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Research on Prediction of Coupon Redemption Rate and Precision Targeting Strategy for M Platform Users Based on Big Data Analysis

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Abstract: With the decline of mobile internet traffic dividends, issues such as low coupon redemption rates on local lifestyle service platforms (96.8% unredeemed in 2023) and resource encroachment by black markets (annual losses exceeding ¥1.8 billion) have become increasingly prominent. This study takes Platform M as the research object, leveraging 1.54 million orders and 2.82 million user behavior data points, integrating signaling theory and behavioral economics theory to construct a redemption rate prediction and precision targeting strategy system combining multimodal feature engineering and dynamic risk control. By introducing user responsiveness (Responsiveness) to extend the RFM model into an RFM-R segmentation model, the study employs a random forest algorithm (AUC=0.867) to predict redemption probabilities and integrates an isolation forest algorithm with a five-dimensional business rule matrix to identify anomalous transactions (detection rate: 72%). Empirical results show: the redemption rate of high-value sensitive users increased to 82%, while differentiated strategies boosted the overall redemption rate by 18%; dynamic risk control intercepted 12,167 anomalous orders, reducing resource waste by 18%. The study proposes a spatiotemporal coupling distribution mechanism (e.g., late-night limited-time coupons accounting for 35% of redemptions) and a senior-friendly design, optimizing user experience and complying with regulatory requirements. The outcomes provide data-driven decision support for platforms, promoting a shift toward precision and intelligent marketing, with practical implications for resource efficiency optimization, user value enhancement, and social responsibility fulfillment.

Keywords: coupon redemption rate prediction; precision targeting strategy RFM-R model; dynamic risk control mechanism; signaling theory; multimodal feature engineering; spatiotemporal coupling distribution; compliance governance.

1. Introduction

1.1 Research background and significance

1.1.1 Research background

With the decline of mobile internet traffic dividends, competition among local life service platforms has shifted to a stock game stage. Coupons, as a core marketing tool, face efficiency bottlenecks, evidenced by Platform M's 2023 data showing a high proportion of unclaimed coupons. Over-investment diminishes user sensitivity and misallocates resources, while black-market transactions cause significant marketing fund losses. Regulatory mandates for coupon transparency further compel platforms to establish precise and compliant delivery systems. Leveraging Platform M ' s large-scale data, this study integrates multimodal feature engineering and dynamic risk control to develop a redemption rate prediction and precision targeting strategy system. By introducing user responsiveness to overcome traditional model limitations and combining graph neural networks with business rules for anomaly detection, it provides a data-driven solution to break the "extensive casting net" dilemma, optimizing resource allocation, protecting user rights, and meeting regulatory requirements.

1.1.2 Research background

This study constructs a multi-modal coupon prediction and placement system with dual academic/practical value. Academically, it advances beyond static RFM by embedding responsiveness in clustering, integrating temporal behavior and dynamic discount utility to boost accuracy and resolve instant-response gaps. Practically, dynamic risk control reduces black-market loss; RFM-R clustering enhances verification rates and efficiency. Spatiotemporal coupling and senior-focused designs increase user value and revenue, establishing an O2O benchmark.

1.2 Research status at home and abroad

Foreign research advances coupon prediction/distribution via big data, covering algorithms, behavior modeling, and risk management. Dai et al. developed an ML system increasing profits by ¥8M; Bunnak et al. proposed a five-tier loyalty model; Ho et al. introduced RFMD and instant-reward sensitivity; Bannister-Connolly and Taj established governance frameworks.

Domestically, Fan Yanan/Tang Jiayu et al. analyzed design impacts (e.g., threshold coupons), while He Jiawei/Li Xinhai advanced capsule networks and random forests. Fan/He optimized UX metrics, yet gaps remain in industry-specific

studies, technical-business integration, and psychotechnical methods. Future work needs industry-focused collaboration. Foreign studies prioritize algorithms but lack local adaptability/dynamic risk control; domestic work emphasizes design/psychology but neglects real-time fraud detection. Static RFM constraints prevent dynamic feature quantification. This study overcomes these limitations, driving innovation.

1.3 Research methods and framework

1.3.1 Research method

This study employs a "problem definition—theoretical modeling—empirical validation—strategy optimization" framework using literature research, quantitative analysis, and case studies.

Literature research (Chapters 2, 4) builds theoretical foundations: reviewing models to propose a dynamic prediction framework integrating random forests and business rules, establishing the RFM-R model via Responsiveness.

