

An Empirical Study of Online Academic Social Networking Patterns in China from a Multi-level Disciplinary Perspective: A Case Study of ScienceNet (Postprint)

Authors: Duan Qingfeng, Feng Zhen

Date: 2023-07-26T00:00:00+00:00

Abstract

[Purpose/Significance] Online academic social networking provides an effective approach and novel perspective for rapid monitoring and in-depth understanding of disciplinary development trends and scientific insights. [Method/Process] This paper proposes a discipline analysis framework based on academic social networking. On the basis of tracking inter-disciplinary association trajectories, it conducts disciplinary comparison from two dimensions of influence and interdisciplinarity to reveal China's academic social networking patterns from a multi-level disciplinary perspective. Taking ScienceNet as the object and focusing on friend relationships, empirical research is conducted respectively from three hierarchical levels of disciplinary classification (disciplinary fields, first-level disciplines, second-level disciplines). [Results/Conclusion] Through descriptive statistical analysis, it is found that the life sciences domain possesses advantages in social scale, while the comprehensive management domain possesses advantages in social intensity. Combining statistical analysis and Sankey diagram visualization, it is found that relevant first-level discipline groups centered on computer science (such as automation, electronics and information systems, management science and engineering, library and information science) become popular in the social network. Through two-dimensional quadrant diagrams, it is found that academic social networking patterns exhibit diverse and dynamic characteristics when switching across multi-disciplinary granularities, and only a few patterns can maintain stability. For example, the comprehensive management domain exhibits high interdisciplinarity tendency, the life sciences domain exhibits low influence, and computer science exhibits high influence.

Full Text

Preamble

An Empirical Study of Online Academic Social Networking Patterns in China from a Multilevel Discipline Perspective: The Case of ScienceNet

Duan Qingfeng, Feng Zhen

School of Management Science and Engineering, Shanxi University of Finance and Economics, Taiyuan 030006

Abstract

[Purpose/Significance] Online academic social networking provides an effective approach and novel perspective for rapidly monitoring and deeply understanding disciplinary development trends and their scientific implications. **[Method/Process]** This study proposes an analytical framework for discipline-based academic social networking research. By tracking inter-disciplinary association trajectories, we conduct comparative analyses across disciplines from two key dimensions—*influence* and *interdisciplinarity*—to reveal China’s academic social networking patterns from a multilevel disciplinary perspective. Using ScienceNet as the research object and focusing on friendship relationships, we conduct empirical research across three hierarchical levels of disciplinary classification: *discipline fields*, *first-level disciplines*, and *second-level disciplines*. **[Results/Conclusions]** Through descriptive statistical analysis, we find that the life sciences field demonstrates advantages in social network scale, while the comprehensive management field shows advantages in social networking intensity. Combining statistical analysis with Sankey diagram visualization, we identify a cluster of first-level disciplines centered on computer science (including automation, electronics and information systems, management science and engineering, and library, information, and archival science) as popular nodes in the social network. Through two-dimensional quadrant analysis, we observe that academic social networking patterns exhibit diversification and dynamism when switching across disciplinary granularities, with only a few patterns maintaining stability. For instance, the comprehensive management field shows high interdisciplinarity, the life sciences field exhibits low influence, and computer science demonstrates high influence.

1. Introduction

Disciplinary cognition constitutes an important foundation for scientific development and management. Traditional scientific monitoring and evaluation are built upon scientific literature, which suffers from limitations such as information lag and single data types. However, against the backdrop of rising social networks, research activities are increasingly embedded in online social platforms, providing a richer and more diverse data environment that offers new possi-

bilities for grasping scientific trends. On one hand, researchers gain research empowerment through the connectivity and network effects of online social networks, forming a new model of individual research behavior that integrates knowledge sharing, relationship expansion, and personal interaction. On the other hand, all online social behaviors, viewpoints, and attitudes of researchers are recorded, stored, computed, and applied by social networking platforms, creating academic social big data rich in implications. Thus, academic social platforms precisely record research behavior trajectories, offering more diverse data foundations and analytical tools for rapidly and cost-effectively grasping disciplinary patterns and perceiving frontier dynamics.

Research applying social big data to disciplinary analysis has begun attracting academic attention in recent years, characterized by a distinct data-driven logic. Existing studies have primarily established benchmarks using a few typical academic social websites such as Mendeley, ResearchGate, and Academia.edu, with Google Scholar and Twitter also commonly used for comparative purposes. Mendeley has likely been the most studied platform. However, different research samples may yield substantially different conclusions. Foreign research has mainly built upon a limited number of typical academic social websites, and further, different platforms and social types may exhibit different disciplinary characteristics. For example, J.S. Oh and J. Wei found that humanities disciplines (arts, literature, and law) had the lowest user proportion in Mendeley discussion groups, while computer science had the highest. J. Jiang et al. discovered that humanities scholars had more followers than other disciplines. W. Jeng et al. found no significant disciplinary differences in Mendeley usage, while E. Mohammad and M. Thelwall observed that social science users showed more significant performance than humanities users in terms of readership and citation correlations. Studies of other academic social websites have also presented diverse results. For instance, M. Thelwall and K. Kousha found that humanities, social science, and medical discipline users were less active on ResearchGate, while Geng Bin and Sun Jianjun found that engineering discipline users demonstrated higher social activity. Deng Shengli and Xiang Yang found that earth and geographic sciences, chemistry, and environmental science disciplines showed high consistency between Mendeley and ResearchGate. These studies on foreign platforms indicate that consensus on academic social networking patterns remains lacking, necessitating further systematic research.

