the field of applied biology, biotechnology, and medical concerns. At the bottom, 'genome.gene.sequence', 'evolution.species.evolutionary', and 'gene.identify.expression' express concerns that have historically driven both

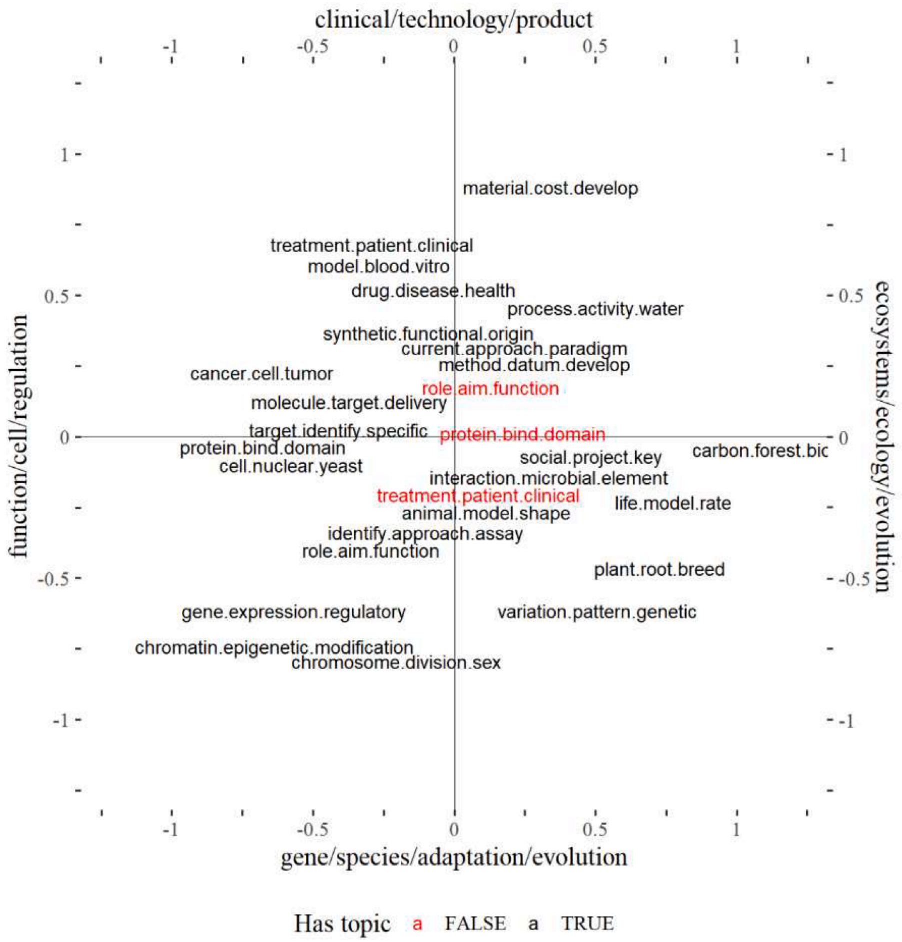

Fig. 3. The space of topics in biology.

functional and evolutionary biologists, however, with different theoretical and methodological approaches (Wilson, 1994; Rheinberger, 2010; Morange, 2020). It is noteworthy that panel LS2 Integrative Biology: from Genes and Genomes to Systems is displayed at the bottom, while LS9 Biotechnology and Biosystems Engineering is displayed at the top of the space. This opposition between the two panels also incorporates symbolic hierarchies. While most funded projects are displayed rather homogeneously in the space, the projects driven by the most supportive organizations are situated on the autonomous side of the space. In the recent period, integrative biology, i.e., research related to genetic and genomic diversity of organisms that aims at integrating across biological levels, seems to have gained credibility with research funding institutions, whereas previously biotechnologies enjoyed maximum legitimacy.

