Construction of College Students' Happiness Index Evaluation Model and Optimization of Budget Allocation—Integrated Application of Analytic Hierarchy Process and Linear Programming

Peiwen Luo[a]
College of Mathematic and Statistic, Chongqing University, Chongqing, 400000, China

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Abstract: The College students constitute a distinct demographic characterized by strong consumption desires coupled with limited financial resources, which poses challenges to their overall well-being as measured by the happiness index. This study aims to enhance the happiness index of college students by first collecting empirical data on the allocation proportions of living expenses and their respective contributions to happiness through structured questionnaire surveys. The Analytic Hierarchy Process (AHP) employing a 1–9 scale was utilized to quantitatively assess the happiness index associated with each expenditure category, with subsequent consistency testing of the judgment matrix confirming the validity of the evaluations. A constrained linear programming model was then developed, defining the maximization of the aggregate happiness index as the objective function and treating the proportional distribution of living expenses as decision variables. By optimizing these allocations, the model seeks to maximize overall student happiness. Validation through a case study on a randomly selected participant's expenditure data demonstrated a substantial increase in the happiness index post-optimization, thereby confirming the model's applicability and efficacy. This integrative methodological approach combining AHP and linear programming provides a novel framework for the quantitative assessment and optimization of subjective well-being among college students, offering significant implications for targeted financial planning and welfare improvement strategies.

1 INTRODUCTION

From the perspective of consumption, college students, as an important component of the social population, have consumption levels that largely reflect the overall development of the national economy. Whether their consumption structure is scientific and reasonable not only affects their own quality of life but also relates to their personal financial stability (Gu, 2024). On one hand, college students tend to have strong consumption desires while lacking comprehensive spending plans, which often leads to situations where their consumption concepts are advanced, but their actual consumption capacity is insufficient. On the other hand, their sources of income are relatively singular, with the vast majority relying on financial support from their parents for living expenses (Chen, 2020). Based on these two conditions, it can be observed that the income and expenditure patterns of college students are relatively simple, making them easier to investigate and optimized yet such efforts are also highly necessary. From the perspective of happiness index, the college stage plays a critical role in the transmission of knowledge and the cultivation of skills for future labour forces. Therefore, ensuring the well-being of college students is not only a key factor in promoting effective learning, but also a proper and necessary approach in line with the goals of 21st-century education outcomes (Cosmas et al., 2022).

Consumer behaviour refers to the comprehensive manifestation of consumers' psychological needs, purchasing motivations, consumption intentions, and their actual behaviours (Khairuddin and Mahmud, 2020). The happiness index, on the other hand, is a quantifiable indicator artificially designed to evaluate the degree of happiness. By combining the two aspects-consumer behaviour and the happiness index-it becomes evident that the sense of satisfaction

[a] https://orcid.org/0009-0008-6719-9751

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derived from consumption can influence consumers' perceived happiness (Shi et al., 2024). Therefore, it can be reasonably understood that appropriate consumer behaviour contributes positively to the improvement of the happiness index. Conversely, inappropriate or irrational consumption behaviour can have adverse effects on the happiness index of college students (Ong et al., 2022).

Existing research generally focuses on the economic attributes of consumer behaviour, emphasizing objective indicators such as the Engel coefficient, while often overlooking the underlying mechanisms linking consumption choices to subjective well-being. Although methods such as Analytic Hierarchy Process (AHP) and linear programming have been applied in the evaluation of quantitative data and the study of economic issues, limited attention has been given to the combined analysis of college students' living budgets and the optimization of quantified happiness indices (Saaty, 2008; Chen and Wang, 2019).

This study innovatively constructs a three-tier analytical framework of "Consumption Clustering – Happiness Quantification – Budget Optimization." First, by integrating data from questionnaire surveys and publicly available databases, key expenditure dimensions in daily life are identified. Subsequently, an improved Analytic Hierarchy Process (AHP) model-enhanced with λ-consistency checks and modified using the entropy weight method-is employed to quantify the contribution weights of each dimension to the happiness index (Wen et al., 2018). Finally, a constrained linear programming model is established, using the minimum necessary expenditure as the boundary condition, to solve for the optimal budget allocation scheme under the objective function of maximizing the happiness index. Compared with traditional single-dimensional economic models, this framework achieves a dynamic coupling between the objective quantification of consumption behaviour and the subjective perception of well-being, thereby identifying an optimal balance point for budget optimization and happiness improvement among college students.

