*A View from Above: The Evolving Sociological Landscape**

JAMES MOODY AND RYAN LIGHT

How has sociology evolved over the last 40 years? In this paper, we examine networks built on thousands of sociology-relevant papers to map sociology's position in the wider social sciences and identify changes in the most prominent research fronts in the discipline. We find first that sociology seems to have traded centrality in the field of social sciences for internal cohesion: sociology is central, but not nearly as well bounded as neighboring disciplines such as economics or law. Internally, sociology appears to have moved away from research topics associated with fundamental social processes and toward social-problems research. We end by discussing strategies for extending this work to wider science production networks.

Introduction

Scientific fields are typically defined by the topics that scientists study, but how can you typify a science with weak substantive boundaries? Sociology is (in)famous for its far-reaching empirical scope, as there are few topics sociologists can exclude (Abbott, 2001). This openness leads to a basic paradox: When viewed locally, sociologists can easily identify a coherent structure to their own specialized fields. We all know the key players, data sources, pressing questions, and probably have a good sense of the topically local research frontier. At the local level, sociology is a normal-science affair. Viewed globally, we see disconnection and chaos. For most, our only exposure to work outside our specialty areas is publications in major general journals, and taken independently, these often appear disconnected. At the global level, sociology appears as a disintegrated discipline. Much like viewing mountain ranges from a single peak on a cold foggy morning, we can see the other peaks but not the valleys connecting them. As such, while we know our own mountain well (having worked hard to scale it), we have little sense of the general topography that links our mountains to the broader sociological landscape.

In this paper, we provide an aerial level view of the topic landscape in sociology over time. Here we focus on a two-level exploration. We first ask where sociology sits in the

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wider body of social science research by examining co-citation patterns among social science journals. We then focus on sociologically relevant work to map the topics sociologists write about. Subfields in sociology emerge as clusters of papers written on the same topic, and we follow the ebb and flow of these topic clusters over time.

Mapping Sociology

The boundaries of sociology have been contested since its first disciplinary steps. Nineteenth century sociologists, such as Durkheim (1966), optimistically evaluated sociology's centrality within the broader scientific landscape. By the end of the twentieth century, however, numerous prominent scholars predicted the increasing fragmentation of the discipline. This largely theoretical research describes a fractured discipline structured by solidly bound, autonomous groups (Friedrichs, 1970; Gouldner, 1970; Horowitz, 1993; Turner and Turner, 1990. These models suggest that resources, market or status-based, or increasing ideational divides bound the discipline (Cappell and Guterbock, 1992). Within the resource model (e.g., Frickel and Gross, 2005; Turner and Turner, 1990), funding bodies support and direct scientific research creating distinctions between the "haves" and "have-nots." On the other hand, the ideational-divide model suggests that autonomous boundaries between groups weaken the structure of sociology.

Theorists observing an ideational divide within the discipline predict two diverse outcomes. Optimistic forecasters claim that the fragmentation of the discipline will lead to a more pluralistic science. For example, Friedrichs (1970) argues that fragmentation does not necessitate the paradigmatic revolutions outlined by Kuhn (Kuhn, 1970), but rather can indicate a healthy democratic sociology. Friedrichs (1970) asserts that the epistemological difficulty in establishing causal proof in the social sciences allows for this more pluralistic approach. Social science knowledge is not the Kuhnian struggle that takes place in the natural sciences, but develops closer to Abbott's image (2001) of a "Silk Road" of ideas. Ideas ebb and flow with few dramatic fissures. Social science knowledge, to Friedrichs (1970), benefits from pluralistic debate.

On the other hand, pessimistic forecasters predict that the increasing fragmentation of sociology will cause its eventual demise. Horowitz (1993), for example, sees pluralism as a sign of disciplinary weakness. According to Horowitz (1993), the influx of new "ideological" disciplines, such as gender studies, American studies, Native American studies, etc., has effaced the foundation of sociology: "[S]ociology has largely become a repository of discontent, a gathering of individuals who have special agendas, from gay and lesbian rights to liberation theology.... Any notion of a common democratic culture or a universal scientific base has become suspect." In contrast to Friedrichs (1970), Horowitz argues that dramatic fissures indeed exist within the discipline and this fragmentation brought about by cultural politics will cause the demise of the discipline. Cultural politics and the ensuing fragmentation, to Horowitz (1993), stall the production of social scientific knowledge.

Recent theory in the sociology of science offers a contrasting, more recombinant forecast depicting a less-bounded discipline. Abbott (2001) claims, "Sociology is irremediably interstitial." This interstitial quality provides the foundation for the claim that sociology is the most general of the social sciences. Situated between the natural sciences and the humanities, the social sciences mediate these disparate disciplines. Dichotomies frequently identified in the ideational model of sociology mirror the differences between the natural sciences and the humanities, such as the familiar distinction between qualitative and quantitative research methodologies.

Abbott (2001) argues, however, the practice and structure of sociology follows a "fractal cycle." "Defeated" ideas, concepts, and methods are remapped onto "victorious" or hegemonic ideas, concepts, and methods. The dichotomization view predicts the elimination of particular sociological theories, methods, and substantive areas due to the social nature and politics of practicing science. The fractal view asserts that the victors resurrect "defeated" sociologies. The boundaries between groups across time are more porous than hypothesized by the ideational divide or resource models. Thus, in analyzing the idea structure of sociology, we would anticipate shifts in dominant topics through time, with some residual effects persisting from previous eras.

Using broader empirical techniques, recent research has identified social boundaries between groups of actors in sociology by analyzing affiliation based on ASA membership data (Cappell and Guterbock, 1992; Daipha, 2001; Ennis, 1992) and by looking at the evolution of a co-authorship networks (Moody, 2004). This research generally finds a less fractured discipline with more porous boundaries and less autonomous groups than suggested by some theoretical models. For example, comparing the self-reported interest areas of sociologists, Ennis (1992) discovers clusters with distinct boundaries, although no single cluster dominates the center of the structure and the boundaries all overlap to some extent (see Daipha, 2001). Ideational and resource-based boundaries exist, but no hegemonic cluster dominates the social structure (Ennis, 1992).

Cappell and Guterbock (1992) and Daipha (2001) analyze joint membership patterns in ASA sections arguing that membership in ASA sections indicates a greater commitment to the fields of interest, both socially and in practice through publication, than the nomination of interest areas used by Ennis (Cappell and Guterbock, 1992; Daipha, 2001). The research suggests that several substantive clusters coexist over time (Daipha, 2001). The clustering depicts a rather solid boundary between theoretical and applied sociology; however, the structure, as a whole, consists of porously bound groups (Daipha, 2001). In his analysis of co-authorship networks, Moody (2004) reaches similar conclusions. Although quantitative sociologists are more likely to co-author than qualitative sociologists, substantive topic differences do not independently determine network embeddedness. Rather, a substantive core of highly productive scientists appears to drive the structure of the network, despite substantive differentiation.

Cumulatively, these analyses of the structure of sociology outline a more complex story regarding the current state and the future potential of the discipline. These analyses also depict the effectiveness of network methodologies to the sociology of science. Recent advancements in information technology allow us to map knowledge domains (Gieryn, 1999; Shiffrin and Borner, 2004). This work, grounded in the citation analyses of early scholars of information science (e.g., Garfield et al., 1964; Griffith et al., 1974; Pool and Kochen, 1978; Small and Griffith, 1974), describes the character of knowledge structures using network and multidimensional scaling techniques (e.g., Callon et al., 1986; Whittaker et al., 1989). The mapping of entire disciplines requires expanding the scope of earlier analyses to very large-scale networks to capture the diversity contained within idea structures and the frequent shifts in the scientific landscape. Shiffrin and Börner (2004) claim that the mapping of knowledge domains moves scientists beyond observing "a few nearby trees in the forest of knowledge" to visualizing the entire structure of ideas. This vision offers bold new methods and challenges for understanding the way scientific ideas develop.

