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A Hierarchical Fuzzy Comprehensive Evaluation Study of Digital Transformation Paths for Elderly Asset Management

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Abstract This paper constructs a digital maturity model of asset management for the elderly with 4 target layers and 13 factor layers. On the basis of the evaluation index system established by the hierarchical analysis method, it combines the fuzzy comprehensive evaluation method to establish the risk evaluation model of elderly asset management. Then the fuzzy set qualitative comparative analysis method is used to explore the digital transformation of assets to provide a scientific and feasible way to make the process of digital transformation of elderly asset management more standardized and procedural. The weighting results of the target layers show that the weights of the four target layers, namely, “organization construction, technology application, operation guarantee and innovation drive”, are small, ranging from 0.2303 to 0.2654, while the weights of the factor layers, namely, “innovation of data technology, business model and technological achievement”, and “innovation of technology results”, are the only factors to be considered. In the factor layer, only “data technology business model and technological innovation” has a weight of more than 0.1, which shows that the digital transformation path of assets is closely related to the development of science and technology. In addition, indicators such as talent and maintenance management are also extremely important to the digital transformation of asset management for the elderly. This paper also emphasizes the importance of the three indicators of “capital investment, internal control of marginal conditions, and talent reserve” to realize the digital transformation of asset management for the elderly.

Index Terms Hierarchical Analysis, Fuzzy Comprehensive Evaluation, Fuzzy Set Qualitative Comparative Analysis, Elderly, Asset Management

I. Introduction

China has entered an aging society, and the challenges posed by the issue of pension have further increased. In the face of a large aging population, how to let the elderly have more assets, how to help young people plan for their future old age, and how to stimulate the purchasing power of the elderly population have become urgent problems to be solved in the current economic and social development process [1]-[4]. After 40 years of reform and opening up, older people have more and more wealth in their possession, which is the economic security for older people in their twilight years; due to age, health, management ability and other reasons, older people's ability to self-manage their property is gradually declining, and they need help from others [5], [6]. At present, China's system of helping the elderly to manage their property is not perfect, which is not conducive to the provision of property management services to the elderly by their relatives, other people, the property management service industry, and the relevant parties in society, resulting in an increasing number of cases in which the elderly cannot receive timely help and their rights are violated [7]-[9].

With the digital transformation of various industries, asset management for the elderly also needs to enter the digitalization process. However, due to the existence of the digital divide in the elderly population, which is a major pain point, the digital transformation of asset management has brought obstacles [10]. At the same time, relevant financial institutions have not designed relevant service systems for the elderly, especially the complexity of the operation of mobile banking, digital counters, intelligent business robots, etc. leads to difficulties in asset management for the elderly, and the effect of services for the elderly is far less than that of adults and young people, both online and offline [11]-[14]. In addition, older adults have little trust in digital asset management due to their high personal vigilance, and their biodata (face, fingerprints, etc.) may be difficult to recognize, exacerbating the difficulty of digital transformation [15], [16]. Therefore, a system for evaluating the digital transformation of elderly asset management is needed in order to seek a better transformation path. While the fuzzy integrated hierarchical evaluation method combines fuzzy mathematics and hierarchical analysis for the evaluation of multifactor complex systems, the method can deal with the ambiguity and uncertainty in the evaluation, so that the results can be more relevant to the reality [17].

This paper first provides an overview of the process of digital transformation of asset management and constructs an evaluation index system based on the digital maturity of asset management. After that, the hierarchical analysis method is used to carry out the determination of the weight coefficients of the asset digital transformation indexes, and then combined with the fuzzy comprehensive evaluation method to comprehensively quantify the many fuzzy evaluation values in the risk assessment. Taking the digital transformation of asset management of the elderly as an example, combined with the determination of the risk level of asset transformation, the risk level of the digital transformation of asset management of the elderly is determined, and corresponding corrective suggestions and recommendations are put forward based on the results of the fuzzy set qualitative comparative analysis method.

II. Digital maturity model for asset management based on fuzzy comprehensive evaluation

II. A. Elderly-based digital maturity model construction for asset management

II. A. 1) Digital integration of asset management

Asset management digitization is the process of using new-generation information technology to develop and utilize asset management data resources, promote the exchange and sharing of asset management data resources, promote the optimization of asset management operations and efficiency enhancement, and realize the innovative development of asset management operations.

The overall framework of asset management digital transformation mainly includes five elements. (1) Strategic elements: top-level strategic planning and objectives of asset management digitalization; (2) Organizational elements: the main body of asset management digitalization and the relationship of the organizational structure composed of it; (3) Operational elements: the business activities of the main body related to asset management digitalization; (4) Technological elements: the application, research, and innovation capabilities of asset management digitalization in data, systems, and other related digital technologies; and (5) Guarantee elements: Asset management digitization relies on the main operational security resources. These five elements are mutually supportive and closely related, in which the business element is the core of the entire asset management digitization, and the transformation and upgrading of the business element is the ultimate goal under the guidance, support, participation and guarantee of the other four elements.