2 METHODS

2.1 Data Resource

The quantitative data on college students' consumption-related happiness, as well as data on the primary expenditure categories and their proportions in students' living expenses, were obtained through a questionnaire survey. The survey was conducted among 100 undergraduate students from various regions.

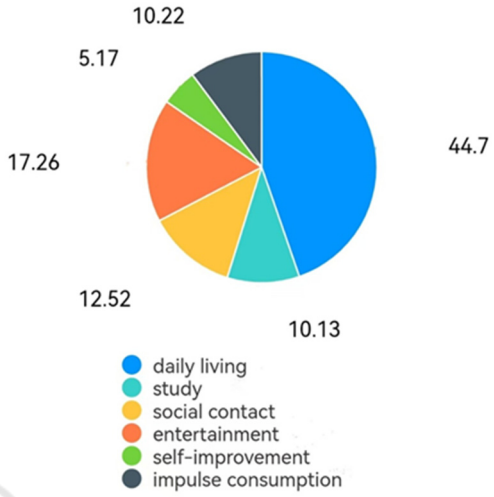

Figure 1: Chart of College Students' Living Expense Categories and Their Proportions (Picture credit: Original).

The figure 1 above presents the statistical distribution of the average proportions of college students' living expenses by category, based on data collected through the questionnaire survey. It reflects the major expenditure categories and their approximate shares in the overall budget.

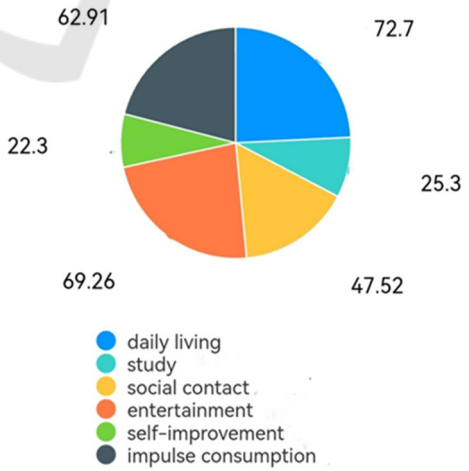

Figure 2: Chart of Contribution Proportions to the Improvement of College Students' Happiness (Picture credit: Original).

The figure 2 above presents the average values of the perceived contribution of each expenditure category to happiness improvement, based on data collected through the questionnaire survey (original proportions normalized from 300%). It reflects a simplified quantitative assessment of how each spending category contributes to the enhancement of college students' happiness.

2.2 Variable Description

The table 1 explains the variables that need to be used in the subsequent mathematical modeling process and their explanations.

Table 1: Table of variable description

Variable	Description
c_i	Quantitative data of the relatively subjective comprehensive evaluation of the happiness index ratings for each expenditure category of college students' living expenses, based on the questionnaire results.
x_i	Proportion of each expenditure category in the total living expenses of college students (calculated as percentages; the percentage sign is omitted in subsequent tables).
M	The total happiness index calculated by summing the happiness indices of all expenditure categories for college students' living expenses.

2.3 Method Overview

This paper utilizes data obtained from a survey to establish a rating system for each category of living expenses. A judgment matrix is constructed, and the consistency of the matrix, along with the value of its determinant, is used to validate the rationality of the rating system. The happiness rating index for each expenditure category is then derived. Subsequently, an objective function is formulated, and constraints are set based on the relevant data of college students' living expenses. Using linear programming, the proportion of each expenditure category is optimized, aiming to maximize the overall happiness index.

