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Unveiling the Determinants of Book Renewals: An Interdisciplinary Exploration using Factor and Regression Analysis

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Abstract

This paper aims to comprehensively analyze readers' borrowing and renewal behaviors, explore the influencing factors, and provide data-driven support for library resource allocation and borrowing policy formulation. Focusing on readers' borrowing data, the study first classifies the data based on whether there is a book renewal behavior and segments it into three periods (2016-2018, 2019-2021, 2022-2024). Then, various statistical methods, such as Logarithmic Transformation, Principal Component Analysis (PCA), Z-score, Binary Logistic Regression, Quantile Regression, and moderation effect analysis using the PROCESS macro for SPSS, are applied. The research reveals that the distribution of total book borrowings and renewals shows that most data cluster around lower volumes with some high-value outliers, and the median values remain relatively stable over time. Different factors have diverse impacts on book renewal and borrowing behaviors; for instance, in different periods, variables like reader types and gender have varying influences on renewal behavior, and in the quantile regression analysis of LogTotal, different variables exhibit different significance levels at different quantiles. This study provides a detailed and systematic multi-perspective analysis using multiple statistical methods, offering new insights into understanding reader behavior patterns and guiding libraries to optimize resource management and formulate more targeted borrowing policies.

Keywords: Behavior, Book renewal, Factor, Library, Moderation effect, Regression.

1. Introduction

Libraries serve as dynamic hubs for knowledge dissemination, with their roles evolving in tandem with technological advancements and shifting user needs. A critical yet underexplored facet of this evolution is book renewal behavior—a practice that bridges reader engagement, resource accessibility, and institutional policy. While library automation and reader service literature occasionally touch on renewal processes, there is a notable gap in research that systematically examines the determinants of renewal decisions, their distributional heterogeneity, and their interplay with institutional policies. This study addresses this gap by analyzing borrowing data from Nanjing Normal University Library, integrating interdisciplinary frameworks to uncover nuanced patterns in renewal dynamics.

Book renewal policies embody the tension between individual learning rhythms and collective resource equity. Traditional manual renewal systems have given way to digital self-service platforms, such as online portals and mobile applications, which offer unprecedented flexibility (She et al., 2023). For instance, Zhejiang Library's circulation data reveals that online renewal users exhibit higher return punctuality, while non-renewing overdue patrons often cite awareness gaps as the primary barrier (Liu, 2015; Kou & Zheng, 2010). Such findings highlight the dual role of renewals: they not only mitigate administrative burdens but also reflect underlying disparities in digital literacy and service engagement.

Disciplinary and demographic differences further complicate renewal patterns. Yu (2010) observed higher renewal rates for social science books compared to natural science materials, a trend linked to curricular structures and knowledge production cycles in STEM fields. Meanwhile, cross-disciplinary research emphasizes the importance of accounting for reader demographics, such as gender and academic status, in educational assessments (Chandra et al., 2024), a principle applicable to library service utilization. Yet, few studies have explicitly modeled how these factors interact with institutional policies, such as Nanjing Normal University Library's tiered borrowing limits (30 books for students/faculty vs. 5 for other readers) and differential renewal periods (30 days for Chinese books, 15 days for foreign language materials).

Existing literature on book renewals is largely descriptive, focusing on usage statistics rather than causal inference or distributional analysis. For example, while studies identify renewal awareness and policy clarity as key barriers (Liu, 2015; Kou & Zheng, 2010), they lack rigorous modeling of how reader type (e.g., undergraduate, faculty) and gender influence renewal likelihood. Additionally, mean-based models (e.g., OLS regression) dominate

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the field, overlooking heterogeneous effects across renewal frequencies, such as whether faculty members exhibit distinct renewal patterns at the upper tail of the distribution compared to students.

This study advances the field through three objectives: Use binary logistic regression to assess how reader type and gender affect renewal likelihood, controlling for borrowing history (LogTotal) and latent behavioral factors (Z-Score components). Employ quantile regression to examine how predictors influence low (10th percentile), median (50th percentile), and high (90th percentile) values of LogTotal, addressing limitations of mean-focused approaches. Investigate how Nanjing Normal University Library's renewal rules—including borrowing caps, language-specific renewal periods, and eligibility criteria—interact with reader demographics to shape renewal outcomes. Guided by these objectives, the study addresses the following questions:

Q1: What factors influence book renewal decisions, and does the reader type's effect on renewal likelihood vary by gender?

Q2: How do reader type, gender, and renewal status differentially impact the distribution of renewal frequency (LogTotal) across quantiles?

Drawing on interdisciplinary insights from education (Schijf et al., 2022) and data science (Bednarowska-Michaiel & Uprichard, 2025), the study employs a mixed-methods approach. Principal component analysis (PCA) reduces dimensionality in borrowing data, while binary logistic regression models binary renewal outcomes. Quantile regression then explores heterogeneous effects, offering robustness against outliers and uncovering asymmetric relationships hidden in traditional analyses. By bridging library science with quantitative methodology and policy analysis, this study yields threefold contributions: Enhances understanding of how interdisciplinary factors (e.g., disciplinary norms, gender socialization) shape library service use. Demonstrates the utility of quantile regression in capturing renewal behavior heterogeneity, complementing mean-based models. Informs "reader-centric" policy adjustments, such as targeted renewal reminders for underutilized groups or flexible limits for rare resources, ensuring equitable access while optimizing circulation efficiency.

In an era of digital transformation, where libraries increasingly balance physical and digital services, this research provides a data-driven foundation for refining renewal systems. By addressing both individual-level behaviors and institutional constraints, it offers actionable insights to enhance library relevance in supporting academic and lifelong learning.

2. Previous Research

Interdisciplinary research and education have garnered significant attention in higher education, with scholars emphasizing their role in addressing complex real-world problems and fostering innovative solutions. Previous research has underscored the growing importance of interdisciplinary research in higher education, highlighting its role in addressing complex real-world challenges and fostering innovative solutions. Schijf et al. (2022) conceptualized interdisciplinary understanding as comprising six core elements—knowledge of disciplinary paradigms, knowledge of interdisciplinarity, reflection skills, critical reflection skills, communication skills, and collaboration skills—and validated a two-tier model (knowledge and skills as higher-order factors) through confirmatory factor analysis. While their study found measurement invariance across academic disciplines, the observed covariances between error terms of latent factors (e.g., critical reflection with communication, collaboration with reflection) suggest potential overlaps in these constructs, calling for further refinement of interdisciplinary competency frameworks to enhance assessment precision in educational contexts. Chandra et al. (2024) explored assessment styles in interdisciplinary education and revealed disciplinary differences in performance—law students excelled in essay-based assessments, while arts students performed better with worksheet-based tasks, highlighting the need for inclusive assessment design to ensure equitable learning experiences. This insight is relevant to the present study, as book renewal behaviors may reflect diverse disciplinary preferences in accessing library resources, warranting consideration of reader demographics in model development.

Klaassen (2018) emphasized the challenges of disciplinary boundedness in traditional higher education, contrasting it with interdisciplinary research that thrives on bridging disciplines, fostering collaboration, identifying novel problems, and generating cross-disciplinary knowledge. However, the study raised questions about operationalizing "problem identification" and "novel solutions" as measurable indicators in research and pedagogy, particularly in applied fields like library science. Hubbard (2021) addressed disciplinary literacies, noting students' lack of explicit training in cross-disciplinary reading and critical thinking, which complicates academic reading in interdisciplinary contexts. This deficit underscores the importance of integrating transferable skills training into curricula, with implications for library services: renewal behaviors may be influenced by readers' ability to interpret borrowing policies, suggesting instructional interventions to improve renewal rates. Spence et al. (2024) explored barriers to early-career academics' interdisciplinary engagement, such as tenure pressures and disciplinary power imbalances, underscoring the need for institutional support. In library science, this suggests that unified renewal policies across departments could mitigate access barriers for researchers navigating multiple disciplines.