While prior work on the structure of the field has focused on either on the social integration of the discipline or changes in the frequency of topics, nobody has picked up the challenge to map the global position or internal structure of sociology. Two types of

data are ideal for this task. First, *citation patterns* allow one to see how scientists situate their work relative to others. While there are many reasons to cite other work (Baldi, 1998; Hargens, 2000), at a minimum a citation is an indication of relevance: it situates one's work relative to others. Whether positive *or* negative, a citation is an essential marker that says the current work operates in the same realm as the works cited. As such, examining the larger pattern of citations allows us to see how fields self-organize.

Moving past citations, the internal structure of a discipline can be seen by focusing directly on the substance of each publication. To speak of a coherent field necessarily implies a body of work addressing the same empirical question. Rather than focus on *a priori* classifications (Moody, 2004), our goal is to allow the substance of such clusters to emerge endogenously by identifying sets of papers that talk about the same thing. Combined, these two approaches provide a unique insight into the position and internal organization of sociology.

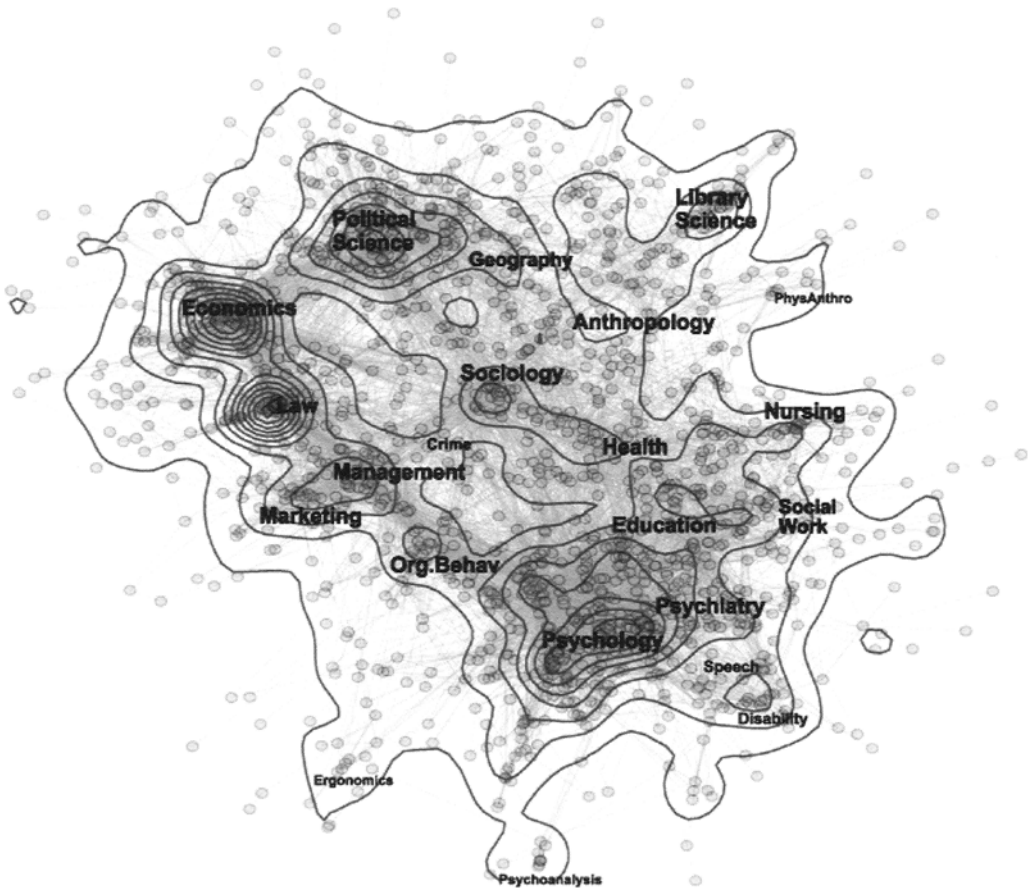
Queen of the Sciences?

Where does sociology fit in the wider arena of social science? Sociologists often purposefully contrast their approach to other disciplines such as economics and psychology, but how is our discipline positioned relative to these competitors? To answer this question, we focus on the co-citation patterns among social science journals. Co-citation similarity represents how "substitutable" two journals are. If both journals are cited by third parties in identical ways, their co-citation similarity score will be very high. Technically, we construct journal-level co-citation similarity networks by compiling local journal citation networks compiled by Loet Leydesdorff (2004). We then combine the local network files to produce a complete social science network.[1] In these networks, each node is a journal and links between journals are the weighted similarity of their citation vectors. It is important to note that these are citation weights calculated on the *cited by* network, not the *citing* network. That is, two journals will have a strong edge connecting them if they *are cited similarly by all other journals*. We use the cosine measure of similarity (Leydesdorff, 2004) and retain edges with a value of 0.30 or stronger.

Once this network is constructed, we map the network using a valued-edge spring-embedder so strongly connected journals will be placed close to each other in the layout space. Large networks are often hard to visualize, since the nodes simply get plotted on top of each other. We correct for this by layering a two-dimensional density estimate for the number of nodes at each xy point over the network, creating a contour sociogram (Moody, 2004; Light, 2004). In such plots, dense clusters—the key marker for disciplines—will appear as peaks in the surface.

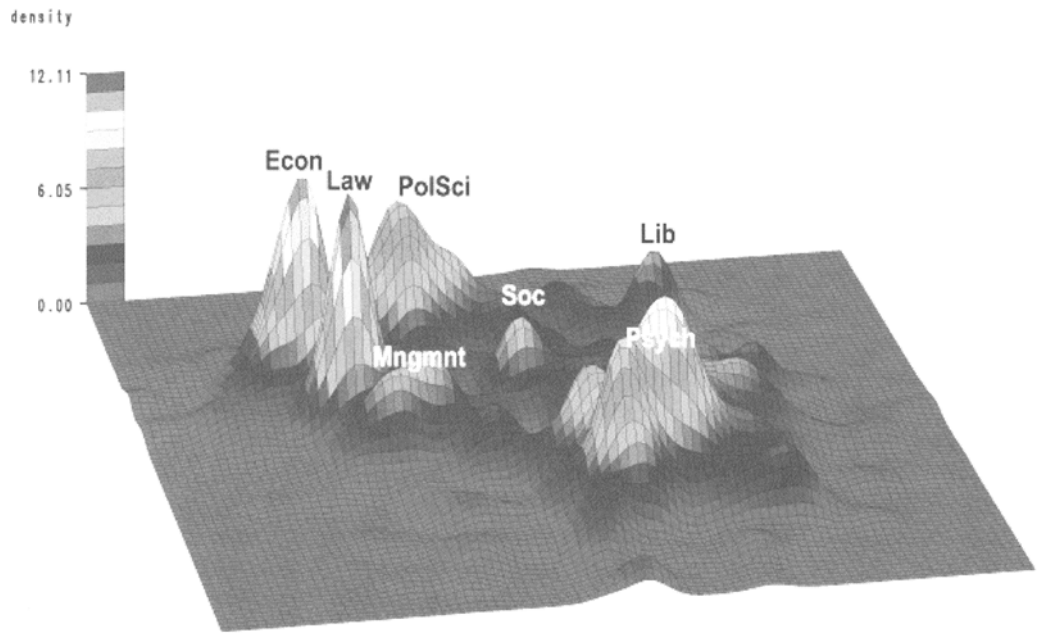
In addition to displaying the network, we also cluster the network and label each cluster's position on the map based on an inspection of the journals in each cluster. Our clustering algorithm, which is a modification of Moody's (2002) recursive neighborhood means routine, partitions nodes to groups and then continuously adjusts node assignment by moving nodes to the cluster (if any) where most of their edges are directed. This is continued until the modularity index (Guimera and Amaral 2005b) is maximized, leading to an optimal assignment of nodes to clusters. Importantly, this procedure (a) allows nodes to not be members of a cluster (truly interdisciplinary work, in this substantive case) and (b) does not require the user to pre-specify the number of clusters.[2] Labels are placed based on the prominent journals in each cluster found at that region of the figure.