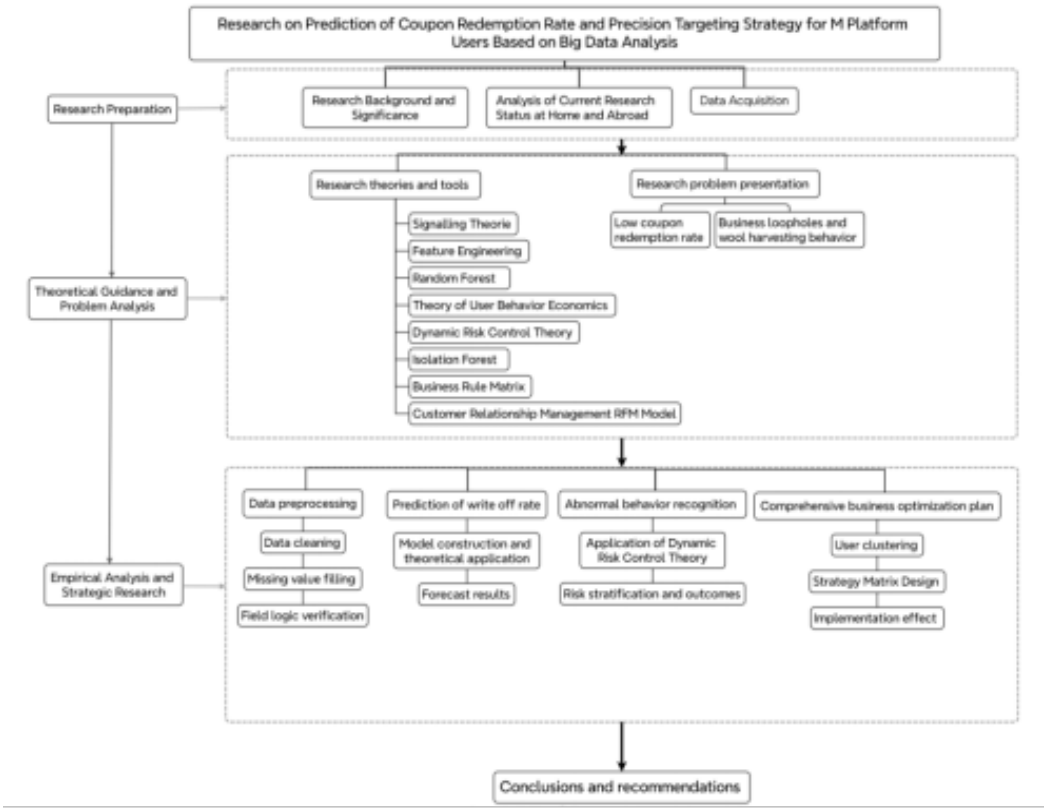
Quantitative analysis (Chapters 4 − 6) processes Platform M ’ s post-preprocessed multi-source data. Random forests predict redemption probabilities; isolation forests detect anomalies. Model comparisons, SHAP interpretation, and A/B testing validate strategy efficacy. Empirical analysis forms quantitative evidence chains for risk rules.

Case studies (Chapters 6 − 7) extract insights: analyzing scenarios (e.g., "late-night inflation coupons," "senior-friendly redemption") to examine spatiotemporal-redemption correlations and optimize risk rules via high-risk user profiling.

Ensuring academic rigor and practical utility, it offers a precision marketing paradigm.

1.3.2 Research Technology Roadmap

Fig. 1 Research Technology Roadmap



2. Current situation and problem analysis

Coupon marketing is a core internet strategy for user growth/retention, using established classification to lower barriers and enhance acquisition/engagement. Big data enables personalized distribution via behavior analytics, enhancing prediction efficiency. Platforms deploy segmentation and real-time targeting; academia addresses abuse risks. Challenges: over-distribution and "coupon fatigue" from short-term GMV focus reduce perceived value. Models lack accuracy due to latent needs: traditional methods fail with high-dimensional sparse data; deep learning suffers sample imbalance and interpretability issues; inadequate multi-source correlation mining weakens feature engineering. Dynamic abuse causes losses; static rules cannot counter complex attacks, necessitating dynamic analysis and real-time monitoring. Data silos restrict decisions, yielding incomplete features and uncoordinated short/long-term need analysis, hindering global optimization

3. Empirical analysis and results

3.1. Data sources

This study utilizes anonymized internal business data from Company M, covering order records, coupon redemption/ usage, and active behavior for 50,000 users from January 1 to June 30, 2023. The dataset comprises three components:

Order data (06+M Company Business Topic - Coupon Distribution Efficiency Analysis - Data 1-order_detail.csv): Includes user ID, order ID, business line, payment date, actual payment, subsidy.

