

Cooperation and Game Theory between Libraries and Library Suppliers during Extraordinary Periods: Postprint

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Abstract

[Purpose/Significance] To clarify the challenges and interest changes confronting libraries and library suppliers during extraordinary periods, and to explore cooperative mechanisms between them in such contexts.

[Method/Process] The cooperation between libraries and library suppliers is analyzed from theoretical and practical dimensions: at the theoretical level, through game-theoretic analysis of payoffs and equilibrium points; at the practical level, via multiple case studies of measures adopted by selected libraries and suppliers during the COVID-19 pandemic, with cross-validation conducted between both dimensions.

[Results/Conclusion] Libraries and library suppliers should adopt a “weathering the storm together” cooperative mechanism, and propose cooperation mechanisms from three aspects: product pricing cooperation mechanism, reputation-trust cooperation mechanism, and value enhancement cooperation mechanism.

Full Text

Abstract

[Purpose/Significance] This paper clarifies the challenges and changes in benefits faced by libraries and book suppliers during extraordinary periods, and explores the cooperation mechanisms between libraries and book suppliers under such circumstances. [Method/Process] The cooperation between libraries and book suppliers is analyzed from both theoretical and practical perspectives. At the theoretical level, game theory is employed to analyze the benefits and equilibrium points of libraries and book suppliers. At the practical level, a multi-case study approach is used to examine measures taken by selected libraries and

book suppliers during the COVID-19 pandemic, with mutual verification conducted between the theoretical and practical analyses. **[Result/Conclusion]** Libraries and book suppliers should adopt a “weathering the storm together” cooperation mechanism, which is elaborated through three aspects: product pricing cooperation mechanism, reputation and trust cooperation mechanism, and value enhancement cooperation mechanism.

Keywords: book supplier; social capital theory; game analysis; multi-case study; cooperation mechanism

1. Related Literature and Theoretical Review

1.1 Research on Libraries and Book Suppliers

1.1.1 Cooperation Between Libraries and Book Suppliers Research on cooperation between libraries and book suppliers primarily focuses on cooperation mechanisms and existing problems in collaboration. Regarding cooperation mechanisms, Yang Shu-qiong argues that book suppliers constitute an important component of library resource construction, and that the library supply market should seek cooperative development through three mechanisms: communication and exchange, collaborative development, and mutual benefit. Cui Yan-li et al. analyze information transmission, business interaction, and deep cooperation between university libraries and book suppliers, constructing eight functional modules based on these three levels. Shen Xiu-qiong reviews the current state of the university library supply market, analyzes the “blue ocean strategy” of book suppliers in the market, and argues that university libraries and book suppliers need to achieve mutual benefit and common development. Liu Ju-xia proposes that when university libraries conduct quality control of information resources to meet personalized information needs, institutional measures should be implemented to compel book suppliers to provide more targeted and high-quality supply services and products.

Regarding problems in library-book supplier cooperation, Cai Yu-fei et al., from the perspective of small and medium-sized libraries, identify issues such as information asymmetry and unfair competition in cooperation with book suppliers, leading to inequitable phenomena. Huang Jin-feng analyzes the problem of trust deficit among book suppliers from the perspective of integrity deficiency, proposing solutions including emphasizing service quality, strengthening supervision and inspection, refining bidding contracts, changing book processing consumables operation methods, and establishing integrity archives and punitive mechanisms for book suppliers. Li Jin-qiu points out various problems in cooperation between university libraries and book suppliers, suggesting that libraries need to implement strict access systems, strengthen cooperation, enhance mutual trust, and improve the business capabilities of both parties to achieve more orderly collaboration.

1.1.2 Library Emergency Services Prior to the COVID-19 outbreak, research on library emergency services was insufficient. Researchers exploring library responses to public safety events typically anticipated possible emergency scenarios and proposed countermeasures for each. The scenarios envisioned by researchers mainly fall into two categories: public safety events and information security events.

