

The Formation and Evolution of Altmetrics: Theoretical Hypotheses, Development Stages, and Disciplinary Relations (Postprint)

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Abstract

[Purpose/Significance] On the tenth anniversary of Altmetrics, summarizing its early development will help steer its future development in a positive direction. [Method/Process] This study employs bibliometric methods for quantitative analysis to reveal the overall state of research and development in the Altmetrics field; elucidates its connotation through examining terminology evolution and definitions; proposes three theoretical hypotheses to establish theoretical foundations for Altmetrics; delineates different stages to trace its developmental trajectory; and analyzes its relationships with other disciplines to clarify its disciplinary attributes and value. [Results/Conclusion] Altmetrics provides a new perspective and methodology for informetrics; the open science hypothesis, digital scholarship hypothesis, and academic inheritance hypothesis reflect emerging features of Altmetrics development in the new scholarly environment, effectively substantiating its existence and growth; Altmetrics has developed rapidly but remains in its initial stage, with notable disparities between domestic and international development levels; based on a critical examination of its relationships with closely related disciplines, it is necessary to advance Altmetrics as an independent discipline while strengthening interdisciplinary collaborative research.

Full Text

Preamble

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Formation and Evolution of Altmetrics: Theoretical Hypotheses, Developmental Stages, and Disciplinary Relationships

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Abstract: [Purpose/Significance] As Altmetrics celebrates its 10th anniversary, reviewing its early development will help steer it in a positive direction. [Method/Process] This study employs bibliometric methods for quantitative analysis to reveal the overall research and development landscape of the Altmetrics field. It examines its connotation through terminology evolution and definitions, proposes three theoretical hypotheses to establish theoretical support for the validity of Altmetrics, divides different stages to outline its degree of development, and analyzes its relationships with other disciplines to clarify its disciplinary attributes and value. [Result/Conclusion] Altmetrics provides a new way of thinking and methodology for metrology. The open science hypothesis, digital academic hypothesis, and academic inheritance hypothesis align with the new characteristics of Altmetrics development in the new environment, effectively supporting its existence and development. Altmetrics is developing rapidly but remains in its early stage, with differences in development levels between domestic and international contexts. Based on the analysis of its relationships with closely related disciplines, it is believed that the in-depth development of Altmetrics as a discipline and strengthened interdisciplinary collaborative research should be promoted.

Keywords: Altmetrics; Alternative metrics; “Five Metrics”

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In 2010, J. Priem et al. [1] published the article “Altmetrics: A Manifesto,” formally introducing Altmetrics to the academic community. As a new favorite in the field of metrology, Altmetrics has sparked extensive discussion among scholars worldwide, injecting fresh vitality into the discipline. After nearly a decade of development, numerous valuable research findings have emerged, with core researcher groups and institutions initially formed and several main research directions delineated. However, many core issues remain unresolved. Throughout the history of metrology disciplines in library and information science, development has evolved from the “Three Metrics” to the “Five Metrics.” What new characteristics and patterns does the development of Altmetrics exhibit in this new environment? The research question is: How did Altmetrics form and evolve? The research objective is to investigate the essential nature, theoretical hypotheses, developmental stages, and disciplinary relationships of Altmetrics, and to explore several key issues for its in-depth development, in order to provide reference and guidance for related research and innovative applications.

1 Altmetrics Bibliometric Study

Research literature serves as the most direct evidence reflecting the evolution of a field. Quantitative research using bibliometric methods can effectively reveal the overall research situation of a domain. This study uses CNKI and Web of

Science Core Collection as data sources for domestic and international Altmetrics research literature. In CNKI, professional search was employed with the search expression: Subject=(“Supplementary Metrics” OR “Selective Metrics” OR “Alternative Metrics” OR “Altmetrics” (exact match)), with no time limit. In Web of Science Core Collection, the topic was limited to “altmetric*” with no time limit. The search date was February 29, 2020. Ultimately, 347 Altmetrics research papers were obtained from CNKI and 326 from Web of Science (WoS).

The following sections present important development profiles of Altmetrics research from annual publication volume (see Figure 1 [Figure 1: see original paper]), highly productive authors (see Table 1), and highly cited papers (see Tables 2 and 3). Annual publication volume can macroscopically demonstrate the development level of a field, highly productive authors can reveal main research forces and contributors, and highly cited papers can identify valuable foundational literature and research achievements.

In Figure 1, WoS annual publications (solid line) represent the international situation, while CNKI annual publications (dashed line) represent the domestic situation. Figure 1 shows that Altmetrics publications in both domestic and international contexts generally show an upward trend, with fluctuations in some years, which basically conforms to the development evolution pattern of emerging phenomena. For example, in 2015, publication volume nearly doubled in both domestic and international contexts, showing rapid development momentum and gradually entering an initial prosperity stage. In 2018, significant differences emerged: international publications reached a small peak followed by a noticeable decline, while domestic publications experienced a slight decline that year followed by substantial growth. This difference precisely reflects the different developmental stages of the topic at home and abroad.

