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Mathematics in everyday financial decisions: developing adult financial literacy courses based on mathematical thinking

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Abstract. Probability-based lucky-draw promotions embedded in retail activities create hidden consumption traps for consumers. Many working-age adults make purchasing decisions based on subjective intuition rather than objective computation and lack practical knowledge of mathematical expectation and compound interest, which leads to impulsive buying and preference for immediate consumption over long-term saving. This study selects two typical everyday financial scenarios and develops practical mathematical courses for adults aged 18-45. Based on questionnaire data collected from 210 employed residents in Jinan, mathematical modeling is adopted to compare benefits of fixed discounts and paid lotteries, and compound-interest asset appreciation. Two supporting video courses and worksheets are designed for teaching experiments. Survey results indicate that 76.2 % of respondents overspend in probability-driven promotions and 82.4 % cannot distinguish simple and compound interest. After course intervention, participants' test performance on marketing-trap identification and compound-interest calculation improved by an average of 68.7 %, and impulsive-shopping desire decreased noticeably. Such courses can fill gaps in adults' quantitative financial-thinking capacity. Nevertheless, short-term learning can only improve theoretical awareness temporarily; sustained practice is required to reshape long-term financial-behavior habits.

Keywords: financial literacy, mathematical thinking, probabilistic marketing, irrational consumption, compound interest

1. Introduction

Nowadays, Chinese consumers can access countless shopping discounts both from offline physical shops and online e-commerce platforms. In recent years, many merchants prefer probability-based promotion methods, such as chargeable lucky draws, tiered random rewards and blind box series sales, to attract more customers. Retailers build such random reward rules by taking advantage of people's misunderstanding of probability, aiming to drive customers to spend more than their pre-set shopping budgets. When handling monthly salaries, residents need to make decisions on long-term wealth accumulation. Many adults overlook the exponential growth power of compound interest deposits and tend to satisfy instant shopping demands rather than keep long-term fixed savings. Basic math education in China is largely exam-driven; it mainly teaches abstract

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formula deduction and rigid exam exercises instead of real-life application. Such teaching mode seldom offers systematic targeted training for students to transfer rigid mathematical knowledge points to complex daily financial decision-making scenarios that everyone will encounter after entering the workplace. Most online and printed financial science articles only use text explanations without objective data and mathematical calculations, which reduces their persuasion effect. These popular science readings rarely adopt rigorous quantitative mathematical calculation to intuitively demonstrate the hidden profit logic behind various commercial marketing designs, which greatly reduces their objective persuasion for ordinary adult readers without professional economic background knowledge. A large number of existing domestic and foreign academic studies focusing on probability calculation theory mostly take blind-box serial consumer products as simple calculation demonstration examples to verify the rationality of probability mathematical models. Only a small number of existing studies apply probability theories to public financial education, and few scholars develop targeted teaching materials to raise adults' ability to judge financial problems with quantitative methods. Mathematical thinking constitutes an essential foundation of modern financial literacy. Quantitative mathematical tools help ordinary citizens translate abstract financial concepts into computable indicators, supporting rational judgment in daily consumption and asset-planning decisions. Integrating mathematical knowledge into adult-oriented financial-education practice helps bridge the gap between school-taught mathematics and real-world citizen decision-making, delivering practical educational value for public financial popular-science [1]. This paper selects two highly representative and widely encountered real-life financial scenarios that every working adult may face: the trade-off choice between fixed direct-discount offers and additional-fee paid-lottery store promotions, and long-term monthly fixed-investment savings plans with compound interest appreciation mechanism. Taking mathematical expectation theory as the core quantitative analytical tool throughout the whole research process, this study quantitatively unpacks the hidden underlying operating logic of various probabilistic marketing consumption traps from a mathematical perspective. Standardized controlled teaching experiments are fully implemented in this research framework, so as to systematically investigate the practical intervention effect of mathematics-oriented popular science courses on mitigating adults' typical irrational daily financial decisions.

