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Types of Collaboration and the Consolidation of Sociological Research

Evidence from publications in five German sociology journals 2000–2019.

Abstract: Research innovation can be fostered under the right circumstances, which include high levels of research autonomy, opportunities for collaborative research, and an open-minded research community able to combine innovation with more conventional lines of research. In the literature, different types of collaboration and team composition are linked to innovation. However, little is known about the association between collaborative research and the consolidation of thought products, innovative or not. We address this research gap based on 2,785 abstracts and 352 'thought products' (theories, methods, research topics) extracted from five German language sociology journals included in Scopus and published between 2000 and 2019. We apply a diachronic research strategy and combine correspondence analysis for topic extraction, network analysis to account for the embeddedness of scholars, and OLS regression to investigate which of the factors present in 2000–2003 are responsible for the consolidation of thought products in 2016–2019. We find that a focus on applied topics (such as management or governance) is positively linked to the consolidation of research. Furthermore, concepts used and disseminated by well-connected scholars between 2000 and 2003 tend to become peripheral over time. Finally, we establish a negative association between concepts used by female scholars and the consolidation of these concepts.

Keywords: Topic consolidation, sociology, geometric data analysis, social network analysis, bibliometrics, natural language processing

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Formen der Forschungskooperation und die Konsolidierung soziologischer Forschung

Eine Untersuchung anhand von Veröffentlichungen in fünf deutschsprachigen Soziologiefachzeitschriften 2000-2019

Zusammenfassung: Forschungsinnovationen benötigen ein hohes Maß an Forschungsautonomie von Forschenden, die Möglichkeit, Forschungskooperationen einzugehen sowie eine aufgeschlossene Forschungsgemeinschaft, die in der Lage ist, Innovationen mit konventionelleren Forschungslinien zu verbinden. Bisher wurden insbesondere die Zusammenhänge zwischen verschiedenen Kooperationsarten und der Teamzusammensetzung (z. B. Teamgröße, internationale Ausrichtung, Geschlechtszusammensetzung) mit Innovation in Verbindung gebracht. Es ist jedoch nur wenig über den Zusammenhang zwischen Forschungskooperationen und der Konsolidierung von Forschung – innovativ oder auch nicht – bekannt. Wir adressieren diese Forschungslücke auf Basis von 2785 Abstracts und 352 „Denkprodukten" (Theorien, Methoden, Forschungsthemen) aus fünf deutschsprachigen, in Scopus gelisteten, Soziologie-Zeitschriften, die zwischen 2000 und 2019 erschienen sind. Wir wenden eine diachrone Forschungsstrategie an und kombinieren Korrespondenzanalyse zur Themenextraktion, Netzwerkanalyse zur Berücksichtigung der Einbettung von Wissenschaftlern und OLS-Regressionen, um Faktoren zu beleuchten, die in den Jahren 2000–2003 für die Konsolidierung von Denkprodukten in den Jahren 2016–2019 verantwortlich gemacht werden können. Unsere Ergebnisse zeigen, dass angewandte Themen (z. B. Management, Governance, usw.) positiv mit der Konsolidierung von Forschung verbunden sind. Darüber hinaus neigen Konzepte, die von gut vernetzten Wissenschaftlern zwischen 2000 und 2003 verwendet und verbreitet wurden, dazu, im Laufe der Zeit peripherer zu werden. Schließlich stellen wir einen negativen Zusammenhang zwischen den von Forscherinnen verwendeten Konzepten und deren Konsolidierung fest.

Schlagwörter: Themenkonsolidierung, Soziologie, Geometrische Datenanalyse, Netzwerkanalyse, Bibliometrie, Computerlinguistik

1 Introduction

Under specific conditions, scientific innovation can result in scientific revolutions (Kuhn 1962), the revival of scientific disciplines (Heinze et al. 2013), and technological progress (Wu/Wang/Evans 2019). If scientific innovation is to thrive, one crucial condition is a sufficient degree of scientific autonomy at the level of the entire academic system (Münch 2014b; Whitley/Gläser/Laudel 2018). Under these circumstances, the forms of collaboration between scientists are equally important to the development of innovation, for instance in facilitating the efficient division of labor and thus allowing novel combinations of specialized knowledge to

emerge (Fontana et al. 2020; Wang/Veugelers/Stephan 2017). For example, recent research indicates a co-emergence of collaborative networks and new paradigms, thus describing how innovation diffuses (Liang et al. 2020). Yet, concurrently, most contemporary research focuses on the prerequisites for innovative research, the generation of scientific breakthroughs, and the processes of diffusion that immediately follow.

So that it does not vanish into obscurity, it is nonetheless essential for any innovation to be applied by a wide range of scholars from 'normal science' in different research contexts. While there have been numerous studies on the impact of the composition of research teams—disciplinary and interdisciplinary—as well as the impact of international collaboration on the primary processes of innovation and subsequent diffusion throughout scientific collaboration networks (Haeussler/Sauermann 2020; Leydesdorff/Ivanova 2020), little is known about the *consolidation processes* in which an original innovation (e.g., a new method) is increasingly adopted and widely recognized by the professional community. Some evidence has been provided by Heinze et al. (2013), but there is still a considerable research deficit, as it can be assumed that consolidation and different forms of collaboration are highly interdependent. Consolidation is not only based on the act of innovation alone, but crucially relies on the subsequent attribution of that innovation and the associated popularization of topics.

In this paper, we examine how the consolidation of research is associated with different forms of collaboration. We assume that consolidation processes apply to innovative as well as to non-innovative research, so that both can be studied together. Another deficit of existing research, however, is that it is primarily concerned with disciplines in the natural sciences (e.g., Lin/Evans/Wu 2022; Wu/Wang/Evans 2019), which may wrongly give the impression that findings can be extended to the entire academic field when they are—in fact—limited to the natural sciences. Consequently, we draw on sociology as a case study, a discipline which is, firstly, *multiparadigmatically structured*, aligned to both the humanities and natural sciences at once while being heavily differentiated internally (Schmitz et al. 2020; Schwemmer/Wieczorek 2020). Sociology is, secondly, simply one example of the many other multiparadigmatically structured disciplines in the social sciences (e.g., political science, communication science, ethnology, and geography c. p. Stinchcombe 1994) or the life sciences (e.g., psychology, see Unger et al. 2022; Wieczorek et al. 2021a). For this reason, we expect that our results will be applicable to these disciplines. At last, the alignment of sociology with both the natural sciences and the humanities will increase the likelihood of identifying consolidation patterns which—to varying degrees—might be typical for either STEM (Science, Technology, Engineering and Mathematics) disciplines or the humanities, rendering sociology a productive test case for different consolidation practices.

To address our research question, we first review the state of research on scientific innovation and research collaboration, as well as their interaction, discussing how consolidation processes and cooperation practices interrelate. We then take the inherent structural and cultural specificities of the various disciplines into account. For this purpose, we use the example of sociology with its paradigmatic and prac-tice-related particularities to assess whether, or the extent to which, interpretative patterns derived from the natural sciences can be generalized. We then conceptual-ize the consolidation of *thought products (*especially *theories, methods,* and *research foci)* based on the literature. We proceed with a description of our analytical strategy and data basis, which comprises 2,785 abstracts from the five most relevant soci-ological journals in German-speaking sociology covered in the Scopus database.[1] As indicated by their low journal impact factor (ranging from 0.29 to 1.269 as of 2020), these journals are in a peripheral position when compared with the English-speaking international center of academic discourse.

This peripheral position, with low levels of acknowledgement outside of German-speaking sociology, renders these journals an interesting test case for established knowledge of the association between collaborative networks and the consolidation of innovative or non-innovative research. In fact, there may be unique structures and processes which are not apparent in the completely internationalized and paradigmatically consolidated natural and life sciences on which research to date has mostly focused.

We proceed by describing how we extracted topic dimensions from the corpus using correspondence analysis. To this end, we construct topic spaces from the abstracts mentioned above for the early 2000s and the end of the 2010s. Subse-quently, we relate the position of the topical space in 2016–2019 to indicators on collaborative approaches and characteristics which correlate with thought products in the early 2000s. Note however, equally, that these timeframes leave enough time for potential innovations—or for less innovative but previously unused thought products—to spread, according to scientometric literature (Dey et al. 2017; van Raan 2004; 2015).

As one cannot compare the topic space in 2000–2003 to earlier periods due to a lack of availability of abstracts in the Scopus database, we cannot claim that everything in this topic space is an innovation. However, by focusing on consolida-tion patterns, our approach yields insights about the consolidation of more or less innovative thought products by implication. In this way, we reveal the particular characteristics of sociology as represented in the major German-language journals and, ultimately, argue for a more differentiated, comparative investigation of inno-vation and consolidation.

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1 Scopus is an abstract and citation databased hosted by Elsevier since 2004. It includes data on more than 30,000 journals.

2 Innovation and research collaboration: state of research

Existing studies identify factors that promote or restrict research innovation. Regarding the former, Gläser and Laudel (2016) found that decentralized third-party funding enables research innovation to emerge. The same applies to low levels of monitoring of research practices by university administrators (Whitley et al. 2018). Regarding the latter, measures which reduce research autonomy inhibit innovation. These include the strong focus on acquiring third-party funding (Boudreau et al. 2016), the pressure to obtain high scores in research assessments and rankings (Münch 2014a: 22–37), and—in Germany with its chair structure—a strictly hierarchical organization of research (Münch 2014b).

For the *consolidation* of a new thought product, it is crucial that it be taken up by conventional research after a certain amount of time. Innovations are more likely to spread if they stimulate conventional follow-up research that is published in high-impact journals (van Raan 2015) and receive legitimacy in the form of scientific prizes (Farys/Wolbring 2021). Furthermore, as Wang/Veugelers/Stephan (2017) show, it is more difficult for innovations to disseminate if they lack connectivity to existing theories, or combine topics, theories, and methods in unusual ways. For an innovation to be considered as such post hoc, it must be recognized as an innovation and begin to accumulate large numbers of citations, lifting it out of obscurity (Dey et al. 2017). It is reasonable to conceive of the attribution of innovation as a genuine social process in which a thought product successfully spreads and diffuses widely (Herfeld/Doehne 2019). Consequently, scholars and publications which are not themselves considered innovative or central are nevertheless, through their reception practices, constitutive of innovation as a social phenomenon. For innovation in a traditional and narrow sense, there are numerous studies showing the relevance of the social organization of acknowledging, using, and disseminating research in the form of research collaborations, as we shall briefly recapitulate now.