Research on China's academic social networking has also achieved preliminary results, particularly studies using ScienceNet and Xiaomuchong as empirical objects. For example, Duan Qingfeng's ScienceNet-based research found that management-related disciplines showed stronger academic social networking tendencies, while information discipline users demonstrated stronger influence in academic social networks. In summary, these studies are valuable for understanding the localized contextual features of China's scientific development, but they also reveal substantial research gaps, such as insufficient depth and systematicity, particularly regarding discipline-focused research.

A comprehensive review of existing literature reveals that while preliminary disciplinary characteristics of academic social networking have been uncovered, several shortcomings remain: (1) Research on domestic academic social platforms is insufficient, potentially hindering timely understanding of new patterns in Chinese scholars' research activities under the social networking context and limiting the formation of theoretical foundations and evidence applicable to China's disciplinary development context; (2) Inter-disciplinary correlations have been neglected, leaving unclear which disciplines tend to form social relationships, thus hindering understanding of interdisciplinary trends in scientific development; (3) The multilevel characteristics of disciplines have been ignored, with no existing literature systematically comparing social tendency differences across different disciplinary levels—yet such comparisons across disciplinary granularities can yield more comprehensive and convincing conclusions.

To address these research gaps, this study conducts empirical analysis using ScienceNet as a case study, revealing Chinese scholars' social networking tendencies and their scientific implications from a multilevel disciplinary perspective. We focus on two fundamental questions: (1) What are the basic disciplinary pattern characteristics and comparative differences in Chinese scholars' social behaviors? We particularly focus on inter-disciplinary association tendencies and mutual influence, as these two dimensions are key to identifying disciplinary social patterns. (2) Are the social patterns consistent across different levels of disciplinary classification? Because conclusions at macro, meso, and micro levels can mutually support and complement each other, multigranular comparisons facilitate understanding of the systematic complexity of disciplinary dynamics.

2. Research Design

2.1 Sample Selection and Data Sources

We selected ScienceNet as our analysis object for three main reasons: (1) **Sample typicality:** ScienceNet is one of China's most mainstream academic social websites, with official authority and high user coverage, making it suitable for revealing the overall characteristics of China's academic social networking. (2) **Strong comparability:** Among domestic academic social websites, ScienceNet has been the most extensively studied, providing both empirical reference and enabling direct comparison. (3) Data were sourced from ScienceNet's blog section webpages. We developed a web crawler using Python to capture academic social metadata, which was then cleaned and processed to create a customized dataset. The crawling strategy involved recursively capturing all user lists under each discipline according to the three-level disciplinary directory structure, then sequentially accessing each user's blog page to extract required information. The main metadata needed for subsequent analysis included username, friends, and discipline. The crawling was conducted in January 2017. After data cleaning and preprocessing, we obtained valid data for 42,716 blog users.

2.2 Analytical Framework and Logic

Existing literature indicates that academic social networking has a dual nature, with strong academic motivations underlying social behaviors. For instance, likes, comments, and recommendations on ScienceNet all stem from users' interest in, agreement with, or opposition to blog content, and these technology-focused topics undoubtedly drive social behaviors. Additionally, user following and friending behaviors reflect new research models for obtaining targeted academic updates and resources through stable social relationships. Thus, academic social behaviors are significantly associated with scientific development dynamics, and analyzing the former can help grasp the characteristics of the latter—this constitutes the logical basis and starting point of our research.

We address the fundamental question of what academic social networking tendencies exist in each discipline and what differences exist across disciplines. Based on this, we propose our research framework, shown in Figure 1 [Figure 1: see original paper]. First, we start with binary social relationships between disciplines, using descriptive statistical analysis and visualization tools to characterize and display the distribution patterns of inter-disciplinary social relationships and discover inter-disciplinary correlations. Second, we construct a two-dimensional quadrant diagram based on the dimensions of social influence and interdisciplinarity to compare and classify disciplinary differences in social patterns.

Discipline serves as the core object of our research. ScienceNet classifies disciplines into three levels (discipline fields, first-level disciplines, and second-level disciplines). All disciplines are categorized into six fields: life sciences, engineering materials, information science, earth sciences, mathematical and physical sciences, and comprehensive management. There are 54 first-level disciplines and 614 second-level disciplines. Compared with the Ministry of Education's latest 2018 "Catalogue of Disciplines for Degree Conferral and Talent Training," although differences exist, the system shows high overall consistency.

