Postprint of a Meta-Synthesis Study on the Interaction Framework of Influencing Factors for Research Data Management Services

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Date: 2023-04-01T00:00:00+00:00

Abstract

[Purpose/Significance][JP2]To investigate the influencing factors of implementing research data management services, so as to promote the enhancement of research data management service quality and safeguard scientific research innovation.[Method/Process]Adopting a meta-synthesis approach, based on mainstream databases, reasonable screening and evaluation criteria were selected to obtain target literature, and through interpretive coding and summarization of the included literature, a model of influencing factors for research data management services was constructed. Simultaneously, the dimensions within the model, [JP2]as well as the associative and functional relationships among main categories were analyzed and sorted out.[Results/Conclusion]The study obtained 108 initial concepts, 33 categories, and 11 main categories, which were summarized into the US2C model composed of four dimensions: user, service, library (internal environment), and external environment. This theoretical model framework can provide certain guidance and reference for promoting the implementation of research data management services in academic libraries and research institutions, and is also of significant importance for the value manifestation, capability enhancement, and sustainable development of academic libraries.

Full Text

A Meta-Synthesis Study of the Interaction Framework of Influencing Factors in Research Data Management Services

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Abstract: *[Purpose/Significance]* This study explores the influencing factors in the implementation of research data management services (RDMS) to promote service quality improvement and safeguard scientific research innovation. *[Method/Process]* Using a meta-synthesis approach, we retrieved target literature from mainstream databases through reasonable screening and evaluation criteria. Through interpretive coding and summarization of the included literature, we constructed a model of influencing factors for RDMS. We also analyzed the relationships and interactions among dimensions and main categories within the model. *[Result/Conclusion]* The study identified 108 initial concepts, 33 categories, and 11 main categories, which were summarized into a US2C model comprising four dimensions: user, service, library (internal environment), and external environment. This theoretical framework can provide guidance and reference for promoting RDMS implementation in academic libraries and research institutions, and is significant for demonstrating the value, enhancing the capabilities, and ensuring the sustainable development of academic libraries.

Keywords: research data management services; meta-synthesis; influencing factors; theoretical framework; US2C model
Classification Number: G252
DOI: 10.13266/j.issn.0252-3116.2022.08.013

With the transformation of research paradigms and researchers' data awareness, the value of research data in scientific activities has gradually increased, giving rise to Research Data Management Services (RDMS). As early as 2013, the United States issued the "Memorandum on Promoting Public Access to Federally Funded Research Results" [1], which regulated public access to and utilization of government-funded research outcomes. In 2018, China' s State Council issued the "Administrative Measures for Scientific Data," providing guiding regulations on general principles, organizational responsibilities, and management behaviors for data management [2]. Subsequently, provinces and relevant research institutions responded actively, issuing targeted specific policies to guide their data management work. In 2020, the 13th Forum on Library Management and Service Innovation emphasized that university libraries need to develop research data management services [3].

Promoting and implementing RDMS not only enhances data management efficiency, enables data sharing and reuse, and avoids redundant research, but also further taps the potential value of research data to promote academic exchange and innovation. However, current management services have progressed slowly, with many research institutions having nominal or non-existent research data management policies, leaving researchers' needs unmet and data underutilized. This has created obstacles to scientific research in the data-intensive paradigm [4-5]. RDMS urgently needs development.

In recent years, to advance the practice of RDMS, scholars have primarily explored data management services from two perspectives: theoretical exploration and case analysis. In terms of theoretical exploration, when the specific content of RDMS was not yet clearly defined, scholars mainly conducted theoretical

analysis based on previous summaries and national development plans. They took a specific aspect of RDMS or the entire RDMS as the research object (such as service model construction, user cognition, data security, etc.), analyzed its necessity and feasibility, and proposed construction strategies or plans to guide practical actions. For example, Li Xiaohui analyzed and explored the model construction of RDMS from the perspectives of technology, data organization, service methods, literacy education, and related configurations [9]; L. Kathryn et al. interviewed researchers about their management willingness and identified eight types of willingness tendencies and their cognitions from the interviews [12]; Liu Guifeng et al. constructed a four-level data security content framework based on service status and lifecycle theory [13].