Bednarowska-Michaiel and Uprichard (2025) examined interdisciplinary data science education, emphasizing collaborative curriculum design to address ethical, societal, and technological challenges. This perspective encourages considering ethical dimensions of data usage (e.g., privacy in reader behavior analysis) and societal contexts of library services in the present study. In interdisciplinary humanities education, Novis-Deutsch et al. (2024) demonstrated its potential to foster identity development and co-constitutive knowledge-building through integrating philosophy, literature, and history. While focused on the humanities, their emphasis on interdisciplinary learning as a site for holistic skill development resonates with library science, where readers' disciplinary backgrounds and identities may influence renewal decisions. Methodologically, Evans et al. (2020) advocated for triangulation (data, method, space, and person) to enhance the validity and reliability of pedagogical research, a framework applicable to interdisciplinary studies integrating diverse methodologies. For the current research, a mixed-methods approach combining quantitative factor analysis with qualitative reader surveys could strengthen findings by triangulating behavioral data with contextual insights into renewal motivations.

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In library science, existing research on book renewals is limited but revealing. Liu (2015) found that renewal users exhibit stronger punctuality in returns, while non-renewing overdue readers often lack awareness of renewal services, pointing to gaps in user education. Kou and Zheng (2010) identified overdue items and renewal limits as common causes of renewal failures, advocating for clearer user guidance and interface improvements (e.g., real-time eligibility alerts). She et al. (2023) highlighted mobile-based self-service renewals but noted the need to investigate digital literacy disparities across demographics. Yu (2010) observed disciplinary preferences in renewals, with social science books renewed more frequently than natural science materials, likely due to curricular structures, emphasizing the importance of subject-specific variables in predictive models.

Prior research provides theoretical and methodological foundations for interdisciplinary inquiry but leaves gaps in linking disciplinary differences to library service utilization. The present study builds on these insights by applying factor and regression analysis to uncover determinants of book renewals, innovating through integrated multimethod analysis (binary logistic regression and quantile regression), introducing gender as a moderator, and using quantile regression to assess predictor effects across different percentiles of renewal frequency. These approaches aim to bridge interdisciplinary frameworks with library user behavior and inform reader-centric renewal policies.

3. Date and Method

3.1. Research Samples

3.3.1. Comparison between the Number of Renewals and the Number of Borrowings

2016 - 2018: The total number of book renewals reached 90,993, in contrast to the 896,244 recorded borrowings. The ratio of renewals to borrowings stood at 10.2%, suggesting that approximately one renewal occurred for every ten borrowings. This statistic implies that the majority of books were not subjected to renewal following their initial borrowing.

2019 - 2021: A decline in renewals was observed, with a total of 43,963, whereas the number of borrowings amounted to 477,481. The ratio of renewals decreased to 9.2%. This reduction indicates a diminished propensity among readers to renew their borrowed materials during this timeframe compared to the preceding period.

2022 - 2024: The renewals increased slightly to 38,956, while borrowings decreased to 303,344. Notably, the ratio of renewals to borrowings rebounded to 12.9%. This resurgence suggests an increase in readers' willingness to renew their borrowed materials relative to the previous period.

3.1.2. Comparison between the Number of Renewing Readers and the Number of Borrowing Readers

2016 - 2018: The cohort of renewing readers totaled 9,421, with 33,205 individuals categorized as borrowing readers. The proportion of renewing readers relative to borrowing readers was 28.4%, indicating that more than a quarter of those who borrowed books opted for renewal.

2019 - 2021: The number of renewing readers declined to 5,325, while borrowing readers decreased to 26,488. The ensuing proportion dropped to 20.1%. This marked decrease illustrates a significant contraction in the demographic actively engaging in the book renewal.

2022 - 2024: The count of renewing readers experienced a slight increase to 5,463, accompanied by a reduction in borrowing readers to 20,850. Consequently, the proportion of renewing readers rose to 26.2%. Despite the nominal increase in renewing readers, the significant decline in borrowing readers resulted in a higher relative proportion of renewals, indicating an enhanced willingness among borrowing readers to pursue renewals.

3.2. Research Design

The research background focuses on the book renewal rules of Nanjing Normal University Library. Different borrowing limits are set according to the types of readers, with undergraduate students, postgraduate students, and faculty members allowed to borrow up to 30 books each, and other readers up to 5 books. The loan periods vary as well, with ordinary books having a general loan period of 60 days and sample books of 7 days. Renewal is permitted under specific conditions, namely when another reader has not reserved the book and the reader's account has no overdue books or fees exceeding ¥1.00. Renewal can be done within 7 days before the due date through online self-service or offline manual methods. The renewal durations differ for various books: ordinary Chinese books can be renewed for 30 days, ordinary foreign language books for 15 days, and sample books are not eligible for renewal. The maximum retention period for a book by a reader is 90 days.

Book renewal policies at Nanjing Normal University Library are significant. They balance library service flexibility with readers' knowledge needs, emphasizing a "reader-centric" ecosystem for academic research and lifelong learning. Renewals reduce the need for physical return and re-borrowing, benefiting readers with limited library access. They also help avoid penalties from unexpected delays, offering financial and logistical ease. Reasonable extensions meet genuine needs, ensuring individual goals and resource sharing, while limits prevent hoarding when a book is reserved. Considering varying reading speeds, renewal policies support slower readers and in-depth research. Longer borrowing periods aid understanding, note-taking, and analysis, especially for core or unique resources without digital alternatives. These policies arise from real academic needs, balance convenience and cost, and reflect readers' pursuit of efficient knowledge and libraries' user-centered, flexible access. The research design is in Figure 1.

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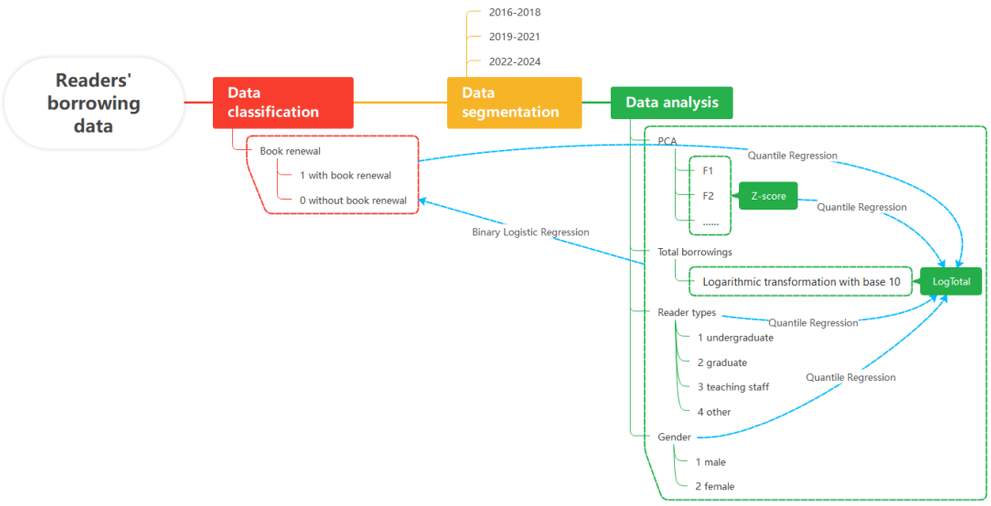

Figure 1. Research design.

3.2.1. Data Source and Initial Processing

Readers are divided into two categories according to whether they have the behavior of renewing books: those with book renewal (marked as 1) and those without book renewal (marked as 0). This step provides a basic classification framework for subsequent analysis and clarifies the characteristics of different behavior groups.