Table 1 shows that among the Top 10 international Altmetrics authors, four are from the UK’ s University of Wolverhampton, indicating that this university is a “stronghold” for Altmetrics research. The Top 10 international scholars are basically well-known scholars and mentors who are regularly active in this field. The Top 10 Chinese scholars are the backbone of introducing and researching Altmetrics in China, distributed across several “Double First-Class” universities, with Wuhan University being the main base. The Top 10 international and Chinese scholars in Table 1 largely correspond to the “international research forces” and “domestic main research groups” in Yu Houqiang’ s monograph “Altmetrics: Concepts, Indicators and Applications”[2]47-49, with core members of each research team basically included.

Tables 2 and 3 present highly cited papers domestically and internationally, effectively screening out valuable foundational literature and research achievements. For example, Paper 1 in Table 2 discusses the validity of Altmetrics, Paper 2 analyzes the correlation between Altmetrics indicators and citation indicators, and Paper 3 verifies the feasibility of Altmetrics indicators in research output evaluation through interdisciplinary empirical research. The top three papers in Table 3 are representative discussions on the Chinese translations of

Altmetrics as alternative metrics, selective metrics, and supplementary metrics, laying a theoretical foundation for the introduction and explanation of some basic issues.

2 Altmetrics Connotation Research

2.1 Altmetrics Terminology and Chinese Translation

Most metrology discipline terms are compound words, i.e., “object + metrics,” such as Bibliometrics, Informetrics, Scientometrics, Knowmetrics, and Webometrics. However, the term Altmetrics is different—it is “Alt + metrics.” The prefix “Alt-” is an abbreviation of “Alternative,” not representing the object of measurement, and has multiple meanings, thus causing divergence in Chinese translation.

Internationally, research related to Altmetrics began in 2005 [3], and many similar terms have emerged to date (see Table 4). From their meanings, these similar terms only reflect the functions and values of Altmetrics from different perspectives. Until 2010, when “Altmetrics” was proposed, it marked the formal rise of the field. In 2014, NISO (National Information Standards Organization) pointed out that “Altmetrics” is the most widely used term to describe “alternative assessment metrics,” making it an internationally recognized term. After the term “Altmetrics” was introduced domestically, different translations also emerged (see Table 5), mainly including “Selective Metrics,” “Supplementary Metrics,” and “Alternative Metrics.” The inconsistency in Chinese translation of Altmetrics has caused considerable confusion for domestic scholars and once triggered fierce debate.

Yu Houqiang et al. [4] discussed the divergence in translating Altmetrics from multiple perspectives, arguing that under China’s policy of vigorously promoting the sinicization of scientific and technological terms, “Alternative Metrics” is the most appropriate Chinese translation, making it the mainstream term domestically. They also called on the academic community to stop worrying about its translation and focus on its essential attributes.

2.2 Altmetrics Connotation and Essential Attributes

What is Altmetrics? Different institutions and scholars have provided their own understandings. The manifesto (Altmetrics: A manifesto) states that “Altmetrics is the creation and study of new metrics based on the Social Web for analyzing and circulating scholarly products” [1]. The definition on Altmetrics.org is: Altmetrics is the creation and study of new metrics based on the social network for analyzing and providing academic information. In a 2014 NISO white paper, Altmetrics is described as: “Altmetrics is the most widely used term to describe alternative assessment metrics. The term generally describes metrics that are alternatives to established citation counts and usage statistics, and/or metrics about alternative research outputs as opposed to journal articles” [8]. In 2014,

J. Priem et al. defined: “Altmetrics is a method to uncover previously invisible traces of scholarly impact by observing activities in online tools and systems” [9]. H. Piwowar proposed in 2013: “Scientists are developing and evaluating alternative metrics, or ‘Altmetrics,’ as a new way to measure engagement with research output” [10]. S. Haustein et al. noted in 2014: “Altmetrics is a metric index based on social media platforms and tools that has recently become another method for measuring academic impact” [11]. K. Weller argued in 2015: “Altmetrics is an evaluation method for academic activities, as an alternative to citation-based measurement; Altmetrics is an evaluation method based on various user activities in the social media environment” [12]. Broadly speaking, Altmetrics is an emerging field that inherits, develops, and breaks through traditional metrology research paradigms, also known as Scientometrics 2.0 [13]. Narrowly speaking, Altmetrics refers to specific indicators different from traditional research evaluation methods, derived from the “third space” of scientific communication activities such as social networks, social tags, and collaboration tools. In such spaces, previously invisible interaction activities (such as reading, saving, discussing, recommending, etc.) become visible, with the most interesting feature being that impact measurement faces the public rather than being limited to the academic community [14].

Domestic scholars have also proposed different insights based on the development of Altmetrics abroad and domestic conditions. Among them, typical viewpoints include: Yu Houqiang pointed out in the monograph “Altmetrics: Concepts, Indicators and Applications” [2] that “Altmetrics (Alternative Metrics) is an emerging interdisciplinary research theme formed by the combination of Scientometrics, Webometrics, and Big Data, specifically measuring the activities and interactions between multiple subjects and academic achievements in the network environment. By collecting and analyzing data formed from digital traces throughout the entire scientific communication process, it aims to build a more efficient scientific communication system and a quantitative evaluation system for the comprehensive impact of academic achievements.”