In terms of case analysis, when the research object was unclear and theory was insufficient, many scholars started from practice, analyzing one or more cases to identify practical deficiencies and experiences (such as service status, librarian capabilities, policy texts, etc.), and proposed practical recommendations based on these. For instance, C. Elisha Rufaro T. investigated and analyzed RDMS in South African university and research libraries, discovering the important roles of management awareness, enthusiasm, and technology [14]; S. Marita, based on analysis of RDMS in 13 university libraries, identified staff experience, training, and professional development as one of the key factors affecting the service [15]; Liu Bing et al. decomposed and explored RDMS policies in 30 universities in the UK, US, and Australia using content analysis, highlighting the role of management stages [16].

Existing research has conducted extensive exploration in both theoretical and practical aspects, primarily investigating service systems, quality, and practical deficiencies to guide RDMS construction. However, RDMS practice remains slow, with data management work progressing sluggishly and research data not being shared or reused. Moreover, current research has limitations worth further exploration: First, most studies offer insufficient analysis of the reasons for the slow progress of RDMS and inadequate promotion of RDMS; second, some existing studies on RDMS influencing factors have been conducted from a single perspective, with researchers' capacity limitations and individual angles leading to omissions, making it difficult to comprehensively and systematically explore the key factors.

Therefore, this study focuses on the influencing factors affecting the progress and quality of RDMS implementation, conducting an interpretive synthesis from multiple dimensions and levels, analyzing the interaction relationships among various factors, and constructing a more comprehensive integrated framework to promote RDMS implementation progress and ensure implementation quality.

1 Research Questions and Design

1.1 Research Foundation and Problem Definition

RDMS has not yet had a unified definition, with scholars at home and abroad offering different interpretations. Foreign scholars such as F. David Jr et al. [6], T. Carol et al. [7], and S. Michael [8] define RDMS as managing data generated in research projects and supporting activities throughout the data lifecycle through guidance, consultation, and training services. Domestic scholars Li Xiaohui [9], Zhou Lihong et al. [10], and Li Zhifang [11] view RDMS as embedded, interactive services that provide support for research data storage, organization, management, training, and consultation based on human resources, policies, and technology. Based on this, this study defines RDMS as services that, based on policy planning, technology, and resources, provide data management for researchers and offer guidance, consultation, and training support for data management needs encountered in research activities.

1.2 Research Design and Methods

Meta-synthesis is a method for extracting and synthesizing important data and concepts from literature on related topics. This method redefines important elements in literature, aggregates concepts with repetitive meanings, and transforms, summarizes, expands, and reconstructs theories [17]. Currently, meta-synthesis has been applied in fields such as medicine, education, management, and library and information science, with representative studies by scholars H. Christina and C. Amy [18-19]. This study synthesizes and expands the research steps of these two scholars and applies them to this research.

The specific steps are as follows: Clarify the research question and develop search strategies; Determine inclusion criteria and literature suitable for the study; Conduct critical evaluation of literature to determine its validity; Extract, transform, and synthesize data using appropriate methods to analyze target literature; Determine the quality of analysis results by assessing their credibility and validity; Discuss this research.

Currently, scholars typically use Meta-analysis and qualitative meta-analysis for comprehensive literature studies, but both methods have limitations on literature types, whereas meta-synthesis does not. Additionally, meta-synthesis can conduct interpretive synthesis of literature, ensuring the universality and rigor of research conclusions and avoiding theoretical gaps caused by single perspectives or individual capacity limitations. Through multi-literature analysis, RDMS implementation influencing factors can be analyzed and explored from multiple angles and more comprehensively. Therefore, considering literature types and result universality, this study adopts the meta-synthesis method.

2 Data Processing and Analysis

2.1 Data Acquisition and Preprocessing

2.1.1 Retrieval Strategy and Literature Screening The study used WoS All Databases, Scopus, and PQDT Dissertation Database as foreign data sources, and CNKI and VIP Database as Chinese data sources. The search was not limited by time range, and the retrieval date was June 29, 2021. After merging and deduplicating Chinese and foreign data, 2,971 foreign documents and 1,155 Chinese documents were obtained.

