

Ordering Method and Empirical Study on Multiple Factor Sensitivity of Group Social Attitudes Based on Entropy Theory

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When studying the various factors affecting a group's social attitudes, minor changes in a factor will easily cause changes to other factors due to their association and relevance to each other; therefore, such a factor is more sensitive, although there is a difference between sensitivity and importance. In order to comprehensively learn about the influence of multiple factors, explorations based on entropy theory have been conducted to determine the sensitivity of each factor, to specify the difference between the frequency and sensitivity priority of entropy theory, and to provide a method, a way of thinking, and a detailed basis for the resolution of actual problems.

Keywords: Entropy Theory, Social Group, Attitudes, Key Factors

1. INTRODUCTION

When exploring the various factors that influence a particular entity, the sensitivity priority of each influencing factor is not always consistent with its order of importance, or at least not consistent with its importance as reflected in a questionnaire. Such is the case with the “happiness” problem, which is currently a hot topic. The factors influencing happiness may be money, relationships, environment, work and health. The response to the questionnaire may indicate that “money” is the most important factor, but “relationships” may be more sensitive, although this is not clearly shown in the questionnaire. That is, the respondent will always choose “money” as the most important when answering the questionnaire, but it is possible that in the deeper law “relationship” is more sensitive. That is,

people's sense of happiness will also increase or decrease by 10% when money is increased or decreased by 10%. However, people's sense of happiness may increase or decrease by 20% when the “relationship” is improved or worsened by 10%. This demonstrates that the “relationship” factor is more sensitive than money. Nevertheless, this kind of deeper law is always buried deep in the data and is difficult to discover. If this law can be discovered, it will greatly help the decision making of managers. This kind of problem is a common occurrence. For example, there are many factors affecting people's satisfaction with the government, and although it is difficult to determine what is the most important factor for some people, some factors which seem unlikely to be the strongest but are more sensitive can be easily discovered, achieving better outcomes when resolved.

Most data reflecting group attitude comes from questionnaires or statistical reports, and there are several factors that influence an entity. The current statistical method mainly calculates the frequency of occurrence of each factor [1], and takes its

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frequency priority as the order of importance of each factor. Although this is clearly an essentially important method, it is one-sided and cannot meet all the demands of management. Managers often hope to make great change in the target variable by changing some of its influencing factors. Each change in the different influencing factors causes a different degree of change on the target because the influencing factors have different levels of sensitivity.

Traditional sensitivity analysis solves the problem of determining the sensitivity of variables to other variables with a relationship function, while the data analysis targeted here concerns random variables and massive statistical data. There are numerous statistical methods [1, 2], in addition to the existing data mining method [3], which can analyze the relationships between independent variables (influencing factors) and dependent variables (the target variables). However, these methods always analyze the relationship between two variables, and do not have a parameter that measures the degree to which a particular variable correlates with other variables. Hence, they cannot measure the sensitivity of a variable to an entity with a parameter. Different methods must be used for different types of variables, such as discrete and continuous variables. Thus, at present, no specific methods can solve the problem of sensitivity analysis for random variables. Also, the current literature does not address this issue. There are other problems in data analysis that are difficult to solve because of the limitations of extant traditional methods. Information entropy theory and its methods provide an effective means of resolving some of these problems.

2. THEORETICAL DISCUSSION

2.1 Limitation of Multi-Factor Studies on the Social Attitudes of Groups

For studies on each factor forming the social attitude of a group, traditional statistics and analysis have two obvious limitations as follows.

First: they lack a parameter reflecting the overall characteristics of a factor. Statistical frequency only counts each factor, but does not show the actual relationship between factors. The overall correlation between each factor can be seen from relevant analysis, but the related coefficient reflects only the relationship between two variables, and can't reflect the distribution characteristics and the degree of sensitivity of a variable in terms of the overall system. Association rules and methods can reflect the overall relevance of things, but need a series of rules instead of a parameter.