Public safety events primarily include earthquakes, fires, and health incidents. Research on library emergency response to earthquakes mainly emerged after the 2008 Wenchuan earthquake, with library scholars proposing recommendations and strategies for establishing earthquake emergency plans. For fire emergency management, library researchers argue for improving library safety management mechanisms, perfecting firefighting organizations, and implementing fire safety responsibilities. Research on public health events primarily examines the role and tasks of libraries in public health emergencies, exploring emergency response mechanisms including resource guarantee and information services. In terms of information security, Xiao Hua analyzes the characteristics and behaviors of information-disadvantaged groups in accessing emergency information, arguing that libraries need to strengthen assistance to these groups and improve emergency information service strategies. Li Chao analyzes the current state of emergency management of library literature and information resources, proposing the establishment of a comprehensive disaster management system for library literature and information resources, and discussing its content, process, and guarantee mechanisms. Additionally, Yang Min et al. review the current state of emergency management in university libraries, analyze existing problems, and propose management strategies based on three dimensions: physical, logical, and humanistic. Zhang Jing summarizes the disaster emergency services of the U.S. National Library of Medicine, suggesting that domestic libraries can learn from American libraries' emergency information services, professional talent cultivation, and resource mining measures.

After the COVID-19 outbreak, library scholars began to focus intensively on how libraries should respond to public health emergencies. Ke Ping et al. examine the position and role of public libraries before, during, and after public emergencies, arguing that libraries' emergency management functions are inadequate before events, service content increases during events, and libraries should emphasize their role in emergency management after events. Zeng Jian-xun argues that libraries need to establish emergency service organizational systems, intra-library emergency service coordination models, emergency resource organization and service systems, and emergency service promotion channels when facing emergencies. Cai Ying-chun et al., using the example of Shanghai Normal University Library' s measures during the pandemic, discuss emergency service mechanisms for university libraries, arguing that they should utilize online services and offline resources to guarantee user needs. Cai Ying et al. analyze the utilization of open access resources by university libraries during the pandemic, suggesting that libraries should integrate OA resources with collection resources, improve the openness of domestic OA institutional and disciplinary repositories,

strengthen promotion of online OA resources, and improve the policy environment for OA resources.

1.1.3 Literature Review Summary In summary, current research on library-book supplier cooperation mainly focuses on cooperation systems and solving problems in collaboration. Research on library emergency management services primarily examines earthquakes, fires, and health incidents. After the COVID-19 outbreak, library scholars began to deeply reflect on the role, function, and emergency mechanisms of libraries during extraordinary periods.

Changes in the external environment during extraordinary periods alter the library supply market, with problems such as volatile markets and information asymmetry becoming prominent. Libraries and book suppliers must address and adapt to these new challenges, as neither party can overcome difficulties alone. This prompts us to consider new directions for cooperation between libraries and book suppliers during extraordinary periods. As responsible institutions and organizations, both libraries and book suppliers must fulfill their social responsibilities during extraordinary periods. Corporate social responsibility primarily influences corporate performance through social capital. Therefore, this paper analyzes the cooperative game between libraries and book suppliers during extraordinary periods from the perspective of social capital theory, then uses multi-case study analysis to examine emergency measures taken by libraries and book suppliers, and finally proposes cooperation mechanisms between libraries and book suppliers.

1.2 Social Capital Theory

Social capital theory posits that enterprises or individuals purposefully establish and develop social relationships, and utilize these relationships to generate tangible or intangible benefits, which can be social, psychological, emotional, or economic. Current research on social capital theory is roughly divided into three perspectives: social resource view, social norm view, and acquisition capability view. The social resource view holds that social capital mainly consists of resources within social relationships, which enterprises or individuals use to improve their benefits. The social norm view argues that social capital comprises trust, networks, and norms, where good social trust facilitates cooperation and improves benefits. The acquisition capability view considers social capital as the ability of individuals within social network structures to mobilize scarce resources.

Researchers' understanding of social capital varies across contexts, leading to different measurement approaches. Currently, social capital measurement features two main characteristics: component-based measurement and hierarchical measurement. Component-based measurement divides social capital into multiple components or dimensions for measurement, with social trust being the most important, stable, and easily measurable component. Hierarchical measurement is divided into individual and collective levels, with social networks as

the main indicator at the individual level, and trust, public participation, and social norms as main indicators at the collective level. The primary problem in social capital measurement is that scholars use widely differing proxy indicators, lacking relatively universal proxies.

