Influence Factors Analysis of PDM Implementation in Tobacco Industry Company Based on ISM and MICMAC Model

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Abstract: The paper establishes interpretative structure model (ISM) to analyze the hierarchical structure relationship of influence factors for PDM implementation, to find out the direct influence factors, indirect influence factors and fundamental influence factors. These factors divided into three categories according to the driving force-dependence graph of impact matrix cross reference multiplication applied to a classification (MICMAC), and the influence factors, dependent factors and independent factors. On this basis, analysis the relationships in these factors, and clear the key factors should to focus and to deal with. The analysis results have certain theoretical reference and guidance for the implementation of PDM system in tobacco industrial enterprises.

1. Introduction

In recent years, tobacco industry companies have done a lot of work on the implementation and expansion of PDM systems, which has played an important role in improving the design and exploitation, quality control, and management of cigarette products [1-2]. Product data management is not a general meaning of application and innovation of information technology. It is a management revolution with a high level. The implementation of the PDM system is a complex system project. The successful implementation of the PDM system depends largely on PDM technical knowledge, business knowledge, the specific environment, and the method and process of implementation. At present, the research on the influence factors of PDM system implementation mainly focuses on technical and non-technical factors, but it does not analyze the complex relationship between factors from the perspective of systems engineering, and does not have deeply hierarchical system research for the influence mechanism between impact factors and the relationship between primary and secondary factors.

The Interpretive Structural Modeling (ISM) combines the knowledge of graph theory, set theory, and discrete mathematics, and mainly used in business management and systems engineering to solve the problem of decision analysis of multi-factor complex systems [3]. The Interpretive Structural Modeling (ISM) been gradually applied in the development of complex social systems. Through this structural model, a complex system can decompose into several sub-systems or elements. Through some basic assumptions and related operations of graphs and matrices, it is possible to obtain reachable matrix and then decomposing the reachable matrix, a multi-level hierarchical structure model is finally constructed [4-6]. Therefore, the ISM model used to analyze the factors affecting the implementation of the PDM system, and the complex relationship between the elements is structured and hierarchically processed to reveal the internal structure of the system and facilitate the targeted disposal of the adverse impact factors. On subsequent implementation of the tobacco industrial enterprise PDM system and the construction has the important practical significance.

2. Main Influence Factors of PDM Project Implementation

Based on the methods of literature research, this paper starts from the implementation of the key

factors of PDM system to sort out the corresponding research literature, and then sorting out and summarizing the influencing factors. Yong Cen [7] analyzed the key factors of management and technological in the implementation of PDM system in tobacco industry. Luo Rong and Yang Fangyan [8] analyzed various non-technical factors in the implementation process of PDM, and based on this established PDM layered implementation model which clearly express the links between various technical and non-technical factors in the implementation of PDM. Zhang Rong [9] established a PDM layered implementation model, which can clearly express the links between various technical and non-technical factors in PDM implementation, and analyzed various non-technical factors in the implementation process of PDM. Li Xiaolong [10] focused on several key issues facing the implementation of PDM projects. Ao Yan [11] analyzed the problems existing in the implementation of PDM projects by Chinese enterprises, and summed up the key success factors of PDM project implementation. Based on the above studies, and 9 key factors were identified by five key business personnel and IT professors who participated in the implementation of PDM project in company, used to this research, as shown in Table 1.

Table.1. Influence factors for PDM implementation

Factor ID	Influence Factors
S1	Top Management Support
S2	Project Management
S3	Business Process Management
S4	Training and Empowerment of Employees
S5	Communication and Coordination Mechanism
S6	Implementers 'Knowledge and Experience
S7	Project Implementation Strategy
S8	Key Users 'Participation
S9	Risk Management

3. Application Procedures of ISM and MICMAC Model

The Interpretative Structure Modeling (ISM) developed by Professor J.N. Warfield in the United States in 1973 to analyze the structural problems of complex social and economic systems. Explaining the structural model is mainly to use the practical experience and knowledge to decompose the complex system into several subsystem elements, simplify the fuzzy and complicated system problems, construct a simplified structural relationship model, and analyze the relationship between the various elements. The cross-impact matrix multiplication method (MICMAC) calculates the driving force and dependence of each factor through the relationship matrix between factors to achieve the effect of factorization and induction, to understand the essential role of factors in the system [12].