Based on the inclusion criteria considerations of Sun Yuwei et al. [20] and H. Christina [18], literature screening criteria were determined, and literature was screened by browsing titles and abstracts. The specific screening criteria were as follows: Included literature must involve RDMS influencing factors, excluding irrelevant literature; The service object of RDMS in included literature must be researchers, and the data must be data collected or generated during the research process; Literature types were limited to journal articles and dissertations, excluding book reviews, journal news, conference papers, and similar dissertations and journal articles by the same author; Included articles must meet literature quality assessment standards.

Through screening, 58 documents were obtained, including 45 foreign and 13 Chinese documents. By tracking the references and citing literature of these 58 documents, 12 additional documents were obtained. Finally, 70 documents underwent Evidence-Based Librarianship (EBL) critical evaluation, and literature with evaluation scores $ $75% was selected, resulting in 36 documents suitable for analysis. The retrieval and screening process is shown in [Figure 1: see original paper].

2.1.2 Literature Quality Assessment Literature quality directly affects subsequent analysis and research result quality. High-quality and targeted papers facilitate meta-synthesis and yield credible and valid conclusions. Therefore, this study adopted the EBL critical evaluation form for the library field. This form includes four parts: overall characteristics (basic sample information and inclusion criteria), data collection (collection methods, method validity, subjectivity, etc.), research design (method appropriateness, process detail, etc.), and research results (result clarity, topic reflection, recommendations provided, etc.) [21]. Each part has 5-8 questions, with four options for each question: Yes (Y), No (N), Unclear (U), and Not Applicable (NA). By reviewing and analyzing each article' s content, questions were answered.

According to the responses, articles passing quality assessment satisfied either Formula (1) $ $75% or Formula (2) $ $25%. Otherwise, they were deemed unsuitable for this study. Additionally, for the question in Section A "Is the sample size large enough for accurate prediction," Formula (3) was used for judgment, where N represents total population, n represents sample size, and e represents the 95% confidence interval. For "Is the response rate large enough for adequate

precision," the criteria were >30% for online surveys and >80% for face-to-face surveys [20].

Formula (1): Number(Y) / Number(Y+N+U)
Formula (2): Number(N+U) / Number(Y+N+U)
Formula (3): $n = N / (1 + Ne^2) = 1 / (1/N + e^2)$ [22]

2.2 Data Extraction and Synthesis

The 36 included documents were coded to extract concepts related to RDMS implementation influencing factors. Through sorting, interpretation, induction, and synthesis, an RDMS implementation influencing factors model was established. For data processing steps and ideas, the study combined Strauss' s coding method with the Critical Interpretive Synthesis (CIS) analysis approach for interpretive coding of literature.

Strauss' s coding enhances research rigor through a three-step process: Open coding labels relevant statements in literature to form initial concepts; Axial coding clusters initial concepts to form categories; Selective coding refines new themes to form core categories [23]. CIS is a "critical" and "interpretive" analytical approach that synthesizes repetitive themes and contradictory concepts through interpretation and critical thinking of various concepts and theories in literature to form new concepts and theories. Its process involves four steps: Study literature to identify, extract, and understand concepts, themes, and metaphors; Transform extracted concepts by expressing them in another form and simplifying similar concepts; Compare transformed concepts to determine relationships and synthesize them; Merge synthesized concepts to ultimately integrate different research findings into a theoretical framework [24-25].

Due to the large number of initial concepts with varying importance, a threshold of 3 repetitions was set, and initial concepts appearing $ $3 times (except for particularly meaningful concepts) were categorized. Data processing results are shown in through .

2.3 Conclusion Verification

This study verified conclusion credibility and validity through three methods. First, drawing on Francis' s research on theoretical saturation testing standards to verify conclusion credibility and validity [26-27], we randomly selected 3 documents from the included literature as test data, then coded the remaining 33 documents formally. After formal coding concluded, test data was coded, and results showed that 3 consecutive data sets produced no new categories, thus passing the theoretical saturation test.

Second, all coded literature had undergone EBL evaluation during the screening stage, with inclusion determined by scores >75% meeting validity standards. Additionally, when conducting source checks on the literature, most were found to originate from CSSCI, Peking University Core, SCI, SSCI, EI, etc., with

content quality validated by experts. Thus, original data quality received dual verification, confirming the trustworthiness and validity of literature content.