Moreover, multilevel disciplinary classification represents a key perspective. All empirical analyses in this study are conducted across ScienceNet's three-level disciplinary architecture, enabling examination of academic social patterns at macro, meso, and micro disciplinary granularities. Multidisciplinary granularity offers research advantages: micro perspectives facilitate fine-grained characterization of disciplinary traits, macro perspectives enable overall grasp of disciplinary relationship patterns, and meso perspectives balance the two to reveal internal logic. Comparing and integrating results across disciplinary granularities yields more comprehensive conclusions.

This study focuses on social dyadic relationships, which serve as the basis for calculating analytical indicators (academic social interdisciplinarity and influence) and as the micro-foundation for revealing social patterns. Among various social types, we selected friendship relationships because they represent strong ties implying long-term mutual attention between users. Compared with weak ties

based on single hot events (such as likes and comments), friendship relationships are more suitable for discovering stable scientific structures. If high proportions of friendships exist between users from two disciplines, this may reflect knowledge dependency or cross-pollination tendencies between the disciplines and suggest potential for collaborative innovation and scientific cooperation.

2.3 Key Techniques

2.3.1 Academic Social Interdisciplinarity Interdisciplinarity represents an important trend in contemporary scientific development and has attracted considerable scholarly attention. Current measurement of interdisciplinarity primarily relies on capturing the multidisciplinary 归属 status of academic publications. In our context, interdisciplinarity refers to the tendency of users from different disciplines to establish academic social relationships, reflecting the outward orientation of academic social networking. We can characterize a discipline's interdisciplinarity social tendency through friendship relationships. Specifically, we define the interdisciplinarity C_i of discipline i as the proportion of discipline i 's user friends who do not belong to discipline i , as shown in Formula (1):

$$C_i = \frac{\sum_{j=1, j \neq i}^n f_i(j)}{\sum_{j=1}^n f_i(j)}$$

where $f_i(j)$ represents the number of discipline i 's user friends belonging to discipline j , and n represents the total number of disciplines. The numerator represents the number of interdisciplinarity friends of discipline i 's users, while the denominator represents the total number of friends of discipline i 's users. The C_i index ranges from 0 to 1; if academic social networking (friendships) is limited within the discipline, it takes the minimum value of 0; if users only select friends from other disciplines, it takes the maximum value of 1.

2.3.2 Academic Social Influence In academic social networking processes, subjects influence each other through information transmission and relationship interweaving. Literature on academic social influence is scarce, with more mature research focusing on academic influence through two main approaches: (1) measurement methods based on absolute quantity scales, such as bibliometric and altmetric indicators; (2) approaches focusing on certain relationships between subjects, 刻画 relative importance through mutual comparison to form influence indicators. Zhang Shuai et al. found generally low user activity on academic social platforms, and our study also found low blog posts and comments on ScienceNet, with many zero values. Therefore, the second approach is more suitable—revealing disciplinary influence levels through the structural distribution of friendship relationships. The logic is: the larger the proportion of a certain type of friend, the greater the influence that type of group should have. For example, if discipline C 's user friend set includes 20% from discipline

A and 25% from discipline B, then discipline A's influence on discipline C should be less than discipline B's influence on C.

We define discipline i 's social influence as the weighted sum of its relative influence on other disciplines, as shown in Formula (2):

$$I_i = \sum_{j=1}^n W_j I_i(j)$$

where $I_i(j)$ is discipline i 's relative influence on discipline j , W_j is the weight of discipline j , and n is the total number of disciplines. If a high proportion of discipline j 's user friends come from discipline i , then discipline i has high relative influence on discipline j , because a high proportion of dynamic information will be transmitted from discipline i to discipline j through friendship relationships. Thus, we define relative influence $I_i(j)$ as shown in Formula (3):

$$I_i(j) = \frac{f_j(i)}{\sum_{k=1}^n f_j(k)}$$

where $f_j(i)$ is the number of discipline j 's user friends belonging to discipline i , and n is the total number of disciplines; the denominator represents discipline j 's total number of friends. In Formula (2), weights reflect each discipline's importance, characterized here by the scale of friendship relationships. Let vector $A = [a_1, \dots, a_j, \dots, a_n]$, where each element a_j represents the number of friends of discipline j 's users across n disciplines. Vector A is normalized using the min-max method to obtain weight vector W . Formula (2) weights different disciplines because inter-disciplinary differences exist; the logic of examining influence is: if the disciplines influenced by discipline i are important, then discipline i should also have high influence.

Through these formulas, discipline influence is determined by two factors: (1) the magnitude of relative influence on other disciplines; and (2) the importance of the disciplines being influenced.