II. A. 2) Asset Management Digital Maturity Model Architecture

(1) Technical analysis architecture

Asset management digitization covers elements with business as the core and strategy, organization, technology, and guarantee as guidance and support, which together build the architecture of asset management digitization. Through the implementation of asset management digitization, the all-round transformation of the organization's asset management is realized, the factors driving this transformation are taken as the driving force throughout the whole process of asset management digitization transformation, and the whole transformation activities are drawn by the effectiveness orientation, so as to systematically design the four processes of organization construction, technology application, operation guarantee, and innovation drive and related methods for the four aspects of the asset management digitization transformation and to establish the interaction relationship between the four aspects, forming the asset management digitalization architecture. It also establishes the interaction relationship between the four aspects and forms the technical analysis structure of the asset management digital maturity model.

(2) Development Stage

The Asset Management Digital Transformation Maturity Model is to build a regular framework for describing and measuring the degree of perfection of the integration and development of asset management business and digitalization, which provides an assessment basis for quantifying the process of gradual integration and development of maturity of the asset management business and digitalization, and expresses the comprehensive level of the digital transformation of asset management through the maturity level. And the maturity level is described by different levels, each level contains a number of necessary conditions, and each level has new content elements on the basis of the previous level, and at the same time, the content of this level is also the basis of the next higher level. The asset management digital maturity level is a reflection of the degree and level of the organization's implementation of asset management digitization, which can be divided into four stages based on the stage of development of asset management digitization: initial, standardized, upgraded, and leading, each of which can be further subdivided into five grades, for a total of 20 grades.

(3) Model framework

The asset management digitalization maturity model consists of maturity levels and evaluation domains, in which the evaluation domains are composed of a number of maturity elements, including 4 domains and 13 sub-domains, such as organization construction, technology application, operation guarantee, and innovation drive. The fundamental task of asset management digitization is to optimize, innovate and extend the organization's asset management and related business, and the organization should systematically and orderly promote the digitization of asset management from the four dimensions of organization construction, technology application, operation guarantee and innovation drive.

II. B.Hierarchical analysis-based digital maturity model for asset management

Hierarchical analysis (AHP) is a multi-objective decision analysis method that combines qualitative and quantitative. The hierarchical analysis method is hierarchical, quantitative and normalized for the system, and requires three processes of system decomposition, security judgment and comprehensive judgment in the assessment process. It can be divided into five steps: system decomposition to establish a hierarchical model; construction of judgment matrix; calculation of the relative weights of the compared factors from the judgment matrix; matrix consistency test; total hierarchical ranking and completion of comprehensive judgment.

II. B. 1) Digital Maturity Model Construction for Asset Management for the Elderly

The basic levels of the hierarchical model have goal and criterion layers, and this paper takes the digital transformation of asset management of the elderly as an example to establish a systematic evaluation index system. The evaluation index system of asset management digital transformation maturity level is shown in Table 1, which includes 4 target layers and 13 factor layers.

Table 1: Asset management digital transformation maturity rating system

Project layer	Factor layer
Organizational construction	Strategic planning
	Organizational leadership
	Regulation
	Talent team
Technical application	Data technology
	System technology
	Technical depth
Operation protection	Facilities
	Standard norm
	Maintenance management
	Information security
Innovation drive	Information security
	Business model innovation

II. B. 2) Constructing judgment matrices

Hierarchical analysis [18] requires the construction of a judgment matrix, which serves to compare the relative importance between factors at the same level, subject to the constraints of a factor at the previous level in the hierarchical model.

Suppose we want to compare n factors at a particular level $C_l, C_2, ..., C_n$ on a factor of the previous layer assumed to be O, two factors C_i and C_j are taken at a time, and the ratio of the effects of C_i and C_j on O is denoted by a_{ij}, and the entire comparison result can be represented by the pairwise comparison matrix A. To wit:

$$A = \begin{bmatrix} a_1 & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix} \quad (1)$$

$$A = (a_{ij})_{n\times n}, a_{ij} > 0, a_{ji} = 1/a_{ij} \quad i, j = 1, 2, ..., n \quad (2)$$

The above equation gives a characterization of the matrix A, which is called the positive reciprocal inverse matrix, and it is clear that there must be $a_{ii} = 1$. The n factors need to make $n(n-1)/2$ pairwise comparisons, and it is difficult to make all the comparison values between the factors satisfy the requirements of Eq. (2).

II. B. 3) Calculation of relative weights from the judgment matrix

First, let's explain the meaning of relative weights. Imagine smashing a large stone O into n small stones $C_1, C_2, \ldots, C_n$, weigh them precisely as $\omega_1, \ldots, \omega_n$, and then compare them in pairs. When letting $a_{ij} = \omega_i / \omega_j$, then obtain:

$$A=\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{21} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}=\begin{bmatrix} \frac{\omega_1}{\omega_1} & \frac{\omega_1}{\omega_2} & \cdots & \frac{\omega_1}{\omega_n} \\ \frac{\omega_2}{\omega_1} & \frac{\omega_2}{\omega_2} & \cdots & \frac{\omega_2}{\omega_n} \\ \cdots & \cdots & \cdots & \cdots \\ \frac{\omega_n}{\omega_1} & \frac{\omega_n}{\omega_2} & \cdots & \frac{\omega_n}{\omega_n} \end{bmatrix} \tag{3}$$

Clearly the matrix A is satisfying consistency. The weights of n small stones over large stones can be represented by the vector $\omega = (\omega_l, \omega_2, \omega_2, \omega_n)^T$, and it can be found that the individual column vectors of A differ from ω by a scale factor only.

