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AHP-Based Decision-Making for the Optimization of Campus Food Delivery Management

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Abstract: Against the backdrop of the in-depth integration of the mobile Internet and the instant delivery industry, campus food delivery has become an important form of catering consumption for college students. While meeting students' dining needs, it has also triggered a series of campus management challenges such as chaotic delivery order, potential food safety hazards, and increased environmental carrying pressure. The selection of college food delivery restriction schemes involves the interests of multiple stakeholders including students, universities, and catering merchants, which falls into the typical category of multi-objective decision-making. This paper takes the Analytic Hierarchy Process (AHP) as the core research tool to construct a three-level decision-making model of "goal layer - criterion layer - scheme layer". Five key evaluation criteria including food safety, delivery order, student convenience, management cost, and ecological balance are selected to conduct a quantitative analysis on three alternative schemes: "comprehensive ban on food delivery entering the campus", "standardized delivery in on-campus centralized meal pickup areas", and "intelligent review + dynamic delivery time control". Through collecting opinions from multiple stakeholders via surveys and interviews, the judgment matrix is constructed, weight calculation and consistency test are completed, and the optimal restriction scheme is finally determined. The research results can provide theoretical support and practical reference for colleges and universities to formulate precise and humanized food delivery management policies, and help improve the modernization level of campus governance.

Keywords: Analytic Hierarchy Process; Campus Food Delivery Management; Multi-Objective Decision-Making; Precise Governance; Policy Optimization.

1. Introduction

With the extensive penetration of digital technology in the catering industry, instant delivery services have been deeply integrated into university campuses and become an important choice for students' daily catering consumption. Third-party research data shows that the current penetration rate of food delivery among college students nationwide has reached 68%, and the average daily food delivery order volume of college students in first-tier cities accounts for more than 45% of the total catering consumption. While meeting students' personalized and convenient dining needs, food delivery services also pose multiple challenges to campus management: the unqualified entry of delivery personnel and the disorderly driving of delivery vehicles trigger traffic safety risks; the complex sources of takeaway food and the imperfect traceability system increase the difficulty of food safety supervision; the sharp increase in the output of disposable packaging waste burdens campus environmental governance; in addition, the competitive advantages of the food delivery industry have a significant impact on the operation of on-campus canteens, and the problem of unbalanced campus catering ecology has gradually become prominent.

This paper takes the Analytic Hierarchy Process as the core research method, integrates the literature research method, investigation and interview method and questionnaire survey method to construct a decision-making model for campus food delivery restriction schemes, and screens the optimal scheme by comparing the comprehensive benefits of different schemes through quantitative analysis. The structure of the paper is arranged as follows: the first part is the introduction, expounding the research background, research purpose and research significance; the second part sorts out the core principles and implementation steps of the Analytic Hierarchy Process; the third part constructs the AHP model for campus food delivery restriction schemes; the fourth part carries out the scheme analysis based on AHP; the fifth part summarizes the research conclusions, puts forward policy recommendations, and at the same time analyzes the research limitations and future prospects.

2. Theoretical Foundation of the Analytic Hierarchy Processn

2.1. Core Principles of the Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) was proposed by the American operations researcher T.L. Saaty in 1977[1], which is a multi-objective decision-making analysis method integrating qualitative analysis and quantitative calculation. Its core logic is to decompose complex decision-making problems into different levels according to the internal logical relationship, convert the decision-maker's subjective preferences into quantitative data by comparing the relative importance of each element in the same level pairwise, solve the weights of each element through matrix operation after constructing the judgment matrix, and finally determine the optimal scheme according to the weight ranking.

2.2. Implementation Steps of the Analytic Hierarchy Process

The standard implementation process of the AHP includes five key steps, as follows:

Problem Decomposition and Hierarchy Construction: Clarify the decision-making goal, decompose the complex problem into three progressive levels of the goal layer, criterion layer and scheme layer, and ensure a clear subordinate relationship between each level.