Research collaborations are regarded as relevant for generating innovations (Zhang et al. 2018). Yet despite a universal trend toward increased scientific collaboration (Bozeman/Youtie 2017), opportunities for collaboration are unevenly distributed. This is reflected in the growth of center/periphery structures in scientific collaboration networks in recent decades (Wieczorek et al. 2021b). This holds true for individuals (Cugmas/Ferligoj/Kronegger 2019), institutions (Li et al. 2018), and countries alike (Barrios et al. 2019). These two aspects, innovation and its consolidation on the one hand and collaboration practices and strategies on the other, interrelate in various ways. Research collaboration fuels innovation insofar as it enables scholars from different fields of study to combine expertise on topics, methods, and theories. These combinations pave the way for incremental innovations, which then may be applied in different research communities (Zhai/Ding/Wang 2018).

Furthermore, collaboration aids in the emergence of completely novel lines of research, if the collaborators recognize that a research puzzle has not been sufficiently solved in each research community. In this case, they might seek to develop completely new theoretical concepts, methods, or approaches which negate older concepts previously central to the respective discourses (Wu/Wang/Evans 2019). At the same time, research collaboration can encourage the consolidation of formerly innovative research concepts. In this case, collaboration facilitates the spread of innovation by applying it to research questions or problems initially not intended by the innovators (Xu et al. 2020).

Even if research might be perceived as an activity that takes place in solitude and freedom, scientific innovations and their diffusion are undoubtedly driven by social factors. One important social aspect concerns the structure of a research team; innovation rarely originates from individuals or teams of two (Larivière et al. 2015). In fact, studies reveal an inverse U-shaped relationship between team size and scientific innovation (van Raan 2015; Wu/Wang/Evans 2019). In large teams, coordination efforts can become too great to generate innovation effectively (Wu/Wang/Evans 2019). Furthermore, the more collaborations maintained by authors associated with a particular thought product, the more widely these products are disseminated, as measured by citations (Uddin/Hossain/Rasmussen 2013). This is due to the fact that each collaboration partner can, at least partially, address and mobilize different audiences.

However, single authors or small teams might also play a significant role for the consolidation of (more or less) innovative concepts. Due to the internal differentiation within disciplines (e.g., life course analysis, or research on social movements), authors might be experts in limited knowledge domains, and as such aim to secure a position within these domains. To do so, they probably seek to address the most relevant theories, appropriate methods, or research puzzles in this domain, and, by doing so, signal their belonging to a specialist discourse. This strategy yields less opportunity for generating innovation, as the knowledge applied stems from a well-known, established canon.

Regarding the consolidation engendered by collaboration at the *university or interuniversity level,* studies provide evidence that an innovation is recognized more broadly if scholars affiliated with different institutions co-author articles. For example, forms of cooperation and article citation rates are associated, indicating higher degrees of recognition, and an increased likelihood of an innovation being linked with different scholarly discourses. In turn, the reception of an innovation in different areas of research renders consolidation more likely. For instance, Bornmann (2017) shows for the case of biomedicine that, regardless of their quality, articles are cited more frequently the more authors from different institutions are involved (cp. also Larivière et al. 2015). By contrast, Sud and Thelwall (2016) show with the example of biochemistry that the association between the number of institutions

and citation count is inversely U-shaped, indicating that a moderate number of institutions is linked with the highest level of recognition for a research innovation.

With regard to *international cooperation*, studies indicate a positive but weak effect of transnational collaboration on the number of citations of articles and, indirectly, on the probability of dissemination of concepts and research innovations (Adams/ Gurney 2018; Leydesdorff/Wagner/Bornmann 2018). This is for the same reasons as discussed earlier: International teams are socialized in different disciplinary contexts, and thus their scholars might add a diversity of expertise to the collaboration and have access to different research communities. Therefore, they provide the necessary prerequisites for innovation, and for the dissemination of their innovations. Yet international collaborations also lead to less innovative and more conventional research (Wagner/Whetsell/Leydesdorff 2017). This counterintuitive finding may be attributed to the high degree of coordination required between researchers from different nationally embedded academic cultures. Consequently, researchers cooperating internationally may only be able to agree on the lowest common denominator: a well-known, established line of research. However, a key aspect that lies behind a general discourse of international collaboration is the position in the global scientific hierarchy of the collaborative partners involved. Thus, the same collaboration between an American and a German scientist may prove to be beneficial for the German participant, while it may not be beneficial—or may even be detrimental—for the American colleague. 'Internationality' must therefore be differentiated by taking the global hierarchy of the respective national fields into account.

Another social factor associated with the consolidation of research innovation is linked to the researcher's socio-demographic characteristics. Most notably, research has assessed the impact of gender and gender diversity in research teams on the recognition of innovations, and thus the chances for the consolidation of research innovation. In general, female researchers are less likely to be cited (Lerchenmueller/Sorenson 2018), which is true even in fields where female researchers are strongly represented (Dion/Sumner/Mitchell 2018). Lower citation counts may indicate that innovations spread more slowly when presented by female scholars. This may be attributed to two potential gender effects: the level of embeddedness in scientific collaborative forms, and the authors' choice of topics. Male scientists collaborate more with other men, while female scientists tend to collaborate in mixed-gender groups (Kwiek/Roszka 2021b). In addition, male scholars collaborate more internationally than their female counterparts, although this varies by discipline (Kwiek/Roszka 2021a). In other words, male scientists may facilitate the dissemination of innovative lines of inquiry by mobilizing colleagues across research communities and national borders.

For mixed-gender teams, Kwiek and Roszka (2021b) show with a sample of 25,463 Polish scholars that these teams are more likely to publish in high-impact journals

compared to single-gender teams. Consequently, mixed-gender teams have higher chances of disseminating their research innovations compared to gender-homogeneous research teams. Maddi and Gingras (2021) confirm these effects for research in management and economics, while also showing that the effect is weaker when a female researcher is the first author. As research has not, to date, focused on the association between gender composition and consolidation of research innovation, we must utilize our empirical findings to establish whether mixed-gender teams promote or prohibit consolidation.

As it turns out, the majority of scientometric studies base their findings on specific contexts, namely the natural sciences in Anglophone practices of publishing and collaboration. While this provides important insights into the dynamics of scientific innovation, and allows us to derive assumptions on subsequent consolidation, it should not be ignored that disciplines differ from each other; they differ not only in terms of their objects and approaches, but also in terms of how innovations are produced, disseminated, and recognized (Xu et al. 2020; Zhai/Ding/Wang 2018). In particular, the aspect of consolidation introduced above, which is essentially based on attribution and recognition, is likely dependent on the particular structural and cultural conditions of a (nationally framed) discipline (Ylijoki/Lyytinen/Marttila 2011).

To conceptualize these structural and cultural specifics of a discipline, the field-theoretical perspective has proven useful (Schwemmer/Wieczorek 2020; Warczok/Beyer 2021). If we consider the evidence from existing research, we can conceive of the conditions of consolidation as a disciplinary field (e.g., Jansen/Von Goertz/Heidler 2009), in which forms of cooperation and networks typical of the field shape scientific discourse in a specific way and define what counts as innovation in each case. A disciplinary field is a differentiated and semi-autonomous sector of the academic field that is comprised of scholars, different types of institutions (e.g., universities, professional societies, publishers), scholarly discourses, and a shared idea of how to conduct research (and on what topics) properly (Bourdieu 2004).

Within a field, actors collaborate and compete for the acknowledgement of more or less innovative research products, and in turn secure a place within the academic discourse. Scholars develop a taste for research (Bourdieu 1989, 19–20), which is mirrored in the way they collaborate, formulate their ideas and whether they follow novel lines of research or consolidate previously innovative research. In turn, both the ideas of how to conduct research properly as well as the taste for research topics, collaborations, and investigating (more or less) innovative research, should be present in the respective articles investigated.

In the context of the current state of research, it can be assumed for scientific fields as a general principle that innovations are introduced and consolidated into the discourse by well-connected authors. This will manifest itself in the form of

co-authorships and institutional and international collaborations, since cooperation of this kind grants access to further important networks. Concepts already present in or introduced into a field at t_0 will eventually be consolidated by occupying a central position in the discipline's discursive space at t_1.

Despite the fact that some studies establish positive relations between research impact and transnational collaboration, we take a more critical stance in regard to the field of German-language sociology. With its *specific conditions*, it is to be expected that these general assumptions cannot simply be transferred. To take into account this special object of study, we set up the following general counterhypothesis: The special structural properties of sociology, and especially of sociology restricted to the German-speaking field, may well counteract ostensibly universal processes. (German) sociology is traditionally separated into different paradigmatic styles of thinking that do not systematically mutually connect (see Collins 1994; Smelser 2015; Varga 2011). There is no unanimous consensus on methods, basic assumptions, and problems among sociologists. As a consequence, there is no expectation of common epistemic progress and the corresponding accumulation of knowledge. The combination of sociology's multiparadigmatic organization and nationally embedded research cultures renders international collaboration even more difficult and increases additional coordination costs among collaborators (see Wagner/Leydesdorff/Bornmann 2017).