It is evident that although many scholars have elaborated on Altmetrics, no unified scientific definition has yet been formed, and there are deviations in understanding its connotation and essential attributes. The author believes that Altmetrics should be explained from narrow and broad perspectives. In the narrow sense, Altmetrics is a new type of metric different from traditional metrology indicators, with data sources mainly (but not entirely) trajectory data generated by user interaction behaviors on social media. In the broad sense, Altmetrics is a new metrology method different from traditional metrology methods, representing an innovative breakthrough in thinking that measures the diverse attributes and reflects the multi-dimensional impacts of objects by integrating big data from academic networks.

3 Altmetrics Theoretical Hypotheses

Hegel proposed in “Elements of the Philosophy of Right” that “what is rational is real.” For science and scientific research, whether something is reasonable requires sufficient theoretical support and practical demonstration. Altmetrics research content is complex and extensive, seemingly making everything on network platforms potential measurement objects. So what exactly does Altmetrics measure? What is the theoretical basis for its reasonable existence? As Altmetrics practice advances, exploring these fundamental theoretical questions is extremely meaningful. Therefore, one of the key issues studied in this paper is: What new theoretical hypotheses does Altmetrics need in the new era?

Liu Chunli [15], the first person to introduce Altmetrics to China, once sorted out and analyzed three theoretical hypotheses, including the “soft peer review hypothesis,” “article-level metrics hypothesis,” and “scientometrics 2.0 hypothesis,” providing good theoretical inspiration for domestic Altmetrics research. However, existing theoretical hypotheses only analyze “what is being measured” but fail to address “why it can be measured this way.” With the in-depth development of Altmetrics and continuous changes in the new situation, existing theoretical hypotheses cannot fully reflect the essential attributes and true value of Altmetrics, requiring new theoretical support from other perspectives. Below, combining existing research results and practical situations, and from the perspectives of the impact of the broader research environment, transformation of academic communication models, and the essence of academic social activities, three new theoretical hypotheses about Altmetrics are proposed to complement existing ones.

3.1 Open Science Hypothesis

The core concept of open science is “freedom, openness, cooperation, and sharing” [16], and the emergence of Altmetrics is precisely based on the development of the open access movement [17]. In the open science taxonomy of the EU FOSTER (Facilitate Open Science Training for European Research) project [18], there exists a hierarchical relationship: “Open Science → Open Science Evaluation → Open Metrics and Impact → Altmetrics.” Tracing to the source, Altmetrics has a natural connection with open science. In an open science environment, the scientific research paradigm has undergone transformation, with openness becoming a mainstream trend in scientific research—open data, open communication, and open evaluation. This new environment forms a new academic ecology with multiple new forms of scientific achievements, providing a broad context for the rapid development of Altmetrics. Therefore, the author proposes the open science hypothesis for Altmetrics: “All scientific research is open” is the rational basis for the emergence of Altmetrics. The open research environment has influenced the research paradigm, requiring open scientific evaluation, while the digitization of open online academic activities makes open metrics and impact measurable. Altmetrics emerged in response to the trend, becoming a new favorite in the field of metrology.

3.2 Digital Academic Hypothesis

With the formation of a new network environment and the popularization of convenient online social media, emerging digital scholarship is gradually becoming a new mode of academic communication. Different from traditional formal communication, scholars now adopt non-traditional communication methods such as “offline academic research + online academic communication” or even “online academic collaboration and sharing,” moving the entire academic workflow to social media platforms. The digital footprints generated in academic dissemination can reflect scholars’ information behaviors from different perspectives, making it possible to dynamically track academic activities. This shift in academic behavior habits provides an application environment for the popularity of Altmetrics. Therefore, the author proposes the digital academic hypothesis for Altmetrics: Assuming that “all academic activities are digitized,” the network data used in Altmetrics measurement are all digital footprints left by scholars conducting online academic communication activities. Unlike traditional offline academic activities, these online activities can generate a large number of digital indicators, while traditional metrology methods are difficult to adapt to the transformation of academic communication models. Altmetrics has obvious advantages in this regard and is therefore favored and has developed rapidly.

3.3 Academic Inheritance Hypothesis

With the popularization of self-media, the public has transformed from passive information receivers to active roles as information generators, sharers, and receivers. Online social behavior has become an important part of daily life for the public. Blog sharing, mobile social reading, and social scholarship (such as push behaviors on WeChat public accounts) have gradually become common phenomena where ordinary citizens and scholars jointly participate in scientific/academic research and communication. This has narrowed the distance between the public and researchers and between the public and science. Therefore, the author proposes the academic inheritance hypothesis for Altmetrics: In the online academic form, “interaction (socialization) is academic,” meaning that only social activities conducted by users that possess academic characteristics such as academic recognition/critique and academic inheritance belong to the research objects of Altmetrics and have academic value. Those modern network social ritual behaviors similar to “like means read” are one of the reasons causing skepticism about Altmetrics and affect the application results of Altmetrics. The academic inheritance hypothesis aims to clarify the essence of academic social activities and enhance academic and professional characteristics.