Social capital creates value for enterprises through three paths: First, it strengthens trust among stakeholders, improving the completion of transaction and social contracts. Second, it forms alliances with external stakeholders, providing access to complementary resources. Third, it reduces transaction costs in negotiation and consultation, thereby generating profits.

Library social capital is divided into external and internal social capital. External social capital refers to social relationship networks between the library and external social environments, including vertical relationships with supervisory departments, parallel relationships with other libraries and information centers, and longitudinal relationships with upstream and downstream enterprises in the library industry. Internal social capital refers to collaborative relationship networks among library departments and staff. These internal and external social capitals constitute library social capital [Figure 1: see original paper].

As an important carrier of social public service resources, libraries' main function is to serve readers and users. Based on user needs, libraries develop various functional programs. Generally, library user needs fall into three categories: resource needs, space needs, and service needs. Resource needs primarily refer to paper resources, electronic resources, literature resources, and special resources. Space needs mainly include information commons, learning spaces, and maker spaces. Service needs primarily involve intelligent inventory, precise book location, self-service borrowing and returning, and personalized services.

However, during extraordinary periods, library user needs change, and libraries' strategic position becomes particularly important. After the COVID-19 outbreak, Chinese scholars focused primarily on the virus and epidemic, making libraries' intelligence support for basic science and think tank disciplinary intelligence services crucial for experts' research. Additionally, due to geographical restrictions, users cannot access in-library resources, utilize library spaces, or enjoy librarian services. Libraries need to reallocate resources, change conventional management models, and use internal and external social capital to ensure service effectiveness.

2. Analysis of Stakeholders

2.1 Challenges Faced by Libraries During Extraordinary Periods

During extraordinary periods, libraries need to use their own resources, social capital, and products, resources, and services provided by book suppliers to serve users. When libraries use their own resources and social capital to help users, they expend substantial funds, manpower, and materials, but their social capital increases, bringing long-term benefits. The library' s benefit function is

$X = M_z + M_{xy} - X'$, where M_z represents financial support from supervisory departments and M_{xy} represents financial support from social capital. X' represents library costs, which consist of two parts: human capital and purchases of book supplier products, resources, and services. Thus, $X' = \sum_i^n k_i P_i + C$, where P represents product prices from book suppliers, k represents product quantities, and C represents library human capital. Therefore, the library's benefit function during extraordinary periods can be expressed as:

$$X = M_z + M_{XY} - \sum k_i P_i - C \quad (\text{Formula 1})$$

Libraries face two strategic choices: “going it alone” or “weathering the storm together.” “Going it alone” means libraries primarily use their own funds and resources to serve users, resulting in high costs (X' is high) and lower service quality, leading to reduced financial support ($M_z + M_{xy}$ is low) and overall lower benefits (X is low). “Weathering the storm together” means libraries collaborate with social capital to serve users, utilizing social capital funds and resources at relatively lower costs (X' is low). With relatively abundant and comprehensive resources from social capital, service quality is higher, attracting more financial support ($M_z + M_{xy}$ is high) and resulting in overall higher benefits (X is high).

2.2 Challenges Faced by Book Suppliers During Extraordinary Periods

Book suppliers are important components of the library industry, primarily including database providers, space designers, and management companies. During extraordinary periods, when social operation basically stalls, book suppliers need to fulfill corporate social responsibility and take active measures to help the public. However, book suppliers' corporate performance faces enormous challenges, with most unable to conduct normal business operations. In this situation, book suppliers must correctly face the situation and adopt self-rescue measures.

Research indicates that corporate social responsibility has an inverted U-shaped relationship with corporate performance. Besides necessary self-rescue measures, book suppliers need to reasonably utilize corporate social responsibility to create social capital, thereby generating performance. Book suppliers' main paths to generating performance during extraordinary periods are twofold: maintaining their own business to create performance, and using social capital to create performance.