Consequently, the attributive definition of innovation and consolidation is not subject to any criteria that are generally valid for the discipline. For example, national or international cooperations should not be associated with consolidation: The significance of both national and international collaborations, and research foci stemming from these, are acknowledged by some fellow sociologists, and refuted by others (strong orientation towards US sociology vs. strong rejection of US hegemony) (Schmitz et al. 2020). It is possible that scholars with an international orientation conduct research on topics relevant for US sociology (e.g., research on race, gender, and class), but are irrelevant to other, specifically national sociologies. At the same time, nationally-oriented sociologies might be centered around certain schools of thought. As seen taking the example of the dispute between the Academy of Sociology and the German Sociological Association, collaborating with scholars aligning to other paradigms might hinder consolidation, at least to the extent that different schools of thought do not acknowledge the arguments provided by others as scientifically valid. For these reasons, we expect international collaboration not to be associated with the consolidation of sociological concepts.

In the case of institutional actors, we expect scientific institutions of high reputation to attract more attention. This, in turn, yields a positive effect on cooperation opportunities between (also highly reputable) scientists who are affiliated with highly reputed universities—and thus increase the attention for thought products,

which can be expected for those disciplines that are close to the institutional pole (cf. Münch 2014a, 79–92).

According to our expectations, consolidation in German-speaking sociology should, to a considerable extent, occur for other reasons. The disciplinary field we are looking at is largely and increasingly dependent on its external relations. As in other disciplines, this should be reflected in socio-structural terms, especially in the particularly great importance that gender has for personal chances of success, but also for the expected success of the topics and concepts researchers deal with. Since there are clear gender differences in sociology, in terms of preferred topics (Heiberger/Munoz-Najar Galvez/McFarland 2021), and since there are also fewer publications by female than male authors in sociology, despite the majority of scholars being female, publications and topics published by women should be less likely to occupy a central position in the discourse space in the future (Turner 2016, pp. 99–103).

The special relevance of the field's external relations is also reflected in its content: The field of (German) sociology is characterized by a high degree of reactivity to the actual prevailing circumstances in a society. Schmitz et al. (2020), for example, show that German sociology is strongly oriented towards a state logic of the ascription of value, on the one hand, and the various forms of social criticism, on the other. Accordingly, it is to be expected that those topics that deal with applied research in the context of management and political governance will become of central importance—be this attention positive or negative in nature. Finally, we have to consider larger, structural forces that may shape the thematic structure of sociology and the opportunities for collaboration among scholars, as well as their ability to follow original lines of research autonomously. These include the funding incentives and research demands introduced by funding agencies and other third parties (Wieczorek/Beyer/Münch 2017).

3 Data and Methods

3.1 Dataset

In light of our theoretical considerations on the interplay of collaboration forms and consolidation, we seek to analyze how different sociological concepts (operationalized as unigrams)[2] become more central to the German-speaking sociology discourse. To do so, we base our analyses on 2,785 journal articles published between 2000 and 2019 in the following five German-speaking outlets covered throughout our period of observation in Scopus: the *Berlin Journal of Sociology*, the *Cologne Journal of Sociology and Social Psychology*, the *Journal of Sociology*, *Forum Qualitative Social Research*, and *Soziale Welt*. These are the core journals of German-

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2 In our case, a unigram is a single sociological term. Unigrams are otherwise defined as a single item stemming from an n-gram (e.g., a sentence in this manuscript counts as n-gram).

speaking sociology according to Leydesdorff and Milojevic (2015). This is why we assume that consolidation of (more or less) innovative research outcomes is most likely to occur in these journals. With their impact factor ranging from 0.29 to 1.269 (as of 2020), these journals are also well suited to reflecting the consolidation process of innovative thought products and to linking them to varying collaborative approaches. Access to the Scopus repository was provided via the Competence Center of Bibliometrics, an association of German research institutions that provides a quality assured data infrastructure for bibliometric applications.[3]

3.2 Data pre-processing

The Scopus repository was subjected to automatic and semi-automatic checks and error corrections. Specifically, numerous unifications and standardizations (including on journal names and country information) were carried out.

The dataset is particularly characterized by the implemented institution coding for German institutions, which makes it possible to assign publications unambiguously to institutions (see https://bibliometrie.info/index.php?id=infrastruktur for further information). The collected data contain English article abstracts from which we extract thought products. Additionally, the data contain author information, which serves as foundation for the construction of network measures and collaboration forms. This comprises first and last names as well as the author identifier generated by Scopus. The Scopus author ID assigns unique author profiles to publications and is the result of an automated disambiguation algorithm which is supplemented by manual entries by individual authors (Baas et al. 2020).[4] The data also contains information on the institutional affiliations of the participating authors, including name of the institution, the country in which the institution is located, publication year, and outlet name.

We then applied a disambiguation algorithm based on Momeni and Mayr (2016) to check for the correctness of author IDs assigned by Scopus. Similarity measures were then used to assign author IDs to unique individuals, such as similar or identical email addresses, coauthors, self-citations, keywords, affiliations, or bibliometric couplings. The main advantage of this approach is that we were able to draw on information that is exclusive to the KB,[5] such as institution coding. Discrepancies in our disambiguation approach to the Scopus author ID were manually checked and improved.[6]

Additionally, data on the gender of all authors were collected in a manually-conducted web search, linked to the Scopus data, and merged with the author, insti-

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3 The data and workflow (in Python and R) are provided by the authors upon request.

4 According to bibliometric literature, the disambiguation algorithm of Scopus is of high quality (Moed/Aisati/Plume 2013; Aman 2018).

5 KB stands for 'Kompetenzzentrum Bibliometrie' ('competence centre for bibliometrics').

6 We identified 51 incorrect ID assignments by using this approach.

tution, and abstract data into a unified dataset. The successful consolidation of a concept during an observation period is characterized by its central position in the research discourse at the end of the observation period, in our case the years between 2016 and 2019. This applies to all topics that are part of the scientific discourse in German sociology. To examine the positions of sociological concepts within this particular discourse, we construct a topic space in which the individual terms related to these concepts are located.

We apply correspondence analysis (CA) (Le Roux/Rouanet 2010) to define our topic spaces at the beginning and the end of our observation window.[7] CA allows us to use a set of active variables to construct this topic space and to passively project terms into this space that are relevant but occur too infrequently on their own to identify them as separate topics. In this procedure, topic dimensions are extracted based on the common occurrence of terms in abstracts. Each dimension ideally expresses a contrast between two mutually exclusive topics and the associated methods (e.g., qualitative versus quantitative methods).

We set the initial time frame for the construction of the topic spaces t_0 to the years 2000–2003, and the end time frame t_1 to the years 2016–2019. The years between our chosen time frames are in line with studies on so-called 'sleeping beauties' (van Raan 2004), which propose that at least 10 years are needed for a research innovation to be accepted by the academic community (Dey et al. 2017). We decided to define a four-year time frame, since smaller time periods yielded an insufficient number of relevant sociological concepts in several CA trial runs, which in turn led to the construction of unstable topic spaces. Conversely, defining longer time windows would largely obscure the view of potential changes.

To conduct the initial CA, text data from the scholarly abstracts were preprocessed using common natural language processing techniques. First, abstract data were tokenized before stop words were removed. The tokens were then stemmed by using the PorterStemmer algorithm implemented in the Python nltk library (Bird 2006). Stemming converts words to their word stem (e.g., "running", "ran", "runs" are all converted into "run"), thereby reducing text complexity and combining tokens that are spelled differently but have the same meanings.

Secondly, we included only terms present in a minimum of 7.5 percent and a maximum of 90 percent of all abstracts in each time frames.[8] We employ the criterion of a threshold for including items between five percent and 10 percent

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7 The factoMineR package was used to conduct the CA (Lê and Husson 2008).

8 To calculate the optimum thresholds, we calculated topic spaces based on five percent, 7.5 percent, and 10 percent thresholds for the appearance of tokens at the lower bound, and 85 percent, 90 percent, and 95 percent at the upper bound. We then interpreted the topic dimensions for each combination. Although the topics remained stable, the topics extracted by the model including tokens appearing in at least 7.5 percent of the abstracts and maximum 90 percent abstracts yielded the highest interpretability.

at the lower bound and between 90 percent and 95 percent at the upper bound (Hjellbrekke 2019; Greenacre 2010). Consequently, we projected all terms that occurred in at least 2.5 percent and at most 7.5 percent of the abstracts as passive variables in our CA. Last, the selection of tokens, and thus sociological concepts, was limited to nouns in order to focus on theoretical and methodological concepts such as 'regression analysis', 'function', or 'system'. As a result, 352 concepts present in both time frames either as active or passive variables were extracted from the data. Figures depicting their distance from the center of the topic space, and any change between these two time frames, are provided in online appendix B. Finally, we create and export a document-term matrix for use in R. A four-dimensional solution for both time periods emerged after communicative validation and review of the most relevant and related texts.[9]

We determined the Euclidean distances to the coordinate origin in 2000–2003 and 2016–2019 for the 352 concepts represented by the terms used in the abstracts based on their location on these four dimensions.[10] Note that a concept can be said to have arrived in the mainstream of German-language sociology if the Euclidean distance 2016–2019 is small, meaning the relevant term is used frequently and equally across all topics. Conversely, if the term's Euclidean distance is high, this indicates a peripheral position in German-language sociological discourse. In this way, we scrutinize the extent to which terms in a central position in 2000–2003 are still in a central position in 2016–2019, or whether they have been replaced by other terms. Periphery at the beginning and centrality at the end of the observation period means consolidation.

3.3 Variables

The Euclidean distance, a ratio-scaled dependent variable, referring here to the distance of a term from the center of the topic space in 2016–2019, with values ranging from zero to 3.44, is used as the dependent variable in this regression

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9   We interpreted the dimensions as "inequality vs. quantitative research on governance and management", "qualitative vs. quantitative research (labor, inequality, family)", "theory-free, applied, micro research vs. sociological (macro-) theory", "meso/macro-embeddedness vs. quantitative methodological individualism" in 2000–2003 and "qualtitative, theoretical and historical sociology versus quantitative rational choice research on education, family, and labor markets", "social problems/engagement and reflexion of the qualitative paradigm versus economy, institutions, organizations", "empirical educational research", "practical applications versus academic self-referentiality" in 2016–2019. We define articles as theory-free if the abstracts are devoid of tokens relating to any sociological theory. Furthermore, we found that theory-heavy abstracts congregate on the opposite side of the dimension, supporting our interpretation of theory-free empirical research.