In general, if a positive reciprocal inverse array A is satisfied:

$$a_{ij} \times a_{jk} = a_{ik} \quad i, j, k = 1, 2, ..., n \tag{4}$$

Then A is called a consistency matrix, or consistent array for short. A is a consistent matrix, and the n-order consistent matrix A has the following properties:

The unique nonzero characteristic root of A is n;

Any row (column) vector of A is an eigenvector corresponding to the eigenroot n.

If the obtained pairwise comparison array is a consistent array, A of Eq. (4) should naturally take the normalized eigenvectors corresponding to the eigenroot n to represent the factors $C_1, C_2, ..., C_n$ to the upper factor O, this vector is called the weight vector. The feature vector that should be at the root of the largest feature of A (denoted as λ) is used as the weight vector, i.e., ω is satisfied:

$$A\omega = \lambda\omega \tag{5}$$

Intuitively, since the eigenroots and eigenvectors of the matrix A depend continuously on the factors a_{ij} of the matrix, when a_{ij} is not far away from the requirement of consistency, the eigenroots and eigenvectors of A are not too far away from the requirement of consistency as well.

In this paper, the relatively simple sum method is used to find the feature vectors in the steps of digital maturity assessment for elderly asset management, which is divided into the following steps:

(1) Normalize each column vector of A to get $\varpi_{ij} = a_{ij} / \sum_{i=1}^{n} a_{ij}$;

(2) Summing ϖ_{ij} by rows yields $\varpi_i = \sum_{j=1}^{n} \varpi_{ij}$;

(3) Normalize ϖ_i by $\omega_i = \varpi_i / \sum_{i=1}^{n} \varpi_i, \omega = (\omega_1, \omega_2, ..., \omega_n)^T$, and ω is the approximate eigenvector;

(4) Compute $\lambda = \frac{1}{n} \sum_{i=1}^{n} \frac{(A\omega)_i}{\omega_i}$, as an approximation of the largest eigenroot.

This method actually normalizes the column vectors of A and takes the average value as the eigenvector of A. Since each of its column vectors is an eigenvector when A is a consistent array, it is reasonable to take the average of the column vectors (after normalization) of A as the approximate eigenvector if the inconsistency of A is not serious.

II. B. 4) Judgment matrix consistency test

The judgment matrix is sometimes not a consistency matrix, but in order to be able to use its eigenvectors corresponding to the eigenroot λ as weight vectors for the factors being compared, the value of the degree of inconsistency of this matrix should be specified as a tolerance range.

It has already been given that the characteristic root of a consistent array of order n is λ, and it can be shown that the largest characteristic root $\lambda \geq n$ of a positive inverse array A of order n is a consistent array if and only if $\lambda = n$.

It can be seen that the larger λ is than n, the more serious the inconsistency of A is, and the larger the judgment error induced by using the eigenvectors as weight vectors. Thus the magnitude of the value of $\lambda - n$ can be used to measure the degree of inconsistency of A. To wit:

$$CI = \frac{\lambda - n}{n-1} \tag{6}$$

Defined as a consistency indicator. A is a consistent array when $CI = 0$, and the larger CI is the more serious the degree of inconsistency of A. In order to determine the permissible range of inconsistency degree of A, it is necessary to find a measure of the consistency index CI of A. n denotes the matrix dimension, and RI denotes the value of the consistency index corresponding to the matrix dimension, where $RI = 0$ when $n = 1$ or 2, because a positive reciprocal inverse matrix of order 1 or 2 is always consistent.

For a pairwise comparison array A of $n \geq 3$, the ratio of its consistency index CI to the random consistency index RI of the same order of the matrix is called the consistency ratio CR, when:

$$CR = \frac{CI}{RI} < 0.1 \tag{7}$$

When the degree of inconsistency of A is considered to be within tolerance, its eigenvectors can be used as weight vectors, otherwise pairwise comparisons have to be performed again to adjust the judgment matrix A.

Each judgment matrix should be tested for consistency to determine that the matrix satisfies the relevant properties, otherwise the resulting data will have a large deviation from the actual data.

In the entire calculation process of hierarchical analysis, in addition to the consistency test for each pairwise comparison array to determine that each weight vector can be applied, but also to carry out a combination of consistency test to determine whether the combination of weight vectors can be used as a basis for the final decision. The combined consistency test can be performed layer by layer, if the consistency index of the P th layer is $CI_I^{(P)},...,CI_n^{(P)}$, the stochastic consistency index is $RI_1^{(P)},...,RI_n^{(P)}$.

Definition:

$$CI^{(P)} = [CI_1^{(P)},...,CI_n^{(P)}]\omega^{(P-1)} \tag{8}$$

$$RI^{(P)} = [RI_1^{(P)},...,RI_n^{(P)}]\omega^{(P-1)} \tag{9}$$

Then the combinatorial consistency ratio of the P th layer to the first layer is:

$$CI^{(P)} = CR^{(P-1)} + \frac{CI^{(P)}}{RI^{(P)}}, P = 3,4,...,n \tag{10}$$

When the combinatorial consistency ratio $CR^{(n)} < 0.1$ of the lowest level to the highest level, then the comparative judgments of the whole level pass the consistency test. If it passes the combinatorial consistency test, then the combinatorial weight vector can be used as the basis for the final decision, otherwise the judgment matrices whose consistency ratios CR are out of range should be reconstructed.