3 RESULTS AND DISCUSSION

3.1 Data Analysis and Production

3.1.1 Quantitative Data for Happiness Index Ratings

Based on the collected happiness rating data, the 1-9 scale method from the Analytic Hierarchy Process (AHP) is used to quantify the happiness index-that is, each expenditure type is rated on a scale from 1 to 9 according to its relative importance (the higher the score, the more important the category). The consumption types are categorized into six groups: daily living, study, social contact, entertainment, self-improvement, and impulse consumption. The happiness rating indices are rounded to the nearest integer to maintain consistency, and the resulting data are presented in the following table 2:

Table 2: Happiness Index Rating Table

Daily living	Study	Social contact
7	2	5
Entertainment	Self-improvement	Impulse consumption
7	2	6

The table 2 above presents a scientific quantification of the happiness index using the 1-9 scale method, based on the proportional distribution of the simplified happiness index ratings. A pairwise comparison matrix is constructed based on the relative importance between the six influencing factors, as shown below (Table 3):

Table 3: Judgment Matrix

1	3/7	5/7	1	2/7	6/7
7/3	1	5/3	7/3	2/3	2
7/5	3/5	1	7/5	2/5	6/5
1	3/7	5/7	1	2/7	6/7
7/2	3/2	5/2	7/2	1	3
7/6	1/2	5/6	7/6	1/3	1

The consistency index (CI) is defined as:

$$CI = \frac{\lambda - n}{n - 1} \quad (1)$$

Where, n represents the order of the judgment matrix, and λ denotes the maximum eigenvalue of the matrix. Next, the random index (RI), which corresponds to the value of n, is obtained from a standard reference table 4:

Table 4: Random Index (RI) Table (Bi, 2023)

n	3	4	5	6	7	8
RI	0.58	0.90	1.12	1.24	1.32	1.41

The table 4 above presents an empirically derived statistical value associated with the matrix dimension n, which is used to assess whether the current judgment matrix demonstrates greater consistency than a randomly generated matrix.

Finally, the consistency ratio (CR) is calculated as:

$$CI = \frac{CI}{RI} \quad (2)$$

The computation yields CR ≈ $1.43 \times 10^{-16} < 0.1$, which is infinitesimally close to zero. Therefore, the consistency requirement is satisfied, and the rationality of the quantified happiness index ratings is validated, allowing for further data processing.

3.1.2 Range of College Students' Living Expense Categories

Based on the collected data on college students' living expense categories and their corresponding proportions, the mean (μ) and standard deviation (σ) for each expenditure category are calculated. To eliminate the influence of outliers on the normal range, the interval μ ± σ, which covers approximately 65.26% of the data, is adopted as the reasonable range for the proportion of each living expense category.

By calculating, the mean proportion μ and standard deviation σ for each expenditure category were obtained. To simplify the computational complexity during model construction, the values were rounded. The results are as follows:

Table 5: Table of Mean Proportions (μ) for Each Expenditure Category

Daily living	Study	Social contact
45	10	13
Entertainment	Self-improvement	Impulse consumption
17	5	10

Table 6: Table of Standard Deviations (σ) of Proportions for Each Expenditure Category

Daily living	Study	Social contact
17	6	11
Entertainment	Self-improvement	Impulse consumption
13	8	9

These two variables from table 5 and 6 can be used to calculate the normal range of living expense proportions for each expenditure category among college students. If the lower bound, calculated as μ - 2σ, is less than 0, it is reasonably adjusted to 0. The final ranges are shown as follows:

Table 7: Table of Normal Ranges for College Students' Living Expense Proportions by Expenditure Category

Daily living	Study	Social contact
(28,62)	(4,16)	(2,24)
Entertainment	Self-improvement	Impulse consumption
(4,30)	(0,13)	(1,19)

The above table 7 can basically clarify the normal range of each expenditure direction, that is, the upper and lower limits of constraints.

3.2 Model Building

3.2.1 Define Decision Variables

Based on the analysis of existing data, it was found that the data type suitable for adjustment and optimization is the proportion of college students' living expenses allocated to different categories. Therefore, this paper defines x_i is the proportion of living expenses allocated to the i category. This approach to defining decision variables focuses the study on the proportions of living expenses, thereby avoiding difficulties in investigating and collecting data caused by the diverse and complex family backgrounds of college students.