ISM and MICMAC joint model used to hierarchically classify and determine the attributes of many factors in a complex system. It is of great significance for in-depth understanding of system factors. The specific modeling steps are as follows:

Step 1: Determine the system analysis elements. Through the analysis of data, the arrangement of data, and inquiries from experts, the scope of the research problem and its related factors defined. The set of factors is S, which includes: $S = \{S_1, S_2, S_3, \cdots, S_n\}$

Step 2: Construct the adjacency matrix A. Analyze whether there is a direct influence relationship between any two elements in order to construct an adjacency matrix $A = \{a_{ij}\}_{n \times m}$. If it directly affects, then $a_{ij} = 1$; if the element does not directly affect it, then $a_{ij} = 0$.

Step 3: Calculate the reachable matrix M. Based on the adjacency matrix $A + I$ (where I is the unit matrix) performing the power calculation based on the Boolean algebraic algorithm, until the following formula is satisfied.

$$(A+I) \neq (A+I)^2 \neq \cdots \neq (A+I)^{r-1} \neq (A+I)^r = (A+I)^{r+1} = M \quad (1)$$

Step 4: Determine the system skeleton matrix. Reduce the reachable matrix and determine the system skeleton matrix A' .

Step 5: Draw a multilevel diagram. Through the formula (2) and formula (3) to determine the reachable set R_i and preemptive set A_i of factors S_i, using the judgment condition (4) for factor grading, and then draw multi-level hierarchical directed graph of system factors.

$$R(S_i) = \{S_j \mid m_{ij} = 1\} \quad (j = 1, 2, 3, \cdots, n) \quad (2)$$

$$A(S_i) = \{S_j \mid m_{ji} = 1\} \quad (j = 1, 2, 3, \cdots, n) \quad (3)$$

$$A_i \cap R_i = R_i \quad (4)$$

Step 6: Draw the driving force-dependency graph. Calculate the driving force D_i and dependence R_j of the factors in the reachable matrix according to Formula (5) and Formula (6) of the MICMAC model, and draw the driving force-dependency quadrant graph.

$$D_i = \sum_{j=1}^{n} a_{ij}^m, (i = 1, 2, 3, \cdots, n) \quad (5)$$

$$R_j = \sum_{i=1}^{n} a_{ij}^m, (j = 1, 2, 3, \cdots, n) \quad (6)$$

Where, a_{ij}^m is the element in the matrix M; The driving force D_i indicates how much the factor drives the other factors of the system; Dependency force R_j indicates how much the factor is dependent on other factors in the system.

With reference to the above steps, the ISM and MICMAC models used to construct and analyze the factors that affect the implementation of PDM projects, and the system attributes, hierarchical structure and internal mechanisms of these risk factors explored to provide theoretical guidance for ensuring the successful implementation of PDM projects.

4. Analysis Influence Factors based on ISM and MICMAC Model

4.1 Determining Influencing Factors of PDM Project Implementation and Building Adjacency Matrix A

Through the questionnaire survey and consultation with experts, determine the influence relationship between these nine factors. Then to construct the 9th-order adjacency matrix A.

$$A = \begin{bmatrix} 0 & 1 & 1 & 0 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

4.2 Determining the reachable matrix

The reachable matrix is a matrix method to describe the extent to which the nodes of a directed connection graph can reach after a certain length of path, that is, the indirect influence relationship of the indicators, which can deduct from the direct relationship between the indicators. The reachable matrix M established by the Boolean algebra algorithm according to formula (1).

$$M = \begin{bmatrix} 1 & 1 & 1 & 0 & 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 1 \\ 0 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

4.3 Determine the hierarchy and draw directed graphs

Based on the reachability matrix M, the reachability set $R(S_i)$, preceding set $A(S_i)$, common set $C(S_i)$, and start set $B(S)$ of each element organized, and the reachable set and set of factors are reachable by the formula (2) and formula (3). The judgment is to use the formula (4) to divide hierarchically the risk factors of the system to decompose the elements contained in each level of the interpretative structure. The decomposition results of each level as shown in Table 2.

Table.2. Safety factor reference table

Layer	Elements
Layer I	S3(Business Process Management); S9(Risk Management)
Layer II	S2(Project Management); S4(Training and Empowerment of Employees); S5(Communication and Coordination Mechanism); S8(Key Users' Participation)
Layer III	S7(Project Implementation Strategy)
Layer IV	S1(Top Management Support); S6(Implementers 'Knowledge and Experience)

Finally, the structural model of risk factor explanation as shown in Figure 1.