4 Altmetrics Development Stages

The time required for different stages varies across disciplines. Correctly grasping the developmental stage reveals the degree and potential of development through appearances. Therefore, the second key issue discussed in this paper is:

What developmental stage is Altmetrics currently in, and what characteristics does it exhibit?

Considering publication patterns, representative events/milestones, and research evolution contexts and characteristics, the author believes that Altmetrics can generally be divided into the following three stages since its inception.

4.1 Before 2010: Incubation and Germination

Although the term “Altmetrics” was formally proposed in 2010, related research predates this. Based on the related terms outlined above, literature searches reveal that research related to “Altmetrics” began as early as 2005. Representative studies include: In 2005, J. Bollen et al. validated alternative metrics for journal impact by comparing download counts and citation counts [3]; In 2007, the MESUR project supported by the Mellon Foundation in the United States aimed to develop quantitative indicators to evaluate the value of various scholarly communication carriers (such as articles, journals, conference literature, etc.) using data [19]; In 2008, D. Taraborelli proposed establishing Soft Peer Review and pointed out that indicators in social bookmarking, CiteULike, and Connotea were important metrics to supplement or replace peer review [20]; In 2009, M. Patterson proposed article-level metrics (ALMs) for PLOS [21], arguing that articles should be evaluated using their own characteristics and that indicators such as bookmarks, comments, and “star ratings” should become basic evaluation metrics. These early studies were relatively scattered and failed to attract significant attention, but they gradually approached the essence of early Altmetrics, opening the source of Altmetrics research and brewing favorable conditions for its formal emergence in the new network environment.

For China, scholars at this stage did not detect the scent of Altmetrics-related research, being immersed in the research boom of the “Three Metrics” and webometrics, and regrettably missed the opportunity to participate in this new discovery. Therefore, domestic development started relatively late.

4.2 2010-2014: Rise and Hot Discussion

The term Altmetrics was first proposed by J. Priem from the University of North Carolina in a tweet in 2010 and was confirmed in October when he published the Altmetrics manifesto with other scholars. Since then, the term has been formally established. The proposal of Altmetrics attracted widespread attention in the academic community and sparked heated discussion internationally. Subsequent discussions mainly focused on the connotation, indicators, and data of Altmetrics, with a large number of research achievements emerging both domestically and internationally. The proposer J. Priem defined Altmetrics on his website as the creation and study of new metrics based on social networks to analyze, evaluate, promote, and reveal online academic activities. In addition, many foreign scholars provided clear definitions for Altmetrics, with most

discussions revolving around its formulation and characteristics, without even reaching a consensus on whether Altmetrics is a new discipline, refers to some new metrics, or represents a method [22]. E. Adie, founder of Altmetric.com [23], believed that Altmetrics is data-driven, enabling these rapidly accumula-ble data to be used as evaluation indicators for papers. H. Piwowar, founder of ImpactStory [24], considered that the number of times a single article is mentioned in blogs or cited in Wikipedia constitutes Altmetrics, even including non-traditional and not exclusively online metrics (such as citations in reviews and commentaries) within the scope of Altmetrics. M. Thelwall [25] believed that Altmetrics research has very similar purposes to the existing field of webo-metrics, and due to the rapid development of social network services, the rise of Altmetrics appears more successful. Nature magazine published articles intro-ducing cases where scientists used social network tools such as blogs and Twitter to promote research through online comments and raising questions within days of publication, indicating that evaluation mechanisms based on social networks have begun to emerge [26]. At this stage, in addition to research on terminology and connotation, discussions also focused on basic research of Altmetrics indica-tors, data sources, and measurement tools, with small-scale empirical analyses in specific fields to verify the rationality and feasibility of Altmetrics.

China introduced Altmetrics in 2012, which also attracted academic attention. However, research at this stage mostly introduced foreign developments, with a batch of introductory and review literature emerging, mainly focusing on basic research such as translation, concepts, indicators, and data sources of Altmetrics, as well as discussions on its proposal process, theoretical foundation, basic issues, and foreign application fields, with less in-depth research.

4.3 2015-Present: Initial Prosperity

First, from the perspective of annual publication volume shown in Figure 1, the number of publications began to grow significantly in 2015 and quickly reached a small peak, indicating that Altmetrics entered a period of prosperity. Sec-ond, from the perspective of authoritative conference themes, Altmetrics has gradually been recognized and moved toward prosperity. For example, the International Conference of the International Society for Scientometrics and Informetrics (ISSI Conference), as a top conference in the field of metrology representing the latest progress and highest level in the domain, has been suc-cessfully held 17 times since 1987 and enjoys recognized international influence. The 15th conference (2015, Istanbul, Turkey) [27-28] first featured the “Alt-metrics” theme, affirming the research and disciplinary status of “Altmetrics” at the international level. Since then, all subsequent conferences have listed it as a conference theme, with the 16th (2017, Wuhan, China) [29] and 17th (2019, Rome, Italy) [30] conferences both establishing independent “Altmetrics” sessions for in-depth discussion, where scholars from various countries demon-strated the latest research trends in the field from different aspects, effectively promoting the international promotion and development of “Altmetrics.”