Second: the order of importance of each factor is not equal to its order of sensitivity. The factor with the highest frequency of occurrence is not equal to the factor having the closest relationship with other factors; that is, it is not the most sensitive factor. Whereas in practice the factor with the highest frequency is always taken as a factor with the biggest degree of influence, this is not necessarily the case, and computation is needed that reflects its degree of correlation with each factor, and shows how any change influences the other factors.

The question then arises in regard to finding a parameter for a multivariate system which can reflect the average level

of intimacy of a variable associated with other variables in the system, rather than measure its level of intimacy associated with a particular variable only.

2.2 The Solution of the Entropy Weight Method

The entropy weight method has been successfully applied in many relevant fields, including weighting expert opinions in solving the problem of group decision, and entropy evaluation of economic indices. Hence, many methods are available for this study [9–12]. In terms of methodology, the management entropy theory of professor and scholar Qiu Wanhua (2011) consolidated the theoretical foundation of the entropy method for solving the differentiation and causality measurement of the group attitudes of organizational behavior. Based on this foundation, Zhang Shiyu, Liu Wenzhi and He Qin (2017) solved the problem of group attitude differentiation [11]. This paper again proposes the concept of “sensitivity”. It is based on entropy theory and organizational behavior theory, and quantifies and measures this concept, targeting groups of people instead of individuals in the analysis.

Entropy theory and its computation method can definitely be used for the data analysis of social investigations, according to the principle of entropy and the various results from previous research. In recent years, some scholars have conducted research on this topic. In China in 2005, He Dayi published a paper [5] titled “Application of entropy in data analysis”, which defined the equivalence and isomagnetics of data based on entropy theory, to address the deficiencies in determining data distribution characteristics with the traditional mean value and variance index methods. This research pioneered the use of entropy theory to overcome the limitations of statistical analysis methods. In 2007, Ma Xiaoying et al. proposed a comprehensive evaluation method [6] using entropy weight theory to gauge the satisfaction of library users. In 2009, Mao Taitian and Jiang Zhiyi established a model based on entropy weight theory [7] to evaluate the satisfaction of library users. These methods have referential significance for the study of an “objective measurement of satisfaction” raised in this paper.

There has also been some research in this field abroad. In 2006, Joseph B. Kadane and Ramayya Krishnan put forward a display table for processing enumeration data [8] based on Poisson distribution and entropy theory. In 2008, Victor Richmond R. Jose, Robert F. Nau, and Robert L. Winkler proposed scoring rules for data weighting, and studied the dual relationship between utility maximization and entropy minimization [9]. All these studies have significantly improved the analysis of data derived from questionnaires used for social investigation.

2.3 Basic Principle of Solving the Factor of Sensitivity With Entropy Theory

Entropy is a function showing the degree of confusion within a system. Higher entropy indicates a higher degree of chaos and confusion; lower entropy indicates a lower degree of confusion, and a higher degree of order in a system. The basic

principle of entropy is the principle of increasing entropy. This principle states that a system without exogenic action is always spontaneously changing in the direction of increasing entropy. In other words, the system is always spontaneously changing in the direction of disorder. To make the system ordered, an exogenic action must be applied.

Entropy can be taken as a measure of the disorder of molecular motion in a natural system, and of management activity when introduced into management science. In data analysis, it can also be regarded as the degree of permeation of an index in the system. Data concerning social problems is always obtained by means of a questionnaire. The traditional analysis of questionnaires focuses mainly on the frequency of an option being selected. Options with a higher probability of being selected are generally believed to have a greater importance or higher ranking; conversely, a lower probability of selection indicates a lesser importance or lower ranking. According to entropy theory, an option with higher or lower frequency is the result of a high degree of ordering, that is, due to the effects of external forces or some factor in the system. Without external forces, the frequency will spontaneously become evenly distributed. Options which are relatively evenly distributed in measuring each index of the system will always have the greatest influence on the system, and will possibly be the sensitive elements affecting the stability of the system.

According to the principle of increasing entropy, during the development process, an entity will spontaneously tend towards greater freedom, with its final goal being to achieve the most uniform distribution of chaos. The greater is the degree of chaos, the less the difference will be, the energy of things in the system will be lower, and the information will be less certain. Disorder and uncertainty are equivalent.