10 To calculate these distances, we used the scikit-learn package implemented in Python (Pedregosa et al. 2011). The Euclidean distances are calculated as follows: We first subtracted the coordination of a token from each of the four extracted topic dimensions from the point of origin. Secondly, these differences were squared and, thirdly, added. Fourthly, we took the square root of the summed distances.

model. In our analysis, we aim to explore how this variable is associated with forms of collaboration, network characteristics, and research topics.

We begin with introducing the collaborative forms. Note that these were calculated on the level of individual papers, whereas the following centrality measures are calculated on author level. We calculate the *average number of co-authors per article* in which the term appears.[11] To assess the influence of inter-institutional cooperation on the consolidation of the terms representing different sociological concepts, we computed the number of participating institutions for those papers in which the terms are applied. We use the *log number of participating institutions* due to a small number of outliers with the participation of more than ten institutions, rendering the distribution highly right-skewed. We recorded the *number of international collaborations dichotomously* (1 = yes, 0 = no) at the article level and then calculated the average value for all papers in which the concept appears.

We also included the gender composition of the authors and research teams who used the concepts. For this purpose, we established two variables. First, whether an *article was written only by female researchers*. This value is dichotomous (1 = yes, 0 = no) at the individual article level. For consistency, we averaged this value across the articles in which a term occurs. Second, we constructed the presence of *mixed-gender author teams* the same way.

In order to construct network centrality measures, we apply *normalized degree centrality* (Opsahl/Agneessens/Skvoretz 2010) and *betweenness centrality* (Newman 2005) to explore the association between authors' collaborative relationships and the consolidation of terms. *Normalized degree centrality* measures the strength of cooperation between authors, normalizing it by the size of the overall network. In our case, degree centrality depicts the number and strength of collaborations. By contrast, *betweenness centrality* measures how many of the shortest paths are assigned to a node, i.e., an author. This is commonly considered a measure of how quickly an author is able to access information circulating in the network. In our case, this would represent the ability to quickly access or disseminate sociological concepts.[12] For example, if an author A is connected to two other authors B and C, but B and C are not connected, then author A has control over the flow of information between B and C. In this case, author A has a high betweenness centrality, authors B and C have a low betweenness centrality.

Since the terms are tied to articles, we calculate the average values of the degree centrality and betweenness centrality of the authors involved in the publication of

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11 We have also included authors² in our model in a test run. However, this showed that there was no correlation between the quadratic term and the consolidation measure. For reasons of clarity in the presentation of our model, we therefore decided to exclude the quadratic term.

12 Centrality measures were calculated using the networkx package (Hagberg/Swart/Chult 2008) in Python. An overview of the most productive and most central authors is provided in appendix E.

the concepts. Finally, we included the *positions of the terms on the four topic dimensions* listed above as well as the *Euclidean distance to the coordinate origin of the years 2000–2003 in the models*. The former is intended to test whether there are topics that are beneficial for the consolidation of a term, the latter whether peripheral topics move into the center of the discourse or remain peripheral regardless of network measures or topic affiliation.

4 Statistical Analysis

Subsequently, the dependent variable—the terms' positions in the topic space 2016–2019—will be explained using OLS-regression.[13] Table 1 summarizes the results of our regression model. Beginning with forms of collaboration, we see that a sociological concept becomes more proximate to the center of the discourse in 2016–2019 with an increasing number of authors per paper in 2000–2003. The negative sign indicates that terms associated with a higher number of authors in 2000–2003 reduces their distance to the point of origin, therefore becoming more central in the discourse space. However, the effect loses its significance when taking other variables controlled for into account, as we shall subsequently discuss.

Next, we turn to the association between the presence of *international collaboration* and the positions of terms in the topic space 2016–2019. Whereas Leydesdorff/Wagner/Bornmann (2018) and Wagner/Whetsell/Leydesdorff (2017) find that ideas spread faster when published in international collaboration, we do not find a significant effect for this phenomenon. This result can be interpreted as resulting from German-language sociology being largely confined to the national scale (Schmitz et al. 2020), distinguishing it from, for example, the discipline of international management (Wieczorek et al. 2021b), or the natural sciences in general (Barrios et al. 2019). However, it is also plausible that the aggregated category 'international' conceals opposing effects that correspond to the global hierarchy of national fields, such as positive effects of cooperation with colleagues from the US and negative effects with partners from less dominant countries.

Regarding *the number of institutional affiliations of authors* using a term in 2000–2003, we identify that a term gets closer to the center of the topic space in 2016–2019 the more affiliations are present (β = -0.130, p < 0.05). This finding implies that terms used by research teams situated at different universities can positively

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13 Point estimates and dispersion parameters are provided in the online appendix A. We also tested for compliance with the model assumptions. The Breusch-Pagan test (BP = 13.82, p = 0.31) indicates homoscedasticity, while the Shapiro-Wilk test (W = 0.9534, p < 0.001) indicates normal distribution of the residuals. Last, the variance inflation factor values indicate that the independent variables assume low levels of multicollinearity with two exceptions of moderate multicollinearity (4 < VIF < 7). However, the VIF values always remained below 10, indicating that the models are suitable for running an OLS regression. To ensure comparability of effect sizes, all independent variables were z-standardized. The online appendix C reports stepwise nested regression models.

Table 1: OLS regression model of collaborative forms, centrality in co-authorship networks, and a term's position in the topic space on its consolidation.

Dependent Variable: Distance of terms from the center of the topic space 2016–2019	Model
Average # of authors p. article	-0.035
	(0.031)
# of int. collaborations of authors	-0.001
	(0.025)
# of participating institutions of authors	-0.130*
	(0.065)
% of female authors per article.	0.044[†]
	(0.023)
% of mixed-gender teams per article	0.035
	(0.030)
Average degree centrality of authors	0.126*
	(0.050)
Average betweenness centrality of authors	0.042[†]
	(0.024)
Distance from the center of space 2000–2003	0.136 ***
	(0.021)
Inequality vs. quant. research on governance and management	0.075 ***
	(0.021)
Qual. vs. quant. (labor, inequality, family)	0.007
	(0.024)
Theory-free, applied, micro research vs. sociological (macro-) theory	-0.011
	(0.022)
Meso/Macro-embeddedness vs. quantitative meth. individualism	-0.025
	(0.021)
Constant	0.508 ***
	(0.011)
Observations	352
Adjusted R^2	0.214

*Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, [†] $p < 0.1$. Standard errors in parentheses, z-normalized effect coefficients.*

impact on the concept's future centrality in German sociology. These scholars, being situated at different institutions, are able to convert their different institutions' prestige into 'surplus' recognition. Being able to jointly mobilize a wider

audience seems to have a positive impact on the future consolidation of sociological concepts. Turning to the effect of *gender composition* on the distance of a term from the center in 2016–2019, we see that the higher the percentage of female authors within a research team, the more distant a term from the center in 2016–2019 (significant at the 10 percent level). If we inspect the terms extracted from our text corpus, we see that female scholars seem disproportionately frequently to use terms such as *crisis, democracy, student, teacher, state, gender, citizen,* or *qualitative design*. These terms are related, for example, to educational research and qualitative approaches. It is not so much that they have not been widespread in the broader German sociology discourse in recent decades, but rather a matter of specialized research milieus. Concepts or tokens associated with male scholars, in contrast, may have higher chances of consolidating over time (for example *variables, company, actor, measure, transition, management, network, employment,* or *unemployment*).

This was to be expected, if only due to the initial statistical situation: Women tend to address peripheral topics more strongly compared to their male counterparts (Bandelj 2019; Heiberger/Munoz-Najar Galvez/McFarland 2021). Female sociologists are also quantitatively less represented in our data (71.76 percent of authors who published in 2000–2003 are male), which may also account for the peripheral position of their thought products in the topic space. However, we control for topics in the model with five variables, so that an additional malus is quite conceivable, namely that work by women tends to be not used. The effect is stable, even under control of *mixed*-gender teams. The latter effect is not significant, but if at all, one can discern the tendency that the higher the percentage of mixed research teams using a term, the more distant the term is from the center in 2016–2019. Mixed-gender teams used terms such as *student, teacher, state, gender, qualitative design, status*, or *occupation*. Initially, these terms overlap with concepts used by female scholars or teams composed of female researchers only. This in turn indicates that peripheral or less prestigious topics were addressed by female and mixed-gender research teams alike.

We now turn to the network measures that depict the network structures underlying the collaborative production of a paper and the concepts thus employed. We see that the higher the *degree centrality* in the collaborative network of the authors applying a term in 2000–2003, the more distant from the center the terms are in 2016–2019 ($\beta = 0.126$, $p < 0.05$). Thus, the higher the centrality of the authors involved in the earlier period, the less relevant the terms they used became over time.

There might be different reasons why thought products used by scholars once central in the collaboration network become more peripheral over time. One potential explanation is the simultaneous control by the numbers of co-authors per paper included in our model. Also, and conversely, degree centrality might suppress an effect of the number of authors as discussed above. Yet there is also

a possible substantive mechanism behind this effect: First, decreasing activity on the part of the formerly productive researchers itself must be taken into account. Beyond that, however, those who were central in the past may have lost this central position, as indicated by the declining levels of attention paid to the concepts they had disseminated. This might be due to the incessant progress or the constant fluctuations of what is and what is not scientifically *en vogue*. Authors who had a central position in 2000–2003 but became more peripheral include prominent figures, some of whose subject areas and concepts have become less central in contemporary sociology (e.g., comparative political economy and social inequality). It also turns out that German sociology is both institutionally and paradigmatically multipolar, i.e., there are several networks, of which each has at least a certain chance of being represented in German journals.[14]

We see that the higher the *betweenness centrality* values of the authors applying a term in 2000–2003, the more distant from the center a term becomes in 2016–2019, meaning that the more central the authors are in 2000–2003, the more peripheral the terms they use become in 2016–2019. The effect coefficient is $\beta = 0.042$ ($p < 0.1$). Again, this may be a counterintuitive finding at first sight, and one has to take into account the simultaneous presence of the numbers of authors and degree centrality. Beyond that, there might be a substantive interpretation for this finding as well: High values of betweenness centrality indicate the ability to span different research discourses, or simply eminence in the field. Researchers with high betweenness centrality values were representative of different sociological sub-discourses in the early 2000s, but lost their ability to do so in the late 2010s. Subsequently, they were replaced by scholars who became the establishment by focusing on more recent topics and concepts. These concepts include *welfare state, gender, qualitative design, occupation, mechanism, status, validity, school, marriage, men,* or *couple*. These terms may have been mediated between discourses by the aforementioned researchers, resulting at first in these concepts becoming more relevant, but by the end of our observation period (e.g., through further differentiation into various sub-discourses), they had moved to the periphery. By 2016–2019, these terms had gone out of fashion and were replaced by terms like *company, firm, manage, employee, movement, practice, choice,* or *transition*.