2.3.3 Pattern Classification Based on Two-Dimensional Quadrant Diagram To further highlight disciplinary characteristics, we construct a quadrant diagram using the two aforementioned features as axes and the means of corresponding indicators as the origin, as shown in Figure 2 [Figure 2: see original paper]. Influence reflects a discipline's status on academic social platforms, broadly divided into strong and weak disciplines—if a discipline's influence indicator I is above average, it is considered a socially strong discipline; otherwise, it is weak. Interdisciplinarity reflects the disciplinary structure of users' academic social networking, which can be divided into extroverted and introverted types—if a discipline's interdisciplinarity indicator C is above average,

it is considered extroverted; otherwise, introverted. Through pairwise combination of indicators, disciplines can be roughly classified into four social patterns: extroverted-strong, introverted-strong, introverted-weak, and extroverted-weak.

3. Results Analysis

3.1 Basic Overview

Table 1 presents descriptive statistics of the overall disciplinary structure and social networking for ScienceNet’s six discipline fields: (1) In terms of disciplinary structure, information science and mathematical/physical sciences have the fewest disciplines, while comprehensive management contains a large number of disciplines—in fact, this field aggregates eight categories from the national disciplinary catalog (philosophy, economics, law, education, literature, history, management, and art), essentially including all liberal arts disciplines. (2) Regarding user scale, registered user numbers decrease sequentially from top to bottom in Table 1, with life sciences being the largest and comprehensive management the smallest, basically reflecting China’s disciplinary human resource allocation. (3) In social relationships, life sciences also shows scale advantages with the largest number of friends, accounting for 20.6% of all friendships on the platform, while earth sciences accounts for the lowest proportion at 12.8%. In terms of friends per user, comprehensive management performs notably with approximately 12 friends per user on average, while engineering materials has the fewest at about 6 friends per user.

In summary, life sciences demonstrates absolute scale advantages in the friendship network, while comprehensive management shows strong social networking tendencies characterized by small user scale but high friends per user.

Based on user numbers and friends per user, Table 2 lists the top 10 fields or discipline dyads. In user scale, both first-level and second-level disciplines concentrate on engineering (except mathematics), aligning with China’s science and engineering-focused disciplinary layout. Notably, computer science and computer application technology are the disciplines with the largest registered user numbers on ScienceNet at the first-level and second-level respectively, implying the formation of a huge virtual disciplinary community. In friends per user, comprehensive management disciplines occupy 7 of the top 10 first-level disciplines and 4 of the top 10 second-level disciplines, reflecting strong academic social expansion behaviors among comprehensive management researchers and further supporting Table 2’s analysis at the micro disciplinary level.

3.2 Inter-Disciplinary Association Patterns

What degree of social relationships exists between disciplines represents an important research question. Table 3 presents the top 10 dyads ranked by friendship relationship quantity. At the discipline field level, the top-ranked dyads (1st, 2nd, 6th, 10th) show that information science has become a popular field

with extensive and high-intensity social associations with other fields. Another popular field is comprehensive management, which appears in dyads ranked 1st, 4th, 5th, and 7th. Although both show similar performance, they are driven by different forces: the former stems from external demand, as breakthrough achievements and wide applications of information science and technology have gained maximum consensus as indispensable tools in the information society; the latter stems from internal motivation, as comprehensive management comprises liberal arts disciplines studying complex and diverse social systems, whose extensive research objects determine the field's rich inclusiveness and generate intrinsic motivation for extensive interaction and deep integration with external disciplines.

The field perspective is too macro; further subdivision is necessary to reveal more association details. Although Table 3 only shows the top 10 dyads for first-level and second-level disciplines, these limited typical examples clearly demonstrate that friendship relationships tend to occur between disciplines with similar knowledge structures, and this trend becomes more pronounced as disciplinary granularity refines. For example, automation and computer science have the largest friendship scale among first-level discipline pairs, reflecting that computer science research achievements have extensive and in-depth applications in automation, demonstrating that close knowledge connections are the bond for academic social networking. At the second-level discipline perspective, numerous social behaviors occur between closely related disciplines, such as library science and information science, which have largely overlapping disciplinary boundaries and similar research paradigms. In summary, positive correlation exists between inter-disciplinary knowledge relevance and academic social networking tendency—the more overlapping knowledge extensions between disciplines, the more likely academic social networking occurs.

To comprehensively and intuitively display the macro panorama of disciplinary associations, we draw Sankey diagrams based on inter-disciplinary friendship relationships. Sankey diagrams, also known as Sankey energy balance diagrams, maintain equal total branch widths at start and end points (energy balance). As a specific type of flow diagram, they effectively visualize complex relationships. Here, each vertical bar represents a discipline, and branches between disciplines represent friendship relationships with widths proportional to friendship quantities, enabling intuitive tracking of the expansion and interweaving patterns of inter-disciplinary social relationships. We used the ECharts software package (an open-source JavaScript visualization library from Baidu) for its rich charts, lightweight design, and ease of development.