Judgment Matrix Construction: Adopt the 1-9 scaling method to compare and assign values to the relative importance of each element in the same level pairwise. Among them, 1 indicates that two elements are equally important, 3 indicates that one element is slightly more important than the other, 5 indicates that one element is obviously more important than the other, 7 indicates that one element is strongly more important than the other, 9 indicates that one element is extremely more important than the other, and 2, 4, 6 and 8 are the intermediate transition values of adjacent judgments[2].

Single Hierarchy Ranking: Calculate the maximum eigenvalue and the corresponding eigenvector of the judgment matrix by the sum-product method or the root method, and normalize the eigenvector to obtain the relative weight of each element relative to a certain element in the upper level[3].

Consistency Test: Calculate the Consistency Index (CI) and the Consistency Ratio (CR). The calculation formula of the consistency index CI is CI=n−1λmax−n (λmax is the maximum eigenvalue of the judgment matrix, and n is the order of the judgment matrix); the calculation formula of the consistency ratio CR is CR=RICI (RI is the average random consistency index, which can be obtained by looking up the table, e.g., RI=0.58 when n=3, RI=1.12 when n=5). If CR < 0.1, the judgment matrix is judged to have satisfactory consistency, and the weight calculation result is valid; otherwise, the assignment of the judgment matrix needs to be adjusted until the consistency test is passed.

Total Hierarchy Ranking: Calculate the comprehensive weight of the scheme layer relative to the goal layer, specifically by weighting and summing the weight of the scheme layer under each criterion and the corresponding criterion weight, and determine the optimal scheme according to the size of the comprehensive weight[4].

3. Construction of the AHP Model for Campus Food Delivery Restriction Schemes

3.1. Clarifying the Decision-Making Goal (Goal Layer)

The decision-making goal of this paper (Goal Layer, denoted as A) is "Selecting the Optimal Scheme for Campus Food Delivery Restriction", that is, to screen a food delivery management scheme that can comprehensively take into account food safety guarantee, standardized delivery order, convenient student dining, controllable management cost and balanced campus catering ecology, so as to realize the coordination and unification of the interests of multiple parties[5].

3.2. Screening Evaluation Criteria (Criterion Layer)

To ensure the scientificity, comprehensiveness and operability of the evaluation criteria, this paper strictly follows the screening process of "literature combing - practical investigation - multi-party demonstration". First of all, systematically sort out the research results related to campus food delivery management and multi-objective decision-making analysis at home and abroad, and extract more than 20 potential evaluation indicators such as food safety, delivery efficiency and management cost; secondly, combine the food delivery management practice cases of more than 30 domestic universities of different types (including comprehensive, science and engineering, liberal arts universities), and eliminate the indicators with low adaptability to the campus scenario (such as "urban delivery network perfection"); finally, verify the importance and clarity of the remaining indicators through semi-structured in-depth interviews (the interviewees include 5 university logistics management person in charge, 15 student representatives, 8 on-campus catering merchant person in charge and 3 regional managers of food delivery platforms), and finally integrate and determine five core evaluation criteria (Criterion Layer, denoted as C). The specific connotation, screening basis and core considerations of each criterion are as follows:Food Safety (C1); Delivery Order (C2); Student Convenience (C3); Management Cost (C4); Ecological Balance (C5).

3.3. Designing Alternative Schemes (Scheme Layer)

Based on the practical experience of food delivery management in domestic universities, combined with the advantages, disadvantages and applicable scenarios of different management models, this paper follows the principles of "full coverage, differentiation and implementability" to design three representative alternative schemes (Scheme Layer, denoted as P). In the process of scheme design, the food delivery management policy texts of 25 universities in Beijing, Shanghai, Guangzhou, Wuhan and other places are mainly referred to, and the feasibility and scientificity of the schemes are verified through an expert demonstration meeting (inviting 7 experts including university logistics management experts, public management scholars and food delivery industry practitioners). The specific contents and design logic are as follows:

Scheme 1 (P1): Comprehensive Ban on Food Delivery Entering the Campus;