5.2. Chemistry

The first axis in chemistry (Fig. 4) of chemistry, contrary to biology, is not field-specific but extend to other disciplines. It distinguishes on the left ‘electronic’, ‘energy’, and ‘semiconductor’ with the most contributing topics ‘electronic.device.graphene’, ‘property.control.film’, and ‘energy.solar.efficiency’ from, on the right, ‘cell’, ‘disease’, and ‘protein’ with the most contributing topics ‘cancer.treatment.therapy’, ‘signal.cellular.disease’, and ‘cell.stem.blood’. The left side is typically associated with panel PE8 Products & Processes Engineering and PE3 Condensed Matter Physics, which we previously identified as the most important ‘other panels’ in chemistry. Also, on the left we find projects with publications in electrochemistry as well as physical and theoretical chemistry journals. The right side is associated with the biological domain and especially publications in molecular biology journals as well as analytical and organic chemistry journals. In contrast to biology where the association between journal classification and panels is rather straightforward, the structure of chemistry is more complex. While the discipline of publications indicates a quite classic opposition between carbonate (organic) and non-carbonate (inorganic) chemistry (Bensaude-Vincent & Stengers, 2001; Benz & Rossier, 2022), it also includes a strong permeability to other disciplines, which seem to be linked to one or other of the poles. Moreover, no symbolic hierarchy seems to be associated to this first dimension.

On the second axis, we find a more field-specific principle of division, which distinguishes between at the top ‘catalysis’, ‘product’, and ‘synthesis’ with the most contributing topics ‘catalyst.reaction.catalytic’, ‘organic.chemistry.molecule’, and ‘bond.activation.

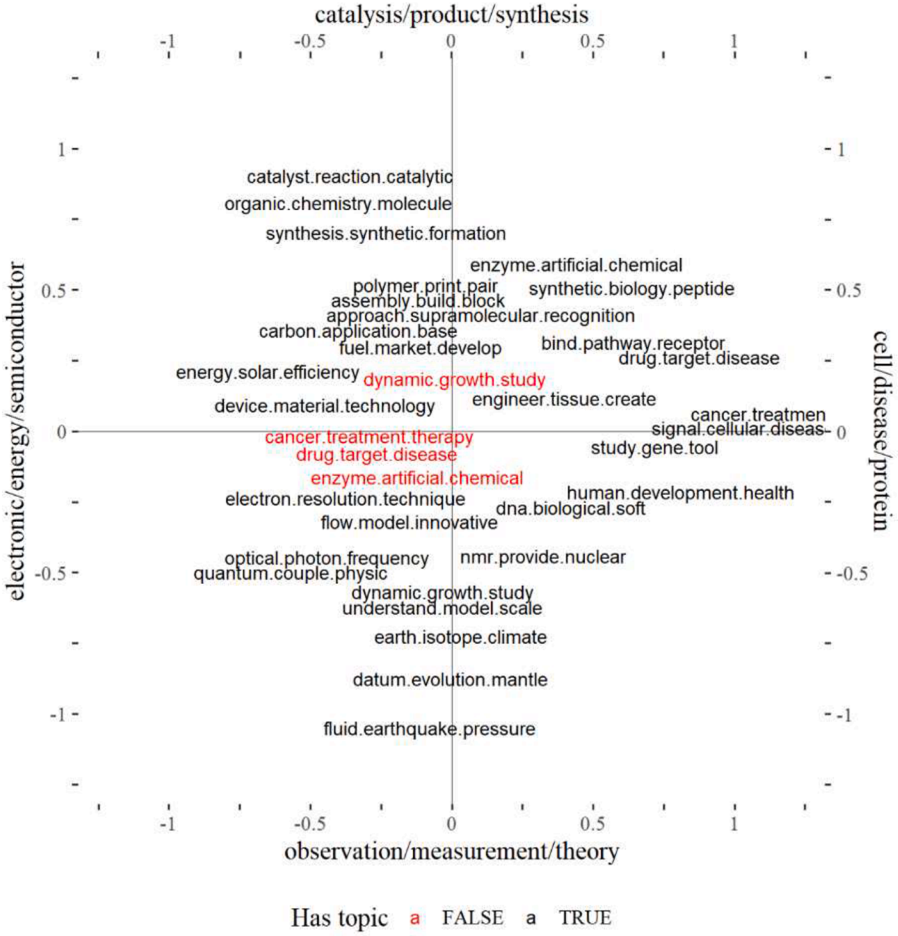

Fig. 4. The space of topics in chemistry.