At the macro level, Figure 3 [Figure 3: see original paper] presents the Sankey diagram of friendship relationships between discipline fields. The online friendship macro pattern shown in Figure 3 aligns with Table 3's conclusion: information science “stands out” as the most active part of the social network, demonstrating strong tendencies to establish relationships with users from other fields. Notably, earth sciences shows small social scale and single-target orientation,

mainly forming friendships with information science users. Compared with socially active comprehensive management, which has similar user numbers, earth sciences shows huge contrasts in external social scale and structure, demonstrating low social tendencies across all aspects.

At the meso level, Figure 4 [Figure 4: see original paper] presents the Sankey diagram of friendship relationships between first-level disciplines. Observing computer science in Figure 4 reveals that it not only has a huge number of external social relationships but also shows diversity in relationship targets, maintaining large-scale friendships with nearly half of the disciplines in Figure 4, suggesting the wide applicability of the discipline's achievements across the scientific system and undoubtedly enhancing its popularity on the platform. Additionally, library, information, and archival science in Figure 4 mainly have large-scale academic social networking with computer science, management science and engineering, macro management and policy, and electronics and information systems, reflecting knowledge structure intersections and even integration with these disciplines. Tracking and mining academic social big data reveals extensive inter-disciplinary trends, including high-frequency interactions between disciplines previously considered distant, such as the high associations shown in Figure 4 between certain engineering and liberal arts disciplines. Large-scale inter-disciplinary academic social networking reflects the trend of cross-innovation development across different scientific branches.

At the micro level, Figure 5 [Figure 5: see original paper] presents the Sankey diagram of friendship relationships between second-level disciplines. Compared with Figure 4's meso-level revelation of inter-disciplinary social characteristics, Figure 5 better demonstrates the cohesion of second-level discipline fragments. For example, several small-scale disciplines are arranged on the right side of the figure (from fluid mechanics to particle physics and field theory), whose social targets are often the most structurally similar disciplines, such as solid mechanics and fluid mechanics belonging to different branches of mechanics, and global change ecology and physiological ecology belonging to ecology. Thus, branch disciplines from the same parent discipline tend to gather on social platforms, often with small user scales and similar knowledge structures. Based on comprehensive macro, meso, and micro analysis, we find that academic social networking patterns have some positive correlation with disciplinary structure patterns—disciplines with close 内涵 tend to socialize more, and this trend becomes more obvious as disciplinary granularity refines.

3.3 Disciplinary Social Pattern Classification

Figure 6 [Figure 6: see original paper] presents the two-dimensional quadrant diagram for ScienceNet's six discipline fields. Based on quadrant regions, they roughly fall into three categories: extroverted-strong fields (comprehensive management, engineering materials, mathematical/physical sciences), introverted-strong fields (information science), and introverted-weak fields (life sciences, earth sciences). Fields in Quadrant I possess both high social influence and

high interdisciplinarity, with comprehensive management being most prominent (interdisciplinarity: 0.776, influence: 0.5657). Quadrant II includes information science with high influence but low interdisciplinarity; compared with Quadrant I fields, these fields show relatively introverted academic social networking with stronger intra-field tendencies. Quadrant III includes life sciences and earth sciences with low influence and low interdisciplinarity, with earth sciences having the lowest influence (0.422) and life sciences having the lowest interdisciplinarity (0.692). Notably, at the macro disciplinary level, positive correlation exists between social interdisciplinarity and influence—fields with high interdisciplinarity tendencies often also have high influence levels.

Figure 7 [Figure 7: see original paper] presents the social pattern quadrant diagram from the first-level discipline perspective. Distribution-wise, Quadrant IV contains the most and densest first-level disciplines, while Quadrant I has fewer disciplines mainly distributed in the lower-left area. Overall, information science shows polarized influence distribution, mathematical/physical sciences show high influence and low interdisciplinarity, life sciences show low influence, comprehensive management shows distinct low influence and high interdisciplinarity, engineering materials show moderate interdisciplinarity overall, and earth sciences show no obvious pattern.

Analyzing by field: (1) Information science's five first-level disciplines show balanced interdisciplinarity distribution but obvious polarization in influence. Electronics and information systems, automation, and computer science appear in the top area as high-influence disciplines, while optics, optoelectronics, and semiconductor science and information devices appear below the horizontal axis as low-influence disciplines. Notably, computer science has the highest social influence among all first-level disciplines. (2) Most first-level disciplines in mathematical/physical sciences (except astronomy) fall in Quadrant II, highlighting the high influence, low interdisciplinarity pattern. (3) Life sciences has many first-level disciplines mainly located at the bottom, showing overall low influence. (4) Comprehensive management's numerous disciplines mostly fall in Quadrant IV, showing distinct low influence and high interdisciplinarity, reflecting the high knowledge complexity and diversity of liberal arts research. Management science and macro management and policy in Quadrant I show dual high characteristics. Notably, only library, information, and archival science falls in Quadrant II with low interdisciplinarity unique within its field, possibly related to its emphasis on computer application composite knowledge structures. (5) Engineering materials' first-level disciplines are scattered, mostly near the vertical axis with moderate interdisciplinarity, among which mechanical engineering, building environment, and structural engineering have relatively high influence. (6) Among earth sciences' five first-level disciplines, geochemistry falls in Quadrant I with high interdisciplinarity; geology and geophysics and space physics fall in Quadrant II with high influence and low interdisciplinarity; atmospheric science and marine science fall in Quadrant III with dual low characteristics. Notably, geology has the lowest interdisciplinarity among all first-level disciplines, with very high intra-disciplinary social tendencies creating a relatively

closed disciplinary community.