Figure 1
The Discipline Structure of Social Science Journals
Co-citation ties among 1657 Social Science Journals



It is instructive to discuss the overall shape of the social science network. The field is dominated in the "north west" by the twin peaks of economics and law. Just to the south of these two lie management and marketing though their peaks are considerably lower. To the north and east of economics lies political science, and combined this ridge (from political science through management) can be thought of as fields that deal with the stuff of power: politics, money, resources, law, and media. The east is largely a flat plain, with a distant low-lying peak of library science, and a foothill of geography merging into political science at the far north. The body of this piedmont region is held by anthropology, with a clearly distinct island for the crystallizing subfield of physical anthropology. One can think of the east as disciplines dealing primarily with questions of *meaning*. The south range is dominated by the study of the mind, with psychology and psychiatry forming a wide and high ridge. The foothills of this range are dominated by applied work and practice in disabilities, general health, education, nursing, and social work. This speaks strongly, we think, to the dominance of a medical and mental model for much applied social problems work. And, at the very center, sociology sits as a middle-height peak surrounded by these topic-specific giants.

Figure 2
The Discipline Structure of Social Science Journals
Co-citation ties among 1657 Social Science Journals

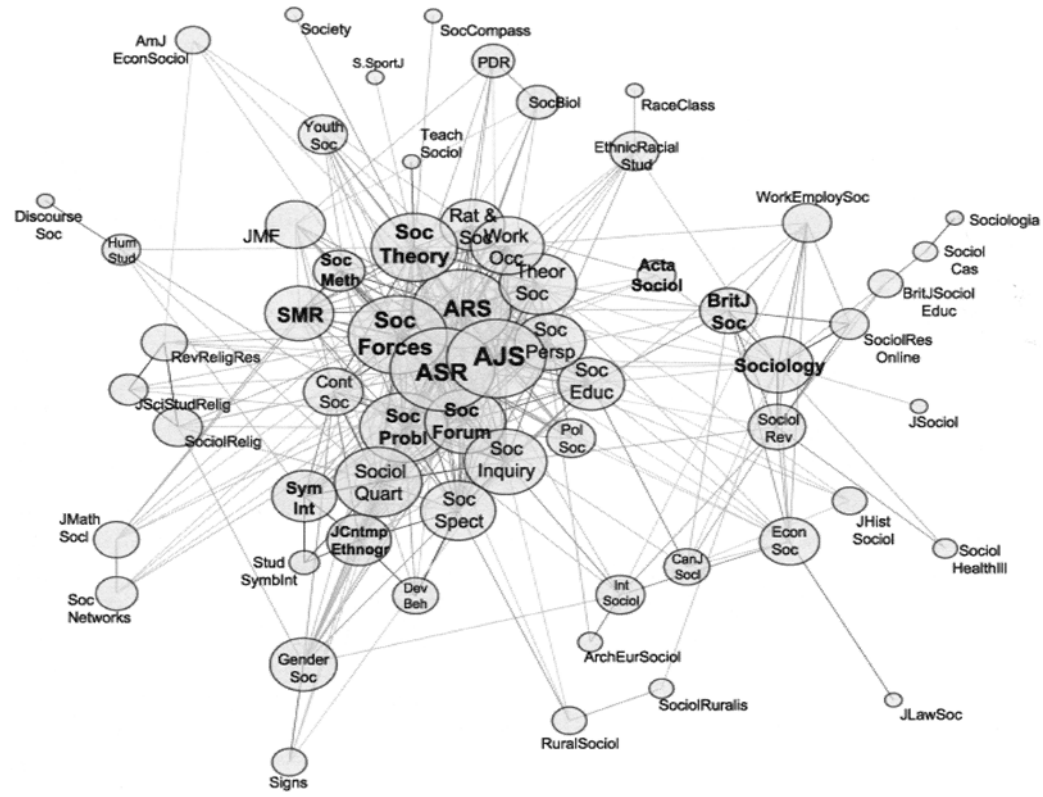


The highest peaks in this figure are clearly economics, law, psychology, and political science. A three-dimensional image of this network in Figure 2 makes the relative height of these mountains quite clear. It is easy to get a sense of the source of some of the self-abuse sociologists layer on our discipline: compared to our mighty neighbors (on every side!), sociology appears a comparatively small foothill. The height of our neighbors results directly from their strong boundaries: there is little work published in law that would be of direct relevance to research in psychology, and each of these fields do a good job of citing within their disciplines. This leads to strong internal coherence and recognition that creates strong similarity in the co-citation network and thus dense clusters. They are also much larger (in terms of simple numbers of journals) than the sociology cluster. Economics, psychology, and political science are disciplines that have successfully carved clear niches in the idea space and anchor that space with their work.[3]

Sociology, on the other hand, has a different structure. We have traded *network centrality* for density. The *ASR* is the most central journal in the network, and seven of the top 10 most central journals are sociology journals.[4] We are not nearly as large or internally self-referenced as many of our behavioral science competitors. Instead of a field devoted to a comparatively narrow niche of the social science idea space, sociology has opted for being a truly *general* discipline. A close examination of Figures 1 and 2 reveals that there are hundreds of journals that fill in the valley space between the most dominant peaks and sociology forms the single discipline at the heart of otherwise deliberately interdisciplinary work (such as that in health, management, or criminology).

Theoretically, this means that sociologists can easily trade in the ideas of multiple disciplines. This means that we can more easily borrow (and have stolen!) ideas from all

Figure 3
The Sociology Co-Citation Network Structure



corners of the idea space. Behaviorally, this centrality also likely reflects an inability to settle on a single theoretical model. The largest-peak fields have (largely) settled on a single approach to the way they ask and answer questions, which helps reinforce their work. Sociology, in contrast, has open boundaries that make it easy to contest particular approaches.

The interstitial nature of sociology raises an obvious question of the *internal* citation structure of the field. If you were to pull out the economics cluster, for example, you would see a largely spherical network with a clear set of central journals. What about sociology? Figure 3 selects out just those journals that fall within the main reach of the sociology peak at the center of this network. Here node size is proportional to degree, and larger nodes are thus more central in the local network. As we would expect, the three most prominent general journals (*ASR*, *AJS*, *SocForces*) and the annual review (*ARS*) are at the center of the network. There is a general left-right break in the network, with largely European journals on the right and American journals on the left. Within the network, there are a few clear clusters based on substantive area. To the far left we see *JmathSoc* and *SocNetworks* closely linked, and the three premier religious journals just above the network cluster (but unconnected to it). We should be somewhat cautious interpreting these figures, however, based on the journal level citations. The general journals are central, but not necessarily internally so. That is, while journals covering

topics as different as *Gender & Society* and *Rationality & Society* both cite *ASR*, they may not be citing the same articles. As such, to get a true portrait of the topical organization of sociologically relevant work, we need to turn our attention *within journals* to the substance of articles themselves.