compound' and, at the bottom, 'evolution', 'model', 'earth' with the most contributing topics 'datum.evolution.mantle', 'fluid. earthquake.pressure', and 'understand.model.scale'. According to the ERC panels, the top of the space is primarily home to applied chemistry, with the projects recorded in panel PE5 Synthetic Chemistry and Materials. At the publication level, however, journals in organic and inorganic chemistry, catalysis, and chemical engineering are all affiliated to this fraction of the space where we also find projects with any publication in highest ranked journals. However, while the most funded projects are homogeneously distributed in the space, the projects funded by very supportive organizations are clearly those who occupy the opposite fraction of the space. At the bottom of the space, concerned with fundamental research in chemistry, we find PE4 Physical and Analytical Chemical Sciences and PE10 Earth System Science, as well as publications in physical chemistry journals.

5.3. *Economics*

The first axis in economics (Fig. 5) differentiates between an autonomous and a heteronomous fraction. The heteronomous pole on the right-side topics is related to topics such as 'productivity', 'growth', 'business', 'firm', 'innovation', 'labor', 'worker', 'inequality', 'income', and 'wealth'. We can interpret those terms as responding to a political demand concerned with economic growth, labor regulation, and inequality in the distribution of income and wealth. The most contributing topics on this right side are 'productivity. growth.business', 'measure.central.evidence', and 'income.country.cultural'. On the left side, the most contributing topics are 'model. equilibrium.inference', 'property.apply.implication', and 'theory.contract.generate'. On this autonomous pole, we spot topics linked to 'behavior', 'choice', 'equilibrium', or 'contract'. Those terms are more related to the vocabulary in microeconomics and to autonomous stakes within the discipline. However, in contrast to biology and chemistry, the structure of the topic space does not associate with disciplinary or symbolic hierarchies. Economics has by far the lowest rate of 'other panels', which explains why we find no opposition according to projects' panel affiliation. At the journal level, all categories (Business, Management and Accounting, Economics, Econometrics and Finance) and sub-categories (Economics and Econometrics and Finance) are homogeneously distributed in the space. And the same is true for high ranked journals, most funded projects, and very supportive organizations. While finance, management, and economics identify as separated fields, their distribution in the space of topics does not show proper distinctions