The benefit function from business operations can be expressed as $Y_1 = \sum_i^n k_i (P_{i1} - P_{i0})$, where P_{i1} represents product prices during extraordinary periods, P_{i0} represents normal period prices, n represents product types, and k represents product quantities. Thus, Y_1 represents benefits gained through price increases during extraordinary periods. The benefit from book suppliers' behavior can be expressed as $Y_2 = a[b - (C_1^2 - C_0^2)]$, where a and b

are constants, C_1 represents social capital during extraordinary periods, and C_0 represents normal period social capital. Corporate performance is represented by the negative square of social capital because the relationship between corporate performance and social capital is inverted U-shaped. Therefore, book suppliers' benefits during extraordinary periods can be expressed as:

$$Y = Y_1 + Y_2 = \sum_i^n k_i(P_{i1} - P_{i0}) + a[b - (C_1^2 - C_0^2)] \quad (\text{Formula 2})$$

Book suppliers also face two strategic choices: “profiteering” or “weathering the storm together.” “Profiteering” means book suppliers prioritize business, taking advantage of market supply-demand imbalance during extraordinary periods to increase prices or hoard products, thereby increasing short-term performance (Y_1 is high) but reducing social capital, which is detrimental to long-term performance (Y_2 is negative). “Weathering the storm together” means book suppliers prioritize social responsibility, sacrificing short-term performance to help users through difficult times (Y_1 is low, Y_2 is positive), thereby rapidly increasing social capital that can generate long-term performance.

2.3 Interest Analysis of Libraries and Book Suppliers

Libraries and book suppliers have a relationship of both cooperation and competition. Libraries need support from book suppliers to serve users, while book suppliers need libraries as customers and to create social capital benefits and improve performance. Libraries focus on the cost-effectiveness of products and services to better serve users, while book suppliers use internal resources and core products to transact with libraries, expand market share, and obtain more profits. During extraordinary periods, normal operations of both parties are greatly affected, breaking the balance of their cooperative and competitive relationship. Both should seek new benefit balance points to continue cooperation.

Supervisory departments and government agencies are the management bodies for libraries and book suppliers. Libraries' supervisory departments concern themselves with library expenditures, functional performance, and user satisfaction, making libraries' main tasks improving resource utilization efficiency and user satisfaction. Book suppliers' government departments concern themselves with tax revenue and social assistance, making book suppliers' main tasks maximizing corporate performance and fulfilling corporate social responsibility.

Several principles exist in library-book supplier cooperation: First, all stakeholders remain rational, making decisions to maximize their own benefits. Second, all stakeholders are influenced by others' decisions and revise their own accordingly. Third, the game between stakeholders occurs under incomplete information, where each has limited knowledge of others and can only base decisions on observed actions. Fourth, the game is dynamic, requiring stakeholders to understand others' actions before deciding.

3. Game Analysis Between Libraries and Book Suppliers

shows the game process between libraries and book suppliers. In incomplete information dynamic games, decision-makers are rational, fully analyzing their own interests after observing opponents' choices and adjusting strategies in real-time. From the library's perspective, choosing "weathering the storm together" clearly yields higher benefits X (higher X) than "going it alone" (lower X). Therefore, libraries will always choose "weathering the storm together," providing better services at lower costs.

For book suppliers, the situation is more complex. Assuming corporate benefits are Y_r when $Y_2 < 0$ and Y_c when $Y_2 > 0$, book suppliers must compare Y_r and Y_c . They choose "profiteering" when $Y_r > Y_c$ and "weathering the storm together" when $Y_r < Y_c$. Let $F = Y_c - Y_r$. Since $Y = Y_1 + Y_2$, when the difference in Y_2 between "weathering the storm together" and "profiteering" is smaller than the difference in Y_1 , F is negative and book suppliers choose "profiteering." Conversely, they choose "weathering the storm together."

Let $g(C_1) = Y_2 = a[b - (C_1^2 - C_0^2)]$, then $g(x) = A - ax^2$, where $A = ab + aC_0^2$ is a constant. Then:

$$\Delta Y = g(x_1) - g(x_2) = -a(x_1^2 - x_2^2) \quad (\text{Formula 3})$$

[Figure 3: see original paper] shows the relationship between the two strategies' social capital performance. Y_1 represents performance gained through price increases, with main influencing factors being price P and sales quantity k per product type. In [Figure 3: see original paper], there exists a $\Delta Y_1'$ equal to ΔY . When $\Delta Y_1 < \Delta Y$ (below $\Delta Y_1'$), book suppliers choose "weathering the storm together." When $\Delta Y_1 > \Delta Y$ (above $\Delta Y_1'$), they choose "profiteering."