From the perspective of research evolution, studies at this stage mainly focus on fine-grained research, conducting in-depth discussions on certain key issues. Currently, researchers have implemented domain-specific Altmetrics research, expanding studies on Altmetrics theory, tools, methods, and applications, as well as conducting deep research on special issues such as sentiment motivation classification, data quality assurance system construction, and expanded application scope. However, some bottlenecks have been encountered that need urgent resolution. Therefore, Altmetrics is currently in the initial prosperity stage, with more and more scholars entering the field and continuous emergence of new achievements. The in-depth development of Altmetrics will undoubtedly form more new branch research fields and generate trends of interdisciplinary joint development, becoming a new direction for metrology.

At this stage, China has also produced a batch of important research achievements with reference value, systematically studying Altmetrics theory, methods, and applications from different perspectives, including systematic summaries of specific aspects, comparative analyses with traditional bibliometrics, construction of methodological models, and exploration of domestic platforms. At the same time, it should be noted that due to the particularity of China's national conditions, Altmetrics has gradually encountered some bottleneck problems in its domestic development. Important research bases in China have successively carried out special discussions, such as the journals *Library and Information* [31] in 2018, and *Knowledge of Library and Information Science* [32], *Information and Documentation Services* [33], and *Agricultural Library and Information* [34] in 2019, which respectively planned Altmetrics special issues, inviting domestic experts and scholars in the Altmetrics field to organize multiple papers for discussion from different perspectives and levels. Additionally, the journal *Library and Information Work* [35] opened the theme "Theoretical and Practical Research on Altmetrics" in its 2019 topic guide, attracting scholars' attention and encouraging their participation. Many research achievements have focused on the relationship between informal communication and Altmetrics evaluation, the relationship between Altmetrics and the evaluation field, article-level impact measurement and evaluation, Altmetrics data usage issues, Altmetrics data quality systems, and some studies have focused on the application of Altmetrics in China. Domestic research has shifted from introduction and testing to key breakthroughs, aiming to solve several critical issues and promote the prosperous development of Altmetrics in China.

5 Altmetrics Relationship with Closely Related Disciplines

Analyzing disciplinary relationships can further clarify the research scope, objects, and application fields of emerging disciplines, helping to define their disciplinary status and development direction. Here, the relationships with related disciplines are discussed from three perspectives: foundational disciplines, interdisciplinary fields, and application fields.

5.1 Relationship with the “Five Metrics”

Altmetrics is the product of Bibliometrics, Informetrics, Scientometrics, Webometrics, and Knowmetrics (the “Five Metrics”) developing to a certain stage, and is closely related to them, being both interconnected and mutually inheriting and developing [36]. In the Web 1.0 era and before, the main carriers of scientific achievements were literature, journals, books, etc., on which basis Bibliometrics, Scientometrics, and Informetrics (the “Three Metrics”) developed as research priorities in library and information science at that time. With continuous expansion in research depth and breadth, Webometrics focusing on network information data and Knowmetrics focusing on knowledge units as measurement objects successively emerged in library and information science. The proposal of Altmetrics in the new environment improves and supplements the development of the “Five Metrics,” with broader research carriers, adding open access, social media, and other research objects, and being more effective with more comprehensive research indicators. It represents the inheritance, supplementation, and development of existing metrology in the Web 2.0 and Web 2.0+ environment [33]. Therefore, Altmetrics is also called Scientometrics in the Web 2.0 environment [5]. The main advantage of Altmetrics relative to the “Five Metrics” is that it can provide fast, real-time measurement indicators with characteristics of openness, accessibility, and transparency, which have been recognized by many scholars.

In the big data era, scholars leave digital academic activity traces on various social platforms, forming multi-source indicators and data. This new type of academic big data provides a good measurement foundation for Altmetrics, making Altmetrics the scientometrics of the big data era [32]. Of course, Altmetrics is most closely related to Webometrics, with some research classifying Altmetrics as a development stage or branch of Webometrics [37]. The author previously used knowledge mapping methods to preliminarily explore the relationship between Altmetrics and Webometrics, believing that current Altmetrics belongs to the new development of Webometrics, a product of Webometrics in the new era and new network environment [38].