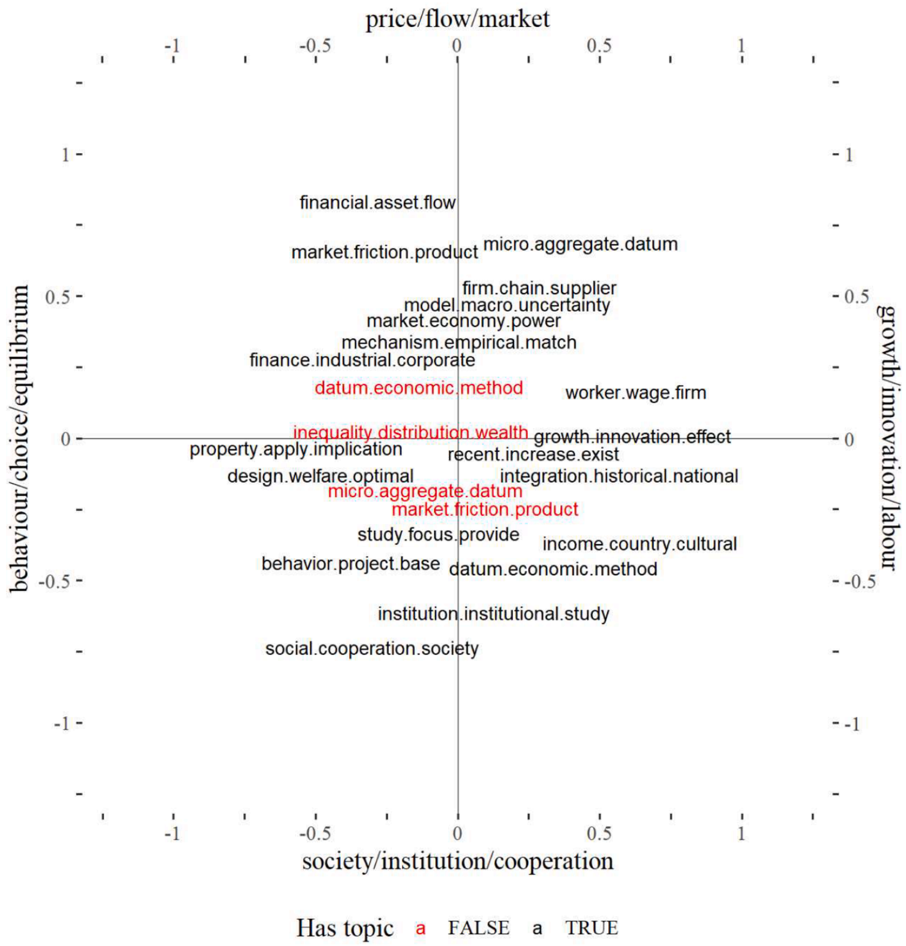

Fig. 5. The space of topics in economics.

between them.

Different from this, the second axis represents a field-specific distinction. At the top, we find 'macroeconomics' terms related to 'financial' topics focusing on 'price[s]', 'flow[s]', 'shock[s]', 'risk[s]', 'cris[e]s', 'market[s]', 'money', 'firm[s]', 'demand', 'growth', or 'investment'. At the bottom, we find 'microeconomics' concerned with 'society', 'institution[s]', 'politic[s]', and 'cooperation' at the 'European' level. On this side we find classic microeconomic terms such as 'behavior', 'experiment', or 'belief' tied with topics related to 'child', 'income', 'culture', or 'development with the most contributing topics 'social.cooperation.society', 'political.economic.european', and 'social.child.program'. This fraction is associated with other panels – SH2 Institutions, Governance and Legal Systems and SH6 The Study of the Human Past – at the lower-right end. This axis seems like a more traditional micro-macro-opposition that structures the discipline internally.

5.4. Sociology

The first axis in sociology (Fig. 6) differentiates, just like economics, between an autonomous and a heteronomous fraction. On the left, 'culture', 'global', and 'social' with the most contributing topics 'diversity.investigate.diverse', 'social.scientist.engagement', and 'study.exist.interaction' correspond to proper sociological (and cultural studies) themes from, hence the autonomous pole. On the right, 'citizen', 'party', and 'opinion' with the most contributing topics 'party.political.voter', 'democracy.citizen.representation', and 'survey.crisis.attitude', relate to political science/political sociology preoccupations, thus a more heteronomous pole. At the panel level, this right side is associated with SH2 Institutions, Governance and Legal Systems, while SH3 The Social World and Its Diversity, SH5 Cultures & Cultural Production, and SH6 The Study of the Human Past are mostly displayed on the left side of the space. At the publication level, however, political science and sociology journals (gathered in one single category) are rather well distributed and, thus, do not echo the position of panels in a straightforward way. They are, however, very well represented on the right side, while journals in especially cultural studies are displayed on the left side. As for economics, high ranked journals, most funded projects, and projects funded by very supportive organizations are rather homogeneously distributed in the space. We therefore observe homologies between position-takings and positions along this first axis, however with no significant associated symbolic hierarchy.