High betweenness values also indicate locally dense cooperations, for instance within certain larger institutions. Thus, similar to the effect of the number of affiliations, the negative effect may also be due to the relatively modest innovative potential and only temporarily relevant research such contexts entail. In light of a disciplinary culture characterized by its low structural potential for discipline-spanning cumulative advancement in knowledge (Schneider/Osrecki 2020), an affiliation between different discourses, instead of specializing, appears to be a

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14 This interpretation is in line with the declared policy of the journals to be open to all paradigms.

detrimental strategy for consolidating research concepts in the German sociological discourse. At the same time, however, we see that journals show a certain openness to change in authorship (different networks can become active) and in topics.[15]

Continuing with the impact of a *term's distance from the center of the overall topic space in 2000–2003* on its position in 2016–2019, we see that terms in close proximity to the center in 2000–2003 remain proximate in 2016–2019, whereas tokens peripheral in 2000–2003 remain so in 2016–2019. This indicates a certain inertia of the thematic structure of German sociology, which however, is far from a deterministic relationship. Still, overall, terms—e.g., theoretical concepts, methods, and certain areas of research—are of durable interest for the German-speaking research community.

This might point towards a shared, common core of knowledge that was stable for German sociology throughout the observational window. More specifically, this stable core seems to engender a certain paradigmatic substance: Based on a semantic inspection of the underlying abstracts it turns out that the terms include *effect, level, (life) course,* and *individual*. Such concepts are—to a considerable extent —employed by quantitative researchers within the framework of methodological individualism. This is research which has taken a rather important position both at the beginning and the end of our observed time frame.

Finally, we focus on the association between a *term's position in the four separate dimensions of the topic space in 2000–2003* and its distance from the center of the topic space in 2016–2019. Beginning with the first topical dimension extracted from our corpus, we observe that the more a term was distant from the '*social inequality*' pole in 2000–2003 and the closer it was to the '*governance and management oriented quantitative research*' pole, the closer it was to the center of the discursive space in 2016–2019. Thus, research present in 2000–2003 that engaged with issues of governing and managing (a range of different subjects) applying quantitative methods continues to be of utmost relevance in contemporary German sociology. In other words, the more strongly a term was associated with applied or application-oriented topics from the fields of management and governance research in 2000–2003, the more central it became in German-speaking sociology in 2016–2019.

Applied topics are embedded in research with a particular connection to extra-scientific institutions and stakeholders: The terms thus employed comprise *management, company, industry, behavior, control, govern, governance, corporation,* and *measure*. Therefore, the consolidation of research concepts in German-speaking

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15 Another reason for this finding may lie in the fact that established scholars at the beginning of the millennium began to publish in English-language journals and thus took collaborations and research concepts with them, i.e., left our observational window. As many scholars decided to publish predominantly in US journals, the concepts applied necessarily became more peripheral in German outlets.

sociology since the year 2000 can be assumed to be a function of relevance for the political, administrative, and economic fields. Such research provides information for powerful (corporate) actors, who seek to use steering knowledge to shed light on their organizations (firms), or politically relevant actors (governance, control, power). This corroborates our earlier interpretation of German sociology's openness to change and implies a particular responsiveness of the discipline towards demands external to academia. These demands are subject to societal trends and are deeply inscribed in science through the corresponding funding programs.

Beyond affirmative research, this phenomenon of the relevance of applied topics may also—at least partially—occur in the form of critical reflections on governmentality, represented by those researchers who dedicate themselves to its service. At the same time, the effect of the first dimension attests to the fact that traditional forms of research on social inequality have become less relevant in contemporary German sociology. This might be interpreted as a manifestation of ongoing differentiation of social inequality into different forms, as actually addressed in current research (cp. Schwinn 2021: p. 383f.). Today, relatively autonomous discourses, such as intersectionality, educational inequality, or the relations between Europe and the global South, have taken the place of the traditional notions of social inequality such as class structure. These 'classical' forms and concepts of social inequality have lost their dominance in each of these different discourses, again, not least due to the changing societal demands which have been increasingly imposed on the scientific field, including sociology.

In the case of dimensions two to four, we found no significant effect in our data. In short: The core antagonistic positions of the beginning of our observation do not impact on the question as to which topics are central or peripheral in current German sociology. This may be caused by the fact that sociological constructs characteristic of these dimensions became equally more central and more peripheral, which would cancel out any average single effect.

In the sub-discourses unfolding over time, some of the concepts have become central, but peripheral in every other topic dimension. Regarding the second dimension, 'theory-free, applied micro-sociological research vs. sociological (macro) theory' for example, terms that have become peripheral include *partner, couple, marriage, children*, and *occupation*, whereas terms such as *transition, income, choice,* and *labor* become more central. It is plausible that these terms were used to describe domestic division of labor in 2000–2003, but split into two distinct fields of study in life-course analysis (e.g., with focus on fertility and divorce, or shifts in the labor-market and analysis of (un)employment histories).

Similarly, in the third dimension—'theory-free, applied, microsociological research versus sociological (macro-) theory'—concepts like *network, function, company, control,* and *actor* became more central, whereas terms like *system, institution, theorize, structure*, and *state* moved to the periphery. This is not least a consequence of

recontextualization and reconfiguration of concepts. For example, *function* has become more central over time, albeit not in its earlier theoretical context but rather in association with very different research endeavors (theoretical, qualitative, and quantitative research, as well as research in the context of political economy, action research, and educational and political systems). This corroborates our perception that sociology in German-language journals is responding to societal demand, and increasingly so over time (cf. Münch 2018).

Finally, the fourth dimension, "meso/macro-embeddedness versus quantitative methodological individualism", provides us with concepts like *manage, behavior, model, choice, response*, and *game*, which have taken on more central positions. At the same time, *state, crisis, democracy, welfare*, and *citizen*, have become peripheral. Combined with the findings from the first topic dimension, we observe, firstly, that terms strongly associated with methodology and readily transferable to other topics have migrated to the center of German discourse. Secondly, concepts that describe state structures and civil society, on the other hand, have been pushed to the margins.

Finally, we carried out a sensitivity analysis of our model to check for the robustness of our interpretations. We conducted the same analysis as depicted in table 1, but instead used the years 2003–2006 as t_0 and 2013–2016 as t_1. The results are listed in appendix D and reveal stable effects of the number of authors per paper, number of participating institutions, average degree centrality, and distance from the center of the topic space at t_0. Gender effects were not detected and betweenness centrality was not significant, meaning that in the case of German sociology, these two effects presumably only materialize after longer periods of time.

5 Discussion

Research innovation is crucial for the advancement of scientific knowledge and for the enlightenment of society. This may explain, and indeed justify, why there has been an enormous amount of research on scientific innovation. However, the majority of studies focus on the conditions for the emergence of research innovation in a narrow sense, as they tend to exclude and neglect the subsequent phase of consolidation. These less exalted processes are of equal importance for the academic field, as novel ideas must be tested thoroughly by critically-minded peers and translated into different applications. Crucially, these subsequent activities serve to retrospectively attribute innovation to the field, especially if one considers that innovation takes at least a decade to be adopted by fellow scholars in the same discipline (Dey et al. 2017; van Raan 2015).

While much is now known about the social conditions of innovative research in the sense of its initial occurrence, it is still largely unknown as to whether the mechanisms that drive innovation are responsible for the consolidation at the end of the innovatory chain. Yet the everyday production of 'normal' science may well

be subject to different conditions and situations (constraints, resources, strategies, experiences, etc.) than the scientific practice that generates innovations in the narrower sense. To shed light on this consolidation process, we focused on the interplay between collaborative forms and the consolidation of 'thought products' in German sociology. Our findings, based on the five most relevant German outlets, reveal similarities and dissimilarities when compared with the findings on the initial conditions of innovation.

Research has established an inverse U-shaped effect of the number of authors on the dissemination of innovation (Wu/Wang/Evans 2019). At first, there is a positive effect, since the actors involved can contribute their expertise and enact a division of labor; subsequently, however, the effort of coordination increases and has a negative effect on the novelty of a publication and its dissemination in the field. In our case, we find no negative or positive effects, which indicates that a sufficiently established concept can be made equally productive (or not) regardless of the collaborative form, i.e., of whether we are dealing with single authorships, dyads, numerous authors, etc.

A further difference can be observed with regard to the role of the relevant researchers' embeddedness in networks. For the beginning of the innovative process, collaborations between central and eminent researchers are involved in the production of research innovation (cp. Uddin/Hossain/Rasmussen 2013; Wu/Wang/Evans 2019). Conversely, in our analysis, more peripheral authors seem to contribute to the consolidation of concepts, as measured by degree and betweenness centrality. We find that terms used by centrally-placed and highly interconnected scholars become more peripheral over time.