Third, member checking was used to verify conclusion validity, where research results were presented to two experts and two students with RDMS research experience for examination and judgment to verify whether the results aligned with expert and general personnel recognition [28]. Based on their feedback, reasonable opinions were adopted to revise analysis results. In summary, this study' s conclusions demonstrate good credibility, validity, and theoretical saturation.

3 Theoretical Framework of RDMS Implementation Influencing Factors Interaction

Through interpretive coding, 108 initial concepts, 33 categories, and 11 main categories were ultimately obtained and summarized into 4 dimensions. Users are the service objects of RDMS and the core factors driving the service; planning is the detailed action plan for services and a key factor in service implementation; libraries (internal environment) are the service providers, reflecting the internal influencing factors of service conditions and capabilities; environment (external environment) is the external influence on services, driving and constraining services from the outside.

Therefore, this study gradually extracted and summarized the core factor (User Dimension/User), key factor (Service Dimension/Service), internal environment (Library Dimension/Internal Context), and external environment (Environment Dimension/External Context) as the RDMS implementation influencing factors framework (US2C Model), as shown in [Figure 2: see original paper].

3.1 User Dimension—User Participation

Researchers, as the service objects of RDMS, are the target subjects and driving factors of service implementation. The user dimension primarily examines how participation affects service implementation, i.e., how personal characteristics and perceptions influence their tendency to participate in services, which can be divided into personal characteristics and user perception. User participation is inseparable from service development and user feedback.

The main user subjects of RDMS are researchers, whose needs are primarily related to their own characteristics. Researchers rarely use metadata to label research data [29], and often use personal devices or cloud storage accounts to save data [30]. These habits make it difficult for researchers to develop awareness and behavior to participate in RDMS. This is related to insufficient RDM skills [31], as inadequate knowledge of metadata [29], archiving and management skills [32], data literacy [33], and basic knowledge [34] also affect users' awareness of participating in services and utilization efficiency [35].

Meanwhile, understanding of RDM awareness [36], RDM importance [29], data value cognition [35], and user attitudes [37] affects researchers' willingness to

participate [38-39] and the penetration of management and services among researchers [32]. Additionally, researchers' interests and needs, as well as service planning, are influenced by disciplinary background and professional background. For example, humanities scholars have less interest in services but actually need more help (such as metadata, version control) [29], while faculty, graduate students, and undergraduates differ in awareness, skills, and needs [35].

However, sometimes researchers, despite having management awareness and service needs, showing agreement and support for data management and services, rarely participate in actual actions [40]. This phenomenon is closely related to user perception. User perception mainly includes perceived usefulness, perceived risk, and perceived culture. When participating in RDMS, researchers typically hope to advance research projects [40], protect data [41], promote new discoveries [40], receive rewards [42], and enjoy ease of use [39]. These service advantages promote researcher participation.

However, issues in services such as data security [43], data misuse [36], academic misconduct [44], competitive disadvantage [42], and intellectual property problems [35] also deter many researchers. Compared with foreign countries, open culture and concepts are not prominent in China, and cultural differences lead to lower interest in RDMS among domestic scholars [35, 45-46]. Additionally, requirements for RDMS from external institutions and policies can enhance researchers' awareness and perception, thereby increasing user participation [47]. Service planning and content must reference target groups' personal characteristics and user perceptions, being influenced by the target group [48]. Therefore, active user participation and feedback enhance the scientific nature of service planning.

3.2 Service Dimension–Scientific Planning

RDMS implementation requires detailed understanding of management objects and comprehensive service planning. Only under scientific planning can services be implemented smoothly and orderly. In the service dimension, this study analyzes the influencing mechanisms of RDMS implementation from the perspectives of data, service planning, and service content, as shown in [Figure 4: see original paper].

Data is the management object of services, and its characteristics and priorities are factors that should be considered in service planning. The data dimension involves data security, data ownership, management standards, and data characteristics. Data security and data ownership are priorities in service planning. Clear guarantees and regulations should be established for data security needs (especially for sensitive data) and copyright ownership [49-51]. Data management standards and data characteristics are the basis for service planning. Data from different disciplines, volumes, types, and contexts have different requirements for data management and services, necessitating service planning based

on target user needs [31, 37, 39].