Paper Topic Networks

If sociologists cannot exclude substantive fields from study, it follows that there are likely many topics being studied at any given time. How are these topics related? For example, do those who write on race link race to class? Is sexuality linked to identity or disease? The answer to these types of questions rests in understanding the pattern of topics studied by sociologists. Here we extend an old technique pioneered in library and information science (Courtial and Law, 1989; He, 1999; Law et al., 1988). The idea is simple. If two documents share a large number of words, then they are substantively more similar than two documents with no terms in common. There are, of course, nuances that are lost here—the English language thankfully admits to much ambiguity. But for our purposes, a gross topology will do. We want to know *what people are writing about.* Thus while there are certainly internal debates we miss with these tools, the large-scale structure of sociological discourse is well captured. More importantly, while prior work using such tools focused on a very course language captured with just the keywords (often not picked by authors), we use all of the information contained in the title, keywords and abstract expanding the "bits" of information from less than a dozen to a few hundred for each paper, which allows for a much more accurate assignment of papers to clusters.

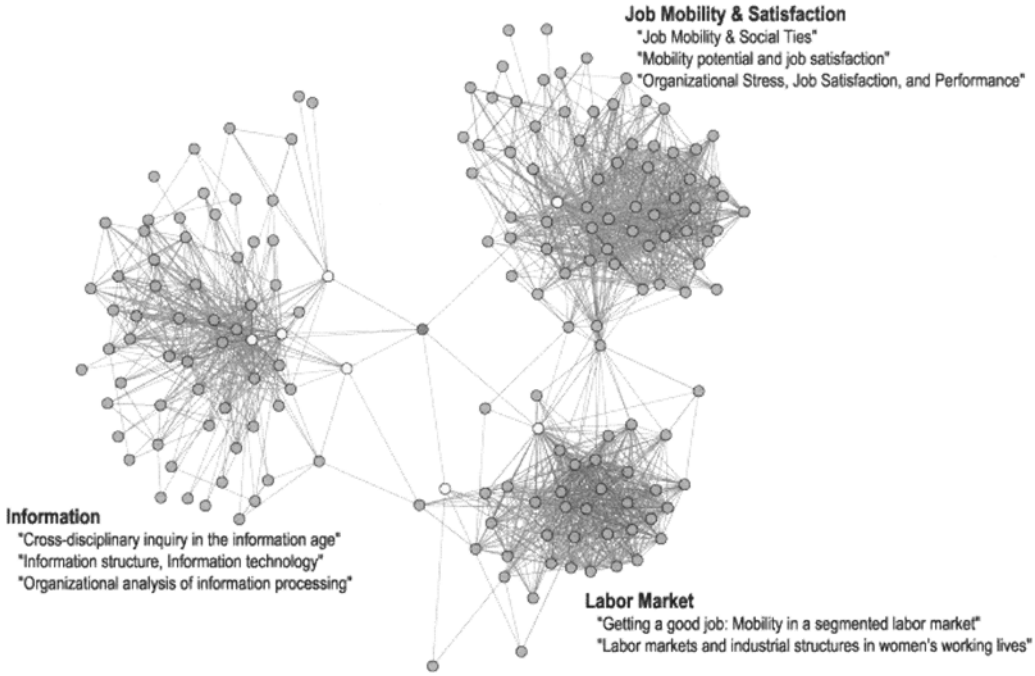
Our method proceeds as follows. Our population consists of all English-language research papers indexed by *Sociological Abstracts* from 1970 to 1990. This frame provides the widest possible set for work relevant to sociology,[5] and allows us to see the basic contours of the discipline for the last 40 years. Our goal is to see how the discipline has changed over time. We thus need a wide enough time frame to smooth over "clusters" generated by single-shot phenomena (such as special issues in journals) but not so aggregated as to wash out real shifts in the work that people study (see Bender-deMoll and McFarland, 2006; Moody et al., 2005 on the general problem of temporal windows for dynamic networks). Here, we focus on four, 3-year windows taken roughly 10 years apart, with samples starting at 1970, 1980, 1990, and 1997.

For each sample, we identify all articles indexed for the three-year period. We summarize each article as a frequency count of the words used in the title, keywords and abstract. We use a common English-language stop-list to remove words with low substantive meaning ("is," "and," "the," or words common to the data source "Tables," "Figures," etc.), and the Porter stemmer to reduce variants of words to a common root (thus "action" and "acting" revert to "act" as a common stem).[6] Each paper is then summarized with an indicator vector that counts the number of times word j was used by paper k. We then construct a weighted network of papers linked by similar word usage, retaining as an edge any correlation between word vectors > 0.40.

This procedure results in a strongly clustered network. Consider as an example Figure 4 below. Here we plot the two-step neighborhood of a paper titled "More Information, Better Jobs" (Kling, 1990).

This paper sits directly between three distinct clusters: one on information and information technology, one on the labor market and one on job mobility and satisfaction. It is clear from this figure that most papers in the neighborhood of "More Information,

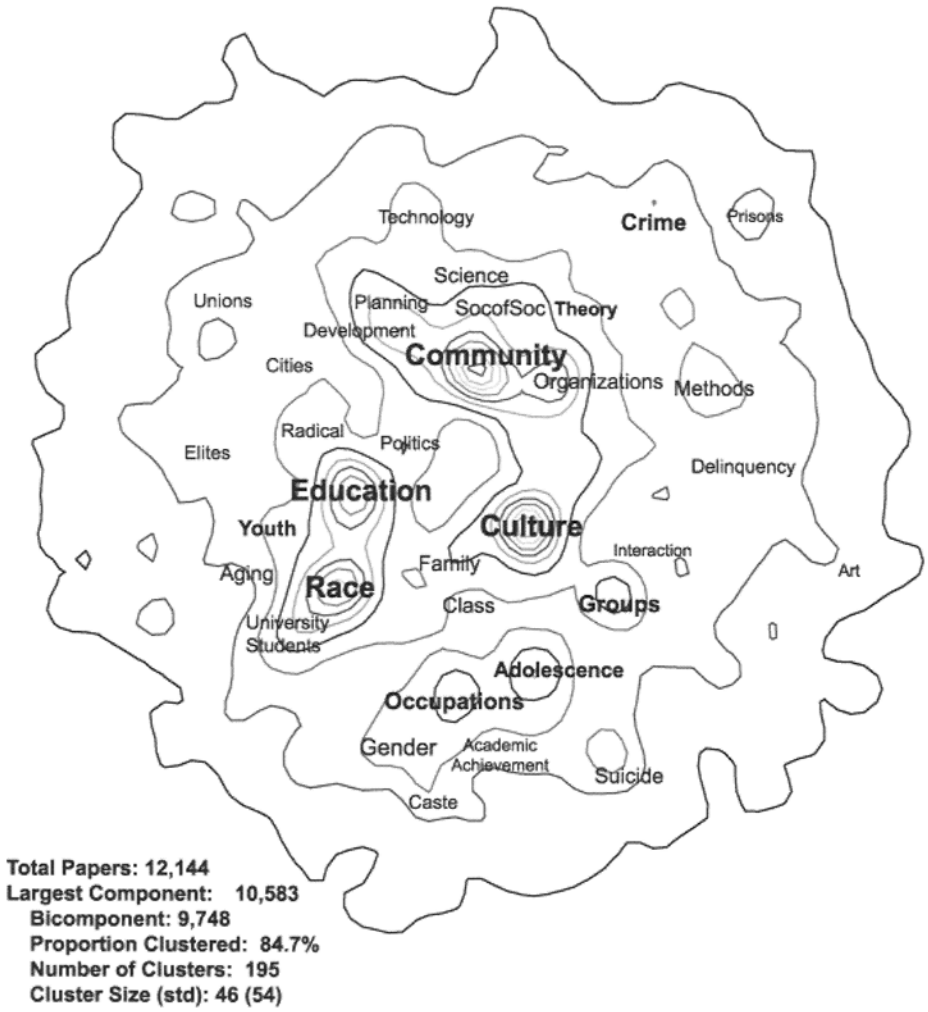
Figure 4
Example paper similarity network surrounding "More Information, Better Jobs?"



