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A Decision Model for High School Students' Summer job Choices: a Study Combining Hierarchical Analysis and Entropy Power Methods

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Abstract: As summer vacation approaches, high school students face an annual opportunity: choosing a summer job. These job opportunities not only provide a way to earn money, but also help students explore their career interests, develop key skills, and prepare them for future educational and career paths. However, high school students often have difficulty in finding the right job. To solve this, we have constructed a decision model that combines the hierarchical analysis of hierarchy (AHP) and entropy weighting method, aiming to find the best match among the many choices for high school students. The problem is essentially a multi-criteria decision-making problem that involves a number of decision-making factors, which need to be taken into account, along with the job characteristics and the applicant's profile and preferences. In our research, summer jobs are evaluated on a total of eight criteria: income, safety risk, job purpose, working conditions, and work. The model takes into account the job characteristics and the user's profile/preferences, and is therefore able to recommend the best job that matches the user's profile/preferences. In this paper, the AHP is used to determine the relative importance of these criteria for each individual, while the entropy weighting method is used to determine the relative importance of these criteria from an objective perspective. The model works as expected by validating it against nineteen types of job and ten fictional characters. Not only can we recommend the best jobs with the highest scores, but we can also rank all candidate jobs according to the calculated priority, providing users with a wider range of job options.

Keywords: Summer job, high school student, hierarchical analysis of hierarchy, entropy weighting method.

1. Introduction

1.1. Background

A summer job is a part-time job that many students take up during the summer vacation to help them accumulate social experience or to get an extra source of income. Businesses choose to recruit short-term part-time jobs during the summer to reduce labor costs, and there are also big companies that recruit summer interns, which saves costs and is used as a way of recruiting a pool of talents as their potential employees in the future. Summer jobs can also bring the following benefits to students: first of all, students who have work experience during their high school time will undoubtedly be more competitive when applying for college or jobs, and work experience in society allows students to adapt more quickly to a new environment; secondly, high school students can take the opportunity of summer part-time jobs to learn in advance how their interests are applied in the society, which is very helpful for students to make a plan for their future. For example, graduates of biology major will choose to be a doctor, ecologist, or botanist, etc. Meanwhile, high school students seek part-time jobs for different purposes, such as payment, improving personal ability or social ability. Nowadays, the Internet is well developed, and the overwhelming number of job-searching websites could easily confuse high school students who want to find summer part-time jobs.

1.2. Problem Description

1. There are many different criteria for defining the best summer job for high school students. The job should not only provide financial reward, but should also promote intellectual and psychological development and match the student's interests. Therefore, we need to identify all the factors that high school students consider.

2. The optimal job choice problem is essentially a multi-criteria decision problem. We need to build a decision model that uses the influencing factors from 1 as evaluation criteria, and considers all the criteria, including job benefits, user profile and preferences, and assigns different weights to different factors to determine which job is the best fit for this group of high school students.

3. We need to create ten representative fictional characters, each with their own characteristics related to the factors mentioned in 1 and 2. Since it is not possible to collect information about real people, we will use a randomization method to assign random profiles to these fictional characters.

2. Hypotheses and Variables

2.1. Hypotheses and Rationale

Hypothesis 1: Wages, working hours and company size are considered to be the same for similar jobs.

Hypothesis 2: High school students are aware of their summer plans.

Hypothesis 3: High school students are paid fairly and equally for their summer jobs.

Hypothesis 4: Randomly generated information about fictional people is representative of real people's situations and preferences and can provide the data needed for the model.

2.2. Variable List

The variables are represented by the symbols shown in Fig 1:

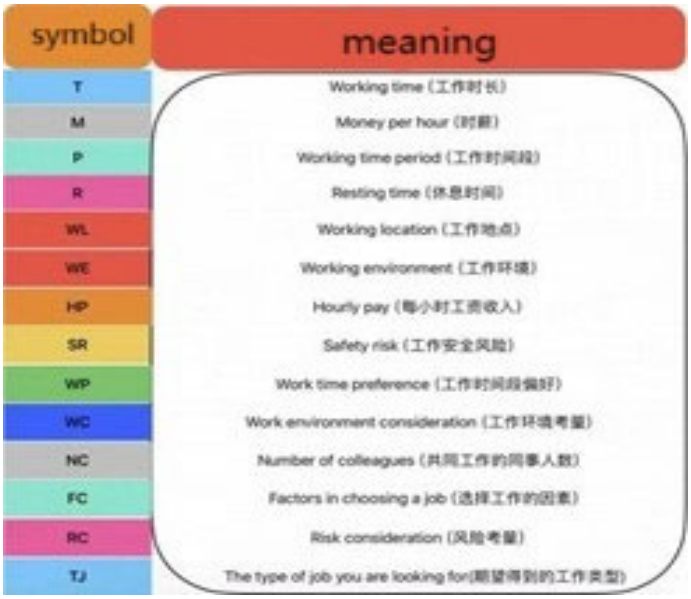

Figure 1. Symbols and their descriptions

Table 1. Mathematical symbols and their descriptions

Symbol	Symbol Meaning	Symbol	Symbol Meaning
λ_{max}	Maximum eigenvalue	E_j	Information entropy
W	Gross income from work	p_{ij}	Weight of the i-th program for the j-th indicator
M	Hourly wage	x_{ij}	Value of the jth variable for the i-th sample
T	Total hours worked	n	Total number of samples
CR	Consistency ratio	w_j	Entropy weight
CI	Consistency indicator	w_j	Combined weight of variable j
RI	Consistency index		

3. Model Overview

3.1. Hierarchical Analysis

As mentioned earlier, the first step is to identify the variables that will be considered by the high school students. In order to make the model more effective, these variables will be arranged in a hierarchical structure. The Analytic Hierarchy Process (AHP) was used to assess the importance of each variable to the user, and the advantage of the AHP[1] is that it can present complex choice factors as simple concepts in a hierarchical structure, which is easy for decision makers to accept. We considered a wide range of variables and used subjective opinions. By using the AHP model, we are able to rank the weight of each variable for each user in order to determine the most suitable job for them. All job options will be tested against the base model and an index will be calculated for each job.

3.2. Entropy Weighting

However, the AHP model itself is susceptible to subjectivity. Therefore, in addition to the AHP, we will apply the Eutrophic Weight Method (EWM) to address the subjectivity aspect of our model.

Using the quantitative variables we have collected about summer job options, we calculate weights for each subset by calculating their entropy. We can then combine the results of the AHP and entropy methods for summer job listings to obtain a subset of jobs that are more appropriate for the user.

4. Basic Variables of The Model

The most basic model for evaluating the most suitable summer job is a function of the effect of a summer job and a number of other independent variables, including age, income, work conditions, risk, purpose of the job and ability. We need to summarize and explain said variables we used for the study then explain our hierarchical analysis and finally perform the test.

4.1. Deterministic variables

There are specific variables that can determine whether or not a high school student can take a job. These are the basic requirements of the job and must be considered as prerequisites. According to Chinese law, individuals over the age of 16 are allowed to work, and because of the immaturity of their physical condition, high school students cannot be trusted with very heavy tasks.

4.2. Probability Variables

In this section, we need to examine variables that other than predetermine a high school student can participate in certain

jobs. The following variables were analyzed statistically and were found to be the most important factors.

- Conditions

In our study, job conditions were considered and played a role in the study, including:

1. whether the work environment is attractive to high school students, such as the geographic location, good transportation, subway or bus nearby, the equipment and the number of employees in the workplace.

2. whether the job requires the employee to sit for a long time.

3. Online or offline working.

- Income

For the majority of high school students who work part-time during the summer, income plays a significant role. We define the total income from the job as W and equate it to the following

$$w = MT \tag{1}$$

where T is the number of hours a high school student works and M is the hourly wage (in dollars per hour). We surveyed job boards such as Doumi[2] to analyze earnings.

- Risks

Due to the age of high school students, there may be some risks associated with jobs. Firstly, there is the risk of mental health, as the sudden change of environment may bring some psychological pressure to high school students, and some jobs may have safety hazards. Moreover, seasonal infectious diseases that may break out in some setting could affect the health of high school students, such as cashiers who come into contact with hundreds of people in a day.

- Purpose of the job

Different high school part-time jobs have different purposes for different people. For example, some high school students are more interested in the financial benefits, and some jobs can help high school students gain social experience, which includes scheduling, making friends, etc. In addition, some summer part-time jobs can enhance their backgrounds and enrich their experiences, which may help them a lot in the future. Also, some high school students may choose a summer part-time job because they are passionate about it. They may choose animal care because they like a certain kind of animal or like the nature, or they may choose game coaching because they enjoy the game.

- Workplace

Some high school students also consider whether the organization they work for has a good reputation or provides valuable resources. Ambitious young high school students are very likely to choose a summer job in a large corporation. In addition, corporate values are likely to influence the future values of high school students during their first exposure to society.