Centrality in collaborative networks seems to hinder consolidation in two ways. This might be attributable to the fact that a given scholar's ability to span different discourses and to collaborate with numerous colleagues has somewhat lost its value. Secondly, the same scholars (along with their concepts) have left the field to specialists, who have then become well-established researchers. This finding differs clearly from the beginning of an innovative chain, where well-connected scholars collaborate, link different areas of the discourse, and enable new research concepts to emerge. For strategic reasons, whose prevalence can be attributed not least to the decreasing autonomy of the scientific field (Münch 2014a: pp. 121–123), it is not profitable for 'consolidators' to engage in the combination of different topics and thought collectives.

Nevertheless, our finding of a positive effect of the number of institutions involved in a collaboration on the future dissemination of its concepts is comparable to existing research (Bornmann 2017; Larivière et al. 2015). Thus, in this regard, the economy of scientific attention in sociology seems to follow a similar pattern throughout the whole process of innovation.

Further, whereas studies have established both a positive (Adams/Gurney 2018; Leydesdorff/Wagner/Bornmann 2018) and a negative relationship between international collaboration and research innovation (Wagner/Whetsell/Leydesdorff 2017), our results show no such effect. Since the field scrutinized in our study is represented by a purely German-language dataset, international cooperations are apparently not associated with consolidation. One possible interpretation is that sufficiently established concepts which are published in German outlets together with international collaborators yield no positive or negative effects, since an original innovation may well date back to before the collaboration came into being. Due to the center-periphery structure of the international field, international co-authorships are mainly successful when authors are involved who work in the USA, the UK, Canada or Australia.

Also, whilst research on innovation in a narrower sense has demonstrated that the focus on broad, abstract topics which connects different strands of research is a prerequisite for innovation (Wu/Wang/Evans 2019; Xu et al. 2020; Zhai/Ding/Wang 2018), the same cannot be observed for German sociology in the timeframe under investigation. Our results rather indicate that concepts related to applied topics have a particularly high chance of consolidation over time. We observe adaptation to overall societal circumstances, outside academic discourse, and a trend towards having to meet expectations of usefulness. This is achieved by focusing increasingly on applied quantitative empirical social research, making sociology less autonomous in its thematic focus.

This is by no means a contradiction: While innovation is in need of concepts spanning knowledge domains in order to address previously unaddressed research puzzles (about which, moreover, there is no agreement in sociology) with novel concepts, this is not the case at the end of the innovative chain. In the process of disseminating thought products, the actual innovative character loses its meaning relative to the applicability of the concepts.

Ultimately, 'practice-oriented' studies consolidate established lines of research even further, as they demonstrate the usefulness of associated thought products to actors outside academia. Consolidation might stem from the strategic orientation of universities and departments in the wake of the Excellence Initiative and increased third-party funding. Researchers and departments have to align themselves with topics that guarantee the acquisition of third-party funding. Only by doing so can researchers be employed; they, in turn, provide the necessary publication output. These researchers are subsequently socialized in such a way that they are exclusively familiar with research oriented towards third-party funding, leading to a loss of recognition of abstract concepts that are not directly applicable. An increasing lack of research autonomy is accompanied by the rise in *applied and applicable* research, which is conducted in a building-block research style, a scientific practice which may increase the chances for consolidation, but lowers the chances of *innovation by*

combination (of topics) and *integration (of scientists).* However, these mechanisms are expected to drive consolidation, not actual innovation.[16]

Specifically, research on social inequality and its associated concepts as published at the beginning of the millennium is scarcely referred to in contemporary German sociology. Since the 1980s, the discourse on social inequality has differentiated into research on gender inequality, intersectionality, educational inequality, regionality, etc.—marginalizing traditional conceptualizations of social inequality such as class-structure. Despite the proliferation of the semantics of inequality, 'classical' forms and concepts of social inequality, as a coherent paradigmatic framework, have lost their relevance in each of these different discourses (cp. Schwinn 2021: p. 383f.).

Also, the thematic structures of the German sociological discourse in the early 2000s have lost their relevance over time: A focus on any of the poles of the remaining dimensions does not have any relevance as to which topics are currently central to the field. This can be explained in the context of the ongoing polarization and disintegration of sociology (Moebius 2021; Münch 2018; Turner 2016; Schwemmer/Wieczorek 2020; Schmitz et al. 2020). No single position (e.g., constructivism, methodological individualism, etc.) has become central to the field over time. Instead, they are now increasingly discussed within their own scientific subfields.

Finally, our findings support the negative association between the spread of innovation and publishing as a female scholar (Lerchenmueller/Sorenson 2018; Dion/Sumner/Mitchell 2018). Gender processes are effective across all special structural properties, due to the underrepresentation of women in networks and the marginalized position of themes preferred by female scholars in the topic space. However, our investigation also sheds light on the fact that the topics chosen—which to a considerable extent remain gender-specific—might hinder the consolidation of the concepts applied by female sociologists. Whereas male scholars apply concepts easily transferable between topics, such as generalizable thoeries, quantitative methodology, and concepts linked to economic sociology, management, and governance, female scholars use qualitative methods linked to different dimensions of social inequality. These in-depth approaches and findings are geared towards specific problems or research puzzles, and therefore cannot easily be tested or applied

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16 The assumption that the instrumental usability of empirical social research for political agendas has increased over time and that application-oriented research is therefore more represented in 2016–2019 than in 2000–2003 can be further substantiated by way of contextualization: First, the funding of this research through third-party funding has increased (but not through the DFG and the Excellence Initiative), second, the researchers in the service institutes are encouraged by evaluation to publish journal articles rather than gray literature or book contributions, and third, because these scholars often work with (or are even involved in the production of) datasets that can be readily used for standard quantitative articles. In contrast, much of the research at university departments still takes place individually.

to different topics, which is the prerequisite for consolidation according to the literature (Xu et al. 2020; Zhai/Ding/Wang 2018).

Taken together, our results show that German sociology as presented in the journals studied does not conform to the pattern of consolidation of innovations expected on the basis of a research literature that is predominantly focused on natural and life sciences. Assumptions that are highly plausible for specific disciplinary and national contexts cannot be applied to (or confirmed by) German-language sociology, due to its specific characteristics. The special structural properties of sociology, especially of sociology in the German-speaking field, counteract the assumed association between collaborative patterns and the consolidation of thought products. A decisive element is the multipolar structure that is characteristic of the field of German-language sociology.

Here, we find no uniform or even single form of knowledge accumulation according to which patterns of innovation and its consolidation through scientific cooperation networks would take place. This is not only because there is no consolidation across the different sociological paradigms, but also because breaks (e.g., 'turns') with their previous stock of knowledge and with the positions of competing approaches are frequent occurrences within many of these paradigms (Schneider/Osrecki 2020). This may facilitate innovation, but it certainly makes cumulative knowledge development—and ultimately consolidation—much more difficult. It is a key factor for the discipline that its internal development is strongly subjected to external factors, such as conjunctures of topics.

The author's gender is another 'extra-scientific' factor, with an additional malus possibly at work apart from the unfavorable statistical starting conditions of female scholars and their thematic preferences. This is because, even controlling for topics, the proportion of female authors on a paper yields a negative effect on the future consolidation of the concepts they deal with. Likewise, the positive effect of the number of institutions involved can be interpreted as resulting from the accumulation of academic institutional capital (Münch 2014a: pp. 144–177).

Yet, even if the field is evolving towards instrumentally exploitable research, our findings also attest that the non-hierarchical multipolar institutional structure of German sociology is conducive to change in concepts, theories, methodologies, and themes. In this respect, there are favorable conditions for the emergence and dissemination of new thinking.

Thus, we do not find much support for the expectations regarding the consolidation of thought products based on investigations of other disciplines. Instead, special conditions with counteracting structures and processes are at work. These include (1) a closed German discourse space and (2) a discipline (a) with less established collaboration and co-authorships compared to the natural and life sciences, (b) with a multipolar, non-hierarchical institutional structure, (c) without a

paradigmatic core, (d) without epistemic progress with corresponding knowledge accumulation, and (e) with high reactivity to actual societal circumstances.

6 Conclusion

The aim of our study was to investigate the association between different forms of collaboration and the consolidation of thought products in German-speaking sociology outlets. To do so, we examined 2,785 abstracts and meta-data published in five German sociology journals between 2000 and 2019. Additionally, we extracted centrality measures from the co-authorship network of authors who issued articles between 2000 and 2003. We then applied correspondence analysis to construct the topic spaces in 2000–2003 and 2016–2019 and conducted a linear regression analysis on the terms used in the abstracts. By doing so, we were able to calculate the shift of thought products towards the center of the academic discourse or their drift to the periphery, and investigated their associations with types of collaboration, author centrality, gender composition of research teams, and research topics extracted from the topic space of 2000–2003.

Three findings stand out in particular: Firstly, we found that consolidation is positively associated with the number of institutions linked to an article. Secondly, consolidation is negatively associated with the number of collaborations with authors using different terms, as well as their initial distance from the center of the sociology discourse in 2000–2003. The latter indicates a certain degree of stability of the discourse prevailing in the five sociology outlets under investigation. Finally, we observed that tokens associated with social inequality research become peripheral over time, while tokens which are associated with research on governance and management become more central. These effects also hold after sensitivity analysis (see online appendix D).

In light of our findings and considerations outlined in the discussion section, future research should engage in the investigation of scientific consolidation processes and, in doing so, employ a more differentiated, comparative perspective, one that takes into account how scientific fields differ and the significance of the embeddedness in national contexts. This is especially true inasmuch as our paper focuses on sociology as the case study, which bears little resemblance to the natural sciences, but may yield indications regarding consolidation mechanisms present in other multiparadigmatically-structured disciplines.

Future research should also assess whether our findings hold for sociological research communities in different countries, especially in Anglophone countries with greater potential to reach audiences globally. We suspect that international research teams that can agree on a common, already proven research program and publish only in English are more likely to consolidate concepts—especially since national journals are more likely to publish topics and associated research concepts that address problems from that country.

Moreover, future research should investigate whether the topics derived from our topic space remain stable, or are re-embedded into new contexts. By focusing on the movement of thought products in the topic space, future studies could trace the reconceptualization and re-embedding of sociological concepts (e.g., from social structural analysis to empirical education science or gender studies) into new topics.