Better Jobs" belong to a strong cluster, while this paper is clearly bridging a niche. This general strong clustering should not surprise us: papers, as units of information production, have to be focused on a particular topic, and most normal science work is directed on a single topic. Our analysis task is to identify these topics endogenously using our clustering algorithm.

After constructing the network for each three-year time slice, we subject it to the same cluster analysis and plotting procedures described for the journal citation network above. We have placed labels on the map for each of the largest clusters, locating the label by centroid for that cluster.[7] We use fonts qualitatively to help indicate the relative size and cluster strength of each topic identified. This provides us with three important pieces of information. First, we can quickly identify each mountaintop in the sociological landscape. Second, we can use proximity in the layout space to see how various topics are inter-related. Our cluster procedure places nodes either within or between clusters. A node, like the focal paper in Figure 4 above, that cannot be uniquely placed is treated as interstitial. For the purposes of this paper, we restrict clusters to a minimum size of 12 papers on the logic is that any nascent subfield with fewer than 12 *total papers* in a three-year period would be unlikely to support the publications needed for a tenure-track faculty member (unless he or she were publishing every paper!). This allows us to ask whether the systems as a whole has become more clustered over time (fewer papers crossing clusters to link the system together), which might be a sign of continued disintegration.

Figure 5
Topic Contour Sociogram - 1970–1972



1970s: Classic General Sociology

Between 1970 and 1972, *Sociological Abstracts* indexed 12,144 papers. Of these, nearly 11,000 are linked together in the largest connected component.[8] About 84% of papers can be clearly assigned to one of 195 topic clusters. Clusters averaged about 46 papers each, but the distribution is highly skewed.

Substantively, the early 1970s represent a field that is largely focused on questions related to social organization and stratification with a clear dominance of cultural approaches. The three main, and most central, peaks correspond to topics about *community*, *culture,* and a closely linked ridge between *education* and *race*. To the far south lies a nascent set of clusters surrounding gender, occupations, and adolescence. The strong link between education and race likely follows from work related to racial integration of schools, and the field just to the "north west" of this is composed of a series of clusters

related to "radical" studies, with a focus on elites, politics, unions, and youth, all of which likely share similar foundations in work on social movements. The community peak displays two distinct watersheds: one toward practical features of physical communities related to cites, planning and development, and a second relating to questions about social communities focusing on social theory and organizations. The culture peak stands squarely at the center of the disciplinary portrait, with strong connections to work on groups, and an open ridge to the work on communities. Note here we also start to see the formation of work on family, as distinct from work on adolescence and gender (but closely related). The southern cluster focuses largely on stratification issues (occupations, academic achievement), which leads to the link with adolescence.

In general, we think this portrait describes the field at the beginning of the end of an era dominated by research devoted to broad general questions, rather than specific problem solving. After this period (as the figures below show), the field grows dramatically and the bulk of the focus shifts toward particular social-problems related topics.[9] At this point in history, we are seeing the clear mix of classical concerns about social order and inequality (groups, community, organizations, gender, race) combined with a set of smaller problem-solving subfields (prisons, planning, suicide), and the in-between status of fields that will later morph toward largely problem-solving questions, such as work in politics, the family, youth, and aging.

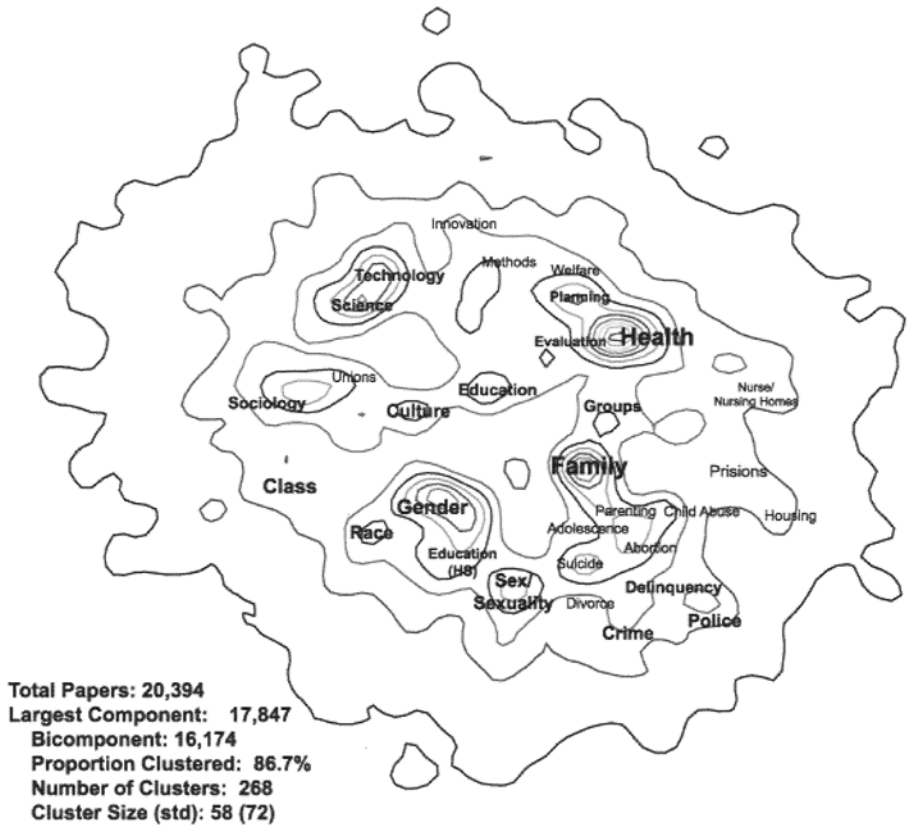
1980s: Identity & Health Rising

Over the next 10 years, we witness a remarkable growth in the number of papers, with this three-year window holding nearly 70% more papers than the 1970s window (20,394 compared to 12,144). We see about a 35% increase in the number of clusters, though average cluster size has not increased as much (about a 26% increase), which implies a fairly substantial growth in the number of smaller topics emerging in the network. Again we find that about 87% of papers are squarely in cluster topics.

Substantively, the landscape "spreads out" in the early 1980s. While the 1970s clusters were all relatively close to each other, the four major cluster-sets in the 1980s are much more separated. The four major clusters are *health, family, gender,* and *science & technology* (though the latter is prominent due to its distinction from the field rather than its height). The health cluster is largely distinct, with strong ties to work in planning, evaluation, and welfare. This work represents, we suspect, a quick rise in the focus of NIH toward funding research on the social causes of health and health disparity.[10] Research on the family becomes particularly prominent in this period, and carries with it work related to adolescence and parenting, that then merges into question about delinquency and crime, likely due to a common focus on the different roles of youth. In the south-central portion of the figure, we see a general body of research related to stratification, but focused mainly on gender, with a lesser peak surrounding questions of race, and a broadly dispersed cluster related to issues surrounding class. Along the ridge connecting gender to family, a relatively cohesive body of work on sex and sexuality emerges. This work focuses substantively on the role of women in families, and the rise of identity-based notions of sexuality linked to gender studies.