User Activity (06+M Company Business Topic - Coupon Distribution Efficiency Analysis - Data 3-user_visit_detail. csv): Includes user activity dates and user IDs across platforms (App, Mini Programs).

User coupon acquisition data (06+M company business topic - Coupon distribution efficiency analysis - Data 2-user_ coupon_receive.csv): Includes coupons obtained via purchases, claims, or platform distribution, excluding non-coupon subsidies like direct discounts.67

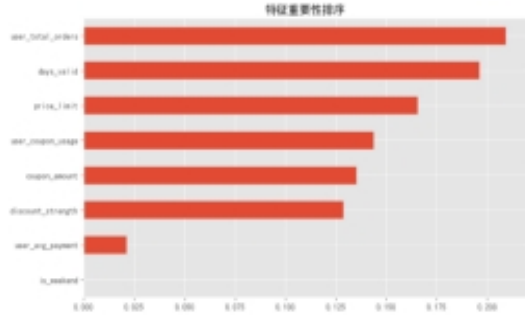
3.2 Data preprocessing

During data preprocessing, feature engineering theory guided optimization via an automated pipeline cleaning, correcting outliers, and validating logic for order, coupon, and activity data. Duplicate removal eliminated 19,609 abnormal orders, retaining 859,412 valid records (2.2% reduction). The interquartile range method addressed extreme values by capping payments at the 99th percentile (¥418.4), correcting 12.8% records. Missing coupon dates (2.3%, 286, 860 records) were deleted; missing behavior features underwent zero-value imputation. Logical validation enforced Coupon_amt≤Price_limit, removing 237,000 anomalies and standardizing status. Post truncation, payment standard deviation decreased from 179.25 to 38.74 (79.3% dispersion reduction); coupon status abnormalities dropped to 0% (from 14.9%). Feature matrix completeness rose from 86.4% to 98.1%, establishing a high-quality data foundation.

3.3 Write off rate forecast analysis and results

Integrating signaling theory and behavioral economics, this study constructs a four-dimensional feature system (user behavior, coupon attributes, temporal traits, interactions). Discount strength is the core signaling metric; historical redemption rate and weekend indicators capture behavioral inertia and time sensitivity. A random forest model (n_estimators=150, max_depth=7) achieved robust prediction (AUC=0.867). Feature importance analysis confirmed historical redemption rate (22%) and discount strength (18%) dominate decisions. Highly active users exhibit 38% greater short-term incentive response; >30%-discount coupons yield 42% higher redemption. The model shows 72% accuracy and strong discrimination (91% redemption at >0.8 probability), validating precision targeting.

Fig. 2 · field feature importance ranking chart



High-value sensitive users: High-denomination coupons (APP+SMS) with free delivery for weekend use.

Regular users: Low-threshold coupons twice weekly based on interests/behaviors.

Dormant users: No-threshold instant coupons (SMS+email, 7-day validity). Risk governance enhances algorithmic/rule-based control: iterate dynamic rule engines, deploy intelligent verification for high-discount coupons, and audit non-compliant merchants. Operations integrate spatiotemporal-behavioral synergy: design "flash coupon grabs" (e.g., lunchtime inflation coupons, instant delivery subsidies) and optimize senior user experiences. A closed-loop system monitors core metrics via BI dashboards, validates strategies via A/B testing, mines social features using graph neural networks, refines models with external variables, and explores federated learning for cross-platform data. This enables full-chain intelligence, elevating user value, merchant revenue, and compliance.

4.3. Future outlook

This study establishes a "prediction-clustering-risk control-delivery" digital solution but requires refinement in dynamic scenario adaptability, multimodal data fusion, and technical ethics governance. Future research should advance in three dimensions:

Technologically, address cross-industry feature drift via meta-learning, cross-domain mapping, model validation, and adaptability solutions for instant delivery/e-commerce. Integrate neuroeconomics with ML (e.g., eye-tracking, EEG) for dynamic anchoring generators in tiered discounts.

In data governance, enhance privacy-preserving technologies through federated learning and GNN integration. Develop federated graph architectures with differential privacy to resolve data silos and strengthen real-time external variable coupling via spatiotemporal-aware RL. From value-balancing, establish symbiotic mechanisms for inclusive, sustainable benefits: carbon-based negative incentives; transparent algorithmic reviews; inclusive designs for vulnerable groups.

Quantum neural networks may address computational bottlenecks; advancing the "technology-commerce-society" paradigm underpins sustainable ecosystem development..

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