In data standards, metadata consistency, organization standards, evaluation systems, and access control requirements can provide guarantees for future service interoperability, quality, efficiency, and security [35, 42, 52-53]. Thus, solving data problems can reduce user perceived risk, enhance perceived usefulness, and guarantee service quality.

Orderly service implementation requires macro- and micro-level planning of processes and content. Therefore, this study proposes two factors: service planning and service content. Service planning analyzes important steps for service implementation from a macro perspective. Institutions should first identify and stimulate target user needs, discovering explicit and potential needs [48, 50]. Based on needs, policies, and institutional goals, strategic planning, service model planning, and service content planning should be conducted as top-level design and internal requirements for service implementation [14, 52, 54].

Simultaneously, institutions should widely conduct publicity and communication to cultivate researchers' RDM awareness and correct cognition [55-57]. Service content analyzes service implementation points from a micro perspective, including service types, service content, and service characteristics. Service types mainly include system training, consultation services, and written guides, but service frequency is low and content is singular, failing to effectively meet user needs, cognition, and skill improvement [10, 32, 41, 58].

Service content should focus on importance and user needs, emphasizing high-demand services such as DMP [30], metadata services [59], data storage services [53], and policy and ethics interpretation [42] to maximize user satisfaction [10, 29, 60]. Regarding service characteristics, current domestic services are relatively general and singular. Services should be more targeted [10] (classifying users from different perspectives), convenient and diverse [61], proactive and friendly [38], and diversified in content (refined services) to enhance user satisfaction by optimizing service experience and increasing user stickiness [10, 52].

Additionally, scholars propose that RDMS implementation requires innovation to avoid mechanical imitation, i.e., conducting differentiated construction of service content, training methods, and data management processes according to institutional user needs and strategic goals [54-55].

3.3 Library Dimension–Internal Environment

The internal environment represents the internal state of the library. As the main service implementer, the library's capabilities and status are closely related to service implementation. A good internal environment comprising qualified librarian teams, complete technical support, strict institutional guarantees, and efficient organizational management can ensure service implementation. Simultaneously, the library' s capabilities and resource quality affect user perception, as shown in [Figure 5: see original paper].

Librarians are service providers who directly face users, and their service awareness and capabilities affect service quality and user perception [58]. Librarians' understanding of their positioning and service importance is a necessary prerequisite, ensuring recognition and attitude toward services from the awareness and cognition level [48]. Librarian capability is a necessary condition for service implementation and an important guarantee for service quality [49, 55], mainly including data literacy, technical capability, and professional knowledge [36, 44].

However, in practice, librarians' literacy, skills, and disciplinary knowledge are relatively poor, and libraries rarely set up dedicated positions [62-63]. Other librarians are too busy with multiple responsibilities, making RDMS difficult to implement [30, 40, 48]. Therefore, librarian skills need training to bridge the gap between required and existing skills [43]. Multiple scholars also recognize the importance of training librarians [41, 57, 64], but currently, librarians have few training opportunities, which should attract institutional attention [40].

Technology is the infrastructure of services. This study proposes four focus areas in the technology category: system functions, system construction, and technology application. System functions should include data storage, retrieval, utilization, security collaboration, and online guidance and training [58, 65]. These functions need to be reflected in system construction and technology application, such as platform and repository construction, tool development, metadata design, and security technology. Additionally, technology suitability affects user perception and service experience. Platforms should be appropriate and tools easy to use to avoid increasing researchers' burden, reduce time and effort required to use services [50, 65], and improve service efficiency and user experience.

Institutions are guarantee measures for service operation, mainly including three important systems. Operation management systems establish multi-department collaboration, embed research work, and implement data lifecycle service operation systems [37, 63]. Incentive systems reward and encourage researchers' management and sharing behaviors, evaluate and reward librarians' service provision, and encourage researchers to participate in services and librarians to serve actively [31, 36]. Supervision and evaluation systems monitor and evaluate services and their effects, identify weak links, improve service quality, and promote the organic growth of RDMS [50, 63].