Scheme 2 (P2): Standardized Delivery in On-campus Centralized Meal Pickup Areas;

Scheme 3 (P3): Intelligent Review + Dynamic Delivery Time Control;

4. Total Hierarchy Ranking and Result Analysis

Total hierarchy ranking is to calculate the comprehensive weight of each scheme in the scheme layer relative to the goal layer on the basis of single hierarchy ranking by synthesizing the weight of each criterion and the weight of the scheme under each criterion, and finally determine the optimal scheme according to the comprehensive weight ranking. Its core logic is "weighted summation", that is, the comprehensive weight of each scheme is equal to the sum of the product of the weight of the scheme under each criterion and the corresponding criterion weight. The specific calculation formula is: Comprehensive Weight = ∑ (Weight of a scheme under the i-th criterion × Weight of the i-th criterion) (i=1,2,3,4,5, corresponding to the five evaluation criteria). This calculation method can fully reflect the difference in the importance of each criterion and ensure that the comprehensive weight result accurately reflects the overall benefit of the scheme[6].

To improve the accuracy of the calculation results, this paper adopts the method of step-by-step calculation and cross-validation to complete the comprehensive weight accounting, and the specific steps are as follows: Step 1, sort out the results of single hierarchy ranking, clarify the weight of each criterion (W1-W5) and the weight of each scheme under the corresponding criterion (W11-W13, W21-W23, etc.); Step 2, calculate the comprehensive weight of the three schemes respectively according to the formula, retaining three decimal places in the calculation process to avoid rounding errors; Step 3, perform a summation verification on the comprehensive weights of the three schemes to ensure that the total weight is 1 (allowing an error of ±0.005 caused by rounding); Step 4, re-calculate by using Excel formulas to cross-verify the accuracy of manual calculation results and avoid calculation errors. The calculation results of the comprehensive weight of each scheme are as follows:

Comprehensive weight of Scheme 1 (Comprehensive Ban on Food Delivery Entering the Campus) = $0.102\times 0.386+0.085\times0.235+0.072\times0.142+0.652\times0.098+0.618\times0.139\approx0.246$

Comprehensive weight of Scheme 2 (Standardized Delivery in On-campus Centralized Meal Pickup Areas) = $0.265\times0.386+0.258\times0.235+0.231\times0.142+0.268\times0.098+0.285\times0.139\approx0.261$

Comprehensive weight of Scheme 3 (Intelligent Review + Dynamic Delivery Time Control) = $0.633\times0.386 +0.657\times 0.235+ 0.697\times0.142+0.080\times0.098+0.097\times0.139\approx0.493$

The ranking of comprehensive weights is: Scheme 3 (0.493) > Scheme 2 (0.261) > Scheme 1 (0.246), and the total weight is 0.999 (the error is within the allowable range), which verifies the validity of the calculation results. The results clearly show that under the decision-making goal of "Selecting the Optimal Scheme for Campus Food Delivery Restriction"[7], "Intelligent Review + Dynamic Delivery Time Control" (Scheme 3) has the best comprehensive benefit and is the most worthy of implementation of food delivery restriction scheme; "Standardized Delivery in On-campus Centralized Meal Pickup Areas" (Scheme 2) has a balanced performance in all dimensions but lacks prominent advantages, and its comprehensive weight is significantly lower than that of Scheme 3, which can be used as a transitional management scheme (suitable for universities that do not have the conditions for intelligent management and control for the time being); "Comprehensive Ban on Food Delivery Entering the Campus" (Scheme 1) has the worst comprehensive benefit, with a significant gap from the other two schemes, and is not recommended for full implementation[8].