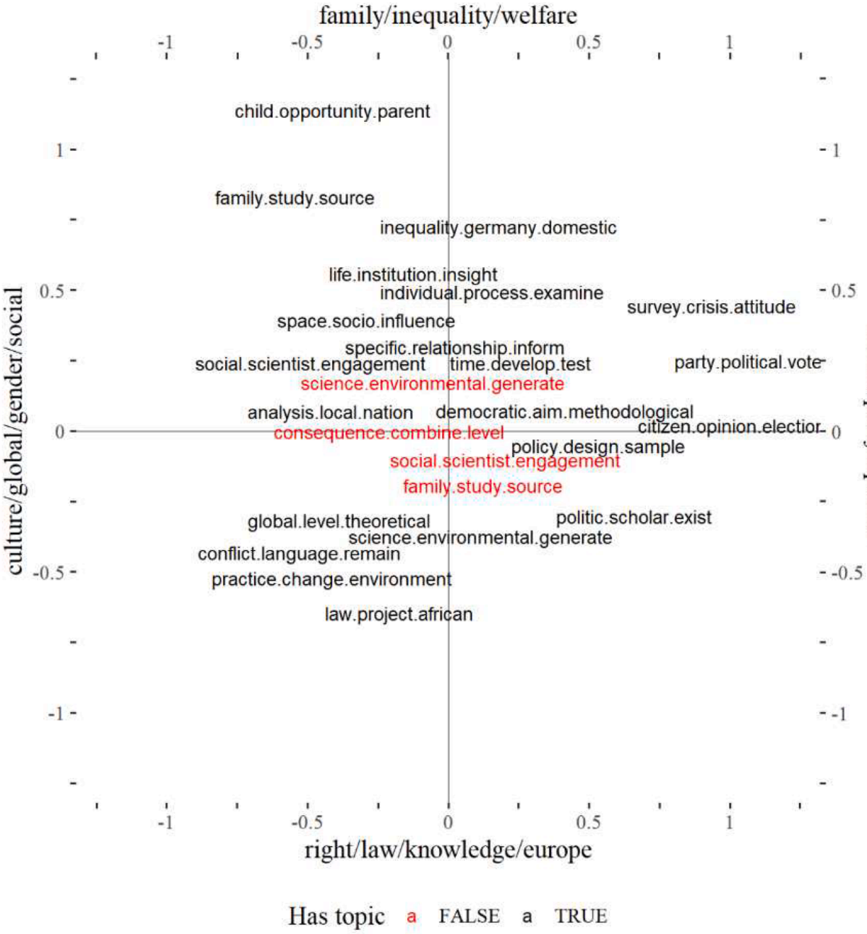

Fig. 6. The space of topics in sociology.

The second axis also distinguished between an autonomous and a heteronomous fraction. We find at the top 'family', 'inequality', and 'welfare' with the most contributing topics 'child.opportunity.parent', 'social.population.education', and 'gender.difference. woman' and, at the bottom, we find 'law.knowledge.europe' with the most contributing topics 'law.project.african', 'practice.change. environment', and 'institution.national.critical'. At the panel level, SH3 The Social World and Its Diversity is located at the top, while SH5 Cultures & Cultural Production and SH6 The Study of the Human Past are located at the bottom and therefore relate to cultural and historical studies. At the journal level, the top-left fraction is close by publications in education and life-course studies. Journals in gender studies show an atypical pattern as they are distributed in a circle all around the space, which indicates that such journals can bring together topics that are usually not taken together. Aside from this case, we again observe homologies between position-takings and positions along this first axis, however with no significant associated symbolic hierarchy.

6. Discussion and conclusion

In this article, we suggested an approach for comparing fields of cultural production and testing the assumption of homology using a field analytical approach relying on topic modeling and multiple correspondence analysis. As the empirical analysis shows, this approach enabled us to understand substantial differences but also similarities across four scientific fields. Using LDA in combination with MCA allows for relatively fine-grained empirical analysis that maps the decisive dimension of a specific social space or field of cultural production. It also enables us to test established theoretical propositions and build new ones in close dialogue with empirical analysis. The approach hence contains the capacities for informing focused case studies and for furthering comparative analysis of the specificity of fields and general principles of vision and division among fields of cultural production.

Focusing on the empirical analysis, we observe both similarities and differences between the four disciplines. In this concluding part, we first synthetize our findings and discuss their implication for the understanding of homologies in broader fields of cultural production. By homology we refer to the assumption that similar principles of vision and division are present across fields, as well as between specific fields and the social space at large. This allows us to question one fundamental property of fields of cultural production and fields in general: their structure remains relatively similar, despite differences in the concrete activity within them. Spaces are multi-dimensional, but also hierarchized. Following this we interpret both the type and the relative importance of each principle in structuring the topic spaces. Table 2 resumes principles associated with the main dimensions (axes 1 and 2) that structure the four topic spaces.