Future studies should also examine whether the central authors have strategically migrated to other (especially Anglophone) journals where they can make use of their ability to link discourses and thus consolidate concepts. This would amount to a *parallel internationalization* of some German authors (who increasingly orient themselves toward international journals) and a *de-internationalization* of the remaining German sociologists. Thus, it might be the case that we are dealing with a kind of migration flow between journals, leading to an impression of consolidation and marginalization of research concepts. Eminent researchers from specific paradigmatic milieus may leave the German-language discourse and enable the consolidation of research content in other research communities, while sociologists and their thought products from other countries or research institutes may, conversely, begin to publish in the journals under investigation.

As is the case in bibliometric studies, our investigation is prone to some limitations. First, our findings may be the result of period effects associated with the Excellence Initiative and Bologna reforms. These might have an impact on forms of collaboration and the spread of ideas, measured in citations. As both are linked to the consolidation of thought products, as argued in section 2, future studies should seek a way to determine possible confounders in the consolidation of thought products. Second, our model of consolidation cannot distinguish between genuine research innovations and thought products which were innovated in different contexts (e.g., the US sociology discourse) and only belatedly adopted by German sociology. Consequently, we treat innovation as the introduction and dissemination of different concepts into the German sociology discourse. Third, our sample is relatively small. Thus, we may have missed some aspect of the dynamics of consolidation in German sociology; future studies should expand the sample to include more obscure journals and also Anglophone journals. The space occupied by researchers specialized in providing useful knowledge in the sociology journals serving as the data basis for this study has been increasingly extended in the observed period of time.

While our findings nonetheless suggest that distinct and relatively autonomous collectives populate the younger field of German sociology, future research should also expand the database to consider publications in books, an approach to publication important to large segments of German sociology. Furthermore, the observational window should be extended, in analyses based on our proposed approach, in order to minimize the problem of left censoring. Most importantly, in doing so, it should be kept in mind that research is a collective process that requires not

only innovative 'superstars', but many researchers who adopt these innovations and implement them productively in different disciplinary contexts. Sadly, this is increasingly forgotten in an academic system which focuses on visibility, increasing publication output, and attracting external funding, and which is also increasingly geared towards competition and addressing externally set research goals.

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Appendix A: descriptive statistics

Table A1: Descriptive statistics of the variables included in the OLS regression model.

	Observations	Mean	Median	Minimum	Maximum	Range	Standard Deviation	Skewness	Kurtosis
Dependent variable: Distance of the terms from the center of the topic space 2016–2019	352	0.72	0.65	0.1	3.44	3.34	0.4	2.17	9.11
Distance of from the center of space 2000–2003	352	0.87	0.83	0.12	2.46	2.34	0.39	0.89	1.13
Av. # of authors p. article	352	1.44	1.43	1	2.43	1.43	0.21	0.68	1.37
Number of international collaborations of authors using the thought product in 2000–2003	352	0.62	0	0	6	6	0.93	2.01	5.34
# of int- collaborations of authors	352	27.15	20	4	250	246	24.51	3.73	23.49
# of participating institutions of authors	352	0.18	0.17	0	0.8	0.8	0.11	1.17	3.5
% female authors per article.	352	0.15	0.14	0	0.57	0.57	0.1	0.72	1.12
% of mixed-gender teams per article	352	0.003	0.002	0	0.01	0.01	0.001	0.69	2.31
Average degree centrality of authors	352	$8.88e^{-06}$	$6.69e^{-06}$	0	0.0001	0.0001	$9.65e^{-06}$	2.6	13.23
Average betweenness centrality of authors	352	0.01	0.01	-1.24	2.02	3.25	0.43	0.49	1.71
Inequality vs. quant. research on governance and management	352	0.04	0.06	-2.18	1.73	3.91	0.58	-0.17	0.26
Qual. vs. quant. (labor, inequality, family)	352	0.03	0.04	-1.33	1.37	2.7	0.46	-0.17	-0.12
Theory-free, applied, micro research vs. sociological (macro-) theory	352	0.05	0.06	-1.29	1.79	3.08	0.41	-0.07	1.06
Meso/macro-embeddedness vs. quantitative meth. individualism	352	0.01	0.01	-1.24	2.02	3.25	0.43	0.49	1.71

Appendix B: Distances to the point of origin of the topic spaces in 2000–2003 and 2016–2019

Figures B1–B4 summarize the central/peripheral positions of each active/passive term included in our regression model. On the x-axis, we plotted the distance of the terms to the point of origin in our topic space in 2000–2003, whereas the y-axis depicts the distance of the terms to the point of origin in our topic space in 2016–2019.

Figure B1: Distance of tokens active 2000–2003 and 2016–2019 from the point of origin in the topic space.
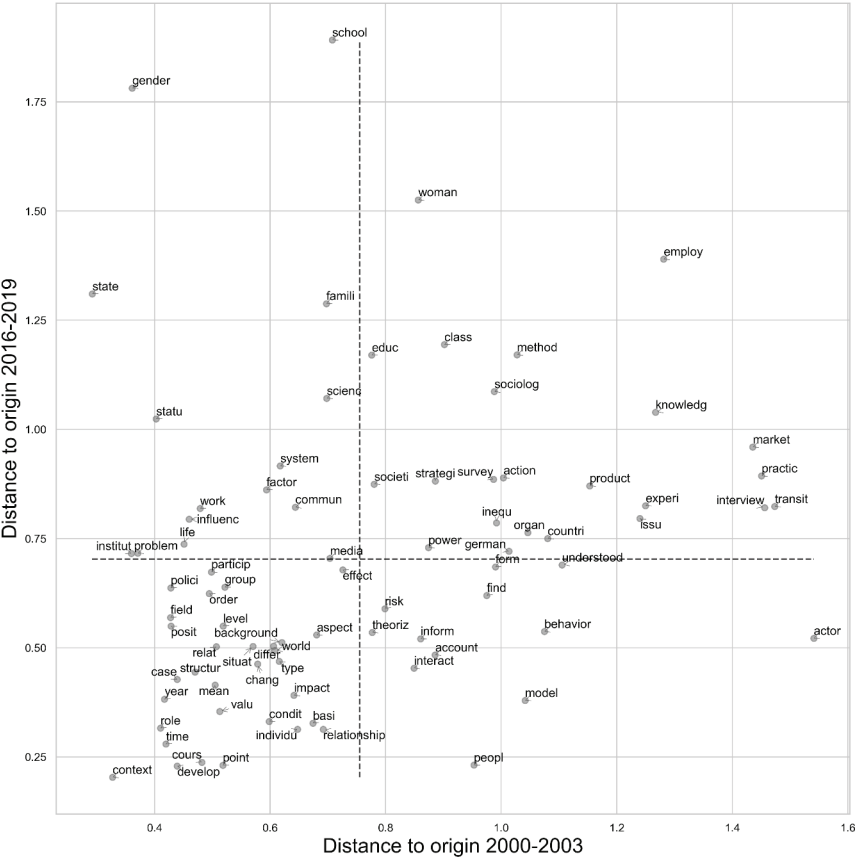
Figure B2: Distance of tokens passive in 2000–2003 and 2016–2019 from the point of origin in the topic space.
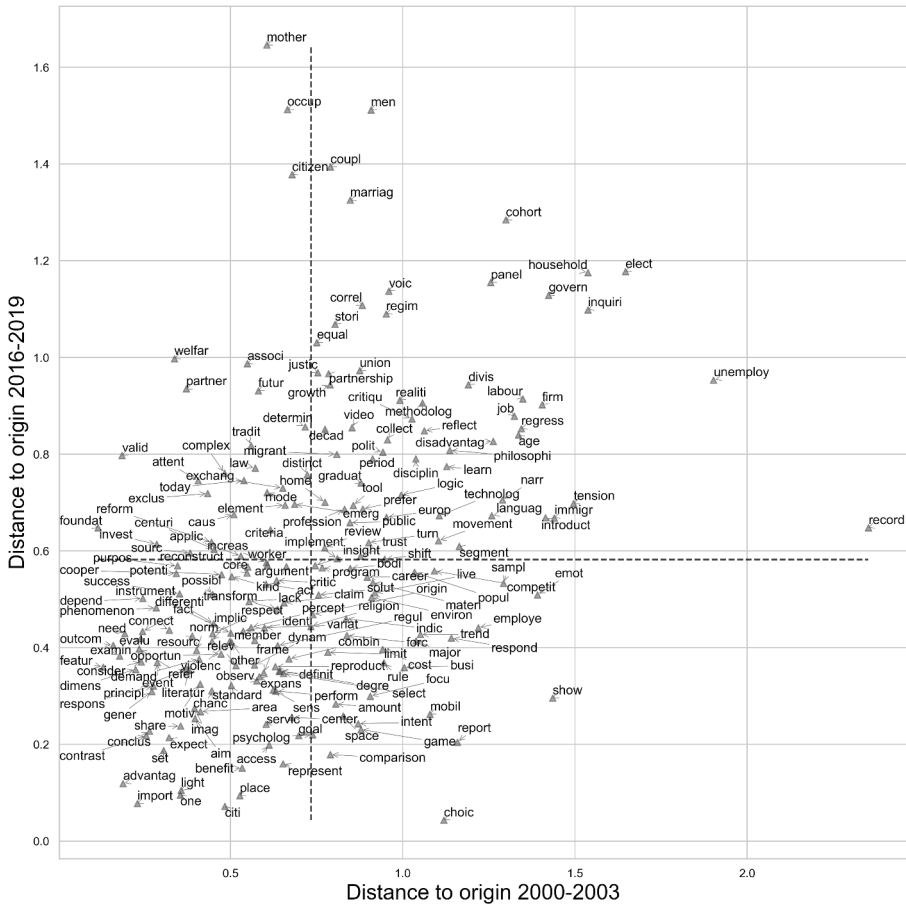
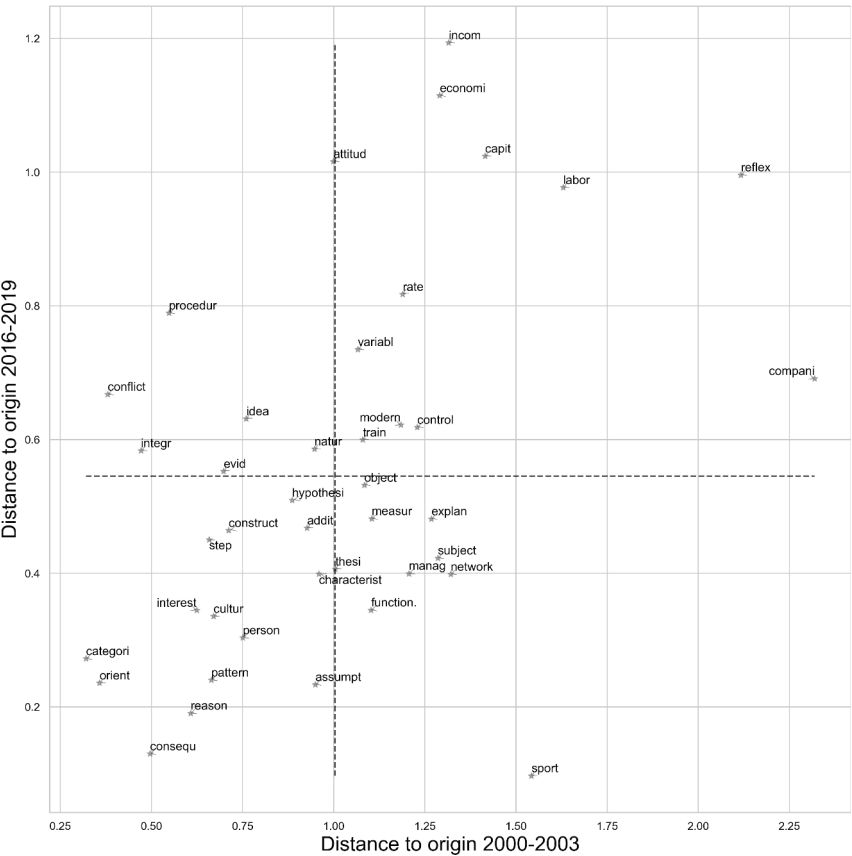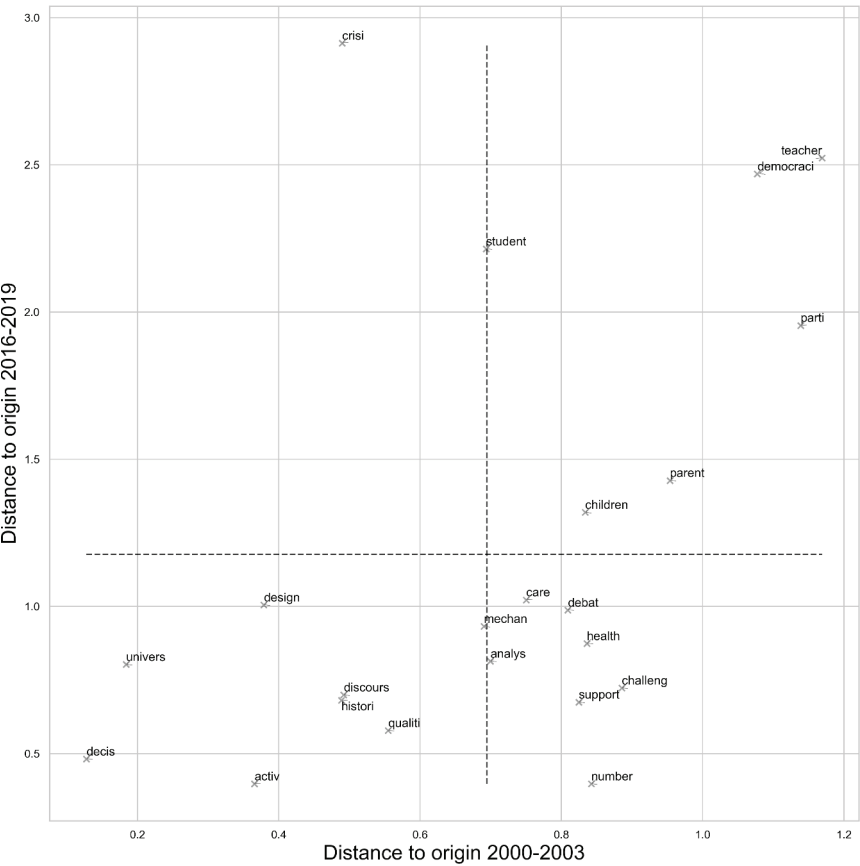**Figure B3: Distance of tokens active in 2000–2003 and passive in 2016–2019 from the point of origin in the topic space.**