Figure 8 [Figure 8: see original paper] presents the social pattern quadrant diagram from the second-level discipline perspective. Overall, the four quadrants have relatively balanced distributions, with comprehensive management having the fewest second-level disciplines (2), followed by earth sciences (4), engineering materials (7), and the other three fields each having 9. From the overall distribution, mathematical/physical sciences show high influence, life sciences show low influence, and information science and engineering materials show dispersed distributions without obvious patterns, while comprehensive management and earth sciences show high interdisciplinarity trends.

Analyzing by quadrant: (1) Quadrant I mainly includes information science (computer networks, signal theory and signal processing) and mathematical/physical sciences (optics, fluid mechanics, computational mathematics and scientific engineering), mostly distributed in the lower-left area. Notably, science and technology management and policy in the upper-right area highlights its dual high characteristics in influence and interdisciplinarity. (2) Quadrant II has sparse distribution, mainly comprising second-level disciplines from mathematical/physical and life sciences, with basic physics and condensed matter physics II showing the highest influence among all second-level disciplines. (3) Quadrant III contains the most second-level disciplines from engineering materials, with other fields each having one discipline in this area; structural engineering shows obvious low interdisciplinarity, while genetics and bioinformatics shows the lowest influence. (4) Quadrant IV has the most and densest second-level disciplines, mainly from information science (6) and life sciences (5); information science second-level disciplines mainly distribute in the upper half, while life sciences second-level disciplines mainly distribute in the lower half. Notably, four life sciences second-level disciplines are located at the very bottom, reflecting the field's obvious low influence characteristics.

Some relatively stable patterns emerge across different disciplinary classification levels. For example, comprehensive management consistently shows high interdisciplinarity, life sciences consistently shows low influence, and computer science consistently shows high influence. These conclusions remain unchanged across analytical granularities, highlighting the basic pattern of China's academic social networking.

Notably, each granularity level often presents unique characteristics, even opposite features. For instance, Figure 6 shows that comprehensive management has high interdisciplinarity and influence at the macro level, while Figures 7 and 8 show that most comprehensive management disciplines have low influence and high interdisciplinarity. Thus, macro levels reflect average disciplinary states under coarse granularity that may not represent individual characteristics, while micro levels reflect individual characteristics under fine granularity that may not reflect overall trends. Different disciplinary classification levels may reveal different social characteristics, making multilevel granularity a powerful tool for revealing the full picture of academic social networking and better adapted to

grasping the inherent complexity of scientific systems.

4. Conclusions and Implications

Academic social big data recorded by social platforms provides convenience for revealing disciplinary preferences. With discipline as the core research object and analytical perspective, we propose a data-driven analytical framework for disciplinary patterns in academic social networking, including social dyadic relationship distribution and social pattern classification. Notably, these research components are placed within a three-level disciplinary system to reveal disciplinary patterns from a panoramic perspective.

Our empirical research uses ScienceNet as a case study, focusing on friendship relationships and analyzing China's academic social networking pattern features from three disciplinary classification levels (discipline fields, first-level disciplines, second-level disciplines). We draw the following basic conclusions: (1) Descriptive statistical analysis reveals that life sciences has advantages in social network scale, while comprehensive management has advantages in social networking intensity. (2) Combining statistical analysis with Sankey diagrams shows that discipline groups centered on computer science have become hot disciplines in social networking, including related first-level disciplines such as automation, electronics and information systems, management science and engineering, and library, information, and archival science, with similar conclusions at the second-level classification. (3) Two-dimensional quadrant analysis reveals that social patterns show complex diversity when switching disciplinary perspectives, with only a few patterns maintaining stable consistency from macro to micro levels—for example, comprehensive management shows high interdisciplinarity, life sciences shows low influence, and computer science shows high influence.

From these conclusions, we derive the following implications:

- (1) **Academic social networking patterns essentially mirror scientific activity patterns.** In-depth analysis of empirical results reveals strong positive correlation between academic social networking patterns and contemporary scientific structures, appearing in multiple aspects of our findings. For example, the distribution of disciplinary scales in academic social networking roughly aligns with China's disciplinary layout (strong engineering and medicine, weak liberal arts); social relationships more easily emerge between discipline pairs with close knowledge structures (such as computer science and automation); social interdisciplinarity relates to disciplinary knowledge structure—higher complexity of research objects often corresponds to higher interdisciplinarity social tendencies (for instance, most disciplines in life sciences and comprehensive management show high interdisciplinarity). Of course, academic social networking is not scientific activity itself, and their disciplinary patterns are not identical. Academic social networking possesses dual scientific and social attributes, enriching

understanding of the socialization process of knowledge production. This online-offline disciplinary association provides theoretical inspiration for further academic social networking research and logical basis for science governance applications.