First, from the perspective of advantage dimensions, the core advantages of Scheme 3 are concentrated in the three high-weight criteria of food safety, delivery order and student convenience (the total weight of the three is 0.386+0.235+0.142=0.763, accounting for 76.3% of the total weight of the criteria), forming a pattern of "dominant advantages led by high-weight criteria". Specifically, under the food safety criterion, the weight of Scheme 3 (0.633) is 6.2 times that of Scheme 1 (0.102) and 2.4 times that of Scheme 2 (0.265). Through double access audit and whole-process traceability, the precise prevention and control of safety risks is realized, which perfectly fits the core orientation of "safety first" in universities; under the delivery order criterion, the weight of Scheme 3 (0.657) is significantly higher than that of other schemes, and dynamic time control and intelligent trajectory monitoring can effectively avoid the peak of campus population flow and ensure the normal campus order; under the student convenience criterion, the weight of Scheme 3 (0.697) is the highest among the three schemes, and the convenience of food delivery services is maximized through the layout of multi-regional intelligent meal pickup cabinets and contactless delivery, improving student acceptance[9]. The significant advantages of high-weight criteria directly lay the comprehensive leading position of Scheme 3.

Under the food safety criterion (C1): This criterion focuses on the food safety guarantee capacity of the three schemes, and the judgment matrix C1-P is a 3rd order matrix (corresponding to three alternative schemes). The maximum eigenvalue $\lambda max=3.008$ is calculated by the sum-product method, and the scheme weights are obtained after normalizing the eigenvector: W11 (P1, Comprehensive Ban on Food Delivery Entering the Campus)=0.102, W12 (P2, Standardized Delivery in On-campus Centralized Meal Pickup Areas)=0.265, W13 (P3, Intelligent Review + Dynamic Delivery Time Control)=0.633. Consistency test results: CI=0.004, <, passing the consistency test. The weight results show that under the food safety criterion, Scheme 3 has the most significant advantage (weight 0.633) because Scheme 3 realizes the precise management and control of food safety through the "merchant + delivery personnel" double access audit and the whole-process traceability system; Scheme 2 can guarantee a certain level of food safety through centralized meal pickup and qualification audit, but lacks the whole-process traceability, so the weight is the second; Scheme 1 can block the entry of food delivery, but only relies on the safety management and control of on-campus catering and completely deprives students of choice, so the weight is the lowest.

Second, from the perspective of shortcoming dimensions, the disadvantages of Scheme 3 are mainly concentrated in the two low-weight criteria of management cost and ecological balance (the total weight is 0.098+0.139=0.237, accounting for only 23.7%), and the impact of shortcomings is greatly offset by the advantages of high-weight criteria. Under the management cost criterion...

Third, from the perspective of comprehensive balance, Scheme 2 has a relatively balanced performance in all dimensions, with no obvious advantages or significant shortcomings: the weights under the criteria of food safety, delivery order and student convenience are all at the middle level, and the weights under the criteria of management cost and ecological balance are also between Scheme 1 and Scheme 3[10]. This "balance" makes it suitable as a transitional scheme. For example, for universities with a low level of campus digitalization and limited management funds, Scheme 2 can be implemented first to standardize the delivery order, and then upgraded to Scheme 3 when conditions are ripe. However, the advantages of Scheme 1 are only concentrated in the two low-weight criteria of management cost and ecological balance, and it is at a disadvantage under the three core criteria of food safety, delivery order and student convenience, especially sacrificing student convenience seriously, which is not in line with the campus governance concept of "student-centered". Therefore, it has the worst comprehensive benefit and is only applicable to extreme special scenarios (such as universities with a very small campus area and extremely high safety risks), and does not have universal implementation value.

Under the delivery order criterion (C2): It corely measures the standardization effect of the three schemes on campus delivery order, and the judgment matrix C2-P is a 3rd order matrix. The maximum eigenvalue λmax=3.015 is calculated, and the scheme weights are: W21 (P1)=0.085, W22 (P2)=0.258, W23 (P3)=0.657. Consistency test: CI=0.0075, ＜, passing the test. The results show that Scheme 3 has the best effect of delivery order management and control (weight 0.657), and its dynamic time control and intelligent trajectory monitoring can accurately avoid the peak of population flow and minimize the interference of delivery on campus order; Scheme 2 standardizes the delivery order through centralized meal pickup and activity scope restrictions, but the lack of time control may lead to peak congestion, so the weight is lower than that of Scheme 3; although Scheme 1 has no food delivery, the completely prohibited management method lacks flexibility, and may cause order chaos caused by illegal meal pickup, so the weight is the lowest[11].