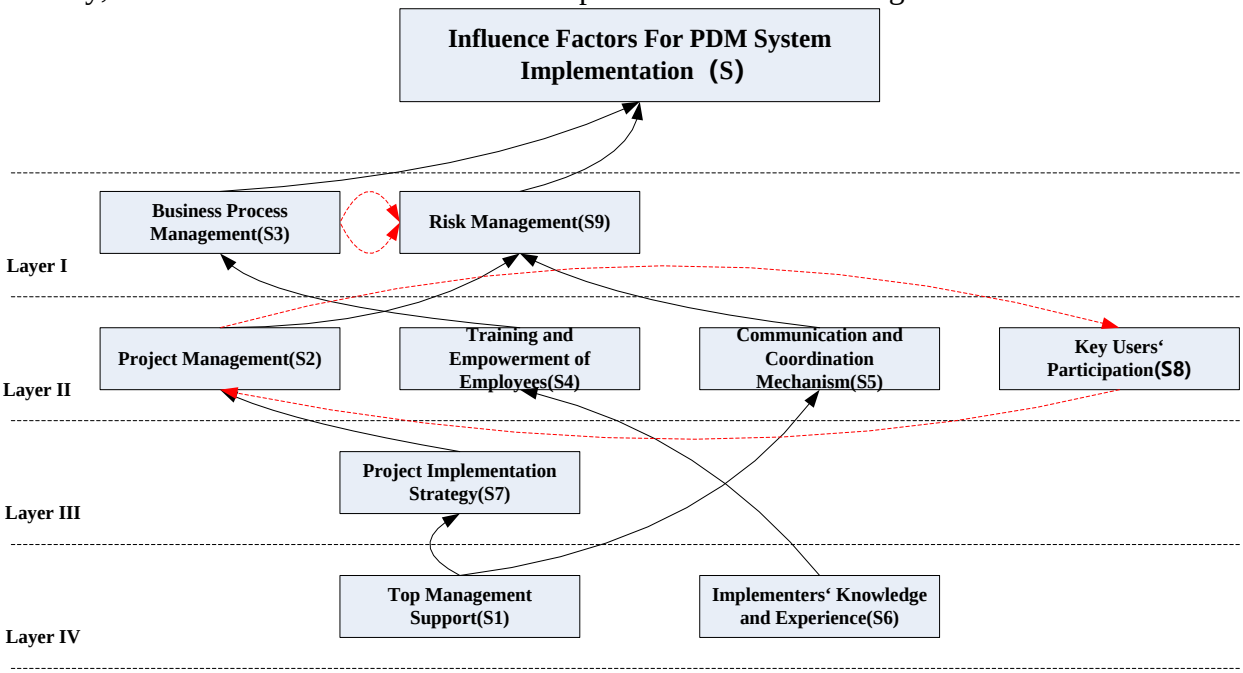

Fig.1 System architecture design

4.4 The driving force-dependency graph

Use formulas (5) and (6) to calculate the dependence and driving force of each factor, and draw a classification chart of the factors according to the factors driving force and dependence degree, as shown in Figure 2.

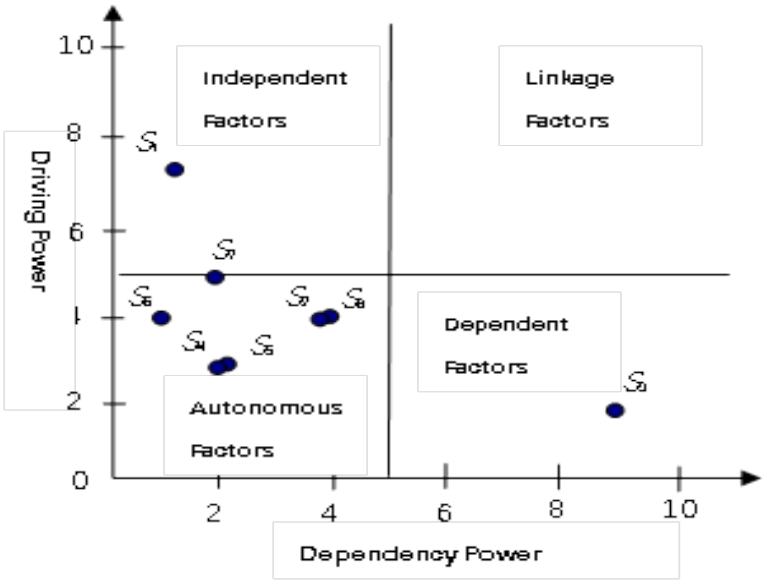

Fig.2 Driving power –dependency diagram

4.5 Result and discussion

According to the multi-level hierarchical interpretation structure model, the influencing factors of PDM system implementation can divide into four levels. Combining the aspects of people, organization, and management in the implementation of the system, the interpretation structural model analyzed necessarily.

