



Research Article

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Information systems' building of small and medium enterprises based on data envelopment analysis

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ABSTRACT

Enterprise' information technology is a key factor in a company's ability to compete effectively. For companies operating this complex multi-input multi-output system, use data envelopment analysis for quantitative evaluation. Proposed enterprise management information system construction method based on data envelopment analysis. There is certain significance for enterprises to adopt a reasonable approach in the assessment. Especially for enterprise development decisions and comparative analysis it provides a theoretical basis and quantitative analysis.

Key words: Enterprise management information system; Information Technology; Comprehensive evaluation; Data envelopment analysis

INTRODUCTION

With informationization becoming the world's economic and social development trend, companies have built their management information system, so that they can have a strong position in the fierce competition of information technology [1]. It has been a hot topic for theoretical and practical workers of how to comprehensive utilization of natural science, management science, system science knowledge, the functional design of management information system, to provide more decision support functions, to give full play to the advantage of the value of information system in enterprise management[2, 3].

Data envelopment analysis[4] is a multi-objective decision-making method which can deal with the problem of multiple inputs and multiple outputs, whose main feature is the objective and comprehensive evaluation. We don't need to artificially determine the weight of each input and output index in advance. Besides, the enterprise operation is a complex system of multiple inputs multiple outputs with a lot of problems which need to be analyzed objectively and comprehensively. It will be of great significance to study the application of DEA in enterprise management information system. System developers will get a new idea to solve the problem of multiple inputs multiple outputs.

The main contents of this paper are as follows: Starting from the general concept of management information system, combining the basic theory of management information system, we summarized the structural characteristics and function of enterprises' management information system. From the structure and function of enterprise management information system, based on the relevant theory of data envelopment analysis(DEA), we built the enterprises' management information system based on DEA.

ENTERPRISES' MANAGEMENT INFORMATION SYSTEM

General management information system refers to the management or use of systems of individual or organization. It does not necessarily require a computer. Narrow sense of management information system generally refers to the enterprise management information system. It is artificial, using computer network communication equipment and other office equipment, collection, transmission, processing, storage, update and maintain system. It is a strategic competition in enterprises to improve business efficiency, for the purpose of supporting enterprise high-level decisions, middle control and basic operation of the integrated man-machine system. It is a management system, and also a social system[5].

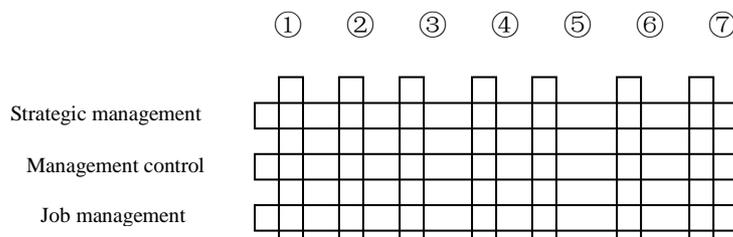
From the adopted technical level of management information system, it has experienced from the lowest levels of electronic data processing (EDP), the office automation system (OAS), and then to computer support collaborative work (CSCW) system, will eventually reach the highest level of intelligent system. The decision support system (DSS) is developing towards the direction of integrated, intelligent and enterprises'[6].

From a different perspective, the structure of information management system is different. Look from the concept, the management information system is composed of four parts, namely the source information, processor information, users and information management. Look from the hierarchy is divided into three different levels like strategic planning (strategic management), management control layer (tactical management), and operation control layer (business process). At the same time, due to the organization's management institution can be divided into several departments, and each department has a certain business functions, management information system can also be built according to the function of management organization.

Enterprise management information system is a human-machine system [5,6], which uses modern management ideas and methods as well as computer, software and network communication technology and collect, store, process the information in enterprise management so as to assist the enterprise daily business process until the formulation and optimization of decision scheme work as well as the tracking, monitoring, controlling and regulation of the whole management process.

a. The structure of the enterprises' management information system

Enterprises' management information system (EMIS) is the structure of the horizontal and vertical division of matrix structure, like figure 1. Longitudinal summarized the hierarchical structure of the management tasks, transverse outlines the main features of the EMIS function from organization. The combination of horizontal and vertical describe EMIS in composition characteristics of each stage.