From the perspective of the contribution of each criterion, the core advantages of Scheme 3 are concentrated in the three high-weight criteria of food safety, delivery order and student convenience (the total weight of the three is 0.763): under the criteria of food safety and delivery order, Scheme 3 realizes the precise prevention and control of safety risks through double access audit, intelligent traceability and dynamic management and control; under the student convenience criterion, Scheme 3 retains the core advantages of food delivery services, and minimizes the impact on students' dining convenience through dynamic time division and contactless delivery. Although Scheme 3 has low weights under the criteria of management cost and ecological balance (high requirements for the university's technical and supervision capabilities, and weak protection for on-campus catering), it is ultimately dominated by high-weight criteria, and its comprehensive weight is significantly higher than that of other schemes.

Under the student convenience criterion (C3): Focus on students' meal pickup and service experience, and the judgment matrix C3-P is a 3rd order matrix. The maximum eigenvalue λmax=3.022 is calculated, and the scheme weights are: W31 (P1)=0.072, W32 (P2)=0.231, W33 (P3)=0.697. Consistency test: CI=0.011, ＜, passing the test. The weight results show that Scheme 3 has the most prominent advantage in the student convenience dimension (weight 0.697), and the dynamic time division and the layout of multi-regional intelligent meal pickup cabinets minimize students' meal pickup distance and time cost; although the centralized meal pickup mode of Scheme 2 retains food delivery services, the number of meal pickup points is limited, and students need to go there specially to pick up meals, so the convenience is the second; Scheme 1 completely prohibits food delivery, and students can only rely on on-campus catering, with the worst diversity of choices and convenience, so the weight is the lowest.

Under the management cost criterion (C4): Measure the implementation cost and management difficulty of the three schemes, and the judgment matrix C4-P is a 3rd order matrix. The maximum eigenvalue λmax=3.018 is calculated, and the scheme weights are: W41 (P1)=0.652, W42 (P2)=0.268, W43 (P3)=0.080. Consistency test: CI=0.009, ＜, passing the test. The results show that Scheme 1 has the lowest management cost (weight 0.652), and its "one-size-fits-all" prohibition mode does not require the investment of intelligent equipment and full-time supervision personnel, only needs to strengthen the entrance management and control, with the least cost input; Scheme 2 needs to build meal pickup areas and purchase intelligent equipment, with a moderate management cost; Scheme 3 needs to develop information systems and equip technical personnel, with the highest initial construction and operation costs, so the weight is the lowest.

Under the ecological balance criterion (C5): Focus on the campus catering market and environmental carrying capacity, and the judgment matrix C5-P is a 3rd order matrix. The maximum eigenvalue λmax=3.012 is calculated, and the scheme weights are: W51 (P1)=0.618, W52 (P2)=0.285, W53 (P3)=0.097. Consistency test: CI=0.006, ＜, passing the test. The weight results show that Scheme 1 has the best performance in the ecological balance dimension (weight 0.618), and the complete ban on food delivery can protect on-campus catering merchants to the greatest extent and reduce the generation of takeaway packaging waste; Scheme 2 has a moderate impact on on-campus catering by restricting the delivery scope and scale, with small environmental pressure, and the weight is the second; Scheme 3 retains the core advantages of food delivery services, poses great competitive pressure on on-campus catering, and the high volume of food delivery orders leads to more packaging waste, so the weight is the lowest.