3.2.2. Data Segmentation

The data is segmented into three time periods according to the time dimension: 2016 - 2018, 2019 - 2021, and 2022 - 2024. This is convenient for analyzing the changing trends of readers' borrowing behaviors in different periods and exploring the evolution of borrowing behaviors over time.

3.2.3. Data Analysis Methods

Principal Component Analysis (PCA): The data is dimensionally reduced, and the main components (F1, F2) are extracted. While simplifying the data structure, key information is retained, which is convenient for subsequent analysis.

Binary Logistic Regression: A binary logistic regression model is specified to investigate the determinants of book renewal behavior, operationalized as a dichotomous outcome variable (Book Renewal; 1 = renewed, 0 = not renewed). The analysis examines the effect of Reader Type (categorical predictor) while controlling for Z-Score factors and LogTotal as covariates. Gender is included as a moderator to test for differential effects of Reader Type across gender subgroups. The model aims to estimate the log-odds of renewal as a function of predictors, providing insights into factors influencing user decision-making; assess the moderating role of Gender in the relationship between Reader Type and renewal likelihood; identify significant predictors and quantify their contributions to the probability of renewal; and control for potential confounders (Z-Score factors and LogTotal) to isolate the unique effects of Reader Type and Gender.

Quantile Regression: A quantile regression analysis is performed to explore the heterogeneous effects of predictors (Book Renewal, Reader Type, Gender) and covariates (Z-Score factors) on the dependent variable LogTotal across distinct quantiles of its distribution (10th, 50th, and 90th percentiles). This approach aims to model distributional heterogeneity by estimating coefficients at specific quantiles, rather than relying on mean effects (as in OLS regression); assess differential impacts of predictors across the conditional distribution of LogTotal (e.g., whether Reader Type influences low vs. high values of LogTotal differently); evaluate robustness to outliers and relax assumptions of homoscedasticity and symmetric error distributions; control for covariates to isolate the unique effects of each independent variable at different quantiles; estimate 95% confidence intervals for coefficients at each quantile, enabling statistical inference about distribution-specific relationships.

These analyses provide a comprehensive understanding of: (1) the factors influencing book renewal decisions and (2) how predictors shape the distribution of LogTotal, offering nuanced insights beyond mean-based models.

4. Results

4.1. Data Distribution Characteristics

4.1.1. Individuals' Total Book Borrowings Distribution

As shown in Figure 2, the distribution of total book borrowings spans a wide range across different periods (2016–2018, 2019–2021, 2022–2024). Each period has some high-value outliers (isolated data points), while most data clusters around lower borrowing volumes. In the box plots for all three periods, the boxes are positioned close to the lower end of the horizontal axis, indicating that most of the total book borrowings are concentrated at relatively low levels.

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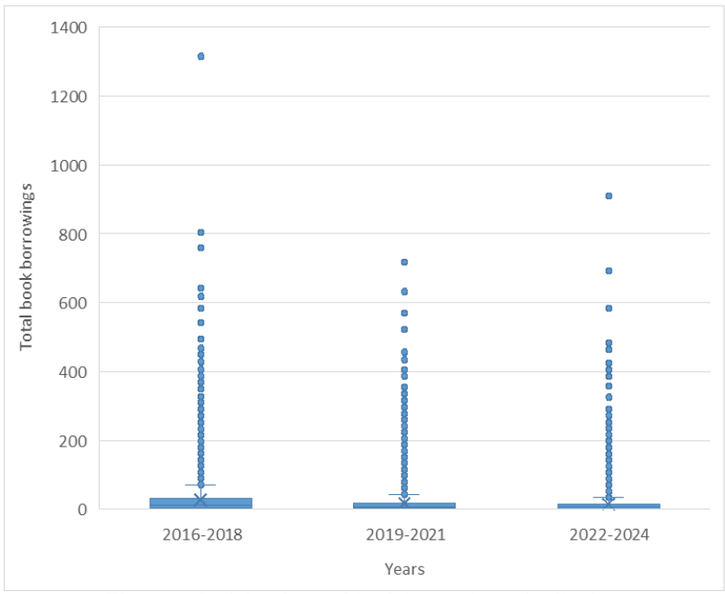

Figure 2. Individuals' total book borrowings distribution.

The median values, marked with "×" in the figure, remain consistently low across the three periods with little variation. This suggests that the midpoint of total book borrowings by individuals has remained stable over time, showing no significant upward or downward trends.

The length of the box in the box plot represents the IQR, which measures data dispersion. The relatively short boxes across all periods indicate that the middle 50% of borrowing volumes are tightly clustered, showing low variability. The boxes for 2016–2018 and 2019–2021 seem slightly longer than that of 2022–2024, suggesting slightly higher dispersion in the middle 50% of data during the earlier periods.

Numerous high-value outliers (denoted by dots) are evident in Figure 2, indicating that a small number of readers borrow far more books than the majority. While the median and box positions show no clear increasing or decreasing trends, the distribution and density of outliers vary across periods. Outliers in 2022–2024 seem more dispersed at higher borrowing volumes compared to the relatively concentrated clusters in 2016–2018 and 2019–2021. This subtle change may reflect evolving reader borrowing behavior, but the stability of core metrics (such as the median) implies that such changes are not yet widespread or following a clear trend.

4.1.2. Individuals' Total Book Renewals Distribution

As illustrated in Figure 2, the distribution of total book borrowings exhibits a broad range across different periods (2016–2018, 2019–2021, 2022–2024). Each period features a few high-value outliers (isolated data points), while the majority of the data clusters around lower borrowing volumes. The box plots for all three periods show that the boxes are situated near the lower end of the horizontal axis, indicating that most total book borrowings are concentrated at relatively low levels.

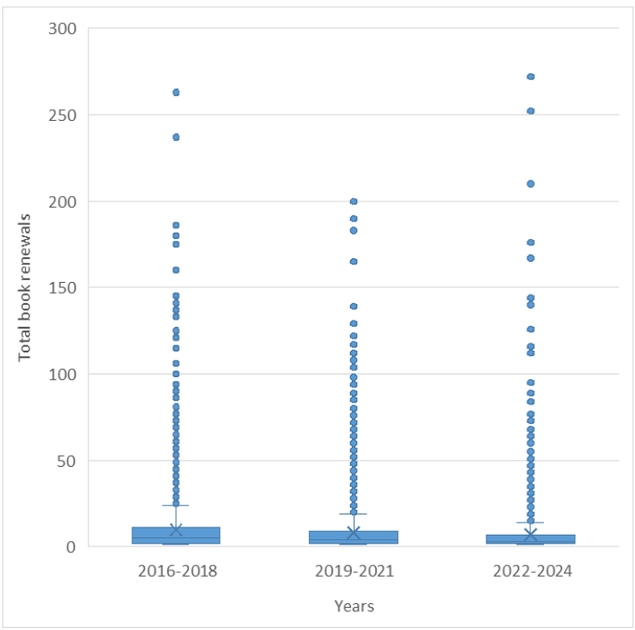

Figure 3. Individuals' total book renewals distribution.

The median values, marked with "×" in the figure, remain consistently low across the three periods with minimal variation. This suggests that the midpoint of reader renewal frequencies has remained stable over time, showing no significant upward or downward trends.

The length of the box in a box plot represents the IQR, which measures data dispersion. The relatively short boxes across all periods indicate that the middle 50% of renewal frequencies are tightly clustered, showing low

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variability. However, the boxes for 2016–2018 and 2019–2021 are slightly longer than those of 2022–2024, suggesting slightly higher dispersion in the middle 50% of data during the earlier periods.