- (2) **Multidisciplinary granularity helps provide comprehensive and reliable analytical perspectives.** Empirical findings show that social patterns diversify as disciplinary granularity refines. Some macro characteristics may mask huge internal individual differences, while micro characteristics may only represent individuals without universality. Only through zooming comparisons across disciplinary granularities can we effectively identify specialities existing only in specific scenarios or extract stable and consistent disciplinary characteristics. For example, comprehensive management consistently shows high interdisciplinarity across macro, meso, and micro levels, but at the first-level discipline perspective, library, information, and archival science becomes an “outlier” within the field, showing opposite intra-disciplinary social tendencies. This multilevel perspective creates mutually supportive and complementary panoramic displays of social patterns, strengthening explanatory power. Additionally, divergent results and viewpoints in existing literature, besides stemming from different samples, may also arise from different analytical perspectives, suggesting the necessity of multilevel comparative 检验 to facilitate scholarly consensus.
- (3) **Rich social big data expands pathways for discovering disciplinary dynamics.** Our findings demonstrate that academic social networking can help reveal scientific status and trends to a certain extent. Traditional scientific monitoring data sources mainly rely on publicly published scientific literature. While possessing obvious advantages in accuracy and reliability, they still suffer from publication cycle lags, dependence on traditional journal media, and limitation to citation and co-authorship behaviors, raising questions from academia and the public. Academic social networking can largely compensate for these shortcomings, containing diverse information that traditional journals cannot carry, with advantages in data type diversification and feedback immediacy. This study represents only a preliminary attempt from a disciplinary perspective; research on academic social networking remains immature, and its rich value has not been fully exploited, particularly in scientific monitoring, forecasting, and evaluation, which hold broad research and application prospects.

In summary, this study’s contributions lie in both theoretical and practical aspects. Theoretically, we propose a data-driven analytical framework and indicators for disciplinary patterns in academic social networking, particularly conducting comparisons across three disciplinary levels to 弥补 existing research gaps. Practically, using ScienceNet as an object, we reveal China’s academic social networking disciplinary structure and distribution, enriching understanding

of China's academic social networking characteristics.

Of course, this study has unavoidable limitations: First, we directly adopted ScienceNet's disciplinary system design. Although this system shares similar logic and high compatibility with the national disciplinary catalog and does not affect final qualitative results, future research should transform it into China's standard disciplinary classification system to further improve result comparability. Second, our conclusions are based on friendship relationships; future research should consider more types of social behaviors to further 检验 conclusion generalizability and reliability.

References

- [1] Han Wen, Liu Chang, Lei Qiuyu. Analyzing the Supporting Role of Academic Social Networks in Research Activities—Taking ResearchGate and Academia.Edu as Examples[J]. *Information Theory and Practice*, 2017, 40(8): 105-111.
- [2] Zhou Qingshan, Yang Zhiwei. Research Progress on User Behavior in Academic Social Networks[J]. *Library and Information Service*, 2017, 61(16): 38-47.
- [3] Zhang Yaokun, Zhang Weijia, Hu Fangdan. Survey on Chinese High-Impact Scholars' Use of Academic Social Networking Sites—Taking Changjiang Scholars as Examples[J]. *Information and Documentation Services*, 2017(3): 96-101.
- [4] Zhao Yang, Li Luqi. Review and Reflection on Domestic and International Academic Social Network Research[J]. *Information and Documentation Services*, 2016(6): 41-47.
- [5] Liu Chunli, He Qincheng. Research on Evaluating Paper Relevance Using Different Types of Selective Metrics—Based on Three Academic Social Networking Tools: Mendeley, F1000, and Google Scholar[J]. *Journal of the China Society for Scientific and Technical Information*, 2013, 32(2): 206-212.
- [6] Oh J S, Wei J. Groups in Academic Social Networking Services and Their Potential as a Platform for Multi-Disciplinary Collaboration[C]//IEEE Third International Conference on Privacy, Security, Risk and Trust. Boston: IEEE, 2011: 545-548.
- [7] Jiang J, Ni C, He D, et al. Mendeley Group as a New Source of Knowledge Flows[J]. *Journal of the American Society for Information Science and Technology*, 2014, 65(8): 1627-1638.
- [8] Jeng W, He D, Jiang J. User Participation in an Academic Social Networking Service: A Survey of Open Group Users on Mendeley[J]. *Journal of the Association for Information Science and Technology*, 2015, 66(5): 890-904.
- [9] Mohammad E, Thelwall M. Mendeley Readership Altmetrics for the Social Sciences and Humanities: Research Evaluation and Knowledge Flows[J]. *Journal of the Association for Information Science and Technology*, 2014, 65(4): 721-731.