Libraries consistently choose "weathering the storm together" and hope more book supplier enterprises will join their service team to better help users through extraordinary periods. Therefore, when facing public emergencies, libraries need to establish reasonable cooperation strategies to incentivize more book suppliers to participate, primarily by reducing the Y_1 difference and increasing ΔY .

4. Multi-Case Study of Libraries and Book Suppliers During Extraordinary Periods

The previous research examined the game process between libraries and book suppliers at the theoretical level, analyzing different choices under different benefit scenarios. However, it did not consider the actual conditions of libraries and book suppliers. Therefore, this study further explores real-world measures taken by libraries and book suppliers, analyzing game outcomes from a practical perspective to validate the theoretical game analysis.

4.1 Data Collection and Research Methods

This study selected libraries and book suppliers as research objects (see). As Wuhan was one of the most severely affected areas in China' s COVID-19 outbreak, this study selected several public and university libraries in Wuhan, which are more representative than libraries in other regions. Book suppliers selected were database providers. Relevant news and materials about libraries and book supplier enterprises during the pandemic were collected and analyzed.

4.2 Data Coding

Based on collected news materials, researchers filtered measures taken by libraries and book suppliers to serve users during the pandemic. Following the sequence of open coding, axial coding, and selective coding, the data were coded (see). The study summarized 12 measures categorized into 4 tree nodes, ultimately deriving two core categories: online and offline.

4.3 Content Analysis

The analysis of raw materials yielded two core categories: online and offline. It is evident that during the COVID-19 pandemic, the vast majority of measures were online, with only three offline measures: psychological counseling, book donations to makeshift hospitals, and book donations to medical teams. Psychological counseling materials mainly came from South-Central Minzu University Library, whose staff went to frontline anti-epidemic positions and used psychology to help with mass psychological guidance. Book donations to makeshift hospitals and medical teams mainly came from public libraries, with Hubei University Library also donating books to makeshift hospitals.

Online measures were relatively numerous, mainly in three aspects: resource opening, online research and teaching, and cultural activities. In terms of resource opening, almost all libraries provided users with access to resources because usual activities could only be conducted online from home. While libraries provided remote access methods such as VPN, many book suppliers made their resources freely available to the public. Additionally, Clarivate Analytics created a special "Novel Coronavirus Research Resources Column" to help research experts obtain timely scientific progress on COVID-19.

Regarding online research and teaching, university libraries basically provided related services. Despite the severe epidemic, Wuhan universities proposed the concept of "suspended classes, ongoing learning; suspended classes, ongoing teaching," organizing teachers and students to attend classes and study at home. As service institutions, libraries undertook tasks to organize teachers and students to learn how to conduct online research and study before the semester began, organizing relevant disciplinary lectures and requiring subject librarians to remain online for disciplinary services.

In terms of cultural activities, many libraries held various cultural events during

the pandemic, such as anti-epidemic essay contests and organizing students to check in daily for reading literature. These activities helped guide library users to demonstrate good spiritual qualities and ensured students gained from their studies.

The analysis of materials from libraries and book suppliers shows that both chose “weathering the storm together.” Libraries used online resources to serve users through resource opening, online training and lectures, and cultural activities. Book suppliers cooperated with libraries by providing free resource access, offering research tools, and creating COVID-19 resource columns. Therefore, during extraordinary periods, the game outcome between libraries and book suppliers is “weathering the storm together.”

5. Cooperation Mechanisms Between Libraries and Book Suppliers from a Game Perspective

Based on the comprehensive analysis of game theory and multi-case studies, libraries and book suppliers need to establish an active and effective cooperation mechanism to jointly address major public events during extraordinary periods.

5.1 Product Pricing Cooperation Mechanism

According to game analysis results, book suppliers’ product pricing affects their choices during extraordinary periods. Libraries should respond in two ways. First, libraries should form alliances to jointly resist abnormal price increases by some book suppliers. Price increases during extraordinary periods reduce corporate social capital, significantly decreasing the performance Y_2 created through social capital. Price increases also reduce product sales quantity k , leaving the performance Y_1 gained through price increases largely unchanged, resulting in overall declining benefits Y . This makes book suppliers more willing to cooperate with libraries and maintain normal price ranges. Second, when cooperating with book suppliers, libraries should consider enterprises’ special circumstances during extraordinary periods. Due to logistics and other factors, book suppliers’ costs are relatively higher. When benefits from social capital cannot be timely transformed into performance, book suppliers can only accept a certain degree of negative income. To maintain normal market balance, libraries should accept appropriate price increases.