II. C.Fuzzy integrated evaluation method

II. C. 1) Establishment of a collection of evaluation ratings

The evaluation rating set V is as follows:

$$V = \{v_1, v_2, \cdots v_m\} \tag{11}$$

V is a collection of evaluation levels, each evaluation level corresponds to a fuzzy subset. When m is too large, it is not easy to make a linguistic description, and it is difficult to judge which grade it belongs to; when m is too small, it can not meet the quality requirements of fuzzy comprehensive evaluation [19], [20]. In general, m is often taken as an odd number; it can also be divided into five grades according to the value of 0~100; and the set of evaluation grades can also be determined according to a qualitative rubric such as {very mature, mature, relatively mature, immature, extremely immature}. In the assessment of digital transformation of asset management for the elderly, V represents the maturity of digital transformation of asset management.

II. C. 2) Establishment of a set of factors for the evaluation of objects

The set of evaluation object factors U is as follows:

$$U = \{u_1, u_2, \cdots, u_n\} \tag{12}$$

The set of factors U is the set of n evaluation indicators. Same as the previous hierarchical analysis method, the fuzzy comprehensive evaluation method should be as specific and comprehensive as possible to reflect the basic characteristics of the evaluation object and the assessment content when selecting evaluation indicators to avoid omissions. In addition, the selection of indicators should follow the MECE principle, i.e., the evaluation indicators at the same level should be independent of each other and have no crossover. In general, the evaluation indicator system consists of multiple levels, and assuming that the indicator C_1 and the indicator C_2 are two indicators on the same level, they must satisfy:

$$C_1 \cap C_2 = \varnothing \tag{13}$$

II. C. 3) Determination of weight vectors for evaluation factors

Determine the weight vector of evaluation factors A as:

$$A = \{a_1, a_2, \cdots, a_n\} \tag{14}$$

Usually, the status of each evaluation factor is not the same, and the influence of each unilateral factor on the system as a whole is not the same, so before performing the fuzzy transformation, the weight vector of the evaluation factors A is determined and normalized.

II. C. 4) Single-factor evaluation

Establish a one-factor fuzzy relationship matrix [21] R :

$$R = \left[r_{ij}\right]_{m\times n} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{15}$$

where r_{ij} denotes the affiliation of the factor u_i corresponding to v_j in the evaluation level V , so r_{ij} is the single-factor judgment of the first i factor u_i on the evaluation object, and it is a fuzzy subset on V . After specifying the set of evaluation ratings V and the set of factors of the evaluation object U , it is necessary to quantify each factor $u_i (i = 1, 2, \cdots, n)$ within the evaluation object one by one and then get the single-factor fuzzy relationship matrix R .

II. C. 5) Calculating evaluation vectors for evaluation objects

The principle of fuzzy comprehensive evaluation is fuzzy change, and the evaluation vector B of the evaluation object is calculated as:

$$B = A \circ R = (a_1, a_2, \cdots a_m) \circ \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} = (b_1, b_2, \cdots b_n) \tag{16}$$

Each row in R reflects the degree of affiliation to the fuzzy subset of each grade corresponding to the different single factors of the evaluation object. After integrating the weight vector A and the different rows, the degree of affiliation of the evaluation system to the fuzzy subsets of each rank from the overall system can be obtained, i.e., B (fuzzy integrated evaluation vector). $B_j (j = 1, 2, \cdots, n)$ is obtained by the numerical operation of vector A and column j of matrix R , which indicates the degree of affiliation of the evaluation object to the evaluation grade v_j from the overall view.

There are four commonly used fuzzy synthesis operators: $M(\wedge,\vee), M(*,\vee), M(\wedge,\oplus)$ and $M(*,\oplus)$. Where "$\wedge$" is the take-small operation, "$\vee$" is the take-large operation, and "$\oplus$" is a bounded sum operation, corresponding to the following calculation.

(1) $M(\wedge,\vee)$:

$$b_j = \underset{i=1}{\overset{m}{\vee}}(a_i \wedge r_{ij}) = \max_{1 \le i \le m}\{\min(a_i, r_{ij})\} \quad j = 1,2,...,n \tag{17}$$

(2) $M(*,\vee)$:

$$b_j = \underset{i=1}{\overset{m}{\vee}}(a_i \wedge r_{ij}) = \max_{1 \le i \le m}\{a_i, r_{ij}\} \quad j = 1,2,...,n \tag{18}$$

(3) $M(\wedge,\oplus)$:

$$b_j = \underset{i=1}{\oplus}(a_j \wedge r_{ij}) = \min\left\{1, \sum_{i=1}^{m}(a_i \cdot r_{ij})\right\} j = 1,2,...,n \tag{19}$$

(4) $M(*,\oplus)$:

$$b_j = \underset{i=1}{\oplus}(a_j \wedge r_{ij}) = \min\left\{1, \sum_{i=1}^{m} a_i \cdot r_{ij}\right\} j = 1,2,...,n \tag{20}$$

Among the four fuzzy operators, $M(*,\oplus)$ fully takes into account both the information provided by the evaluation vectors and the role of weights, and thus is most used in comprehensive evaluation.

II. C. 6) Determination of evaluation levels

Different from other comprehensive evaluation methods to get a comprehensive evaluation value, the fuzzy comprehensive evaluation result of each evaluation object is a fuzzy vector, which can be easily compared and ranked on the comprehensive evaluation value. When comparing and ranking different multidimensional fuzzy vectors, it is necessary to apply the principle of maximum affiliation or the principle of weighted average to further synthesize the fuzzy vectors.