3.2.2 Establish the Objective Function

To establish the objective function, the goal must be clarified: using a mathematical model to optimize the proportions of college students' expenditures to maximize the overall happiness index. Based on the existing data and analytical results, linear programming is identified as the optimal method for this optimization. Therefore, the objective function can be defined as follows: $M = c_i x_i$. Where, c_i represents the happiness index associated with each

expenditure category, and x_i denotes the proportion of living expenses allocated to each category.

By optimizing this objective function through adjusting the decision variables, the maximum overall happiness index can be achieved.

3.2.3 Set General Constraints

Based on previous calculations, the normal range of the decision variables, the proportions of college students' living expenses allocated to each category-can be clearly defined as: $(\mu_i - \sigma_i,\ \mu_i + \sigma_i)$, where μ_i represents the meaning of the data for the ith expenditure category, and σ_i represents the standard deviation of the data for the ith category. By using the normal range of college students' living expense proportions as constraints on the decision variables, approximately 98% of the typical data is included, while the influence of outliers is effectively excluded.

3.2.4 Set Type Constraints

Individual consumption behaviors and habits vary and tend to be persistent over time. In other words, long-established consumption habits are difficult to change drastically in a short period, and abrupt adjustments to expenditure structures are neither practical nor scientific. This consideration represents an innovative aspect of this study. Considering the diversity of consumption habits among college students, this paper classifies the population into two types: impulsive consumers and non-impulsive consumers.

When the proportion of impulse consumption exceeds 10% (approximately μ), the individual is classified as an impulsive consumer. This personality type is characterized by a lack of clear consumption plans and a relatively high share of impulsive expenditures in living expenses. The emotional value provided by this behavior, i.e., the enhancement effect on the happiness index, is more pronounced. Accordingly, this paper sets the constraint on impulse consumption proportion as: $(0.1, \mu + \sigma)$.

Conversely, when the impulse consumption proportion does not exceed 10% (approximately μ), the individual is classified as a non-impulsive consumer. This personality type features well-defined consumption plans and a relatively low share of impulsive expenses, with a weaker contribution to the improvement of the happiness index. Thus, the constraint on impulse consumption proportion for this type is set as: $(\mu - \sigma, 0.1)$.

By incorporating these type-specific constraints, the model scientifically addresses the optimization needs of different consumption habit groups among college students, further enhancing their overall happiness index.

3.3 Model Application

A randomly selected student's living expense allocation from the questionnaire is used for optimization. The original proportion data for each expenditure category is as follows (Table 8, 9):

Table 8: Table of Original Living Expense Proportions.

Daily living	Study	Social contact
40	10	15
Entertainment	Self-improvement	Impulse consumption
15	10	10

Based on the formula, the original total happiness index is calculated to be 5.6. The established mathematical model is then applied to optimize the living expense proportions. The optimized results are as follows:

Table 9: Table of Optimized Living Expense Proportions.

Daily living	Study	Social contact
62	4	2
Entertainment	Self-improvement	Impulse consumption
30	0	2

By applying the objective function again, the optimized total happiness index is calculated to be 6.74, which is significantly higher than the original value of 5.6. This result validates the effectiveness and rationality of the proposed model.

4 CONCLUSION

Through the above discussion, this paper constructs a mathematical model that first quantifies the happiness index ratings associated with each category of college students' living expenses. The model then optimizes the allocation of these expenses to maximize the total happiness index. To validate the model's effectiveness, a randomly selected student's data was used for optimization, and the increase in the total happiness index from pre-optimization to post-optimization confirmed the model's feasibility.

This model addresses the challenge of coordinating college students' living expense

allocations and contributes to enhancing their overall happiness index.

However, the model has certain limitations. For instance, it only considers constraints based on the average values of each indicator, without accounting for the differentiated preferences of students with varying personalities. This presents a potential direction for future refinement.

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