5.2 Relationship with Data Science

Data science is a discipline that uses data to derive knowledge, integrating theories and methods from multiple disciplines and playing important roles in numerous fields. In the big data era, the scientific community advocates establishing data science belonging to different scientific fields to form differentiated and specialized data science with disciplinary characteristics. Library and information science should also actively absorb theories, technologies, and methods of data science to catalyze its transformation and development [40]. Big data and data science will become a new research entry point for library and information science [41]. Altmetrics, based on digital academic data, has natural similarities with data science, both focusing on data as a research object, which can easily cause confusion and is not conducive to the independent development

of Altmetrics as a discipline. Therefore, it is necessary to differentiate and clarify the relationship and boundaries between Altmetrics and data science, highlighting the advantages of this discipline.

The author believes that from the perspectives of Altmetrics research thinking, research objects, and application methods, this discipline is a specific application of using network big data for academic quantitative evaluation in the new environment. Data science, meanwhile, is an emerging interdisciplinary discipline in the big data era, representing a collection of thinking, means, and methods at the broad level. At the same time, data science in the big data era, combined with artificial intelligence and other new technologies, provides new perspectives and methods for Altmetrics. Therefore, while adhering to the metrological disciplinary characteristics and advantages of Altmetrics, it is also necessary to break disciplinary boundaries, promote interdisciplinary integration, and actively absorb and integrate valuable theories, methods, and technologies from the data science field to promote the development of this discipline and obtain high-level innovative achievements. Authenticity and reliability are fundamental requirements for data in all fields [42]. As a new metrology field in the big data era, future research needs to strengthen Altmetrics data quality assessment [43] and improve the management of Altmetrics measurement data quality, which will help Altmetrics application results become more scientific and gain wider acceptance.

5.3 Relationship with Evaluation Science

The metrology disciplines in library and information science are known for their “applicability,” and the application value of Altmetrics is even more significant, closely related to evaluation science in the new era. With the deepening of Altmetrics research, its influence continues to expand, with more and more researchers using Altmetrics indicators to evaluate the impact of academic research. Typical studies include Li Yong et al. [44] using Altmetrics and other new paradigms to conduct exploratory research on the multi-dimensional evaluation of academic journals. Wang Feifei et al. [45] combined traditional metrology indicators and Altmetrics indicators to achieve more comprehensive and effective evaluation applications, providing new perspectives for the comprehensive evaluation of researchers’ academic influence. Zhao Rongying et al. [46-47] elaborated on the research ideas of academic influence evaluation from the Altmetrics perspective and proved that Altmetrics can effectively reflect the academic influence and social impact of literature. Liu Chunli et al. [48] discussed the research status and application challenges of Altmetrics indicators in evaluating the social impact of research output. It is evident that the feasibility and scientific nature of Altmetrics applied to the evaluation science field have gradually been verified. Although the universality of its evaluation results has not yet been widely recognized, many fields have shown good evaluation effects, and its outstanding advantages have made Altmetrics favored and applied in the evaluation field.

Based on the above analysis and practical situations, the author believes that an important application field of Altmetrics is evaluation science, fully demonstrating the advantages of Altmetrics in the evaluation field in the new environment. Compared with existing evaluation methods, it provides new evaluation perspectives, methods, and indicators, and can more comprehensively reflect the diversity of evaluated objects from multiple dimensions, contributing to the improvement and perfection of existing evaluation systems. The two have a complementary relationship. Against the background of strongly calling for the construction of an evaluation science discipline system [49], the emergence and development of Altmetrics help enrich and improve the evaluation system, and future multi-field evaluation empirical research is needed to verify the tremendous application value of Altmetrics in evaluation science.

6 Conclusions and Discussion

In the Web 2.0 era, the emergence of Altmetrics has injected new vitality into the field of metrology, presenting a challenging trend to traditional metrology based on citations as the golden rule while simultaneously showing a relationship of supplementation and innovation. As Altmetrics celebrates its 10th anniversary, sorting out and summarizing its early research achievements is conducive to promoting the correct development of this discipline. This paper focuses on the formation and evolution of Altmetrics, based on relevant domestic and international research achievements, exploring current key issues to be solved, in order to leverage the advantages of Altmetrics, integrate it with traditional metrology methods to achieve transcendence, and demonstrate its value in the new environment. This research summarizes the following core viewpoints:

1. Altmetrics provides a new way of thinking for metrology in library and information science, but many key issues remain to be solved at the current stage. From existing research achievements, Altmetrics research is still in its early stage, especially in China, where a complete research system has not yet been formed.
2. A comprehensive understanding of the connotation of Altmetrics helps recognize its essential value. Altmetrics has different levels of understanding. In the narrow sense, Altmetrics is a type of metric different from traditional metrology indicators, mainly (but not entirely) measuring and analyzing scholars' communication behavior trajectories on social media. In the broad sense, Altmetrics is a new metrology method different from traditional metrology methods, representing an innovative breakthrough in thinking that measures the diverse attributes and reflects the multi-dimensional impacts of objects from the level of academic network big data.
3. From the perspective of formation and evolution characteristics, Altmetrics provides new perspectives and methods for measuring and evaluating the multi-dimensional attributes and impacts of objects from multiple di-

mensions.