Figure B4: Distance of tokens passive in 2000–2003 and active in 2016–2019 from the point of origin in the topic space.

Appendix C: Hierarchical nested regression models

Table C1: OLS regression models of collaborative forms, centrality in co-authorship networks, and a term's position in the topic space on its consolidation.

DV: Distance of terms from the center of the topic space 2016–2019

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Av. # of authors p. article		-0.03			-0.06 †		-0.03
		(0.03)			(0.03)		(0.03)
# of int- collaborations of authors		-0.01			-0.01		-0.01
		(0.02)			(0.02)		(0.03)
# of participating institutions of authors		0.01			-0.12 †		-0.13 *
		(0.03)			(0.07)		(0.07)
% female authors per article.		0.04 †			0.06 **		0.04 †
		(0.02)			(0.02)		(0.02)
% of mixed-gender teams per article		0.04			0.05 †		0.04
		(0.03)			(0.03)		(0.03)
Average degree centrality of authors			0.03		0.12 *	0.03 †	0.13 *
			(0.02)		(0.05)	(0.02)	(0.05)
Average betweenness centrality of authors			0.05 *		0.05 *	0.04 *	0.04 †
			(0.02)		(0.02)	(0.02)	(0.02)
Distance of from the center of space 2000–2003	0.14 ***	0.15 ***	0.14 ***	0.13 ***	0.14 ***	0.14 ***	0.14 ***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Inequality vs. quant. research on governance and management				0.08 ***		0.08 ***	0.08 ***
				(0.02)		(0.02)	(0.02)
Qual. vs. quant. (labor, inequality, family)				0.02		0.00	0.01
				(0.02)		(0.02)	(0.02)
Theory-free, applied, micro research vs. sociological (macro-) theory				0.01		0.01	-0.01
				(0.02)		(0.02)	(0.02)
Meso/macro-embeddedness vs. quantitative meth. individualism				-0.01		-0.01	-0.03
				(0.02)		(0.02)	(0.02)
Constant	0.52 ***	0.52 ***	0.52 ***	0.52 ***	0.51 ***	0.52 ***	0.51 ***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Observations	352	352	352	352	352	352	352
Adjusted R^2	0.13	0.14	0.15	0.18	0.18	0.19	0.21

Legend: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, † $p< 0.1$.
Confidence interval in parentheses, z-normalized effect coefficients.

Appendix D: Sensitivity analysis of the regression model

Table D1: OLS regression models of collaborative forms, centrality in co-authorship networks, and a term's position in the topic space on its consolidation with t1 = 2013–2016.

	DV: Distance of terms from the center of the topic space 2013–2016
	Model
Average # of authors p. article	-0.07 **
	(0.02)
# of int- collaborations of authors	0.02
	(0.03)
# of participating institutions of authors	-0.19 ***
	(0.05)
% female authors per article.	0.02
	(0.02)
% of mixed-gender teams per article	0.03
	(0.02)
Average degree centrality of authors	0.15 **
	(0.05)
Average betweenness centrality of authors	-0.01
	(0.02)
Distance from the center of space 2003–2006	0.16***
	(0.02)
z.Dim_1_2003_2006	-0.01
	(0.02)
z.Dim_2_2003_2006	0.01
	(0.02)
z.Dim_3_2003_2006	-0.06 ***
	(0.02)
z.Dim_4_2003_2006	0.02
	(0.02)
Constant	0.57 ***
	(0.01)
Observations	367
Adjusted R^2	0.30

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; † $p < 0.1$.

Appendix E: Most productive authors, most central authors, and biggest component of the co-authorship-network 2000–2003

Table E1: The ten most productive authors according to the number of papers issued in 2000–2003.

	Name	Number of Observations
1	ROTH, WOLFF-MICHAEL	5
2	KONIETZKA, DIRK	5
3	GERHARDS, JÜRGEN	5
4	BREUER, FRANZ	5
5	NOLLMANN, G	4
6	KLEIN, THOMAS	4
7	WINDZIO, MICHAEL	4
8	LIEBIG, STEFAN	4
9	KUHL, STEFAN	4
10	ROSSEL, JÖRG	4

Table E2: Most central authors in 2000–2003 by normalized degree centrality. Own calculations.

	Name	Normalized degree centrality
1	MARTIN_HÖPNER	0.0186
2	RAINER_ZUGEHÖR	0.0149
3	ANKE_HASSEL	0.0149
4	BRITTA_REHDER	0.0149
5	ANTJE_KURDELBUSCH	0.0149
6	THOMAS_KLEIN	0.0149
7	DIRK_KONIETZKA	0.0149
8	JUDITH_PRINGLE	0.0112
9	SUSAN_COPAS	0.0112
10	BRIGID_CARROLL	0.0112

Table E3: Most central authors in 2000–2003 by normalized betweenness centrality. Own calculations.

	Name	Normalized betweenness centrality
1	STEFAN_LIEBIG	0.00019
2	ROLAND_VERWIEBE	0.00017
3	THOMAS_KLEIN	0.00014
4	DIRK_KONIETZKA	0.00014
5	MARTIN_HÖPNER	0.00011
6	UWE_WILKESMANN	0.00006
7	FRANZ_BREUER	0.00006
8	MICHAEL_GROTHEER	0.00006
9	JÜRGEN_GERHARDS	0.00006
10	JÖRG_RÖSSEL	0.00006