Work on *culture* and *education* is still at the center of the disciplinary field, but notice they have become significantly less prominent (and issues of race have become disconnected from issues about education). We also see fewer of the clearly "radical" approaches to the discipline, though work on unions is still distinct. Finally, there is a fairly strong cluster in the north-west of the figure surrounding science and technology. This work

Figure 6
Contour Sociogram - 1980–1982



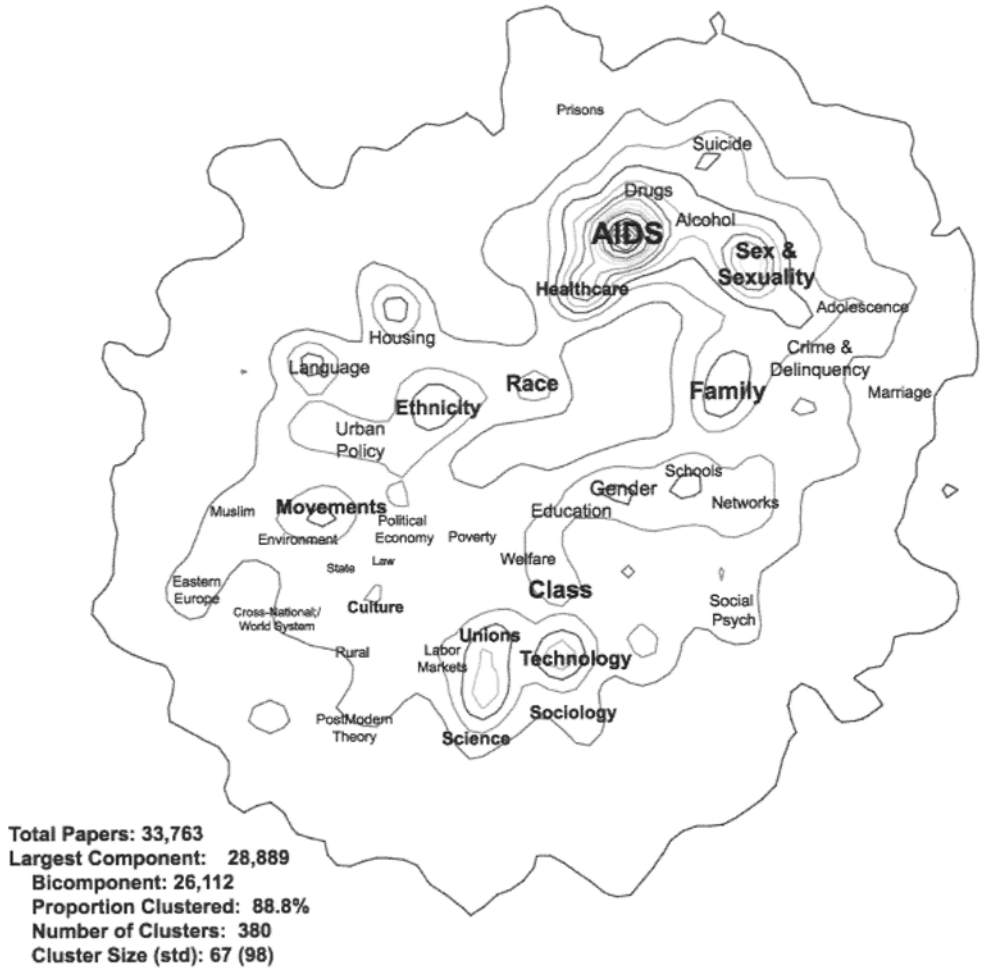
represents a clearly distinct focus on the sociology of science and technology, with ties both to practical questions (sources of scientific innovation) and links back to education and culture. Overall, the rise of stratification linked to identity (race, gender and sexuality) and the prominence of health, combined with the comparative demise of culture, organizations, community and education mark the primary shift from the 1970s to the 1980s.

Early 1990s: The Dominance of HIV/AIDS

The growth of social science work continues through the early 1990s, with about a 65% increase over the 10-year period. Most of this growth is in new small topic clusters with a 42% increase in the number of clusters but only a 15% increase in the average size of clusters. As before, the vast majority of papers can be assigned to a topic cluster (89%).

If the 1980s saw a quick rise of research on health, the early 1990s are characterized by a veritable eruption in work on HIV/AIDS. The rapid rise of, and initial threat posed by, HIV is clearly reflected in the broad body of sociologically relevant work. Moreover, unlike many health threats or epidemics, HIV/AIDS was quickly seen as both cause and

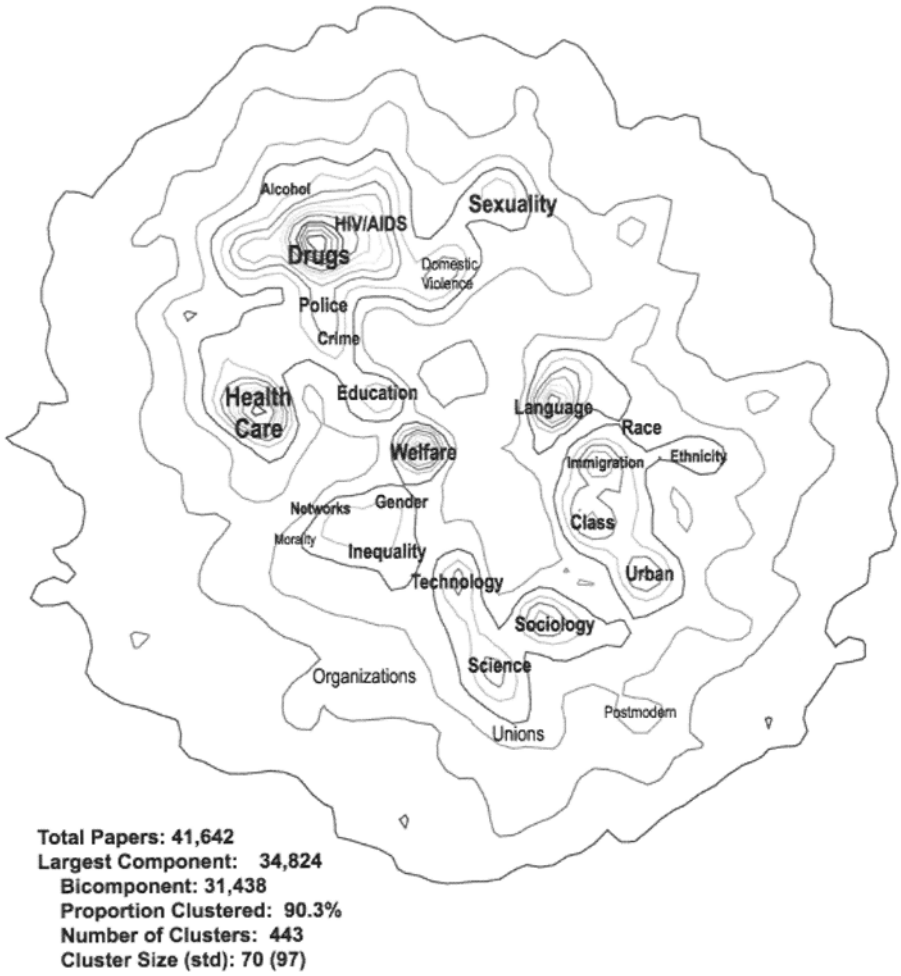
Figure 7
Contour Sociogram - 1990–1992



consequence for social and behavioral sciences. Work in this clusters focuses on both the social causes of HIV (sex and needle exchange networks) and the social problems faced by those with HIV (discrimination, social movement work, etc.). The large size and diverse nature of problems associated with HIV make it a general attractor in this network. This is seen most strongly in work on Sex and Sexuality, which became much more problem-relevant than identity relevant in this period.