4. Exploring the formation and evolution characteristics of Altmetrics helps promote its in-depth development. First, changes in the broader research environment are influencing factors for the emergence and rapid development of Altmetrics, the transformation of online academic communication models is a direct factor, and the academic nature of academic social activities is the rational basis for its existence. Thus, the open science hypothesis, digital academic hypothesis, and academic inheritance hypothesis are proposed. Second, there are differences in the development degree of Altmetrics between domestic and international contexts, requiring careful treatment and avoiding blind following. Finally, from the perspectives of foundational disciplines, interdisciplinary fields, and application fields, Altmetrics is rooted in the “Five Metrics.” Current Altmetrics belongs to the new development of Webometrics in the new environment. Altmetrics has many similarities with data science but also has its own unique research content and methods, requiring strengthened interdisciplinary collaborative research. An important application field of Altmetrics is evaluation science, providing new evaluation perspectives and methods that help improve the evaluation system, with the two having a complementary relationship.

In conclusion, the rise of Altmetrics has brought opportunities and challenges to the field of metrology, but it is currently in the early stage of development, with several key issues needing gradual resolution. The mature development of the Altmetrics discipline is a slow evolutionary process requiring time accumulation, and it needs sufficient patience and full enthusiasm to promote its development in the right direction.

References

- [1] PRIEM J, TARABORELLI D, GROTH P, et al. Altmetrics: a manifesto [EB/OL]. [2020-03-20]. <http://altmetrics.org/manifesto/>. [2] YU Houqiang. Altmetrics: Concepts, Indicators and Applications [M]. Beijing: Scientific and Technical Documentation Press, 2019: 3. [3] BOLLEN J, DESOMPELH V, SMITH J A, et al. Toward alternative metrics of journal impact: a comparison of download and citation data [J]. Information Processing & Management, 2005, 41(6): 1419-1440. [4] YU Houqiang, REN Quane, ZHANG Yang, et al. The divergence in Altmetrics translation: confusion, impact and analysis [J]. Journal of Library Science in China, 2019, 45(1): 47-59. [5] LIU Chunli. Scientometrics in the Web 2.0 environment: Selective metrics [J]. Library and Information Service, 2012, 56(14): 52-56. [6] YOU Qingbin, TANG Shanhong. Supplementary metrics and its application prospects [J]. Information Studies: Theory & Application, 2013, 36(12): 6-10. [7] QIU Junping, YU Houqiang. The proposal process and research progress of Altmetrics [J]. Library and Information Service, 2013, 57(19): 5-12. [8] NISO. NISO alternative metrics (altmetrics) initiative phase 1 white paper [EB/OL]. [2020-03-20].

http://www.niso.org/apps/group_public/download.php/13809/Altmetrics_{{project}}_{{phase1}}.{{wh}}

[9] PRIEM J. Altmetrics [M]// CRONIN B, SUGIMOTO C R. Beyond bibliometrics: harnessing multidimensional indicators of scholarly impact. Cambridge, MA: MIT Press, 2014, 263-287. [10] PIWOWAR H. Altmetrics: value all research products [J]. Nature, 2013, 493(7431), 159-159. [11] HAUSTEIN S, PETERS I, BAR-ILAN J, PRIEM J, et al. Coverage and adoption of altmetrics sources in the bibliometric community [J]. Scientometrics, 2014, 101(2), 1145-1163. [12] WELLER K. Social media and altmetrics: an overview of current alternative approaches to measuring scholarly impact [M]// Incentives and Performance. Cham: Springer, 2015: 261-276. [13] MINGERS J, Leydesdorff L. A review of theory and practice in scientometrics [J]. European Journal of Operational Research, 2015, 246(1): 1-19. [14] BARBARO A, GENTILI D, REBUDD C. Altmetrics as new indicators of scientific impact [J]. Journal of the European Association for Health Information and Libraries, 2014, 10(1): 3-6. [15] LIU Chunli. Altmetrics: from theoretical hypotheses, term proposal to redefinition of connotation [J]. Library and Information Service, 2015, 59(6): 82-89. [16] LIU Guifeng, QIAN Jinlin, TIAN Lili. Open science: concept analysis, system analysis and idea exploration [J]. Library and Information Service, 2019, 63(2): 20-27. [17] LIU Limin, WANG Qing. Foreign theoretical research and practical progress of Altmetrics [J]. Information Studies: Theory & Application, 2019, 42(6): 154-158, 143. [18] FOSTER [EB/OL]. [2020-03-10]. <https://www.fosteropenscience.eu/project>. [19] BOLLEN J, RODRIGUEZ M A, HERBERT V D S. Mesur: usage-based metrics of scholarly impact [C]// ACM/IEEE-CS Joint Conference on Digital Libraries. Vancouver BC: ACM, 2007: 474. [20] TARABORELLI D. Soft peer review: social software and distributed scientific evaluation [C]// ACM/IEEE-CS Joint Conference on Digital Libraries. Vancouver BC: ACM, 2007: 474. [21] PATTERSON M. Article-level metrics at PLoS-addition of usage data [EB/OL]. [2020-03-10]. <https://theplosblog.plos.org/2009/09/article-level-metrics-at-plos-addition-of-usage-data/>. [22] ZHAO Rongying, WANG Shaozhen, CHEN Zhiyi. Exploration of supplementary metrics and its analysis tools [J]. Information Studies: Theory & Application, 2015, 38(6): 29-34. [23] ADIE E, ROE W. Altmetric: enriching scholarly content with article-level discussion and metrics [J]. Learned Publishing, 2013, 26(1): 11-17. [24] PIWOWAR H. Introduction altmetrics: what, why and where? [J]. Bulletin of the American Society for Information Science & Technology, 2013, 39(4): 8-9. [25] THELWALL M. A brief history of Altmetrics [J]. Research Trends, 2014(37): 3-4. [26] MANDAVILLI A. Trial by Twitter [J]. Nature, 2011, 469(7330): 286-287. [27] Proceedings of ISSI 2015 [EB/OL]. [2020-02-28]. <http://www.issi-society.org/publications/issi-conference-proceedings/proceedings-of-issi-2015/>. [28] QIU Junping, CHAI Wen. Viewing global scientometrics development from the 15th ISSI conference [J]. Information Studies: Theory & Application, 2016, 39(8): 1-5. [29] Proceedings of ISSI 2017 [EB/OL]. [2020-02-28]. <http://www.issi-society.org/publications/issi-conference-proceedings/proceedings-of-issi-2017/>. [30] Proceedings of ISSI 2019 [EB/OL]. [2020-02-28]. <http://www.issi-society.org/publications/issi-conference-proceedings/proceedings-of-issi-2019/>.