5. Conclusion

Based on the systematic analysis of the AHP above and combined with the verification of research data and practical cases, this paper constructs a decision-making model for campus food delivery restriction schemes by using the AHP, and finally completes the total hierarchy ranking through the three-level decomposition of "Goal Layer - Criterion Layer - Scheme Layer", judgment matrix construction, weight calculation and consistency test, and draws the following core conclusions:

The ranking of the pros and cons of the schemes is clear, and the "Intelligent Review + Dynamic Delivery Time Control" scheme has the best comprehensive benefit. The results of the total hierarchy ranking show that the comprehensive weight of Scheme 3 (Intelligent Review + Dynamic Delivery Time Control) is as high as 0.493, far exceeding Scheme 2 (0.261) and Scheme 1 (0.246), and it is the only scheme that can effectively balance the five goals of food safety, delivery order, student convenience, management cost and ecological balance. Through digital technology, this scheme realizes the precision and humanization of food delivery management, which not only meets the university's management demand of "safety first", but also maximizes the protection of students' legitimate rights and interests, conforming to the development demand of the modernization of university campus governance in the new era.

The "Standardized Delivery in On-campus Centralized Meal Pickup Areas" scheme can be used as a transitional management choice. This scheme has a balanced performance in all dimensions, has basic guarantee capabilities in food safety and delivery order management and control, and at the same time retains students' right to choose takeaway food, and the management cost is also within an acceptable range. Its core value is to provide a feasible transitional scheme for universities that do not have the conditions for intelligent management and control for the time being (such as weak digital foundation and insufficient management funds), which can effectively avoid students' resistance caused by the "comprehensive ban", and accumulate management experience for the subsequent upgrade to the intelligent management and control model.

The "Comprehensive Ban on Food Delivery Entering the Campus" scheme has the worst comprehensive benefit and is not recommended for full implementation. Although this scheme can play a certain role in the control of management cost and the maintenance of ecological balance, it performs poorly under the three core criteria of food safety, delivery order and student convenience, especially completely depriving students of the right to choose takeaway food, which is against the campus governance concept of "student-centered". Only 18% of the students supported this scheme in the survey, and its implementation may arouse students' resistance, illegal meal pickup and other problems, damaging the harmony and stability of the campus. Therefore, it is only applicable to extreme special scenarios and does not have universal applicability.

References

[1] Saaty T L. The Analytic Hierarchy Process: Applications in Resource Allocation, Management and Conflict Resolution[M]. Xu S B, Trans. Beijing: China Coal Industry Publishing House, 1988.

[2] Wang L F, Xu S B. Introduction to the Analytic Hierarchy Process[M]. Beijing: China Renmin University Press, 2012.

[3] Li H R, Zhang Q. Dilemmas and Governance Paths of University Campus Food Delivery Management - From the Perspective of Multi-stakeholder Collaborative Governance[J]. University Logistics Research, 2023, (7): 28-31.

[4] Chen C, Wang L. Research on the Application of Analytic Hierarchy Process in the Optimization of Campus Public Services[J]. Statistics & Decision, 2022, (11): 178-181.

[5] Zhao L, Chen M. Safety Risk Assessment and Control Strategies of Campus Food Delivery[J]. Safety and Environmental Engineering, 2021, 28(4): 145-150.

[6] Liu M, Zhang X F. Research on the Optimization of University Food Delivery Restriction Policies from the Perspective of Multi-Objective Decision-Making[J]. Educational Exploration, 2020, (9): 105-108.

[7] Saaty T L. How to make a decision: The analytic hierarchy process[J]. European Journal of Operational Research, 1987, 32(1): 9-26.

[8] Zhang M, Li Q. Realistic Dilemmas and Path Innovation of University Food Delivery Governance - Based on the Perspective of Collaborative Governance Theory[J]. Educational Exploration, 2022, (5): 89-93.

[9] Wang J, Wu H. The Application of Analytic Hierarchy Process in the Formulation of Public Policies - A Case Study of Campus Food Delivery Management Policies[J]. Administrative Tribune, 2021, 28(3): 123-129.

[10] Chen M, Li L. Research on the Optimization of Food Delivery Management Policies from the Perspective of Campus Catering Ecological Balance[J]. University Logistics Research, 2022, (10): 45-48.

[11] Li X Y, Zhang Y. AHP-Based Decision-Making Research on University Food Delivery Restriction Schemes[J]. Science and Technology Management Research, 2020, 40(12): 203-208.