The remainder of the field is composed of (comparatively) smaller peaks (though clusters are not smaller in absolute terms from prior periods) with a cast of familiar characters. Family is still dominant, and closely associated with work on sex and sexuality, but has become slightly further removed from the work on gender. The nascent "identity" range in the 1980s splits, with work on race and ethnicity becoming less associated with work on gender, class, or education and more closely aligned with work on ethnicity, urban policy, movements, and language. We see a comparative increase in work on general stratification, particularly tied to class, unions, welfare, poverty, and education. These

Figure 8
Contour Sociogram - 1997–1999



come together under a broadly diffuse cluster on "movements," which touches on a number of topically relevant issues (such as political strife/upheaval in Eastern Europe at the time). Work on the sociology of science (and sociology) remains clear and distinct, and we start to see a connection to more self-referenced postmodern work in this part of the field. Between the rise of HIV and the reflection of crossnational interest in movements at this period, we might think of this as a largely "responsive" image of sociology: with researchers following events in the world rather than focusing internally on topic development.

Late 1990s: Diversity and a Revision of Classical Topics

By the late 1990s, the growth rate has started to slow. Between 1990 and 1997 we see only a 23% increase in papers indexed by *Sociological Abstracts*, which is comparatively small even considering the shorter time period. The number of clusters increases

about 16% and the size grows only slightly (from about 67 papers to about 70 papers), and the vast majority of papers are still clearly identified with cluster topics (about 90%). The overall distribution of peaks has changed with the lowering of the HIV/AIDS work. We see now a much larger number of distinct peaks, falling into roughly four regions. At the north end of the figure, we see a strong group related to health, drugs and HIV/AIDS. There is likely some semantic overlap here between "drugs as crime" and "drugs as treatment," though the shift in substantive focus of HIV research from sexual networks to drug exchange networks blurs this line. We see a distinct cluster emerge in this region on *health care* (as opposed to health), and work on sexuality has started to again become more distinct from the HIV/AIDS research, with an interesting link to work on domestic violence. Just to the south of this health-focused set of clusters lies work on inequality, dominated by a strong peak about welfare, surrounded by work on education, gender, inequality and social networks. To the far east, we see a largely separate line of work on race, language, class, urban, and ethnicity. We find it interesting that the work on class here is largely distinct from the work on inequality discussed around gender, though we would need to dig deeper into these clusters to identify key differences. Finally, the south region of the figure reflects the distinct work on sociology of science and technology (with much work on the boundary between "technology" and "inequality" related to the digital divide). We also see the continued growth in work on "sociology" of sociology, which (like this paper) is consciously about the structure, focus and impact of the discipline. While not clear in the figure, the cluster analysis also indicates a (relative) return in work on classical topics, such as groups, organizations, social psychology and culture. In general, we think this figure might represent a "return to equilibrium" from the shock of HIV/AIDS to the field. There simply was not room for academic distinction within the narrow field of HIV/AIDS to support that continued level of work, and thus research returned to more distinctive topics.

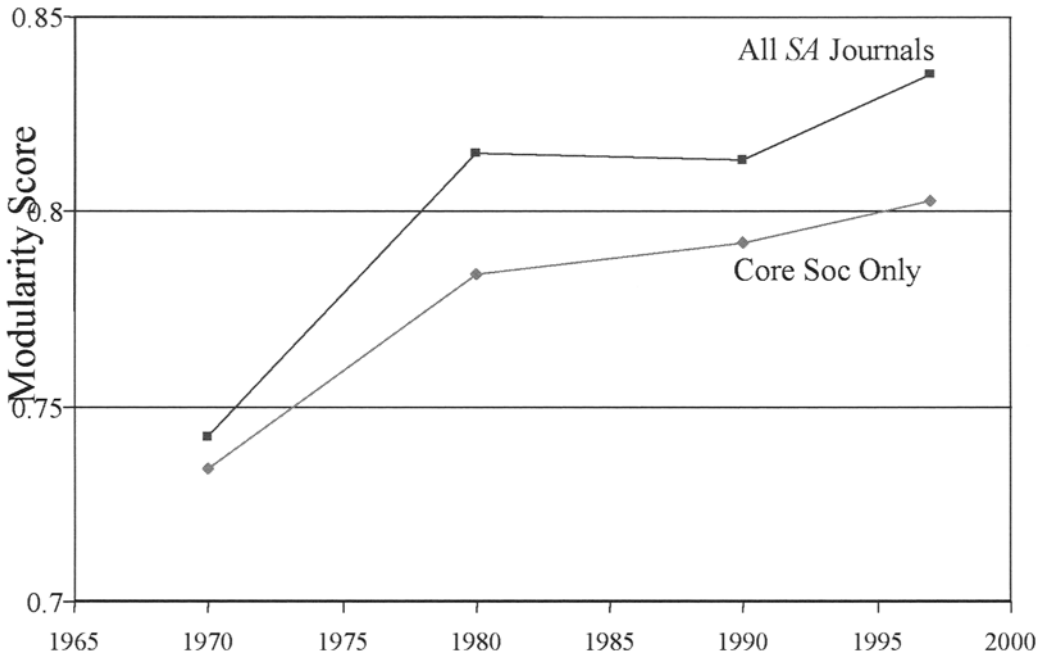
A Structural Overview: Clustering and Consensus

The sketches provided above are necessarily at a very high level of abstraction. The topics sociologist (and fellow travelers) have written on in the last 40 years have ebbed and flowed rather dramatically, with a movement away from general interest topics to work perhaps more responsive to current social problems. What do these portraits say about the theoretical and empirical consensus of the discipline? If each paper fell squarely into its own research area with very few papers bridging these gaps or very little similarity across clusters, we might have reason to worry about the substantive integration of the discipline. We have been using the modularity score (Guimera and Amaral 2005a) to measure the extent of clustering in the network. Modularity is given as:

$$M = \sum_s \left[\frac{l_s}{L} - \left(\frac{d_s}{2L} \right)^2 \right]$$

Where s indexes clusters, l_s are the number of lines within cluster s, L is the total number of lines, and d_s is the sum of the degree within each cluster. When all edges of a graph fall within clusters, modularity will be 1. If ties were distributed at random with respect to cluster boundaries, modularity would be zero. Figure 9 plots the modularity score over time for the full sample and restricted to "sociology only" journals.[11]

Figure 9
Network Modularity



The clustering algorithm is designed to maximize the modularity score, so this should be high. We see here that the modularity scores have been steadily increasing since the 1970s, with the largest change in the waves from the 1980s on. This high level of modularity suggests that papers are (a) increasingly finding homes within topic clusters and (b) that the clusters are becoming more distinct over time (fewer edges crossing between clusters). This is not due solely to increased number of clusters—since between 85 and 90% of all papers in each period can be placed in at least a small cluster. There is some evidence, however, that this is partially due to a growth in the tails of the clusters. In the 1970s, only about 35% of papers were in clusters of more than 100 papers, compared to nearly 55% in the 1997 wave. These large clusters are doing a better job of encapsulating topics. With the ever increasing specialization of journals (and the vast majority of journals are specialty journals), it may be easier to find a local-niche home for each piece.