Numerous high-value outliers (denoted by dots) are evident in the figure, indicating that a small subset of readers renew books far more frequently than the majority. While the median and box positions show no clear increasing or decreasing trends, the distribution and density of outliers vary across periods. Outliers in 2022–2024 appear more dispersed at higher renewal frequencies compared to the relatively concentrated clusters in 2016–2018 and 2019–2021. This subtle shift may reflect evolving reader behavior, though the stability of core metrics (e.g., median) suggests that such changes are not yet widespread or systematic.

4.1.3. Book Categories Renewed

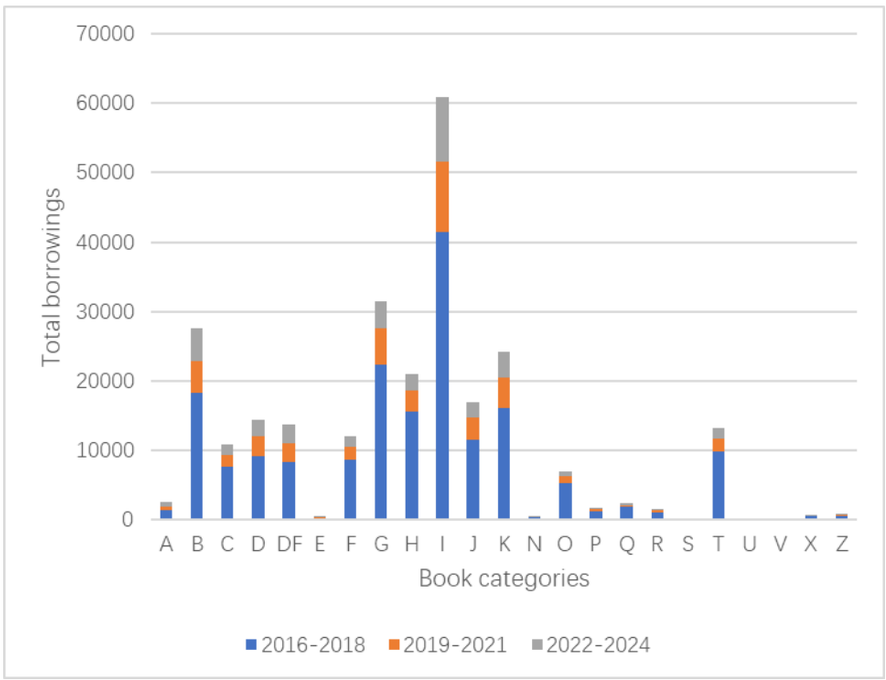

Figure 4. Book categories renewed.

The primary categories for renewed books are concentrated in a few areas: I (Literature), G (Culture/Education), H (Language), K (History/Geography), and B (Philosophy/Religion), which together account for over 75% of the total renewal volume. These categories reflect the core interests of readers (see Figure 4). Literature (I) has consistently been the largest category for reader renewals. While the total volume has decreased over time—potentially due to shifts in overall book circulation—the proportion of renewals remains stable, ranging from 22% to 24%. Notably, the proportion of Culture/Education (G) significantly increased from 2022 to 2024, indicating a rising demand for educational content and popular cultural readings. Conversely, the demand for Language (H) continues to decline, likely influenced by the availability and popularity of digital resources, such as online language learning platforms. History/Geography (K) and Philosophy/Religion (B) have exhibited minimal fluctuation, suggesting a certain resilience in the demand for humanities and social sciences.

In contrast, the overall renewal volume for natural science and technology categories (N, O, P, Q, R, S, T, etc.) remains low, each accounting for less than 5% of the total and displaying a downward trend. For instance, the renewal volume for category T fell from 16,186 in 2016-2018 to just 3,714 in 2022-2024, indicating that readers tend to favor humanities and social sciences when selecting print books.

4.2. Readers' Common Factor Extraction

4.2.1. Results of KMO and Bartlett's Test

2016–2018: The Kaiser-Meyer-Olkin (KMO) test produced a value of 0.678, indicating a moderate correlation among the variables and affirming the suitability of conducting factor analysis. Additionally, Bartlett's test demonstrated significant results ($p < 0.001$), supporting the presence of substantial correlations among the variables.

2019-2021: The Kaiser-Meyer-Olkin (KMO) test yielded a value of 0.636, implying a moderate correlation among the variables. Bartlett's test results were also significant ($p < 0.001$), confirming the existence of substantial correlations among the variables.

2022-2024: The Kaiser-Meyer-Olkin (KMO) test resulted in a value of 0.671, suggesting a moderate correlation among the variables. The results of Bartlett's test were significant ($p < 0.001$), further corroborating the presence of substantial correlations among the variables.

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4.2.2. Disciplinary Composition and Interpretation of Reader Preferences

2016–2018

Factor 1: Proposed label "Humanities, Social Sciences, and Education Factor".

Variable (Discipline)	Factor Loading	Interpretation
C (Social Science)	0.684	Core Variable. This loading denotes the predominant influence and demand for literature in the social sciences.
G (Education)	0.610	Sub-core variable. This loading indicates a strong correlation with Factor 1 and underscores the readers' demand for educational resources.
B (Philosophy)	0.542	Moderate loading. This loading suggests a noteworthy intersection between philosophy and social sciences, particularly regarding theoretical explorations.

Factor 2: Proposed label "Science, Technology, and Natural Sciences Factor".

Variable (Discipline)	Factor Loading	Interpretation
T (Technology)	0.636	Core Variable. This loading reveals a substantial demand for technology-related literature (e.g., information technology, engineering).
P (Astronomy, Earth Science)	0.583	Sub-core variable. This loading indicates a strong correlation with Factor 2, signifying interest in natural sciences, including space exploration and geography.
O (Mathematics, Physics, Chemistry)	0.512	Moderate loading. This loading alludes to a relationship between fundamental sciences and their technological applications.

Factor 3: Proposed label "Military History and Comprehensive Knowledge Factor".

Variable (Discipline)	Factor Loading	Interpretation
E (Military Science)	0.682	Core Variable. This loading signifies a concentrated demand for military literature, encompassing war history and strategic analysis.
Z (Comprehensive Books)	0.610	Sub-core variable. This loading signals a reader's preference for multidisciplinary references, including encyclopedias and comprehensive texts.
K (History)	0.602	Moderate loading. This loading indicates a substantial interrelation between historical literature and military science narratives.

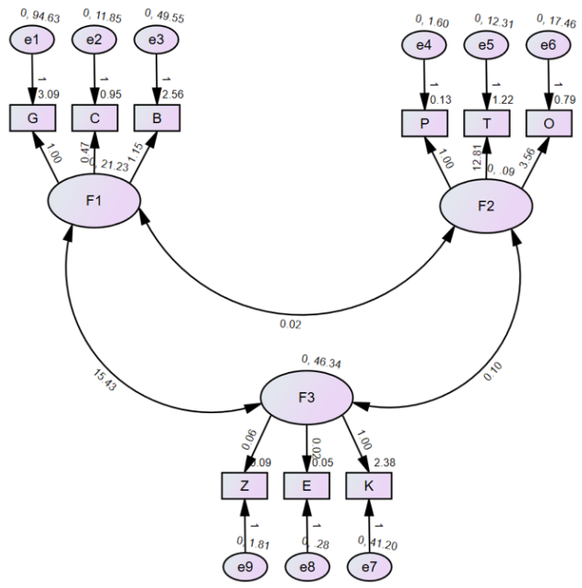

Figure 5. Structural equation modeling (2016–2018).