In a well-organized and effectively managed social system, its entropy develops in a decreasing direction, and the correlation between each index reflecting its characteristics is low with high independence. Conversely, when the correlation of each index is high with low independence, the disorder of the system tends to increase, and the effectiveness of management declines. In the moment, the manager always hopes to control the easiest element which can improve its effectiveness, which is not the element that is most important on the surface, but rather the one whose change can make the entropy of the system significantly decrease.

The purpose of improving the effectiveness of management is to reduce the entropy of the managed system, and find the sensitive elements and control them, thereby improving the system's degree of order. To achieve this aim, data analysis based on the entropy theory is carried out, and the entropy and each index of the overall system, and the contribution of each element to the total entropy of the system, are computed.

3. ENTROPY CALCULATION METHOD FOR THE ANALYSIS OF SENSITIVE FACTORS

Multiple-choice questions are often asked in social investigations, and in the research of certain social phenomena, multiple "yes or no" questions are designed for multiple influence

factors, requesting that the respondents choose answers. To put such questions in an abstract form: K (number of variables) variable/variables, and X_j ($j = 1, 2, \dots, k$) are used as a thing's measurement index. The number of valid questionnaires is n (line number of the data), and every respondent chooses m variable/variables from k variable/variables ($0 \leq m \leq k$). The purpose of the analysis of sensitive factors is to find the variables whose effects are the greatest overall among the other variables. Table 1 shows the sensitive factors affecting research objects.

For this problem, we can calculate the total entropy value of the variables chosen by every respondent according to the calculations of entropy theory. That is to say, we can record the relative entropy of variable X_j on line i of the data table as H_{ij} . The variable chosen in line i is recorded once, and the probability $p_j = 1/m$. For the data in each line, $\sum p_j = 1$, and thus we can obtain an entropy value:

$$H_{ij} = -p_{ij} \ln p_{ij}$$

We can get a total entropy value by adding the H_j values in each line of the j lines, namely the entropy sum H_j of this variable, as in the following equation:

$$\sum H_j = - \sum_{i=1}^n p_{ij} \ln p_{ij}$$

From this equation it can be seen that a higher selection ratio (p_{ij} value is higher) does mean that the entropy value of a factor is greater. Generally speaking, a factor with a higher selection ratio is an important one, and we agree. We refer to factors with higher entropy as sensitive factors, and the important factors are not equal to sensitive factors.

We assume that three factor variables, X_1 , X_2 , and X_3 , can be used to designate one object. For all 10 lines of data in the table, whenever X_j is chosen in each line, we record 1; if not, it is none. It is fixed that if a factor is not chosen, its entropy value is 0.

The entropy value of H_1 in first line:

$$H_{11} = -(1/1) \ln(1/1) = 0$$

The entropy value of H_1 in the second line:

$$H_{21} = -(1/2) \ln(1/2) = 0.35$$

The same calculation method is applied to the remaining factors.

As can be seen from this example, even though the variable X_1 is selected most frequently (7 times), its entropy value (1.79) is not the largest; rather, the entropy value (2.14) of variable X_2 is greater. Therefore, we believe that the variable X_2 is distributed most homogeneously in the system of this entity. It can most easily affect the entity, and even a tiny change in X_2 can exercise a significant influence on the whole system.

This conclusion is consistent with the theory of frequent item sets in data mining. In Table 1, the frequent item sets of these three variables (3 frequent item sets) is twice, namely $\{X_1, X_2, X_3\} = 2$, 2 frequent item sets $\{X_1, X_2\} = 4$, $\{X_2, X_3\} = 4$. That is to say, the variable X_2 appears most frequently in multiple frequent item sets; thus, the variable X_2 most commonly coexists with the other variables.

Table 1 Research data and entropy calculation for a research object's influencing factors.