(1) Maximum affiliation principle

The principle of maximum affiliation is to take the grade corresponding to $\max_{1 \le j \le n}\{b_j\}$ as the final grade of the evaluation object. This method is simpler, but more information will be lost, and even obvious bias may occur. Therefore, the following method is to be used for validity verification. Namely:

$$\beta = \frac{\max_{1 \le j \le n}\{b_j\}}{\sum_{j=1}^{n} b_j} \tag{21}$$

$$\gamma = \frac{\sec_{1 \le j \le n}\{b_j\}}{\sum_{j=1}^{n} b_j} \tag{22}$$

where $\sec_{1 \le j \le n}\{b_j\}$ denotes the second largest component in B, and β and γ are the proportions of the largest and second largest components in B to the composite of the components, respectively. Obviously, $\beta \in \left[\frac{1}{n}, 1\right], \gamma \in \left[0, \ \frac{1}{2}\right]$. I.e:

$$\beta^{'} = \frac{\beta - \frac{1}{n}}{1 - \frac{1}{n}} = \frac{n\beta - 1}{\text{n} - 1} \tag{23}$$

$$\gamma^{'} = \frac{\gamma - 0}{\frac{1}{2} - 0} = 2\gamma \tag{24}$$

Then $\beta^{'} \in [0,1], \gamma^{'} \in [0,1]$. Definition:

$$\alpha = \frac{\beta'}{\gamma'} = \frac{n\beta - 1}{2\gamma(n-1)} \tag{25}$$

Obviously, $a \in [0, +\infty)$, the larger a is, the more effective the principle of maximum affiliation is. When $\alpha < 0.5$, it is not appropriate to use the principle of maximum affiliation, but the principle of weighted average should be used.

(2) Weighted average principle

Weighted average is to view the rank as a relative position to make it continuous. For quantitative treatment, use $1, 2, ..., n$ to denote each rank in turn and call it the rank of each rank, and then the rank of each rank is weighted and summed with the corresponding component in B to obtain the corresponding position B' of the evaluation object, i.e.:

$$B' = \frac{\sum_{j=1}^{n} b_j^k \cdot j}{\sum_{j=1}^{n} b_j^k} \tag{26}$$

where k is a coefficient to be determined in order to control the role played by the larger b_j. Generally k is taken as 1 or 2, and when k tends to infinity, the weighted average principle is the principle of maximum affiliation.

III. Digital transformation and optimization of asset management for older persons

III. A. Analysis of the results of the digital maturity evaluation of asset management for older persons

III. A. 1) Structure of the evaluation system

The evaluation system in this paper mainly establishes a four-level hierarchical structure, namely, the target layer (A1-A4) is divided into: organizational construction, technology application, operation guarantee and innovation drive; the project layer (B1-B13) is divided into: strategic planning, organizational leadership, regulations, talent team, data technology, system technology, technical depth, facilities and equipment, standard specification, maintenance management, information security, business model innovation and technical achievement innovation.

III. A. 2) Analysis of the weighting of indicator elements

The results of the weighting of the indicator elements of each factor layer are shown in Table 2. The weight of organizational construction is ranked in the second place (0.2526), which includes four project layers, namely, “strategic planning, organizational leadership, rules and regulations, and human resources”, with the weights of 0.0235, 0.0943, 0.0527 and 0.0821 respectively. The weight of technology application is 0.2517, which contains 3 factors, and the weight of data technology (0.1301) is the largest. The weight of operation guarantee is 0.2654, which contains 4 factors of “facilities and equipment, standardization, maintenance and management, and information security”, and its weight is between 0.0551-0.0754. The weight of innovation-driven is the lowest (0.2303), and it includes business model innovation and technological innovation, which rank 2nd and 3rd respectively, with weights of 0.1226 and 0.1077 respectively.

Table 2: The weight of each factor is graded

Project layer	Weighting	Sequence	Factor layer	Weighting	Sequence
Organizational construction	0.2526	2	B13: Strategic planning	0.0235	13
			B4: Organizational leadership	0.0943	4
			B8: Regulation	0.0527	11
			B5: Talent team	0.0821	5
Technical application	0.2517	3	B1: Data technology	0.1301	1
			B6: System technology	0.0815	6
			B11: Technical depth	0.0401	12
Operation protection	0.2654	1	B12: Facilities	0.0551	10
			B9: Standard norm	0.0717	8
			B10: Maintenance management	0.0631	9
			B7: Information security	0.0754	7
Innovation drive	0.2303	4	B2: Information security	0.1226	2
			B3: Business model innovation	0.1077	3

III. B. Analysis of the maturity level of digital transformation of older adults interviewed

This questionnaire data distribution time for six months from June 1, 2024 to December 1, 2024, a total of three times to go to the scene of the questionnaire research, the overall questionnaire actually issued the target number of 400, of which the number of valid questionnaires is 397, the effective rate is 99.25%. From the questionnaire data of the personal attribute characteristics of the elderly interviewed, the number of men and women in this research questionnaire is 193 and 207. in terms of cultural level, the subject of this research data is more of a bachelor's degree level of 308 people, accounting for 77.58%, followed by high school or secondary school proportion of the number of people there are 87 people, accounting for a percentage of 21.91%.

The Cronbach.α coefficient of this research questionnaire is 0.9937, which is greater than 0.95, thus indicating that the questionnaire's data reliability is of high quality, while its KMO is 0.9908, which suggests that the study is well suited for factor analysis, and the significance value is 0.000, which indicates that the data comes from a normal overall distribution and is suitable for further analysis.