Biology is predominantly characterized by field-specific cognitive distinctions that relate to disciplinary and symbolic hierarchies, thus displaying a strong homology between topics and disciplinary affiliations. This is in line with the socio-historical knowledge of the discipline, which stresses the division of the discipline in two poles: functional and evolutionary biology (Mayr, 1961). This opposition has been institutionalized and is therefore observable through the distribution of panels, journal disciplines, and prestige. Biology is secondly structured by its relative autonomy to other disciplines. Again, this finding corroborates prior literature and the observation that biological concerns extend far beyond the boundaries of the disciplines (Morange, 2020; Benz & Bühlmann, 2024). These two structuring dimensions are also homologically structured along lines of symbolic hierarchies and disciplinary distinctions. Projects with publications in *highest ranked journals* are situated in the pole of functional biology along the first axis, and the projects driven by PIs from 'very supportive' institutions are situated on the other side.

Chemistry is more heteronomous than biology and constitutes only a fraction of the topic space of chemistry. The discipline is firstly structured by its relative autonomy to other disciplines, especially physics and biology. This echoes the literature, which evokes chemistry as the center of a triangle it forms with biology and physics (Reinhardt, 2002) and thus the plastic nature of the chemical sciences. This feature allows chemists to easily integrate and legitimate the study of living things in their own disciplinary journals and research projects (Louvel, 2015, p.4). The second principle represents a more internal logic. Just like biology, this is associated with a symbolic dimension. Fundamental research is associated with publications in *highest ranked journals*, while applied research is associated with the funding from very supportive organizations. These observations of homology between position-takings and positions depict chemistry a highly standardized and professionalized discipline (Beyer, 2021, p.198), albeit with an extended openness to other disciplines. As in biology, the presence of symbolic and disciplinary hierarchies demonstrates the institutional anchoring of these oppositional dimensions when it comes to internal principles of vision and division.

Economics is also primarily structured by its relative autonomy, not to other disciplines but to the field of power. The first axis opposes topics related to growth, labor, and income and wealth inequality, corresponding to a political demand, to topics linked to more internal logics such as the study of individual behavior and choices. More than the empirical evidence of some imposed principles of vision and division through field intrusion (Schmitz et al., 2017), the absence of relation between the structure of topics, disciplines and symbolic resources can be interpreted as the coexistence of different hierarchical principles that are both competing and complementary (Bourdieu, 1984a, p.150). Bourdieu (1994, p.56) introduced the notion of the field of power to account for such structural effects that cannot be understood in any other ways: using the example of certain properties of writers' or artists' practices and representations that cannot be fully explained by reference to the literary or artistic field alone. In the case of economics, our results indicate that the first dimension is not structured by institutionalized scientific struggles, which would relate to disciplinary distinction or the intrusion of other disciplines. Hence, the "definition of what is at stake in the scientific struggle is part of what is at stake in the scientific struggle" (Bourdieu, 2001, p.126) seems, here, defined by an opposition between autonomous issues and those constrained by interests from the field of power. The discipline is secondly structured by a more classical internal macroeconomics vs. microeconomics distinction which, however, is not associated to disciplinary or symbolic hierarchies. This duality between an important epistemological autonomy and strong relations to the field of power is consistent with the literature on the discipline, which observed that political logics and mechanisms that find their origin in the field of power contribute to the formation of disciplinary controversies in economics, and this before purely internal disciplinary stakes (Lebaron, 2001; Rossier & Benz, 2021). The cognitive autonomy of the discipline is enforced by it forms one major field in disciplinary classifications, is assigned in its own panel, and publishes in its own journals as economists are quite isolated from other social science disciplines (Fourcade et al., 2015).

The case of sociology is ambiguous and somewhat resists our attempt to objectify the structure of the field. By its very nature, the theory of knowledge is inseparable from political theory (Bourdieu, 1984b, p.86). This is observable from the fact that the topic space of sociology is primarily structured by an opposition between nationally oriented topics, close to political science/political sociology themes, and more transnationally and culturally oriented sociology. The second principle then reflects the same kind of structure opposing education and life-course studies to cultural and historical studies. Unlike economics, but in a similar way to the biological sciences, the sociology forms an archipelago of (sub-)disciplines which are associated to specific topics, which is in line with previous scholarship (Warczok & Beyer, 2021, p.16). In contrast to biology, these sub-disciplines are not associated with symbolic hierarchies, and we cannot conclude on the existence of homologies between positions and position-takings in this case. Sociology, like chemistry, is somewhat dissolved in the mass of related themes that are taken up by other disciplines.