- [10] Thelwall M, Kousha K. ResearchGate Articles: Age, Discipline, Audience Size, and Impact[J]. *Journal of the Association for Information Science and Technology*, 2017, 68(2): 468-479.
- [11] Geng Bin, Sun Jianjun. Research on User Behavior in Online Academic Social Platforms—Taking Nanjing University Users on ResearchGate as an Example[J]. *Library and Information*, 2017(5): 47-53.
- [12] Deng Shengli, Xiang Yang. Research on Literature Reading and Disciplinary Focus Differences Based on Academic Social Networks[J]. *Library and Information Service*, 2017, 61(6): 99-106.
- [13] Hou Zhiping, Huang Shaojie, Li Xinchun, et al. Research on Social Network Structure and Information Dissemination Patterns of Academic Events—Taking ScienceNet Blog Posts about Tu Youyou’s Nobel Prize as an Example[J]. *Information and Documentation Services*, 2017(5): 34-41.
- [14] Zou Runan, Yu Jianrong. Social Network Analysis of Informal Academic Communication in the Digital Age—Taking Xiaomuchong Life Science Forum as an Example[J]. *Information Science*, 2015(7): 81-86.
- [15] Duan Qingfeng. Empirical Research on Chinese Researchers’ Online Academic Social Networking Patterns: A Case Study of ScienceNet[J]. *Journal of Intelligence*, 2015(9): 97-101.
- [16] Thelwall M, Kousha K. Academia.Edu: Social Network or Digital Libraries[C]//*Proceedings of the 13th ACM/IEEE-CS Joint Conference on Digital Libraries*. Indianapolis: ACM, 2013: 135-138.
- [17] Van N R. Online Collaboration: Scientists and the Social Network[J]. *Nature*, 2014, 512(7513): 126-129.
- [18] Huang Ying, Gao Tianshu, Wang Zhinan, et al. Interdisciplinarity Measurement Based on Web of Science Classification[J]. *Science Research Management*, 2016, 37(3): 124-132.
- [19] Porter A L, Cohen A S, Roessner J D, et al. Measuring Researcher Interdisciplinarity[J]. *Scientometrics*, 2007, 72(1): 117-147.
- [20] Duan Qingfeng, Pan Xiaohuan. Research on Identifying Emerging Disciplinary Topics Using Social Media[J]. *Journal of the China Society for Scientific and Technical Information*, 2017, 36(12): 1216-1223.
- [21] Duan Qingfeng, Zhu Donghua. Research on Collaborative Evaluation Methods Based on Hybrid Co-Authorship and Citation Networks[J]. *Journal of the China Society for Scientific and Technical Information*, 2012, 31(2): 189-195.
- [22] Zhang Shuai, Li Jing, Wang Wentao. Exploring the Influence Mechanism of Social Insufficiency Among Academic Social Networking Site Users: A Qualitative Approach[J]. *Library and Information Service*, 2018, 62(4): 81-88.

Author Contributions: Duan Qingfeng: Responsible for topic selection, data analysis, empirical research, and paper writing; Feng Zhen: Provided revision suggestions for the paper.

Empirical Research on the Pattern of Online Academic Social Networking in Views of Multilevel Discipline Categories in China: A Case of ScienceNet

Duan Qingfeng, Feng Zhen

School of Management Science and Engineering, Shanxi University of Finance and Economics, Taiyuan 030006

Abstract: [Purpose/significance] Online academic social networking provides an effective way and novel views to quickly monitor the trend of science development and deeply understand scientific implication. [Method/process] An analytic framework was proposed to find the pattern of academic social networking in China by tracing the relations among all pairs of disciplines, with the comparisons in the two dimensions of impacts and trans-disciplines respectively. Furthermore, empirical research was conducted by using samples from the platform ScienceNet, in views of three levels of disciplines categories respectively, i.e. field of disciplines, first-level disciplines, second-level disciplines, in which friend relationship was concerned. [Result/conclusion] Firstly, it was found that field of life sciences shows an advantage in size of users registered in the online platform, while field of comprehensive management presents an advantage of tendency to carry out academic social networking, with method of descriptive statistics. Secondly, in term of method combining statistics analysis and Sankey diagram, it was found that a group of relevant disciplines belonging to the first-level disciplines, with computer sciences as their core position, have become hot disciplines in social networking, such as automation, electronics and information system, management science and engineering, library information and philology. Lastly but not least, based on the two-dimensional quadrant diagram, conclusions came out that discipline pattern of academic social networking show the characteristics of diversity and dynamics during the switching among three levels of disciplines, and only a few patterns can be stable all the time. For examples, field of comprehensive management exceedingly tend to be trans-disciplines in academic social networking, high impacts would turn out in the field of life sciences, but low impacts in the first-level discipline of computer science.

Keywords: academic social networking, multilevel discipline categories, science net

Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv — Machine translation. Verify with original.