5.2 Reputation and Trust Cooperation Mechanism

Cooperation between libraries and book suppliers requires establishing a mechanism based on corporate reputation. Extraordinary periods provide excellent opportunities for libraries to evaluate book suppliers’ reputations. When cooperating with libraries, book suppliers should maintain good service conditions to enhance their reputation and build more trusting cooperative relationships. Improved reputation and trust can effectively increase corporate social capital and enhance performance Y_2 created through social capital. During extraordinary

periods, book suppliers can adjust their paid service strategies, changing from prepayment to post-payment for higher service efficiency and improved mutual trust. Furthermore, during service processes, book suppliers should maintain staff numbers and guarantee levels to enhance libraries' recognition of their capabilities and improve their reputation, particularly ensuring network resource services with huge library user demand. When cooperating with book suppliers, libraries should support their development by recognizing their services during extraordinary periods, issuing certificates or materials proving their participation in joint anti-epidemic efforts. Such proof serves as social capital for book suppliers, making it easier for them to gain library recognition in future cooperation.

5.3 Value Enhancement Cooperation Mechanism

On April 8, 2020, President Xi Jinping mentioned at the meeting of the Standing Committee of the Political Bureau of the CPC Central Committee: "Facing the severe and complex international epidemic and world economic situation, we must adhere to bottom-line thinking and make mental and work preparations for responding to external environmental changes over a relatively long period." This indicates that changes in the external environment brought by the epidemic are complex and long-term, making long-term cooperation between libraries and book suppliers a new normal. Long-term cooperation will bring changes in cooperation concepts, methods, breadth, and depth, inevitably enhancing the core values of both parties.

Libraries' core value is mainly reflected in their service capabilities and levels. Innovating service models and improving service levels cannot be achieved without librarians. Under the new normal of long-term cooperation, book suppliers maintain more frequent online and offline contact with libraries, transmitting the latest service concepts, new products, and technologies to librarians, providing platforms and channels for librarians' lifelong learning and academic research. Through online and offline business learning, academic exchanges, and product experiences, librarians can combine their actual work to expand new service projects, improve service processes, scientifically evaluate resource utilization, use book suppliers' technical support to build library special resources, optimize collection resource allocation, and ultimately improve overall library professional service levels, demonstrating libraries' core value.

Enterprises' core competitiveness lies in their products' advancement, effectiveness, and good user experience. Through frequent and in-depth exchanges with libraries, book suppliers become familiar with libraries' new business needs and readers' service requirements, providing favorable help for launching new products and discovering new business opportunities. Additionally, book suppliers' contact with library directors, department heads, and staff provides first-hand feedback on product usage, which can improve product functions and quality, reduce production costs, improve after-sales service quality, expand market share, and win good reputation, thereby promoting the enhancement of book suppliers'

core corporate value.

Conclusion

From late 2019 to early 2020, China faced a fierce outbreak of novel coronavirus pneumonia, which subsequently entered a normalized prevention and control stage. Under this major public event, the library industry also faced significant challenges. During the pandemic, libraries needed to consider how to serve users and meet their needs during extraordinary periods, and how to maintain the stability of the library supply market for long-term stable development. This paper analyzed challenges faced by libraries and book suppliers during extraordinary periods, examined both parties' benefits from a theoretical perspective, and used game analysis to identify equilibrium points that lead both libraries and book suppliers to choose "weathering the storm together." At the practical level, multi-case study methods were used to analyze measures taken by selected libraries and book suppliers during the COVID-19 pandemic. Finally, this paper proposed cooperation mechanisms between libraries and book suppliers from three aspects: product pricing cooperation mechanism, reputation and trust cooperation mechanism, and value enhancement cooperation mechanism.

However, this study has certain limitations. The game analysis could consider more parameters, and the multi-case study only examined measures taken by libraries and book suppliers without exploring deeper influencing factors. Future research should continue to investigate cooperation between libraries and book suppliers to comprehensively promote their cooperative development.

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