The results of the maturity questionnaire scores of the digital transformation of the interviewed older adults are shown in Figure 1. The total quality evaluation scores of the digital transformation of the elderly range from 1-5, and the average score of this time is 3.87047, which indicates that the overall evaluation results of the digital transformation of the elderly are rated as good, the score of the talent team is 4.2739, and the rating level is very mature, the average score of the maintenance and management level is 4.1598, and the average score of the information security level is 4.0955, and the rating levels of these two dimensions rating levels are both mature. The top five scores of the interviewed seniors for landscape quality were “talent team, maintenance management, technical depth, regulations and data technology” with scores of 4.2739, 4.1598, 4.0955, 4.0707 and 4.0526 respectively, and the bottom five scores for the factor tiers were The scores for the next five factors were 3.1995, 3.5714, 3.5984, 3.7284 and 3.8324 for “innovation in technical achievements, information security, facilities and equipment, standards and norms, and organizational leadership”.

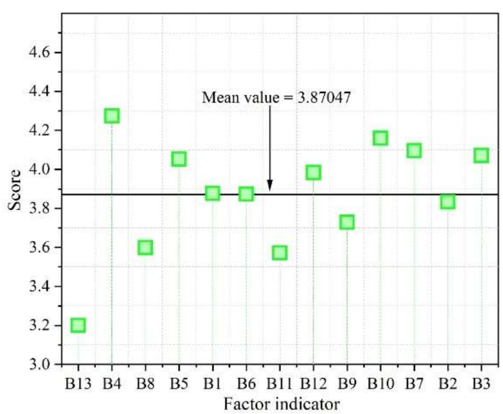

Figure 1: The maturity of the digital transformation of the elderly was scored

III. C. Optimization of digitalization paths for elderly management from a configuration perspective

III. C. 1) Characteristics of Asset Management Digital Survey Respondents

The definition of the goal of digitization of elderly asset management and the characteristics of the survey respondents are shown in Table 3. This study adopted a questionnaire analysis method to select the elderly management digitizers within the public welfare class of institutions with asset size of 50-90 million as the target. The same belongs to the public welfare category of S city, i.e., government fully funded institutions, with similar conditions; at the same time, there are obvious differences in the selection of these specific antecedent conditions.

Twenty-five objects belonged to institutions with an asset management digitization scale for the elderly of more than 30 million yuan. 14 participating objects belonged to units with assets in the range of 70 million yuan to 100 million yuan, accounting for 56% of the total; 7 participating objects belonged to units with assets in the range of 50-70 million yuan, accounting for 28% of the total; 4 participating in the range of 30-50 million yuan, accounting for 16%; 4 participating in the range of 30-50 million yuan, accounting for 16%; 4 participating in the range of 30-50 million yuan, accounting for 16%. 50 million yuan range, accounting for 16%.

Of the 25 respondents, the number of years of experience in managing digitizers for seniors varies. Among them, there are 3 with 0-1 years of management experience, accounting for 12%; 6 with 1-3 years, accounting for 24%; 11 with 3-6 years, accounting for 44%; and 5 with more than 5 years, accounting for 20%. The above conditions have differential conditions and meet the basic criteria for the selection of survey respondents.

Table 3: The definition of the digital target and the characteristics of the survey

Cost perception	Capital investment	Risk awareness	Internal control	Acceptance synergy	Information transfer	Asset inventory	Talent reserve	Fixed asset management target performance
1	3	3	5	2	4	2	3	0.773
1	3	3	3	3	3	3	4	0.538
2	5	7	4	3	7	6	6	0.382
4	6	7	8	3	7	6	7	0.201
2	7	6	7	1	7	4	7	0.953
2	2	2	4	1	1	1	3	0.814
1	6	3	5	1	4	4	2	0.766
1	7	8	7	3	7	3	5	0.552
1	4	2	3	1	2	2	2	0.877
1	2	2	3	2	3	2	3	1.000
1	3	4	3	3	3	2	3	0.631
2	5	9	5	4	8	4	6	0.426
1	3	3	3	1	3	3	5	1.096
2	2	4	2	1	2	2	2	0.866
3	3	2	2	1	3	2	2	0.377
2	3	3	5	3	6	2	3	0.818
3	4	5	5	2	3	2	5	0.623
2	5	5	6	0	6	6	5	1.043
1	3	2	4	1	3	1	3	1.048
2	3	4	2	2	3	3	5	0.607
1	9	8	8	2	10	10	8	0.811
2	5	5	2	2	4	6	3	0.436
3	3	3	2	1	3	3	3	0.834
2	2	2	4	1	3	3	2	0.818
1	3	5	3	2	3	3	4	0.587

III. C. 2) Variable Measurement and Calibration

In this paper, eight conditional instruments, namely, "risk awareness, internal control, capital investment, information transfer, asset inventory, talent reserve, cost perception, and acceptance coordination" were used as the antecedent variables affecting the performance of digitalization objectives of elderly management, and the questions corresponding to each variable were weighted and summarized in the questionnaire survey of this study.

The results of antecedent variable quantile determination are shown in Table 4. The calibrated pooled affiliation scores for the case variables are shown in Table 5. For the variables involved in this paper, the quartiles were determined while the outcome variables used six-valued fuzzy sets, i.e., 1.0=fully affiliated, 0.8=very affiliated, 0.6=somewhat affiliated, 0.4=somewhat unaffiliated, 0.2=very unaffiliated, and 0.0=not at all affiliated.