There is a strong positive association between Factor 3 ("Military History and Comprehensive Knowledge") and Factor 1 ("Humanities, Social Sciences, and Education"). This suggests that readers interested in military history (F3) also tend to engage with social sciences, education, and philosophy (F1) (refer to Figure 5). The relationship may reflect shared themes of historical analysis, social structure, or strategic thinking across disciplines. A weak but statistically significant positive association exists between Factor 3 (military history) and Factor 2 ("Science, Technology, and Natural Sciences"). This could indicate marginal overlap in readership or thematic links, such as technological applications in military science (e.g., weaponry, logistics) or curiosity about historical scientific advancements in warfare. No statistically significant association between Factor 1 (humanities/social sciences) and Factor 2 (STEM). This suggests readership in these domains is largely independent, with minimal overlap. Readers of humanities/social sciences may prioritize theoretical or cultural

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content, while STEM readers focus on technical or empirical knowledge, with little cross-disciplinary preference in this model.

Approximately 49% of the variance in F3 and F1 is shared. This aligns with the covariance result, indicating a substantial relationship driven by common underlying factors (e.g., intellectual curiosity about human behavior, historical patterns, or societal organization). Only 5% of the variance is shared between F3 and F2. The significant covariance (due to the large sample size) contrasts with the negligible correlation, highlighting that the association is statistically detectable but practically trivial. Any overlap may stem from niche interests (e.g., military applications of STEM) rather than broad readership trends. Essentially no linear relationship between F1 and F2. This reinforces the independence of humanities/social sciences and STEM readerships in this dataset.

2019–2021

Factor 1: Proposed label "Literature and Cultural Studies Factor".

Variable (Discipline)	Factor Loading	Interpretation
I (Literature)	0.650	Core Variable. This loading indicates a strong preference among readers for literary works, encompassing genres such as fiction, poetry, and essays.
Z (Comprehensive Books)	0.562	Sub-core variable. This loading reflects multidisciplinary knowledge requirements, represented by materials like encyclopedias and general non-fiction.
K (History)	0.523	Moderate loading. This loading indicates that historical works, including narratives and biographies, show thematic or reader-based overlaps with literature.
H (Language)	0.523	Moderate loading. This loading suggests a connection to linguistic studies or language-learning materials, likely driven by literary readers' interests in language mastery.

Factor 2: Proposed label "Social Sciences, Education, and Health Factor".

Variable (Discipline)	Factor Loading	Interpretation
C (Social Science)	0.681	Core Variable. The highest loading reflects a renewed emphasis on social science topics, including sociology, psychology, and politics.
G (Education)	0.646	Sub-core variable. This loading shows a strong correlation with educational materials, such as pedagogy and academic resources, which may be linked to ongoing policy or educational reforms.
R (Medicine & Health)	0.502	Moderate loading. This loading indicates a growing interest in health-related content, encompassing public health and medical guides, potentially influenced by global events, including the pandemic.

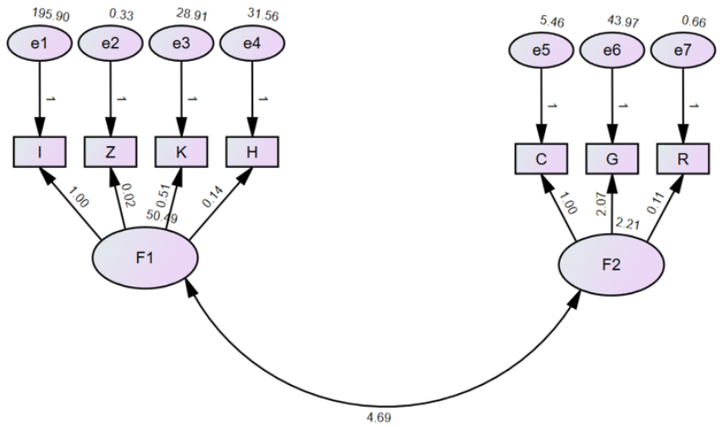

Figure 6. Structural equation modeling (2019–2021).

A statistically significant positive association exists between F1 and F2 (refer to Figure 6). This indicates that higher values in one factor are systematically associated with higher values in the other. The magnitude of the covariance reflects a meaningful linear relationship; however, its practical significance is contingent upon the scale of the latent variables. Approximately 19.7% of the variance is shared between F1 and F2, suggesting a substantial, albeit not overwhelming, relationship. This implies that while the factors are interconnected, they still maintain distinct characteristics.

2022–2024

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Factor 1: Proposed label "Humanities and Classical Literature Factor".

Variable (Discipline)	Factor Loading	Interpretation
K (History)	0.646	Core Variable. This loading signifies strong demand for literature on historical narratives, cultural memory, and societal evolution, reflecting a societal trend toward learning from the past to navigate contemporary challenges.
Z (Comprehensive Books)	0.606	Sub-core variable. This loading highlights reader interest in comprehensive and interdisciplinary content (e.g., philosophy, sociology, cultural studies). This may indicate a preference for holistic knowledge frameworks that integrate ideas across disciplines, addressing themes like human nature, ethics, or civilizational progress.
I (Literature)	0.586	Moderate loading. This loading suggests a significant but secondary role for literature in this factor. It points to engagement with classical literature, literary theory, and narrative arts, emphasizing timeless themes (e.g., human emotion, morality) over contemporary popular genres. This could reflect a desire for intellectual enrichment and cultural literacy.

4.3. Book Renewal Behavior Predictions

4.3.1. Analysis of Book Renewal Behavior Prediction (2016-2018)

This study presents a moderation effect analysis utilizing the PROCESS macro for SPSS to examine the moderating role of gender (Gender) in the relationship between reader types (Reader) and book renewal behavior (Renewal) while controlling for additional variables (Z-score F1, Z-score F2, Z-score F3, LogTotal). The analysis is based on a sample comprising 33,205 borrowers and employs a binary logistic regression model.

The statistical validity of the model is underscored by a significance level of $p < 0.0000$. The goodness-of-fit indices reveal the McFadden $R^2 = 0.2642$, suggesting moderate explanatory power that approximately 26% of the variance in renewal behavior can be accounted for by the predictors included in the model. The coefficient for reader types is 0.4307 ($p < 0.0000$), indicating a positively significant effect. This result suggests that specific reader profiles exhibit a higher propensity for book renewal. The coefficient for gender is 0.1294 ($p = 0.1866$), revealing no significant effect and suggesting that gender differences play a negligible role in influencing renewal behavior. The coefficient for the interaction effect is 0.0100 ($p = 0.8594$), indicating no significant interaction. This suggests that the relationships between reader characteristics and gender concerning renewal behavior function independently. Influence of Control Variables:

Z-score F1: Coefficient = 0.0521 ($p = 0.0039$), demonstrating a positively significant effect.

Z-score F2: Coefficient = 0.1481 ($p < 0.0000$), indicating a strong positive significance.

Z-score F3: Coefficient = -0.0222 ($p = 0.1216$), revealing no significant effect.

LogTotal: Coefficient = 2.5283 ($p < 0.0000$), strongly positively significant, indicating that total borrowing volume significantly influences renewal behavior.

4.3.2. Analysis of Book Renewal Behavior Prediction (2019-2021)

This study presents a moderation effect analysis utilizing the PROCESS macro for SPSS, with the objective of examining the moderating role of gender (Gender) in the relationship between reader types (Reader) and book renewal behavior (Renewal), while controlling for additional variables (Z-score F1, Z-score F2, LogTotal). The analysis is based on a sample comprising 26,488 borrowers and employs a binary logistic regression model.