2. Literature review and research hypotheses

2.1. Research on probabilistic marketing and mathematical expectation

Li Fei's research uses probability addition formulas and overall expectation models to analyze the long-term average gains and losses brought by retail lucky draw consumption [2]. The study finds that merchants can cut customers' long-term average returns by setting multi-level random rewards with different winning odds. Extra commercial profits are successfully generated by retail operators through making full use of widespread public cognitive blind spots for basic probability mathematical principles. This complete set of quantitative measurement frameworks constructed in the research has strong universal applicability across different consumer industries. Apart from simple blind-box product demonstration calculation cases in the paper, the mathematical analysis logic can also be freely migrated and applied to various mainstream commercial retail scenarios, including daily store-consumption lotteries, points-based serial reward collection activities and online lucky draw promotions launched by e-commerce platforms. The standardized quantitative mathematical analysis tools proposed in the research provide solid theoretical support for this paper's comparative research between fixed direct discount preferential policies and additional-cost random lottery marketing activities [2]. Behavioral economics studies mention two typical cognitive flaws that affect consumers during random reward activities: gambler's fallacy and sunk cost bias. When participating in repeated random draw activities,

many participants subjectively tend to firmly believe that consecutive failure attempts will automatically raise the probability of obtaining high-value reward prizes in subsequent drawing rounds. Under this false cognitive judgment, consumers keep continuously increasing their additional monetary investment just for the purpose of obtaining the expected high-value rewards they desire, which further triggers obvious irrational over-consumption behaviors in retail shopping scenarios. Simple verbal warning and plain text persuasion cannot effectively correct such deep-rooted intuitive cognitive biases formed by long-term life experience. In sharp contrast, rigorous quantitative mathematical calculation can directly display the objective long-term average loss risk hidden behind all kinds of probabilistic promotional activities, producing more straightforward, convincing warning effects for adult consumer groups.

2.2. Research on compound interest and long-term financial decision-making

China Registered Financial Planner Association pointed out that industry financial research proves compound interest can realize exponential asset growth, as interest can create new interest in every settlement cycle [3]. Compound interest investment thus serves as one of the most accessible and low-risk wealth-growth tools for ordinary working people with limited disposable monthly income. Even with such clear financial advantages widely recognized by professional financial planners, most ordinary adults only acquire superficial fragmented conceptual understanding of the simple phrase "interest generating interest" without deeper quantitative cognition. They cannot accurately quantify the huge asset return gap brought by different long-term saving cycles under compound interest rules, which directly creates widespread short-sighted savings decision-making phenomena among domestic adult consumer groups. From the perspective of adult financial education, learners should not be required to mechanically memorize scattered mathematical and economic knowledge. Instead, educators should build effective connections between abstract mathematical theoretical models and real-life daily financial decision-making scenarios that adult learners can easily understand. Only by mastering quantitative mathematical calculation as a daily analysis tool for personal financial planning can adults fundamentally correct inherent short-sighted consumption biases [4].

2.3. Research hypotheses

H1: Most adult residents in China do not master systematic financial math knowledge about expectation theory and compound interest operation rules. Such cognitive deficiency makes them extremely vulnerable to various probabilistic commercial marketing traps, and they tend to produce typical irrational financial decisions such as neglecting long-term regular savings plans.

H2: Custom math courses that unpack probability marketing tricks and teach compound interest calculation can greatly boost adults' ability to judge financial issues via quantitative analysis and effectively reduce their subjective willingness to participate in blind impulsive consumption activities.

H3: Short-term centralized learning can only lift learners' surface-level financial math awareness, and it cannot create lasting changes to daily shopping and saving habits and a noticeable obvious gap always exists between theoretical cognitive improvement and actual lasting behavioral transformation for adult learners.

3. Research design

3.1. Research objects

The questionnaire targets employed adults aged 18–45 living in urban Jinan. At the beginning of data collection, 236 electronic questionnaires were sent out via various social media groups. After strictly

eliminating all invalid questionnaires containing incomplete blank answers, obvious logical contradictions and perfunctory uniform filling content, 210 fully valid complete sample data sets were finally retained for subsequent unified quantitative statistical analysis. 60 representative participants with balanced age, income and gender distribution were further randomly selected from all valid respondents. These selected subjects were randomly divided into an experimental group receiving complete standardized two-set course learning and a blank control group without any corresponding financial mathematics course intervention. Formal unified pre-test and post-test controlled comparative experiments were carried out synchronously for both groups to measure knowledge mastery level changes.