Based on the variables considered, we analyzed the characteristics of some of the more common summer jobs chosen by high school students, as shown in the table below:

Table 2. Characteristics of summer jobs chosen by some of the more common high school students

Job/Subjob	Number of Employees	Hourly Rate (RMB)	Average Daily Hours (hours)	Online (0)/Offline (1)	Work Environment (1-5)	Risk Factor (1-5)	Age Requirements	Other Requirements
Babysitter	1	40	11	1	4	2	18	Junior high school graduate and above
Video Chat Host	900	58	10	0	3	2	16	Have good chatting skills
Hourly Electronics Factory Worker	500	25	8	1	2	1	18	Junior high school graduate and above
Video editing	100	250	2	0	3	1	17	More professional editing skills are required
Business Consultant	10	18.75	8	1	2	1	16	Responsible and career-oriented
Teahouse clerk	50	20.875	8	1	2	1	18	Knowledge of beverage production
Bicycle-Sharing Maintenance Staff	10	5	8	1	1	3	16	Hardworking and obedient
Restaurant Waiter	10	12.2	5	1	1	2	16	Good attitude
Airport Catering Staff	10	8.3	10	1	2	2	18	Friendly attitude
Basketball trainer	3	40	4	1	3	2	17	Have good basketball skills
Clothing sales	20	25.6	13	1	2	1	16	Relevant working experience
Lego shopper	100	18	13	1	2	1	18	Good communication skills
Bread baker	30	10	7.5	1	1	1	17	Genuine learner
Supermarket sorter	10	30	10	1	2	1	17	Strong affinity
Flower store cashier	4	23	8	1	2	1	16	Enthusiastic and patient
Japanese restaurant clerk	10	23	15	1	3	2	18	Catering experience preferred
Video production intern	100	60	3	0	3	1	19	Interest in short videos
Part-time KTV singer	12	22	4	1	1	1	18	Good singing skills
Calligraphy teacher	1	55.5	3	1	3	1	18	Basic calligraphy theory and writing skills

5. Mathematical Modeling

5.1. Data Normalization

In order to eliminate the effect of magnitude and to transform all variables to the same scale, we normalized the data. Specifically, we used the min-max normalization method, which maps the raw data to values between 0 and 1. Mathematically, this process is expressed as:

$$X_{norm} = (X - X_{min}) / (Xmin - Xmax) \quad (2)$$

where X is the original data point, Xmin and Xmax are the minimum and maximum values of the variable in the dataset respectively, and Xnorm is the normalized data point. This step allows direct comparison between data points to ensure that our next modeling can be carried out smoothly.

5.2. Analytic Hierarchy Process

After identifying the variables and standardizing the data, the next section is to address the weighting of each variable. This will help us assess the relative importance of each variable so that we can recommend the most suitable summer job for each student. First developed by Thomas Saaty in the 1980s, the AHP model is suitable for dealing with a hierarchy of variables and is capable of calculating the weights of each variable[3]. Below is a summary of the hierarchy of our variables.

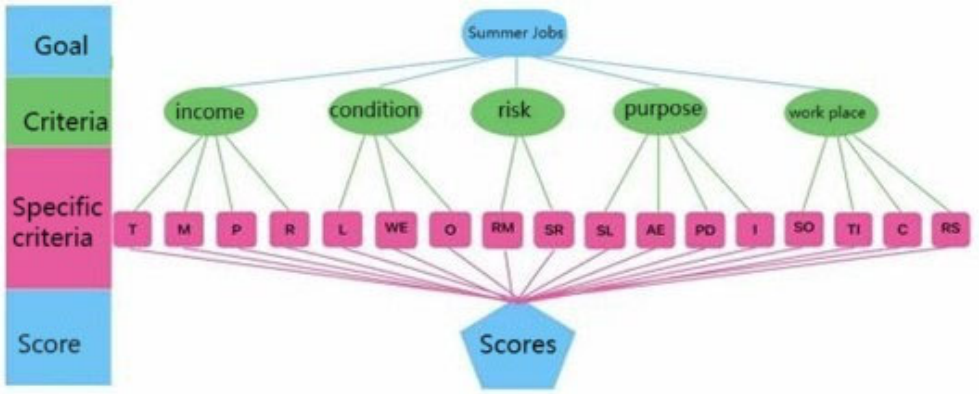

Figure 2. Hierarchical hierarchy

We now use the hierarchical approach to determine the relative importance of the different job factors. First, we construct a pairwise comparison matrix that reflects the relative importance of the different factors. Each element represents the importance of the row factors relative to the column factors. For example, if income is considered twice as important as the work environment, the corresponding element is 2. In this example, Jasper focuses more on salary, work environment, his interests. The student's main goal for the job is to earn a living wage while doing something he enjoys. Therefore, we created a comparison matrix based on Jasper's personal preferences, as shown in the table below:

Table 3. Results of the two-by-two comparison

	Working Location	Working Time	Hourly wage	Working Time Preference	Rest time	Work environment considerations	Number of colleagues	Job selection factors	Risk considerations
Working Location	1	1/3	1/5	1/3	1/3	1/5	1/3	1/5	1/3
Working Time	3	1	1/3	1	1	1/3	1	1/3	1
Hourly wage	5	3	1	3	3	1/2	3	2	3
Working Time Preference	3	1	1/3	1	1	1/3	1	1/3	1
Rest time	3	1	1/3	1	1	1/3	1	1/3	1
Work environment	5	3	2	3	3	1	3	2	3
Number of colleagues	3	1	1/3	1	1	1/3	1	1/3	1
Job selection factors	5	3	1/2	3	3	1/2	3	1	3
Risk considerations	3	1	1/3	1	1	1/3	1	1/3	1

After the comparison matrix has been successfully created, we need to calculate the weights and normalize the matrix. The matrix is normalized by dividing the sum of the columns. Subsequently, the weight vector is determined by calculating the average value of each row of the normalized matrix. The mathematical expression is:

$$wi = \frac{1}{n}\sum_{j=1}^{n}\frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} \quad (3)$$

We have:

Table 4. AHP weighting

Guidelines	WL	T	HP	WP	R	WC	NC	FC	RC
Weights	0.0296	0.0714	0.2016	0.0714	0.0714	0.2367	0.0714	0.1751	0.0714

After obtaining the weights for each indicator, the weights for Jasper were reorganized and classified according to the five categories we proposed (income, risk, working conditions, purpose of work, work unit). The results of the calculations are shown below:

Table 5. Composite weights

Categories	Income	Working conditions	Purpose of work	Work place	Risks
Combined weights	0.273	0.2663	0.1751	0.1428	0.0714

Meanwhile, to verify the consistency of the pairwise comparison matrix, we calculated the maximum eigenvalue λmax and the consistency ratio (CR). The consistency index (CI) is calculated as:

$$CI = (\lambda_{max} - n)/(n-1) \quad (4)$$

For the case of n criteria (in this example, n = 9), the random consistency index (RI) is a predefined value of 1.49. Therefore, the consistency ratio (CR) is calculated as:

$$CR = CI/RI \quad (5)$$

A pairwise comparison matrix is considered to have a satisfactory level of consistency if CR < 0.10. In our case, the CR value of 1.51% is well below the 0.1 threshold, indicating that our evaluation system has a high level of consistency.

By using these formulas in Python to iteratively validate our fictitious matrices, we were able to ensure that our consistency ratios, CR, were all well below 0.1, meaning that our comparison matrices.

5.3. Objective weighting system using the entropy weighting method

In order not to rely only on the AHP method, it is necessary to consider the degree of dispersion of the assessment indicators. Therefore, we introduced another assessment method called Entropy Weight Method (EWM), which determines the weights by calculating the information entropy of each indicator [4]. This provides a more comprehensive basis for decision making.

Since survey data often includes both categorical and continuous data, the raw data needs to be pre-processed to be able to apply entropy weights. The preprocessing steps include: 1) Removing non-numeric rows; 2) Dealing with multiple choices

Then, we normalize the data again and calculate the information entropy for each variable. In our context, the lower the information entropy, the greater the variability of the variable in the dataset and the higher the potential decision impact. For each variable j, the information entropy Ej is calculated by the following formula:

$$E_j = -\frac{1}{\ln(n)} \sum_{i=1}^{n} p_{ij} \ln(p_{ij}) \quad (6)$$

Pij is calculated as follows:

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}}$$

where xij is the value of the jth variable for the ith sample and n is the total number of samples.

The entropy weight of each variable is calculated based on its information entropy, which reflects the relative importance of the variable in the selection of the assessment. The entropy weights are determined by the following formula:

$$w_j = \frac{1 - E_j}{\sum_{k=0}^{n} (1 - E_j)} \quad (8)$$

5.4. Combining AHP and Entropy Weighting Methods

Finally, in order to improve the accuracy and reliability of the AHP model, we need to combine the AHP process and the entropy method, and adopt the following formula to reduce the difference:

$$w_j = w_j^{AHP} \times w_j^{Entropy} \quad (9)$$

where Wj is the composite weight of variable j, wjAHP is the weight of variable j obtained by the AHP method, and wjEntropy is the weight obtained by the entropy method. Therefore, we can derive the combined weight of each indicator based on Jasper's personal preference and objective evaluation of the indicators.