The likelihood ratio test of the model is statistically significant ($\chi^2 = 11.1259$, $df = 1$, $p = 0.0009$), indicating a meaningful interaction between reader types and gender. This finding suggests that gender serves as a significant moderator in the relationship between reader types and renewal behavior. The model exhibits moderate explanatory power, as evidenced by a McFadden R^2 of 0.2697, indicating that approximately 27% of the variance in renewal behavior can be accounted for by the predictors included in the model. The coefficient for reader types is positive (0.2447, $p = 0.0414$), signifying a significant positive influence on renewal behavior. The coefficient associated with gender is negative (-0.3760, $p = 0.0021$), suggesting a significant negative effect on renewal behavior, potentially indicating that a specific gender is more inclined to engage in renewal practices.

The interaction effect of reader types × gender exhibits a positive coefficient (0.2269, $p = 0.0008$), indicating that gender significantly moderates the relationship between reader characteristics and renewal behavior. For males (Gender = 1), the effect of reader types on renewal behavior is quantified at 0.4717 ($p < 0.0001$). Conversely, for females (gender = 2), the effect is recorded at 0.6986 ($p < 0.0001$). These results underscore that the influence of reader types on renewal behavior is markedly stronger among the female group. The coefficient for LogTotal is substantial (2.6263, $p < 0.0001$), indicating a robust positive predictive effect on renewal behavior. Neither of the Z-score F1 and Z-score F2 demonstrates a statistically significant effect ($p > 0.05$).

4.3.3. Analysis of Book Renewal Behavior Prediction (2022-2024)

This study presents a moderation effect analysis utilizing the PROCESS macro for SPSS, to examine the moderating role of gender (Gender) in the relationship between reader types (Reader) and book renewal behavior (Renewal) while controlling for additional variables (Z-score F1, LogTotal). The analysis is based on a sample comprising 20,850 borrowers and employs a binary logistic regression model.

The model's likelihood ratio test shows that the interaction between Reader and Gender is not significant ($\chi^2 = 0.5031$, $df = 1$, $p = 0.4781$). This indicates that gender does not moderate the relationship between reader characteristics and renewal behavior in this analysis. McFadden $R^2 = 0.2434$ (moderate), suggesting that approximately 24% of the variance in renewal behavior can be explained by the model. The coefficient for reader types is 0.0710 ($p = 0.5875$), indicating no significant effect on renewal behavior. The coefficient for gender is

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0.0797 (p = 0.5359), suggesting no significant effect on renewal behavior. The coefficient for the interaction effect of reader types × gender is 0.0523 (p = 0.4781), indicating no significant interaction between reader characteristics and gender on renewal behavior. The coefficient of Z-score F1 is -0.0783 (p < 0.0001), indicating a significant negative effect on renewal behavior. The coefficient of LogTotal is 2.6294 (p < 0.0001), indicating a strong positive predictive effect on renewal behavior.

4.4. Book Borrowing Behavior Predictions

4.4.1. Analysis of LogTotal Quantile Regression Prediction (2016-2018)

Given the noteworthy impact of LogTotal, quantile regression was conducted on LogTotal to explore its relationship with other variables and to make predictions at different quantiles. Pseudo R Squared represents the proportion of variation in LogTotal explained by the model at different quantiles. The median (q=0.5) shows the highest explanatory power (0.245), indicating the model fits the central distribution of LogTotal best. The lowest average prediction error at q=0.5 (0.3724) suggests more accurate predictions for central values, while higher MAEs at q=0.1 and q=0.9 indicate greater uncertainty in predicting extreme low/high values of LogTotal. Parameter estimates are shown in Table 1.

Table 1. Parameter estimates at different q levels (2016-2018).

Parameter	q = 0.1	q = 0.5	q = 0.9
Intercept	0.972	1.300	1.730
Z-score: F1	0.181 (*)	0.248 (***)	0.135 (*)
Z-score: F2	0.081 (*)	0.082 (**)	0.045 (ns)
Z-score: F3	0.073 (ns)	0.161 (***)	0.135 (*)
Gender=1 (Male)	-0.034 (ns)	-0.127 (**)	-0.068 (ns)
Reader=1 (Undergraduate)	-0.015 (ns)	0.115 (*)	0.204 (***)
Reader=2 (Graduate)	-0.002 (ns)	0.135 (**)	0.227 (***)
Reader=3 (Staff)	-0.012 (ns)	0.108 (*)	0.224 (***)
Renewal=0 (Without)	-0.845 (***)	-0.463 (***)	-0.377 (***)

Note: Significance levels assumed based on typical thresholds: * p<0.05, ** p<0.01, *** p<0.001; "ns" = non-significant.

F1: Positive and significant at all quantiles, but strongest at q=0.5 (0.248***). Indicates that factor F1 has a consistent positive impact on LogTotal, with moderate influence at extreme quantiles.

F2: Significant at q=0.1 (*) and q=0.5 (**), but not at q=0.9. Suggests F2 primarily affects lower-to-middle ranges of LogTotal.

F3: Only significant at q=0.5 (***), implying its effect is most pronounced in the central distribution.

Male (Gender=1): At q=0.5, males show a significant negative coefficient (-0.127**), meaning males tend to have lower LogTotal than females in the median range. This effect is non-significant at extreme quantiles.

Reader Type: At q=0.5, all three reader groups, undergraduate/graduate/staff, have positive, significant coefficients (0.115* to 0.135**), indicating higher LogTotal compared to "Other" readers. At q=0.9, the coefficients are larger (0.204*** to 0.227***) and highly significant, suggesting these groups have a stronger impact on high LogTotal values (e.g., heavy resource usage). No significant effects at q=0.1, implying reader type has little influence on low LogTotal observations.

Without Renewal (Renewal=0): All quantiles show significant negative coefficients (-0.845*** to -0.377***), meaning users without renewal records consistently have lower LogTotal. The effect is strongest at q=0.1, suggesting non-renewers are strongly associated with minimal resource usage.

4.4.2. Analysis of LogTotal Quantile Regression Prediction (2019-2021)

The value of Pseudo R Squared increases from q = 0.1 to q = 0.9, indicating that the model explains a larger proportion of the variation in the upper tail of the distribution. The median (q = 0.5) also shows a relatively good fit with a Pseudo R Squared of 0.267. The lowest measures the average prediction error at q = 0.5 (0.3428), suggesting that the model is more accurate in predicting the central values of LogTotal. The higher MAEs at q = 0.1 and q = 0.9 indicate that the model has more difficulty in predicting the extreme values. Parameter estimates are shown in Table 2.

Table 2. Parameter estimates at different q levels (2019-2021).

Parameter	q = 0.1	q = 0.5	q = 0.9
Intercept	1.087	1.549	1.737
Z-score: F1	0.159 (*)	0.320 (***)	0.286 (***)
Z-score: F2	0.158 (*)	0.222 (***)	0.150 (*)
Gender = 1 (Male)	-0.001 (ns)	-0.038 (ns)	0.042 (ns)
Reader = 1 (Undergraduate)	-0.297 (***)	-0.363 (***)	-0.131 (ns)
Reader = 2 (Graduate)	-0.294 (***)	-0.315 (***)	-0.076 (ns)
Reader = 3 (Staff)	-0.298 (***)	-0.338 (***)	-0.085 (ns)
Renewal = 0 (Without)	-0.698 (***)	-0.372 (***)	-0.302 (***)

Note: Significance levels assumed based on typical thresholds: * p < 0.05, ** p < 0.01, *** p < 0.001; "ns" = non-significant.

F1: Positive and significant at all quantiles, with the strongest effect at q = 0.5 (0.320***). This indicates that factor F1 has a consistent positive impact on LogTotal, and its influence is relatively stable across the distribution.

F2: Positive and significant at all quantiles, but with a relatively weaker effect compared to F1. The coefficient at q = 0.5 is 0.222 (***), suggesting that F2 also contributes to the variation in LogTotal, especially in the central part of the distribution.