III. C. 3) Empirical analysis of conditional instrument combinations

(1) Univariate necessity analysis line spacing format

The purpose of the necessity test is to find out whether the explanatory variables are sufficient but not necessary conditions for the outcome variables, i.e., there is an effect of the explanatory variables on the outcome variables, but it is not the case that this single conditional variable can fully explain the outcome variables. Among them, consistency and coverage are the two main indicators for determining whether there are sufficient and necessary relationships between variables. Consistency is similar to significance in traditional empirical research, which refers to the extent to which all cases included in the analysis share a given condition (or combination of conditions) that led to the outcome; and coverage is similar to strength, which indicates to what extent the pooled relationship that passes the consistency test explains the outcome . Generally, 0.9 is taken as the basic condition for discrimination; if condition X is a necessary condition for outcome Y, then the set corresponding to Y is a subset of the set corresponding to X, and then the value of its corresponding consistency metric should be greater than 0.9; otherwise, X cannot be regarded as a necessary condition for Y.

Table 4: The index of the previous dependent variable is determined

Percentile	Cost perception	Capital investment	Risk awareness	Internal control	Acceptance synergy	Information transfer	Asset inventory	Talent reserve
0.38	1.87	1.91	3.05	3.01	1.26	3.09	2.73	2.99
0.47	1.83	2.97	4.01	3.99	1.93	3.85	3.47	3.81
0.76	2.93	5.32	6.02	4.91	2.9	5.36	5.03	6.16

Table 5: The collection membership score of the case variable calibration

CBGZ	CSBZ	FXYS	NBKZ	YSXT	XXCD	ZCPD	THCZ	Result
Cost perception	Capital investment	Risk awareness	Internal control	Acceptance synergy	Information transfer	Asset inventory	Talent reserve	Result
0.94	0.57	0.17	0.52	0.04	0.49	0.00	0.04	0.79
0.01	0.48	0.18	0.52	0.07	0.49	0.12	0.51	0.60
0.97	1.00	0.02	0.50	0.94	1.00	0.97	0.95	0.40
0.97	0.99	0.02	1.00	0.95	1.00	0.99	0.97	0.21
0.93	0.96	0.01	1.00	0.98	0.97	0.73	1.00	0.99
0.52	0.49	0.08	0.49	0.48	0.00	0.00	0.06	0.78
0.03	0.93	0.19	0.53	0.06	0.49	0.76	0.04	0.80
1.00	0.99	0.01	0.98	0.98	1.00	0.14	0.80	0.61
0.01	0.48	0.04	0.03	0.06	0.00	0.11	0.07	0.79
0.51	0.51	0.17	0.03	0.49	0.05	0.01	0.49	1.00
0.43	0.55	0.21	0.05	0.50	0.04	0.12	0.06	0.62
0.95	0.97	0.00	0.99	0.94	0.97	0.98	0.94	0.41
0.96	0.47	0.13	0.05	0.94	0.07	0.16	0.49	0.99
0.02	0.00	0.17	0.01	0.05	0.02	0.02	0.00	0.77
0.04	0.01	0.13	0.01	0.03	0.00	0.00	0.00	0.38
0.92	0.51	0.13	0.51	0.51	0.92	0.12	0.04	0.82
0.45	0.76	0.53	0.48	0.51	0.05	0.00	0.49	0.60
1.00	0.99	0.05	1.00	0.95	0.98	0.98	0.96	1.00
0.49	0.54	0.11	0.51	0.49	0.03	0.00	0.05	0.98
0.51	0.51	0.46	0.04	0.51	0.04	0.13	0.50	0.61
1.00	1.00	0.01	1.00	0.99	1.00	1.00	1.00	0.78
0.97	0.88	0.17	0.00	0.95	0.06	0.98	0.04	0.37
0.02	0.48	0.16	0.05	0.50	0.02	0.13	0.05	0.41
0.05	0.00	0.10	0.04	0.04	0.06	0.01	0.00	0.82
0.96	0.48	0.15	0.07	0.52	0.50	0.10	0.83	0.61

The results of univariate necessity condition detection are shown in Table 6. The results show that the consistency of single variables are all less than 0.9, that is to say, none of the eight explanatory variables are sufficient to constitute the necessary conditions for the digital target performance of high elderly management, that is to say, a single variable can not explain the emergence of the resultant variable, and the enhancement of the digital target performance of the management of the elderly is the result of the joint action of multiple factors, so it needs to be further analyzed.

Table 6: Test of necessity condition of single variable

For short	Conditional variable	Consistency	Coverage ratio
CBGZ	Cost perception	0.8368	0.6277
CSBZ	Capital investment	0.6785	0.7842
FXYS	Risk awareness	0.6846	0.8111
NBKZ	Internal control	0.6278	0.7125
YSXT	Acceptance synergy	0.6871	0.7489
XXCD	Information transfer	0.7865	0.7378
ZCPD	Asset inventory	0.8607	0.8951
THCZ	Talent reserve	0.8234	0.7831

(2) Truth table construction

The truth table is a direct test of the types of cases present in a given dataset. After assigning values to the variables, the variable truth values are shown in Table 7. It reflects all the logical combinations between the condition variable and the outcome variable. Where 0 and 1 in the condition variable represent that the condition does not exist or the condition exists respectively, 0 in the outcome variable represents that the consistency score of the antecedent combinations constituting the fuzzy subset of the outcome is less than the critical value, i.e., the antecedent combinations of the degrees of affiliation do not constitute the fuzzy subset of the degrees of affiliation in the outcome, and 1 represents the opposite of what 0 means.