Table 6. Combined weights

WL	T	M	P	WE	NC	FC	RC
0.0054	0.0147	0.0071	0.0075	0.0106	0.0104	0.0172	0.0028

5.5. Conclusion

Based on Jasper's composite weights, we will use a weighted sum to calculate a composite score for each task. The score for each metric is obtained by multiplying its value by the corresponding weight.

$$S_i = \sum_{j=1}^{m} w_j N_{ij} \quad (10)$$

It can also be expressed in the following equation:

$$f(x) = w_1 WL + w_2 T + w_3 HP + w_4 WP + w_5 R + w_6 WC + w_7 NC + w_8 FC + w_9 RC \quad (11)$$

Based on our model, the higher the final rating a job receives, the more suitable a job it will be. Using the data from the summer job list for each job, we calculated that the most suitable job for Jasper is "Video Chat Host" (77.52 points), followed by "Video Editor" (41.89 points), while the least suitable job is Bicycle Sharing Maintainer (2.77 points).

6. Testing the Model

6.1. Background of the fictional characters

In the previous section of the paper, we explained how we applied the mathematical model to Jasper (Liu Qi). In this section, we will add nine more characters, and we follow the principle of making them as representative as possible. We will objectively compare the relative importance of each student in relation to the different variables, using the entropy weighting method.

1. Wang Lin (16) attaches great importance to the choice of workplace, and prefers online part-time jobs due to the lack of transportation and his introverted personality. He has no preference for working hours and does not care about daily breaks, but he can work from home.

2. Han Li (16) He is currently in his first year of high school and he has limited free time each day because of assignment. He does not care about the number of coworkers he works with.

3. Lin Qi (17) is a high school student who prioritizes an hourly wage because he needs to support his family. He doesn't care how long he can rest every day, as long as he earns more, it is worth it.

4. Fang Han (17) He is a sophomore in high school and has a regular daily routine, so he is more concerned about working hours. He doesn't care about work environment as long as it doesn't interfere with his schedule.

5. Ye Qingyun (17) does not want to be too busy during the summer vacation. He doesn't care much about where he works, or it's not important to him whether it's online or offline.

6. Li Feiyu (16) cares a lot about his work environment. He was born in a privileged family and does not work to make more money.

7. Zhu Jing (18) would like to have more coworkers. He is a hard worker and doesn't get tired no matter how many hours a day he works.

8 Wu Hao Yang (17) prefer to have a part-time job that's about technology. He likes to socialize, so he is very interested in offline work. He doesn't really care about working environment or working hours.

9. Bi He (17) is a freshman in high school and comes from a wealthy family. He is more concerned about whether the job is safe. Meanwhile, he wants to work in the best possible working environment.

10. Jasper (18) is mainly interested in the income, the working environment, and whether the work is meaningful.

6.2. Test conclusions

Table 7. Optimal job choice for all characters

Wang Lin (16)	Han Li (16)	Lin Qi (17)	Fang Han (17)	Ye Qingyun (17)	Li Feiyu (16)	Zhu Jing (18)	Wu Hao Yang (17)	Bi He (16)	Liu Qi (18)
Video Chat Host	Babysitter	Japanese Restaurant Server	Video Editor	Basketball Trainer	Video Chat Host	Video Chat Host	Video Chat Host	Video Editor	Video Chat Host
Video Editor	Bike Sharing Maintainer	Babysitter	Video production intern	Video Editor	Hourly Electronics Factory Workers	Hourly Electronics Factory Workers	Hourly Electronics Factory Workers	Video Chat Host	Video Editor
Program Developer	Restaurant Server	Bicycle Sharing Maintainer	Calligraphy Teacher	Video production intern	Video Editor	Video Editor	Video Editor	Video production intern	Hourly Electronics Factory Workers

For most of these characters, work environment considerations and hours of work tend to be weighted more heavily in the recommended summer jobs. Additionally, we can conclude that for jobs such as "Video Chat Anchor," "Video Editor," and "Video Production Intern," which appeared multiple times, they should have been more likely to be among the top summer jobs for high school students.

7. Test Evaluation

7.1. Advantages

a) Our model includes real data that we have collected from around us, which makes the model comprehensive;

b) Our model includes multiple variables, making the model more comprehensive;

c) Our fictional characters are representative of their own cities;

d) That we used the entropy weighting method to offset the subjectivity of the model and ensure the objectivity of the results;

7.2. Shortages

a) The AHP model is still subjective and can have an impact on the results derived from our model;

b) We did not take into account the summer jobs that all high school students would choose;

c) Our data was collected from multiple districts, and there may be geographic differences between districts that affect our modeling;

d) We have only provided one possibility for our indicator.

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