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Male (Gender = 1): The coefficients for males are not significant at any of the quantiles. This suggests that gender does not have a significant impact on LogTotal in this analysis.

Reader Type: At q = 0.1 and q = 0.5, all three reader groups (Undergraduate, Graduate, Staff) have negative and significant coefficients compared to the "Other" reader group. This indicates that these reader types tend to have lower LogTotal values in the lower and middle parts of the distribution. At q = 0.9, the coefficients for these reader groups become non-significant, suggesting that the differences in LogTotal between these reader types and the "Other" group are not significant in the upper tail of the distribution.

Without Renewal (Renewal = 0): All quantiles show significant negative coefficients (-0.698*** to -0.302***), meaning readers without renewal records consistently have lower LogTotal. The effect is strongest at q = 0.1, indicating that non-renewers have a particularly low level of resource usage in the lower part of the distribution.

4.4.3. Analysis of LogTotal Quantile Regression Prediction (2022-2024)

The model's explanatory power increases with quantile levels, from 16% at q=0.1 to 24.4% at q=0.9. This indicates the model better captures variation in high LogTotal values (e.g., heavy borrowing) compared to low values. The prediction error is lowest at the median (0.3527), consistent with prior periods, but errors at q=0.1 and q=0.9 are more balanced (0.6085, 0.6017), suggesting similar uncertainty in predicting extremely low/high borrowing volumes. Parameter estimates are shown in Table 3.

Table 3. Parameter estimates at different q levels (2022-2024).

Parameter	q = 0.1	q = 0.5	q = 0.9
Intercept	0.642	1.332	1.897
Z-score: F1	0.154 (*)	0.313 (***)	0.228 (**)
Gender=1 (Male)	0.002 (ns)	-0.024 (ns)	0.035 (ns)
Reader=1 (Undergraduate)	-0.009 (ns)	-0.205 (*)	-0.328 (**)
Reader=2 (Graduate)	-0.004 (ns)	-0.109 (ns)	-0.220 (*)
Renewal=0 (Without)	-0.597 (***)	-0.523 (***)	-0.393 (***)

Note: Significance levels assumed based on typical thresholds: * p<0.05, ** p<0.01, *** p<0.001; "ns" = non-significant.

F1: Positive and significant across all quantiles, with peak impact at q=0.5 (0.313***). This suggests F1 remains a consistent driver of LogTotal, particularly for median and high usage. At q=0.9, the coefficient (0.228**) is slightly lower than in 2019–2021, implying diminishing marginal returns of F1 for extreme borrowing.

Gender: No significant effects at any quantile, consistent with the 2019–2021 findings. Gender remains a negligible predictor of LogTotal in this period.

Reader Type: At q=0.5, Undergraduates show a significant negative coefficient (-0.205*), indicating lower median borrowing compared to Staff. At q=0.9, Undergraduates (-0.328**) and Graduates (-0.220*) have significantly lower LogTotal than Staff, suggesting Staff are more likely to be heavy borrowers. Only significant at q=0.9, highlighting specialization in high-usage patterns among Staff.

Without Renewal (Renewal=0): Strong negative effects across all quantiles (-0.597*** to -0.393***), with the largest impact at q=0.1. This reinforces renewal behavior as a critical predictor of engagement, especially for low-usage users.

5. Discussion

5.1. Book Borrowing Trend Analysis and Speculated Causation

The analysis of total book borrowings over the three specified periods reveals a discernible downward trajectory, marked by a consistent decline in median borrowing volume. While individual readers demonstrated an uptick in borrowing from 2022 to 2024, this resurgence proved insufficient to offset the overarching decline observed in aggregate data. The ascent of digital reading formats, encompassing e-books and online reading platforms, has significantly diverted a considerable readership away from traditional borrowing practices. The increasing prevalence of alternative social entertainment avenues, such as short videos and interactive gaming, has commandeered substantial portions of individuals' time, reducing the available time for engagement with literary works. Moreover, additional factors, including the frequency with which the library updates its collection and the overall quality of its services, may further influence readers' motivation toward borrowing.

Within this context, it is noteworthy that most readers consistently exhibit low and stable renewal rates, while a minority engage in exceptionally high renewal activity. To effectively address the needs of high-renewal readers, conducting targeted surveys to ascertain their specific requirements is recommended. Optimizing resource allocation or instituting tailored policies, such as extended borrowing terms for specialized users, may enhance their engagement. Conversely, for low-renewal readers, it is essential to amplify resource promotion through reading campaigns and personalized recommendations, thereby encouraging more frequent borrowing and renewals.

5.2. Cross-Year Trend Comparison and In-Depth Interpretation of Factors

2016- 2018: Social science and education books remained core needs from 2016 to 2018, possibly linked to social development, policy guidance (e.g., education reforms), or public awareness of self-improvement. High loading of technology books reflects readers' urgent need for technical knowledge in the digital era (e.g., internet, big data). High loading of astronomy and earth science may correlate with social hotspots like environmental policies or space achievements (e.g., lunar exploration projects). Steady demand for military and history books suggests a stable reader base (e.g., military enthusiasts) or influence from international political events (e.g., local conflicts).

The covariance and correlation results highlight a strong bond between military history and humanities/social sciences (F3-F1), a peripheral link between military history and STEM (F3-F2), and virtual independence between humanities and STEM (F1-F2). The strong association between military history (F3) and humanities/social sciences (F1) supports the idea that military studies are often contextualized within broader social, political, and

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philosophical frameworks. For example, readers of military history may seek to understand how warfare influences societal development (F1 variables like sociology, education), or how philosophical ideas shape strategic decisions (e.g., just war theory). The minimal link between military history (F3) and STEM (F2) suggests that while technology is integral to military applications, reader interest in military history is not strongly driven by technological curiosity. Instead, it may focus on human narratives, strategic psychology, or historical causality (all F1 domains).

2019- 2021: Contrasting with trends from 2016 to 2018, where Factor 1 predominantly featured themes of social science and education, a shift is evident in the current analysis. In comparison to the earlier period, literature (I) now emerges as a distinct factor, signaling a growing readership that prioritizes humanities and creative content over technology and natural sciences. Social science (C) and education (G) have re-emerged as core components of Factor 2, which may reflect challenges faced by society post-2018, including policy changes and educational debates. The notable inclusion of medicine & health (R) indicates a demand for health-related knowledge potentially influenced by the COVID-19 pandemic. In contrast to the "Science & Technology Factor" identified in the previous analysis, disciplines about technology and natural sciences are conspicuously unrepresented in the current dataset. This absence may suggest a prevailing shift toward a focus on the humanities and applied social sciences.

The moderate positive correlation and significant covariance between F1 and F2 suggest a growing interdependence between the domains they represent, likely reflecting societal trends toward interdisciplinary learning and problem-solving.

2022-2024 : The trends observed between 2022 and 2024 indicate a pronounced emphasis on historical scholarship, suggesting that readers are increasingly prioritizing contextual and analytical approaches to the past. Social science and health are no longer prominent, suggesting reduced focus on immediate policy issues or pandemic fatigue. STEM factor in not listed in the 2022–2024 data, implying a temporary shift from tech/natural science dominance to humanistic inquiry. This shift appears to be shaped by post-pandemic reflections on societal resilience and collective memory, alongside a growing interest in identity politics and the preservation of cultural heritage, as well as educational initiatives that promote critical historical thinking. Additionally, the significant focus on comprehensive intellectual discourse reflects a robust demand for expansive ideas and interdisciplinary dialogue, correlating with public debates surrounding contemporary issues such as democracy and globalization. This trend is further reinforced by the emergence of non-fiction genres that intersect philosophy, history, and science, highlighting a collective desire for intellectual synthesis amidst an era characterized by an overwhelming influx of information. Furthermore, while literature maintains its status as a cultural anchor, the moderate engagement observed suggests that readers' interactions with classical literary works are increasingly selective, influenced by educational curricula that emphasize canonical texts and cultural initiatives such as literary festivals and the rerelease of classic novels, contrasting with the more ephemeral nature of digital entertainment.