□ Sales market □ Production □ Physical supply □ Personnel □ Financial accounting □ Information processing □ Top management

Fig. 1: Matrix structure of management information system

According to the analysis of EMIS information processing, grass-roots management will specific changes and it requires higher precision and has large amount of data. We can integrate EMIS matrix structure to form different styles of management information system. Horizontal comprehensive let same management levels of various functions together, like letting the management who belongs to the same job market supply and accounting subsystem join together, forming a horizontal multistage structure of management system, making information integration. Horizontal multistage structure is conducive to the unified management of all kinds of resources. Vertically integrated let the same management function of the different management levels together. This structure can do good communication on the relationship between the subordinates, and it is easy to master by the decision makers. Such as departments and finance systems can combine to form the comprehensive financial subsystem.

b. The function of enterprises' management information system

The basic function of EMIS can be summarized as four subsystems, the market operation and management subsystem, production (supplies) management subsystem, financial management subsystem and the personnel

management subsystem. These systems connect with the center of a logical database, and they Share information resources and provide the information management for enterprise. [7]

(1) The function and structure of market operation and management subsystem. Market management subsystem's main function is to provide information about the market for corporate decision makers, such as production and solving what product, what marketing methods and channels to sell products as soon as possible. Therefore, its function structure consists of order, sales and customer service module, the module planning and market research, distribution module, etc.

(2) The function and structure of production (supplies) management subsystem. Production (supplies) management subsystem' main functions of for production management staff to provide all kinds of factors of production information. It solves the problems such as the realization of the product structure, production plan, how to control the normal supply of raw materials or production schedule, resource consumption situation of each working procedure, how to control the quality of the products. The function structure consists of product design module, production plan module, material inventory management module and production control module.

(3) The function and structure of financial management subsystem. The main function of financial management subsystem is providing the capital flows for policymakers and financial personnel. It also solves problems such as how to get money, how to make a budget, how to effectively use fixed assets and current assets and how to reduce the production and operation cost. Therefore, its function structure maintained by accounting module, general ledger module, accounting and financial planning module, financial reporting module.

(4) The function and structure of personnel management subsystem. The main functions of the personnel management subsystem are to provide relevant personnel information and solve such as how to allocate human resources, rewards and punishment, and the personnel management problem. Its function structure consists of the personnel file management module, personnel planning module, labor management module.

c. The features of enterprises' management information system

From the current application of all kinds of enterprise information management system generally, the following features are as follows [8][9]:

(1) In addition to general management software and MRP (Material Resource Planning), OA (Office Automation) and WFS (Work Flow Systems), most software is needed to do a lot of demand analysis. On the basis of summarizing the past experience and enterprise development requirements carefully, consultants (mostly are industry experts) and enterprise employees at all levels formulate information management system tailor-made according to the actual situation of enterprises.

(2) Starting from the perspective of corporate strategy most systems design the enterprise management information system on the premise of global and overall consideration. From enterprise personnel management, product management, rights management system, sales management, purchasing management, production management, quality management and other aspects of the system, the realization of the strategy and the correlation between information and conditionality are taken into consideration .

(3) The key data of the daily work done by each staff and each department can be stored in a database, and it can be reviewed and called according to the authority.

(4) All kinds of data can be processed through the computer to get various kinds of analysis results from different angles, and through the alarm way the decision makers can get information about it the first time.

(5) Due to the timeliness and relevance of information, when the system elements of certain information changes, other information associated with it will also change. At the same time, because the enterprise external environment and internal factors are in a dynamic change, the system is also required to adapt to this change.

DATA ENVELOPMENT ANALYSIS

The famous operational researcher A.C harnes W.W.C ooper and E.R hodes first proposed data envelopment analysis (DEA for short) method to evaluate the relative effectiveness in 1978. It's a method which can deal with multi-objective decision problem with multiple inputs (input as small as possible) and multiple outputs (output is larger, the better). Its basic principle is Pareto Optimality principle. Under the configuration of resources, the state of Pareto Optimality is only to reduce the interest of certain people can increase the interest of one or more people. Judging DEA efficiency from input and output can be understand from the following two points:

(1) Input principle: Reduce spending one production unit but not reduce other production units, the level of output will not change as a result, which shows the production unit is inefficient.

(2) Output principle: Increase one production unit output without reducing other production unit of output, still doesn't increase investment, which said the production unit is inefficient.

Only the above two criteria have been rejected, the production unit is completely effective. It particularly pointed out that the DEA method is a purely technical, which can have nothing to do with the market (price).

C^2R method is a system analysis method, mainly based on the principle of relative efficiency evaluation. Suppose there are n decision-making units (DMU), each DMU has m kinds of input and p kinds of output. x_{ij} said the i kinds of inputs in j DMU, y_{rj} said the r kinds of outputs in j DMU. The respectively corresponding weight coefficient are $v = (v_1, v_2, \dots, v_m)^T$, $u = (u_1, u_2, \dots, u_p)^T$.

$$\begin{aligned} & \min \theta \\ & \begin{cases} \sum_{j=1}^n \lambda_j x_j + s^- = \theta x_0 \\ \sum_{j=1}^n \lambda_j y_j - s^+ = y_0 \\ s^- \geq 0, s^+ \geq 0, \lambda_j \geq 0, j = 1, 2, \dots, n \end{cases} \end{aligned} \quad (1)$$

The meaning of the basic variables in C^2R model.