3.2. Research methods

(1) Questionnaire Survey Method: The self-designed questionnaire independently measures three core research dimensions: individual daily consumption behavioral habits when facing various probabilistic retail promotions, basic cognitive mastery level of simple interest and compound interest theories, and subjective psychological willingness of blind impulsive consumption under marketing inducement.

(2) Mathematical Modeling Analysis Method: Construct a general universal mathematical-expectation quantitative model to compare the actual economic benefits brought by lottery-type additional-cost promotion and fixed direct-discount promotion. Build a standard compound-interest final-value mathematical model to accurately calculate total asset returns of long-term monthly fixed-investment regular saving plans.

(3) Action-research Teaching Experiment Method: Two complete independent sets of systematic video teaching courses with matching after-class calculation exercise handouts are fully developed exclusively for this research project. Complete links including formal classroom teaching implementation, unified knowledge-mastery written tests and semi-structured respondent offline interviews are finished in strict sequential order.

(4) Comparative-statistics Analysis Method: Unified comparison is conducted between knowledge-mastery test accuracy data and subjective impulsive-consumption willingness score data collected from the experimental group and blank control group, so as to objectively test the actual intervention effect of the two self-designed financial mathematics courses.

3.3. Core mathematical models

3.3.1. Mathematical Expectation of Random Probabilistic Promotions

The economic benefit of participating in paid lottery promotions can be measured via mathematical expectation, as shown in Equation (1):

$$E = \sum_{i=1}^{n} P_i V_i - C \tag{1}$$

where P_i represents the independent winning probability of each tiered reward setting, V_i represents the real market value of the corresponding reward prize, and C stands for the extra additional monetary cost consumers need to pay to join the random lottery activity. When the calculated value of $E < 0$, it proves that consumers will obtain negative average economic benefits in long-term repeated participation of such lottery promotions. Fixed 20% direct-off discount generates definite stable preferential returns, which can be directly compared horizontally with the expected return value calculated from Equation (1).

3.3.2. Final Value of Monthly Fixed Investment Savings with Monthly Compound Interest

To calculate the long-term asset appreciation of monthly regular deposits under monthly compound interest settlement, this study constructs the asset final value model shown in Equation (2):

$$FV = PV \times (1 + \tfrac{r}{12})^{12t} \tag{2}$$

In this formula, PV represents the fixed monthly investment savings amount, r stands for the annualized stable financial rate of return, and t means the total number of continuous saving years of the fixed investment plan. This study further uses Equation (2) to calculate asset returns under different saving cycles in the subsequent numerical case analysis.

3.4. Complete course schemes

Course 1: Saving One Thousand Yuan Monthly to Accumulate Long-term Wealth: Compound Interest Theory and Long-term Personal Wealth-growth Financial Decision-making. Combined with the daily fixed-investment savings scenarios widely applicable for ordinary office workers with fixed monthly salaries, this course clearly distinguishes the essential operational differences between simple interest and compound interest settlement rules. The teaching content quantitatively calculates and compares huge asset-return gaps generated under different continuous saving cycles, helping adult learners establish scientific long-term-oriented personal-finance planning thinking to balance instant consumption desire .

Course 2: Consumption Routines Hidden Behind Probabilistic Paid Lotteries. Taking the mainstream physical-store dual-choice promotion mode of "direct 20% off / additional-fee paid lottery participation" as the core practical teaching case throughout the whole lesson, blind-box serial product consumption is only briefly introduced as an auxiliary extended calculation demonstration example for auxiliary understanding. This course systematically explains two basic core mathematical concepts: mathematical expectation and independent random events in probability theory. Detailed horizontal comparison is conducted to analyze long-term comprehensive economic returns generated under these two completely different merchant preferential policies, guiding adult learners to master standardized quantitative analysis methods for quickly identifying various hidden probabilistic-marketing consumption traps in daily retail shopping.