- [31] Special Planning: Altmetrics Evaluation Research [J]. Library and Information, 2018(5): 1. [32] WANG Xianwen. Altmetrics: scientometrics in the big data era [J]. Knowledge of Library and Information Science, 2019(2): 4. [33] LI Changling. Special Research: Characteristics and Application Research of Altmetrics Indicators for Academic Papers—Host' s Introduction [J]. Information and Documentation Services, 2019, 40(6): 5. [34] YANG Siluo. Altmetrics Special Issue [J]. Agricultural Library and Information, 2019, 31(5): 4. [35] Library and Information Work Magazine. 2019 Topic Guide for Library and Information Work [J]. Library and Information Service, 2019, 63(22): 150. [36] ZHAO Rongying, WEI Mingkun, WANG Shaozhen. Analysis of Altmetrics development trends [J]. Information Science, 2017, 35(2): 171-176. [37] ZHAO Danqun. Review of webometrics research and development [J]. Information Studies: Theory & Application, 2017, 40(3): 132-137. [38] ZHANG Yang, PANG Jinjing, ZHU Jiaqi, et al. Research on the relationship between Altmetrics and webometrics from the perspective of scientometrics [C]// 15th Annual Conference of China Science and Technology Policy and Management. Nanchang: China Association for Science of Science and S&T Policy, 2019. [39] YU Houqiang, Murat. Interpreting new progress in Altmetrics research from ISSI 2019 conference [J]. Information Studies: Theory & Application, 2020, 43(7): 157-164. [40] BA Zhichao, LI Gang, ZHOU Liqin, et al. Data science and its impact on the transformation of information science [J]. Journal of the China Society for Scientific and Technical Information, 2018, 37(7): 653-667. [41] REN Quane. Research progress and disciplinary integration of bibliometrics in the context of big data [J]. Information Studies: Theory & Application, 2019, 42(1): 48-52. [42] WANG Fang, ZHAO Hong, MA Jiayue, et al. Research and practice progress of data provenance from the perspective of data science [J]. Journal of Library Science in China, 2019, 45(243): 79-100. [43] YU Houqiang, CAO Xueting. Research on the construction of Altmetrics data quality assessment system [J]. Knowledge of Library and Information Science, 2019(2): 19-27, 50. [44] LI Yong, SHAO Zhongyu, ZHAO Xing. Research on multi-dimensional evaluation indicators of journals in the context of Altmetrics [J]. Journal of the China Society for Scientific and Technical Information, 2017, 36(2): 190-196. [45] WANG Feifei, LIU Jiayu, JIA Chenran. Research on comprehensive evaluation of academic influence of university researchers based on Altmetrics [J]. Science Research Management, 2019, 40(4): 264-276. [46] ZHAO Rongying, GUO Fengjiao. Altmetrics: A new perspective for academic influence evaluation [J]. Information Science, 2017, 35(1): 14-18. [47] ZHAO Rongying, ZHANG Yang, CHEN Jing. Application of Altmetrics in paper influence evaluation [J]. Information Science, 2018, 36(6): 3-8, 39. [48] LIU Chunli, LIU Liping, MA Fengmao. Research status and application challenges of Altmetrics indicators in evaluating the social impact of research output [J]. Agricultural Library and Information, 2019, 31(5): 13-21. [49] JIANG Chunlin. Disciplinary system and creation strategies of academic evaluation science [J]. Journal of Southwest Minzu University (Humanities and Social Science), 2018(2): 225-232.

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

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