First, as can be seen from Figure 1, top management support (S1) and implementers' knowledge and experience (S6) are at the bottom of the structural interpretation model, and are the most influential and most fundamental influencing factors in the implementation of PDM system projects. The macro manifestations of the influencing factors, through the influence of the transitional layer (middle layer) factors, have a direct effect on the direct layer factors. Only if the underlying factors are increased enough attention can we fundamentally guarantee the successful implementation of the PDM system. The implementation of PDM system is a complex system engineering. In the implementation process, not only the original business will change, but also the new requirements will put forward to the management. At the same time, the PDM system will often have business with ERP and MES systems in the company collaboration, so only the resolute support of high-level leaders can clear the various obstacles in the implementation process. The level of knowledge and experience of the implementers determines the level of their ability and methodology to deal with various issues during project implementation, and will have an important impact on project implementation strategies, organizational management, and knowledge transfer.

Second, the factors in the intermediate transition include project implementation strategy (S7), project management (S2), training and empowerment of employees (S4), communication and coordination mechanism (S5), and key users' participation (S8). These factors at the same time convey the influence of the bottom-level fundamental factors, and ultimately affect the directly factors which in surface structure of the system, and jointly affect the specific implementation of the PDM system. The relationship between these factors is relatively complex and easy to change, which is the difficulty and focus of the implementation of the system. In view of this, during the implementation of the PDM project, it is necessary to establish an effective project management organization, formulate implementation strategies that suit the characteristics of the company, establish an effective communication and coordination mechanism, effectively handle various problems encountered in the process, and ensure steady progress in the implementation. Continuous training and knowledge transfer for employees can increase users' awareness and acceptance of PDM systems, reduce the conflict between system construction and business management, and ensure that

the system should accept by the actual landing applications.

Finally, the direct layer factors include two factors: business process management (S3) and risk management (S9). The direct factors are more intuitive and easier to understand, and have a direct impact on the implementation of the system. At the same time, they are be affected by the factors in intermediate and underlying transition layer. Therefore, for risk management, risk control measures can put forward from multiple dimensions such as personnel, business, data, and management to reduce the impact of risk management on system implementation. For business process management, it is necessary to straighten out and clarify the relationship between information system implementation with business process change, and combine the implementation of the system to achieve the improvement of performance is the real purpose of the process change. Only in this way, we can minimize the business process changes impact on system implementation.

Calculate the dependence degree and driving force of each risk factor through the MICMAC model, and divide the risk factors into four categories according to the corresponding dependence degree and driving force value [12]: 1) Autonomous factors; 2) Dependent factors; 3) Independent factors; 4) Linkage factors. Autonomous factors include project organization and management (S2), communication and coordination mechanism (S5), key user's participation (S8) and implementers' knowledge and experience (S6). These factors are relatively less affected, and their governance is relatively simple and easy. Controlling is the influencing factor that should consider first in system control; Dependent factors include business process management (S3) and risk management (S9). Dependent factors are been influenced by the rests of the system. These risk factors are mostly in the direct layer of the interpretive structural modeling and the upper layer, which is a major form influence the success or failure of the system implementation; Independent factors include top management support (S1) and project implementation strategy (S7). Independent factors have a greater impact on the rest of the system's factors. They are generally located at the bottom of the interpretive structural modeling and at the lower level of the transitional layer, as they are more complex in the system. The influence of large influences and attention to the control of independent factors can have a significant effect on the implementation of the safeguard system.

5. Conclusion

There are many key factors affecting the implementation of PDM systems in enterprises. Through the ISM method, the interactions among the main influence factors analyzed, the role and direction of the main influence factors in the complex system constructed are determined. At the same time, the MICMAC model used to apply risk factors. It roughly divided into four categories: autonomous factors, dependent factors, independent factors and linkage factors. This helps to study the effect of each influence factor on the PDM system implementation path and degree. According to the characteristics of the influence factors, the characteristics of the risk factors in the system analyzed in depth, and the methods and suggestions for controlling the influence factors are initially proposed. Changes in business process management and risk management factors directly affect the implementation of the project and are the most direct influence factors. Project management, project implementation strategies, and key users' participation in the implementation process play an intermediary role in guiding, coordinating, and supervising. The top management support and implementers' knowledge and experience are the most fundamental influencing factors, affecting the implementation of PDM projects from the most fundamental aspects and affecting other relevant influence factors. According to the ISM and MICMAC model, the order of each influence factor can provide a certain theoretical basis and guiding significance for the follow-up tobacco industry enterprises to implement the PDM system.

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