4. Empirical analysis

4.1. Descriptive statistical analysis

Comprehensive statistical results generated from 210 valid questionnaire samples show that 76.2% of all survey respondents have actively participated in various paid-lottery commercial retail promotions in daily shopping experience, and 31.4% of these participants reported that they spent extra money exceeding their pre-set shopping budget due to the psychological attraction of random high-value reward expectation. Only 12.9% of all respondents can independently complete mathematical calculation to measure the average expected economic return of random promotional activities without external assistance. Up to 82.4% of participants cannot clearly tell the essential operational differences between simple interest and compound interest settlement mechanisms. Besides the above cognitive deficiency data, 67.1% of all respondents admitted that they had the real experience of continuous additional blind consumption driven by sunk-cost psychological bias in probabilistic retail promotion scenarios. All these collected statistical results jointly provide preliminary objective empirical evidence supporting research Hypothesis H1 proposed in this paper.

4.2. Quantitative calculation case of long-term monthly compound interest savings

This study adopts Equation (2) to calculate the total asset value of monthly fixed deposits under a 3% annualized return rate for 5-year, 10-year and 20-year saving cycles. Unified fixed calculation conditions are set as follows: fixed monthly regular savings amount of 1,000 yuan, annualized stable low-risk financial

investment return rate of 3%, with monthly compound interest settlement mode adopted. Total asset final values under 5-year, 10-year and 20-year continuous saving cycles are calculated and compared separately:

• 5-year saving cycle: Total principal invested 60,000 yuan, total principal and compound interest asset value 64,654 yuan, pure compound interest income 4,654 yuan;

• 10-year saving cycle: Total principal invested 120,000 yuan, total principal and compound interest asset value 138,965 yuan, pure compound interest income 18,965 yuan;

• 20-year saving cycle: Total principal invested 240,000 yuan, total principal and compound interest asset value 329,502 yuan, pure compound interest income 89,502 yuan.

The longer the continuous regular saving cycle lasts, the more prominent the exponential asset-appreciation effect brought by compound interest settlement rules will become. Nevertheless, most ordinary adult consumers completely ignore such huge long-term asset return potential of regular monthly savings, and unconsciously prioritize instant short-term consumption satisfaction over long-term wealth accumulation plans, thus forming typical widespread short-sighted financial-decision bias among domestic working adult groups.

4.3. Quantitative calculation case of typical probabilistic retail promotions

The official marked selling price of a daily consumer commodity is fixed at 160 yuan, and the retail merchant provides two mutually exclusive alternative preferential plans for all customers to choose voluntarily. Plan 1 offers consumers a direct fixed 20% off discount, bringing stable fixed preferential economic benefit of 32 yuan for each single commodity purchase. Under Plan 2, after consumers complete a 160-yuan commodity transaction, they can pay an extra additional cost of 15 yuan to join a store random lottery activity with two reward tiers: the probability of winning a 12-yuan store-wide shopping coupon is set at 92%, and the probability of obtaining full commodity price exemption (worth 160 yuan) is only 8%.

Standard mathematical calculation of single-time lottery participation expected economic return:

This paper calculates the single-time lottery expected economic return according to Equation (1): $E = 0.92 \times 12 + 0.08 \times 160 - 15 = 8.84$.

The average preferential economic benefit obtained from one-time lottery participation is merely 8.84 yuan, which is far lower than the fixed 32-yuan stable discount benefit brought by choosing the direct 20% off plan. Retail merchants deliberately design such lottery promotion routines by fully taking advantage of ordinary consumers' speculative psychological tendency of pursuing rare large-value full-price-exemption reward prizes. From a long-term statistical perspective, consumers will gain much fewer average economic benefits by choosing to participate in paid lottery activities rather than fixed direct discounts. Blind-box serial product consumption belongs to a typical derivative commercial retail scenario operated under the identical probabilistic profit logic adopted by store lottery promotions.