Organizational management adapts organizational structure and leadership behavior to service implementation [14], involving department setup, multi-party cooperation, and leadership characteristics. Department setup refers to adding professional teams to enhance RDMS status and service quality [45], such as establishing management committees and dedicated service teams [57, 66]. Multi-party cooperation is an effective way to avoid defects and solve challenges in service implementation. The capabilities and technologies required for services cannot be met by a single institution, requiring cooperation to merge resources and compensate for deficiencies [14].

Ultimately, organizational setup is related to leadership characteristics, and even service implementation is connected to them. Managers' service awareness and attitude, administrative support, and leadership capabilities are inseparable from service implementation effects. However, in reality, corresponding departments and teams are rarely established [36], cooperation is lacking [40], managers often remain in a wait-and-see state [45], and very few institutions elevate RDMS to the organizational level, greatly reducing the enthusiasm and proactivity for service implementation [35].

3.4 Environment Dimension–External Environment

The external environment refers to external forces and threats outside the service institution that are closely related to services, representing external influences on service implementation. The environment dimension mainly involves practical foundations (external institutions, funding, practical guidance) and policies, as shown in [Figure 6: see original paper].

External institutions refer to external stakeholder institutions related to services, such as governments, funding agencies, and research journals, whose requirements and standards for research data affect service implementation and researcher cognition. Taking China as an example, national-level attention to RDMS is insufficient, and funding agencies and academic journals have not proposed requirements for data management [45, 58]. In the early stages of services, the simultaneous absence of researcher cognition and external enforcement leads to research institutions and researchers underestimating data management and services [35].

Additionally, RDMS faces threats from external alternative platforms, such as national large-scale data management platforms and professional data storage platforms on the internet, which have gained favor among many researchers [14, 45]. Due to insufficient attention from external institutions, policy formulation and improvement for RDMS are often inadequate. Macro policies are incomplete [35, 40], micro policies are few [56], and content protecting participants' rights is missing [44], leading to unclear RDMS implementation directions, non-standard data management, and insufficient policy constraints [43, 52].

The formulation and improvement of policies at all levels provide legal environment guarantees, can promote service implementation progress and user participation [36], facilitate standardized data management, and avoid potential problems and directional errors in services from the regulatory level [64]. Regarding funding, when stakeholders and policies do not propose requirements and management support is insufficient, RDMS funding inevitably becomes short, leading to inadequate talent and infrastructure [14, 49] and hindering service implementation [31]. Therefore, establishing multi-channel, long-term stable special funds is the material foundation for ensuring service implementation [35, 48].

Additionally, in terms of practical guidance, the absence of sufficient theoretical

guidance and experience is also a reason why many institutions have not yet launched services [40, 56].

Conclusion

RDMS is a response to the rise of data-intensive research, providing solid data support for scientific research development and innovation. This study adopted the meta-synthesis method, obtaining valid literature from a large body of domestic and foreign research through screening criteria and EBL evaluation. Based on systematic literature review, fine-grained analysis and interpretive coding were conducted to construct a US2C influencing factors model. This model includes four dimensions—user, service, library, and external environment—and 11 main categories.

At the dimension level, users and data, as service objects and management objects, are the core of service implementation, affecting user participation and service planning. Meanwhile, libraries and the external environment, as internal and external environmental conditions, importantly influence service implementation support and guidance (human resources, financial resources, technology, policies, etc.), with resource guarantee conditions affecting service progress. At the main category level, personal characteristics, user perception, and data requirements serve as the basis for service implementation, influencing RDMS implementation direction and content; librarian teams, technology, organizational management, and practical support (funding) are the basic support for service implementation, affecting service progress; systems, service planning, service content, and practical support (theory and cases) are factors guiding service implementation to determine service implementation plans.

The framework model proposed in this study can provide ideas for subsequent RDMS-related research and offer relatively comprehensive guidance and reference for RDMS practice.

The study also has some limitations. The research object (RDMS) is relatively new, with relevant terminology not yet standardized, leading to the same object being described by different terms by authors. Although the search scope was expanded as much as possible and multiple keywords were used for retrieval, literature omission may still occur. Therefore, future research will further explore service models and implementation in combination with practical development, and revise and expand the model framework.

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