Line No.	X1	X2	X3	H1	H2	H3
1	1			0	0	0
2	1	1	1	0.37	0.37	0.37
3	1	1		0.35	0.35	0
4	1	1		0.35	0.35	0
5	1	1	1	0.37	0.37	0.37
6		1	1	0	0.35	0.35
7		1	1	0	0.35	0.35
8			1	0	0	0
9	1		1	0.35	0	0.35
10	1			0	0	0
Σ	7	6	6	1.79	2.14	1.44

4. EMPIRICAL ANALYSIS

The empirical analysis was performed by taking the dissatisfaction factors and countermeasures of Beijing City for employees in dissolved enterprises in non-capital function dissolving as an example. This problem is a multi-factor decision-making problem in group social attitudes, and is of a certain typical and representative nature. The core of the Beijing-Tianjin-Hebei coordinated development strategy is to disperse the industries that do not conform to the functional orientation of the capital city. The function dispersal has disrupted the originally stable labor relations of enterprises, and many inevitable problems and risks emerged during the relocation of enterprises. If not resolved properly and effectively, these problems will lead to employee dissatisfaction and labor-capital conflicts between employees and relocated enterprises, or even group labor-capital conflicts, affecting social stability. For this study, we selected 20 typical enterprises from the Beijing Industry Dispersal Directory, and collected survey data from 998 employees, with 964 valid questionnaires returned.

The question on the questionnaire read: "What is the issue that you are most dissatisfied with, compared with the situation before the adjustment and dispersal?":

1. Wages 2. The price levels 3. Work stability 4. Development prospects 5. Working environment 6. Work pressure 7. Convenience of transportation 8. Supporting children's education 9. Convenience of taking care of the family 10. Medical treatment 11. Social security treatment 12. Social security 13. Leisure and entertainment facilities This problem has 13 dissatisfaction items, $k = 13$. The results for frequency, frequency and entropy of variable entropy are summarized in Table 2.

The quantity ranking refers to the number of people who selected the item and the ranking of the percentage, which in this paper is referred to as the "importance ranking". The entropy ranking is, in effect, the sensitivity ranking. The importance ranking and the entropy ranking are the same for the top three responses, namely, "wage income", "development prospects" and "traffic problems". There is a difference in the fourth and the fifth. According to the importance ranking, the fourth is "the price levels", and the fifth is "taking care of the family". However, according to the sensitivity ranking, the order reverses, and the fourth is "taking care of the family", while the fifth is

"the price levels". This difference indicates that "taking care of the family" is more sensitive than "the price levels", and that improvement or deterioration in "taking care of the family" will have no significant impact on the increase or decrease of employee satisfaction. Thus, for the managers of these enterprises, the positive effect of resolving the "taking care of the family" issue is far more than that of resolving "the price levels" issue. In this question, the top three items are consistent in importance and sensitivity, which could be due to chance rather than theoretical certainty. Therefore, when studying and resolving problems, we need to simultaneously rank both importance and sensitivity. That is to say, after we calculate the frequency value and the frequency, we need to also calculate the entropy values to obtain a comprehensive multi-factor ranking, consider many aspects when adopting countermeasures, and determine the key sensitive factors that will achieve the best results.

After ranking the importance and sensitivity of dissatisfaction factors among the dispersed employees, the top five factors emerge as "wage income", "development prospects", "traffic issues", "the price levels", and "taking care of the family". Whether they are ranked by importance or by sensitivity, the top three factors are the same, the difference being reflected in the ranking of "the price levels" and "taking care of family". It can be concluded from the analysis that the dispersed employees' worries about price level changes can be eliminated through an increase in wage income. When the dispersed employees receive wage increases higher than the costs of job changes, the price level changes do not influence them. Therefore, if we want to solve this problem, we should focus on "wage income", "development prospects", "transportation", and "taking care of the family". Therefore, the following solution is proposed:

First, establish a new wage management system that meets employees' need for a wage increase. Since employees will face pressure due to changes made to their posts and duties, and even to the workplace, more flexible and incentivizing wage measures should be taken to reduce employee dissatisfaction. The reward ratio of human resource wages should be increased. Skill-based pay and performance-based pay should replace workload pay. Especially for the management backbone, their basic wage and treatment should be ensured, and stock options and stock wages should be implemented at the same time to offer

Table 2 Sorting and comparison of the importance and sensitivity of dissatisfaction factors among dispersed workers.