5.3. Practical Implications of Book Renewal Behavior Prediction

2016-2018: It is imperative to concentrate on the characteristics denoted by the Reader variable (e.g., borrowing frequency, reading preferences) to formulate marketing strategies that target groups with a heightened renewal propensity. The absence of substantial gender differences indicates no necessity to devise specialized renewal promotion strategies based on gender. The considerable impact of LogTotal suggests that encouraging patrons to augment their borrowing volume may effectively enhance renewal rates.

2019-2021: It is recommended to develop customized renewal promotion strategies tailored to different gender groups. Enhancing the recommendation system, based on reader characteristics, particularly for females, may amplify renewal conversion rates. Given the noteworthy impact of LogTotal, encouraging users to augment their borrowing volume is essential for enhancing renewal rates. Further investigation into the specific metrics associated with the Reader variable (e.g., borrowing frequency, reading preferences) is warranted to develop accurate user profiles and to provide exclusive services to groups with elevated renewal inclinations. The identified gender moderation effect highlights the necessity for in-depth exploration of the renewal motivations that differ by gender. For instance, it may be postulated that females prioritize the relevance of book content, while males may place greater emphasis on the convenience of the borrowing process.

2022-2024: Since the interaction between reader characteristics and gender is not significant, there is no need to design different renewal promotion strategies based on gender. Libraries should pay more attention to the factors represented by F1 and LogTotal. For example, reducing the negative impact of F1 and further promoting borrowing volume (as indicated by the strong positive effect of LogTotal) may help improve renewal rates. Although the Reader variable does not have a significant effect in this model, it may still be important to understand reader characteristics in combination with other variables to develop more effective renewal promotion strategies.

5.4. The Value of Quantile Regression for Capturing Distributional Differences

Quantile regression reveals how predictors influence different segments of the distribution, rather than assuming a uniform effect across all values of the response variable (e.g., LogTotal).

Example from 2016–2018: Reader type (e.g., Graduate/Staff) and renewal status showed stronger effects at q=0.9 (high borrowing) than at q=0.1 (low borrowing). This highlighted that graduate students and staff drive high resource usage, while non-renewing users are concentrated in low-usage tiers. A mean-based model would overlook these distributional nuances, potentially masking critical differences in engagement drivers between user segments.

Quantile regression helps identify predictors that are relevant in specific parts of the distribution, enabling targeted interventions. 2019–2021: Factors F1 and F2 (e.g., latent constructs like borrowing efficiency or resource relevance) were most influential at q=0.5 and q=0.9, indicating their role in shaping moderate-to-high usage. In contrast, their impact at q=0.1 was weaker, suggesting that other factors dominate minimal borrowing behavior. 2022–2024: Staff emerged as the primary drivers of high borrowing (q=0.9), while students showed significant

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deficits in this segment. Quantile regression isolated this shift in demographics, which might stem from policy changes (e.g., staff access to specialized resources) or behavioral trends (e.g., student reliance on digital materials).

Quantile regression illuminates non-linear relationships and thresholds where predictor effects change sign or magnitude. Renewal Status Across Periods: The negative effect of non-renewal (Renewal=0) was consistently strongest at q=0.1 (e.g., -0.845*** in 2016–2018, -0.698*** in 2019–2021), indicating that renewal is critical for escaping minimal usage. At higher quantiles, the effect diminished (e.g., -0.377*** at q=0.9 in 2016–2018), suggesting high-usage users renew more naturally. Quantile regression confirmed that gender had no significant effect at any quantile in 2019–2024 or 2022–2024, reinforcing that resources should not be allocated based on gender.

Low-usage users (q=0.1): Across all periods, non-renewal was strongly linked to minimal borrowing. Libraries should prioritize renewal reminders and user education for this group (e.g., personalized notifications or simplified renewal processes). High-usage drivers (q=0.9):

2016–2018, focus on graduate students and staff (e.g., faculty research support). 2022–2024, invest in staff-specific resources (e.g., advanced research tools) to sustain high engagement. The decline in student high-usage (2022–2024) warrants investigation into curriculum demands, digital resource access, or borrowing limits.

While quantile regression is powerful, it requires careful interpretation. Small sample sizes in tails (e.g., q=0.1 or q=0.9) can lead to unstable estimates. Bootstrapping or larger datasets may mitigate this. Quantile regression identifies associations but does not establish causality. For example, while renewal correlates with higher borrowing, it may not be the direct cause (e.g., engaged users may renew and borrow more). Latent factors (e.g., F1, F2, F3) require clear operationalization to translate coefficients into actionable insights.

Quantile regression is indispensable for understanding the heterogeneous nature of borrowing and renewal behavior. By decomposing effects across the distribution, it reveals how demographics, behaviors, and latent factors shape engagement at different scales, from minimal to heavy usage. This granularity is vital for evidence-based resource allocation, user segmentation, and intervention design. As demonstrated in the 2016–2024 analyses, quantile regression enhances descriptive accuracy and empowers libraries to address specific user needs, driving more effective and equitable service strategies.

6. Conclusion

This study systematically analyzed book borrowing and renewal patterns at Nanjing Normal University Library across three periods (2016–2018, 2019–2021, 2022–2024) using quantitative methodologies, including principal component analysis (PCA), binary logistic regression, and quantile regression. Key findings reveal temporal fluctuations in renewal behaviors, with the proportion of renewals to borrowings decreasing from 10.2% to 9.2% before rebounding to 12.9%, reflecting shifts in reader engagement likely influenced by external events and resource accessibility. Disciplinary analysis shows a consistent preference for humanities and social sciences (e.g., Literature, Education, History), accounting for over 75% of renewals, while natural science categories exhibited minimal renewal activity, possibly due to the proliferation of digital resources. Predictive models identified reader type (e.g., staff, graduate students) and total borrowing volume (LogTotal) as significant drivers of renewal behavior, with gender demonstrating moderating effects in specific periods. Quantile regression further highlighted those non-renewing readers clustered in low-borrowing tiers, whereas staff dominated high-usage segments in recent years.

The study underscores the importance of institutional policies in shaping user behavior, such as Nanjing Normal University Library's renewal rules, balancing flexibility and resource equity. The identified disciplinary trends suggest libraries should prioritize humanities collections while re-evaluating STEM print resources in light of digital alternatives. Practical recommendations include targeted engagement strategies for high-renewal groups (e.g., extended borrowing terms for staff), renewal reminders for low-usage readers, and gender-sensitive interventions where moderating effects are evident (e.g., enhanced recommendations for female users). Methodologically, the integration of PCA and quantile regression offers a robust framework for uncovering latent factors and distributional heterogeneities in library usage data, providing actionable insights for resource allocation and user segmentation.

While this research contributes valuable insights, several limitations warrant attention. The single-institution dataset limits generalizability to broader academic library contexts, and the absence of qualitative data restricts deeper exploration of reader motivations. External variables (e.g., curriculum changes, digital resource adoption rates) were not systematically measured, potentially affecting causal interpretations. Future studies should expand to multi-institutional datasets, incorporate mixed-methods approaches, and explicitly model policy and technological shifts. Additionally, investigating the interplay between print and digital usage, as well as the long-term impact of AI-driven recommendation systems, could enhance understanding of evolving library user behavior in the digital age. These advancements would strengthen the theoretical foundation and practical relevance of library science research.

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