4.4. Comparative statistical results of course intervention test

After receiving complete standardized course intervention teaching, the average accuracy rate of probabilistic-promotion economic-benefit calculation test reaches 98% within the experimental group, while the corresponding accuracy figure is only 29.3% for the blank control group without any financial mathematics course learning experience. The average accuracy rate of compound-interest-related asset return calculation test is 94.3% for the experimental group and merely 23.7% for the control group without learning intervention. In terms of subjective psychological impulsive-consumption willingness scoring (1–10 scoring standard, higher score represents stronger blind consumption willingness), the average score of the experimental group drops to only 3.14 after course learning, in obvious contrast to the average score of 7.21 recorded from the

blank control group before any teaching intervention. All these groups of objective test data effectively and fully verify research Hypothesis H2 proposed in this paper, adequately proving that the two self-designed financial mathematics courses can substantially improve ordinary adults' comprehensive financial quantitative-judgment ability in daily consumption and savings scenarios.

4.5. Research limitations verified by post-test interview materials (supporting hypothesis H3)

Feedback collected from post-test semi-structured offline interviews indicates that 73% of all participating subjects within the experimental group can fully understand all mathematical logic and quantitative analysis methods systematically taught in the two supporting courses. Even with complete theoretical cognition mastered after course learning, these adult learners are still extremely susceptible to blind impulsive consumption behavior when facing various real offline retail promotional scenarios with strong marketing atmosphere. Short-term concentrated course learning only provides one-time systematic knowledge input for participants, yet it lacks persistent auxiliary behavior-restraint supervision mechanisms to consolidate long-term financial decision-making habits. Moreover, the current two sets of course teaching content only cover basic daily consumption and regular fixed-savings financial scenarios, while complex high-risk financial-product investment scenarios such as stock funds, consumer credit and commercial insurance are not incorporated into the current teaching design framework. All the above interview findings jointly support the rationality of research Hypothesis H3: simple short-term theoretical cognitive improvement cannot automatically transfer to stable long-term rational financial consumption and savings behavioral transformation for adult consumer groups. The research design also fails to refer to the quasi-experimental research framework for policy intervention evaluation proposed by Guceri and Liu [5], which can be supplemented in follow-up research to enhance the rigor of experimental data comparison.

5. Conclusion

(1) Adult consumer groups in domestic China commonly lack systematic basic financial-mathematics cognitive mastery related to probability mathematical expectation theory and compound interest settlement rules. When encountering various random probabilistic-style retail marketing activities in daily shopping, ordinary adults are very easy to fall into commercial profit traps set by merchants and produce typical irrational financial decisions such as neglecting long-term regular wealth accumulation savings plans.

(2) Targeted adult mathematics courses focusing on quantitatively disassembling hidden operational routines of probabilistic retail marketing and popularizing compound-interest long-term asset-return calculation methods can significantly improve the general public's comprehensive quantitative financial-judgment competence and effectively reduce subjective psychological willingness of blind impulsive consumption. Such life-oriented financial mathematics popular science courses constitute an effective and feasible practical path for systematically popularizing rational financial literacy among domestic adult consumer groups.

(3) Short-term concentrated mathematics course intervention teaching can only promote temporary superficial improvement of learners' financial theoretical cognition level. Simple cognitive advancement cannot be directly and automatically transformed into stable long-term rational daily consumption and regular savings behaviors. Corresponding persistent after-class practical guidance and auxiliary calculation tool mechanisms need to be matched synchronously to realize lasting positive influence on adults' daily financial decision-making habits. Future research can adopt the quasi-experimental identification strategy from fiscal

incentive policy research proposed by Guceri and Liu [5] to optimize the experimental grouping design and eliminate confounding variables.

(4) The essential practical social value of basic mathematics education lies in providing simple quantitative-analysis thinking tools for ordinary citizens to objectively understand hidden operating logic behind various commercial economic behaviors. Such mathematical thinking tools help the general public thoroughly see through diverse probabilistic-marketing consumption traps widely existing in domestic consumer retail markets, and assist individual adults in forming balanced daily financial plans to coordinate short-term instant consumption demands and long-term personal wealth-planning targets.

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