When comparing the structure of biology, chemistry, economics, and sociology through the three principles of vision and division, we observe partial homology. Chemistry and sociology are at first structured by their relative autonomy to other disciplines. While chemistry appears as a highly standardized discipline with obvious homologies between positions and position-takings, we do not observe such relation in the topic space of sociology. In biology, the different sub-fields are, in contrary to sociology, highly hierarchized, as the discipline's first structural dimension related to a homology between positions and position-takings. As for sociology, economics are not characterized by a homology between position and position-takings, namely topics are not related to symbolic hierarchies. However, the discipline combines a high cognitive autonomy with extended relationships to the field of power.

Table 2
General principles of differentiation.

	Main principle	Second principle
Biology	Homology between topics and disciplines	Relative autonomy to other disciplines
Chemistry	Relative autonomy to other disciplines	Homology between topics and disciplines
Economics	Relative autonomy to the field of power	Autonomy with no homology topics and disciplines
Sociology	Relative autonomy to other disciplines	Relative autonomy to other disciplines

Reading through the literature on fields of cultural production reveals the pervasive presence of principles of vision and division in a significant portion of studies.[h] As an example, the field of theatrical producers in Flanders is very autonomous, with the main principles of distinction related to some forms of symbolic capital hierarchy (Roose & Vandenhaute, 2010). Other fields, such as French literature in the 1940s (Sapiro, 2002), young newcomers in the field of jazz in Sweden (Nylander & Melldahl, 2015), the theatrical field in Campania (Serino et al., 2017), the humanities in Denmark (Johansson et al., 2020), or US elite sociology (Warczok & Beyer, 2021) are firstly structured by an internal distinction, then by more external logics. In our study, that would be the case of biology, which is the only discipline to be primarily characterized by a homology between positions and position-takings, namely topics related to specific disciplinary and symbolic hierarchies. However, other spaces from our study follow more closely heteronomous logics, either by following demands from the field of power (economics) or by being permeable to the logics of other disciplines (sociology and chemistry) and in that case, could be comparable to fields that primarily follow external dynamics before relying on purely internal opposition (see also Lebaron, 2001 and Rossier & Benz, 2021, on the primacy of heteronomous logics in the field of economics in France and Switzerland). Comparing the structure of fields of cultural production is needed to understand the more general structural logics leading to field formation and consolidation. The ambition of a comparative field analysis of cultural production calls for both conceptual and methodological refinement. Conceptually, furthering the concept of homology and establishing criteria for comparing fields are imperative. Methodologically, developing approaches that enable linking practice indicators and institutional properties for generalization while preserving the specificity of individual fields is essential. Proposing an advancement in comparative field theory for cultural production involves emphasizing two key features: the utility of field theory in comprehending relative autonomy and homology within and between fields, and the necessity for empirical consideration of the interplay between content and positions within a specific field. This entails examining relationships with both other cultural fields and the broader field of power.

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CRediT authorship contribution statement

Pierre Benz: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Kristoffer Kropp:** Writing – review & editing, Writing – original draft, Validation, Project administration, Methodology, Investigation, Funding acquisition. **Trine Cosmus Nobel:** Resources, Methodology, Investigation, Data curation, Conceptualization. **Thierry Rossier:** Validation, Methodology, Investigation, Conceptualization.

Declaration of competing interest

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.poetic.2024.101945.

[h] For example, we found fifteen articles in *Poetics* that mention using 'correspondence analysis' and consist of a geometrical study of *cultural producers* and/or their *cultural production* over the years. These studies differ regarding their object, data collection, analysis, and presentation of the results. We nevertheless were able to qualify the main axes presented in these papers according to an *internal* vs. *autonomy-heteronomy* distinction.

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