Table 7: Variable truth table

CBGZ	CSBZ	FXYS	NBKZ	YSXT	XXCD	ZCPD	THCZ	Result	Frequency
1	1	0	1	1	1	1	0	0	1
0	0	0	0	1	1	1	0	0	1
1	0	0	1	0	0	0	1	1	1
0	0	0	0	1	1	1	1	1	1
0	1	1	0	0	0	1	0	1	0
1	1	0	1	1	1	1	1	0	10

(3) Complex solutions using qualitative comparative analysis methods

The empirical results of the complex solution of the digital target performance of asset management for senior citizens are shown in Table 8. The complex solution does not allow the existence of any counterfactual cases, does not use “logical residuals” and only analyzes groupings with actual observation cases, and the conclusions are usually more cumbersome; the complex solution expresses the results by incorporating logical residuals of some significance into the solution, and by incorporating theoretically and practically supported “logical residuals”, i.e., easy counterfactual cases, into the solution. “i.e., easy counterfactual cases to express the results. Raw coverage refers to the proportion of the resultant cases covered by a given grouping, including coverage of overlapping interpreted parts between groupings. Net coverage, also called unique coverage, refers to the extent to which a single grouping explains the result after eliminating the common parts with other groupings. Gross coverage refers to the proportion of result cases covered by all groupings.

Table 8: Empirical results of the complex solution of target performance

Configuration	Raw coverage	Unique coverage	Solution coverage
~CBGZ*YSBZ*~FXYS*~NBKZ*~YSXT*~XXCD*~ZCPD*~THCZ	0.6602	0.3773	1.0000
~CBGZ*YSBZ*~FXYS*~NBKZ*~YSXT*~XXCD*~ZCPD*~THCZ	0.3809	0.0621	1.0000
~CBGZ*YSBZ*~FXYS*~NBKZ*~YSXT*~XXCD*~ZCPD*~THCZ	0.5296	0.0932	1.0000
Solution coverage:0.9579			
Solution consistency:1			

(4) Analysis of High Performance Constructs

The core condition is able to explore whether the combinations that pass the consistency criterion are subsets of the outcome from the case of the outcome variable, and to distinguish between consistent subsets of the outcome and subsets that are not the outcome based on the combinations that meet the frequency threshold. On the contrary, the influence of marginal conditions on the outcome variable is not particularly strong, and marginal conditions refer to antecedent conditions that have a relatively weak causal relationship with the outcome but are still complementary and contributory. The results of analyzing the high performance constructs are shown in Table 9. Among the outcome variables obtained in this paper, the target performance in line with the digitalization of the management of the elderly is high, and the core-marginal condition conformation of this outcome variable can be divided into the following configurations for the three groupings: configuration 1 emphasizes the use of financial inputs; configuration 2 adds the tool of internal control on top of configuration 1; and configuration 3 incorporates the three tools as the core condition of financial inputs, the internal control of the marginal condition, and the reserve of human resources into the combination, emphasizing the three conditions. Inclusion of the three tools as core conditions of capital input, marginal conditions of internal control, and talent pool in the combination emphasizes the parallel development of the three conditions of the tool.

Table 9: High performance configuration analysis results

For short	Conditional variable	Configuration 1	Configuration 2	Configuration 3
CBGZ	Cost perception	⊕	⊕	⊕
CSBZ	Capital investment	●	●	●
FXYS	Risk awareness	⊕	⊕	⊕
NBKZ	Internal control	⊕	·	·
YSXT	Acceptance synergy	⊕	⊕	⊕
XXCD	Information transfer	⊕	⊕	⊕
ZCPD	Asset inventory	⊕	⊕	⊕
THCZ	Talent reserve	⊕	⊕	·

IV. Conclusion

This paper establishes a set of risk assessment model for digital transformation of elderly asset management based on hierarchical-fuzzy comprehensive evaluation method after studying the risk assessment index system for digital transformation of elderly asset management.

(1) This paper establishes a risk assessment index system for digital transformation of asset management of the elderly based on hierarchical analysis method, calculates the weights of each index, and conducts consistency test to establish the reliability of the index system. After that, it combines the fuzzy comprehensive evaluation method to evaluate the risk of digital transformation of asset management for the elderly, which provides a scientific and feasible way to assess the risk of digital transformation of asset management for the elderly.

(2) The weights of the four target layers of “organization construction, technology application, operation guarantee and innovation drive” are 0.2654 at the maximum and 0.2303 at the minimum; among the 13 factor layers, the weight of data technology (0.1301) is the largest, followed by the innovation of business model and technological achievements, with the weights of 0.1226 and 0.1026, respectively. 0.1226 and 0.1077, which shows that the digital transformation path of assets is theoretically closely related to the development of science and technology.

(3) The higher performance of target variables in line with the digital transformation of asset management for the elderly, which emphasizes the inclusion of the three indicators of “capital investment, internal control of marginal conditions, and talent reserve” in the combination to accelerate the optimization process of the path of digital transformation for the elderly.

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