Dissatisfaction items	Quantity	Percentage (%)	Entropy	Quantity (importance) ordering	Entropy (Sensitivity) ordering
Wage income	489	52.9	434.94	1	1
The price levels	218	23.6	167.62	4	5
Work stability	167	18.1	164.80	6	6
Development prospects	257	27.8	235.27	2	2
Working conditions	128	13.9	124.74	8	7
Work pressure	134	14.5	118.51	7	8
Traffic problems	232	25.1	206.37	3	3
Children's education issues	72	7.8	75.95	11	11
Taking care of the family	183	19.8	174.76	5	4
Medical treatment	109	11.8	110.33	9	9
Social security issues	79	8.5	83.86	10	10
Public order	0	0	0	13	13
Leisure and entertainment facilities	42	4.5	0.00	12	12

long-term incentive value in terms of wages and treatment. In order to encourage enterprise innovation, a "team salary system" can be adopted for teams with innovative potential to promote entrepreneurship and further develop the enterprise. Second, the career promotion channels for employees should be specified, combining both job development and spiritual improvement. Career planning should be developed for the dispersed employees, and clear personal development channels should be specified. For staff with outstanding performance, not only should job promotion opportunities be provided, but also attention should be paid to professional and personal improvement; this could include training, paid leave, and the pursuit of academic qualifications. In addition, employee travel benefits should be increased. The dispersed enterprises will have to relocate, which means that the distance between relocated staff and their families will increase. Hence, it is necessary to increase employees' travel subsidies. In addition to financial subsidies, shuttle buses should be provided to facilitate the employees' commute, or flexible working hours should be established, giving employees more freedom to choose the time they have off. Finally, for sensitive factors such as the issue of taking care of the family, enterprises should give employees more understanding care, establishing a private staff area to facilitate family reunions, or offering more education and medical benefits to their children and elderly relatives, thereby easing the burden on employees. The risk of labor-capital conflicts is then reduced by taking measures to reduce employees' dissatisfaction after the dispersal.

By ranking and comparing the importance and sensitivity of the factors causing dissatisfaction in dispersed employees, we can obtain a comprehensive and clearer understanding of the impact of each factor on the employees. According to the importance and sensitivity ranking, we can: analyze which factors can be classified under one category (thereby solving multiple problems by solving one key problem); determine the sensitive issue affecting the dissatisfaction of employees; and solve the problems by specifically targeting each one. If a problem that is facing enterprises is carefully thought out

and thoroughly analysed from multiple perspectives, there is a greater chance of understanding the problem, facilitating the targeted conflict resolution, and improving management efficiency.

5. RESEARCH CONCLUSIONS

1. In studying the factors that affect a certain subjective attitude of social groups, the ranking of traditional methods according to the frequency of the factors reflects the importance of each factor. However, this addresses only one aspect of the problem rather than all aspects. It is necessary to sort the relevance of the various factors in terms of the overall system. Entropy theory can solve this problem. The key factors can be found by ranking their sensitivity, and then targeted measures can be applied.
2. The relevance of the various factors in the overall system is related to their sensitivity. Through research, the following effect in management practice has been shown: through a small adjustment to sensitive factors, managers have a scientific basis through which they can achieve control and their management objectives.
3. The case analysis of 13 dissatisfaction factors for employees in dispersed enterprises in Beijing shows that the importance and sensitivity of some factors are consistent in their ranking. However, there is a difference in the ranking of some factors. It is necessary to pay attention to those factors which have this difference, analyze the relationship between the factors having differences and other factors, comprehensively analyze the degree of relevance between the factors from multiple perspectives, specify the impact of sensitive factors on other factors, and propose targeted solutions to improve management efficiency.

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AUTHOR CONTRIBUTIONS

He Qin and Dong Shuang designed the experiments, which were conducted by Cheng Yaxin; He Qin and Dong Shuang applied the tools for data analysis; Dong Shuang wrote the paper.

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