Summary: An Ever-Changing Sociological Landscape

Where does sociology fit in the body of social science research? The answer based on large-scale citation patterns is "squarely in the center." From a topical standpoint, there is little that sociologists do not study, and our connections to the other primary social science disciplines are clear. This centrality and boundlessness is reflected internally through the ever-shifting pattern of topics that sociologists study. While a core of work on organizations, stratification, social institutions (family, science, religion), identity and difference (race, sexuality, language), and culture remains throughout the period under study, these core concerns are sometimes swamped by rapid eruptions of particular social problems (such as HIV/AIDS, welfare reform, the fall of communism). Our

centrality makes it easy to be responsive to these types of exogenous events, but perhaps this also contributes to the oft-felt sense that sociology lacks a solid foundation. Perhaps in addition to the trade-off between centrality and cohesion, we have similarly made a trade between immediate relevancy (work on social problems) and deep theory (work on the consistent foundations of social organization).

This paper has been deliberately descriptive and at a very high level of observation. We will be extending this work to more detailed studies of the "life history" of social science topic clusters as well as linking broad changes to funding and political research environments. At this point, we want to make two conclusion points. First, the increasing modularity of the topic network might leave many to wonder if the discipline is truly disintegrating into a set of self-contained, unique topic clusters. Second, how does this empirical sketch relate to broader theoretical questions about the evolution of science and the conditions for generating new ideas?

As for the theoretical or empirical cohesion of the discipline, we feel that it would be a mistake to read into the topic modularity scores a general sense of disciplinary fragmentation, because the topic clusters are analytically separate from the network of scientific *producers*. That is, what we observe here is a network of papers without any reference to authors. However, the key question for scientific integration will come by linking authors to topics, and there are at least two possible outcomes. First, a segregation and normal science model would suggest that as topics grow, authors could build careers directly within these topics and thus remain completely self-contained. If they do so, then the work becomes internally referencing and divorced from the wider body of sociology, perhaps feeding into one of the applied disciplines such as health, education or social work. Alternatively, if authors work in multiple fields, *but are relatively unconstrained in their field overlaps*, then authors serve to knit together topically distinct clusters, and thereby transfer ideas from one field to another. Given the generally porous nature of sociological boundaries, we think this latter process most likely. The clearest empirical evidence for this is that coauthorship networks admit to no strong clustering akin to that seen in topic networks (Moody, 2004). That is, there is no way to partition co-authors to subgroups that could generate the kinds of modularity scores evident in the topic network. This means that authors are crossing substantive boundaries to work with each other, and thus likely carrying the ideas and insights between fields.

Finally, we think the evidence arrayed here fits perfectly with Abbott's (2001) theoretical model for the development of the social sciences, though we see the process happening in a more rapid manner than his work describes. In a field without strong boundaries, scientists are faced with two challenges: finding an audience and filling a niche.[12] These challenges work at cross-purposes. The simplest way to "find and audience" is to write squarely in the middle of a topical cluster. But such work is likely to go unnoticed, precisely because it will typically be exactly what normal-science predicts and people expect. The capacity for generating success working solely *within* a topical area is thus likely limited to a small number of prominent authors. On the other hand, writing in areas that fall between clusters can generate a great deal of recognition for newness and innovation, if anyone notices the work at all. That is, interstitial work tends to be high-risk but high-reward. As such, it might be in many author's interest to pursue a split-risk strategy, focusing their work within a single field for long enough to establish a reputation, then using that reputation to strike out in multiple directions. This might take the form of using a technique developed in one field to another, extending a dataset intended for one purpose to a new application, or transposing a theory from one

domain to a new one. In each case, when successful, the result will be for authors to weave together otherwise distinct topic clusters.

If this hypothesis is correct, then perhaps our initial paradox is less stark than first stated for two reasons. First, the mountain peaks we sit atop are not stable, and each grows at different rates. Second, while most of us may have a strong disciplinary home on a single peak, we nonetheless often "go visiting" to other peaks. When doing so, we work with those who have gone visiting at still other peaks, and thus carry the same idea and methods seeds throughout the landscape. This, happily, should result in a heavy mixing of ideas across the sociological landscape.

Notes

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1. These files are found here: http://users.fmg.uva.nl/lleydesdorff/jcr03s/cited/index.htm. The data pertain to 2003. Unfortunately, this data source is not as complete as many would like. *The American Sociologist*, for example, is not indexed by the ISI Web of Knowledge, and thus no entry for *TAS* will be found. Still, ISI is the best source we have for citation data. We have a much more inclusive data source for the paper topic networks.
2. There are two drawbacks to this procedure. First, since it is iterative, it is not quite as fast as the original RNM algorithm (2001" Moody, 2001), but it does significantly outperform the original algorithm in terms of maximizing modularity. Second, because the procedure includes a random initial assignment, the results are not required to be the same with each run of the algorithm. In practice here, however, the results of multiple trials were essentially identical. The modularity score will be at a maximum value when nodes are assigned to groups such that most ties fall within groups. This index is essentially a modification of the Freeman Segregation Index (Freeman, 1972), such that the modularity index will take a value of zero if there is only 1 group, making it meaningful to speak of maximizing the index for search purposes.
3. It is interesting to note, though we have no direct way to tap this here, that the fields with the most internal cohesion are also those with clear tracks for practitioners that generate undergraduate degrees (or, in the case of political science, a strong pre-law track).
4. Based on closeness centrality, the top 10 most central journals (in order) are: *AmSociolRev*, *PsychBull*, *AmBehavSci*, *AmJSociol*, *AnnuRevSociol*, *SocialSciMed*, *JhealthSocBehav*, *SocPsycholQuart*, *AcadManageJ*, *HumanRelat*. Results are similar for betweenness centrality, though more education and econ journals slip into the top 10. While one would expect much higher peaks and more distinct clusters using the alternative *citing* (corresponding to how journals see themselves), the overall pattern is not that different.
5. There are two clear limitations to the SA sample. First, by taking the widest possible frame, we include work that might better be classified in another field. Given the central position of sociology relative to all fields, we think this is a strength rather than a weakness. Future work will compare this portrait to that indexed to just the major sociology journals. Any major difference highlights where sociology differs from the wider body of social science research. Second, we have no information on work published in books or edited volumes. This leads to a possible under representation of work in Social Movements, Historical Sociology, some branches of Feminist/Gender studies, and other more humanities-focused subfields that are typically thought of as "book" sections of the discipline. We are currently in the process of indexing all book reviews to help alleviate this bias.
6. The stop list and word stemmer (modified for data source terms) are provided by the Information Visualization CyberInfrastructure, Information Visualization Lab at Indiana University, http://iv.slis.indiana.edu. While IVC provides a co-word analysis routine, the scale of our project requires a homegrown solution, which we have implemented in SAS. All routines are available from the first author by request.
7. Here we focus on the largest and thus most prominent clusters. This masks the continued presence of small clusters and in many ways the growth and decline of particular clusters over time. Here "large"

is deliberately relative to the temporal field of other clusters, rather than specified as a hard-and-fast percentage of the total number of papers.

8. All of the figures work with the largest component, as isolated papers (those not similar to any others) or very small isolated cliques (sets of paper otherwise completely distinct from the rest), cannot be meaningfully arrayed in the space).
9. This only partly reflects the large *Sociological Abstracts* sample, as similar results hold when restricting the sample to just core sociology journals.
10. We should point out this is a hypothesis—we have not attempted to link these changes directly to funding changes yet.
11. The core sociology sample contains 150 journals, including all of the ASA journals plus every other journal listed by *Sociological Abstracts* with "sociology" in the title, plus a handful of other journals well recognized as disciplinary journals. The full list is available on request.
12. There is an obvious volume issue here, and we have shifted our discussion now to those who produce the majority of papers. From a population standpoint, the modal number of publications is still 1, as most authors produce a single publication then leave the production to others. Here we are focusing on those who make careers out of direct science production, and thus likely the ones who shape the future direction of fields.

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