(1) θ is the valid value for decision making unit DMU_0 (The effective use of input relative to output).

(2) x_j is the unit of inputs in DMU_j , which can be represented by $(x_{j1}, x_{j2}, \dots, x_{jm})$.

(3) y_j is the unit of outputs in DMU_j , which can be represented by $(y_{j1}, y_{j2}, \dots, y_{jp})$. λ_j represent the reconstruct an efficient DMU in which the j decision-making unit relative to DMU_0 . S^+, S^- are the slack variable.

The efficiency of the model value in C^2R model is technical efficiency, its economic meaning is when the i th DMU output level remains the same, best performance in the sample (DMU) in the efficient frontier surface as the standard, the investment proportion of the actual need. $1 - \theta$ is the more investment proportion of i th DMU, the biggest reduced input proportion (or waste). In particular it is divided into the following three kinds of situations:

(1) When $\theta = 1$ and $S^+ = S^- = 0$, we call that DMU_0 is DEA efficiency. In the economic system composed of n decision making units, the output on the basis of the original input has reached optimal.

(2) When $\theta = 1$ and $S^+ \neq 0$ or $S^- \neq 0$, we call DMU_0 is weak efficiency. In the composed economic system of n decision making unit, adding input x_0 can reduce S^- and keep the original output y_0 unchanged, or under the condition of invariable input x_0 , S^+ output can be improved.

(3) When $\theta < 1$, we call DMU_0 is DEA inefficiency. In the composed economic system of n decision making units, for the input x_0 down to the original input x_0 , θ proportion and keep the original output y_0 not reduce.

Model of C^2R implicit assumptions that DMU can be increased in proportion to expand the scale of output, that is the size of the DMU does not affect its efficiency. This assumption is quite strict, in many cases it can not be satisfied. In order to solve this problem, Banker, Charnes and Cooper (1984) considering the size of the variable remuneration and put forward the improvement scheme C^2R model. Variable size remuneration assumptions can made it remove the influence of scale efficiency when calculate the technical efficiency. The resulting efficiency is type (2) which represents the pure technical efficiency:

$$\begin{aligned} & \min \theta \\ & \left\{ \begin{array}{l} \sum_{j=1}^n \lambda_j x_j + s^- = \theta x_0 \\ \sum_{j=1}^n \lambda_j y_j - s^+ = y_0 \\ \sum_{i=1}^n \lambda_i = 1, \lambda_j \geq 0, j = 1, 2, \dots, n \\ s^- \geq 0, s^+ \geq 0 \end{array} \right. \quad (2) \end{aligned}$$

Because “technical Efficiency = pure technical efficiency × scale efficiency”, we can separately count the technical efficiency and pure technical efficiency of DMU use C^2R model or BC^2 model, and we can get scale efficiency through it.

If the optimal solutions of C^2R model are $\lambda_0, s^-, s^+, \theta_0$, when meet $\theta_0=1$, and $s^- = s^+ = 0$, DMU_{j_0} is technological efficient, else or not. The reason is that production input is too large, or not been fully made use of production capacity, resulting the shortage of output. If we want to make the invalid unit be effectively, it is necessary to adjust the input vector and output vector to its efficient frontier "projection": $x_0^* = \theta x_0 - s^-$, $y_0^* = \theta y_0 + s^+$. As long as the input reduce to x_0^* and the output increased to y_0^* , DMU_{j_0} is effective comparing with other $n - 1$ decision unit.

When applicate DEA method to evaluate, we need to multiple replication on the next steps in order to obtain a more reliable results, sometimes may be combined with other quantitative or qualitative methods[10].

a. Determine problem stage

To make the information provided by the DEA method is more exact and scientific, this stage needs to be done the following work:

- (1) It is necessary to define the target of evaluation and around the target of evaluation to be analyzed to object of evaluation. It is including identifying the main goals and sub-goals as well as the factors that affect these targets, and established a hierarchical structure.
- (2) Determine the nature of the various factors, such as the factors are divided into mutable or immutable, controllable or uncontrollable as well as major or minor.
- (3) Considered the possible qualitative and quantitative relationship between factors.
- (4) Due to some decision-making unit is open, sometimes need to identify the boundary of the decision-making unit and analyze the structure and layer of decision-making units.
- (5) The results need to be qualitative analysis and forecasting.

b Modeling computation stage

This stage needs to be done the following work:

- (1) To establish evaluation index system. According to the analysis of the first stage, determine the index system which can fully reflect the evaluation target, and some of the qualitative relationship between the indicators reflect to the constraints of weights. At the same time, we also can consider the diversity of input and output index system, comparative studies between the analysis results in each case and then get a reasonable management information.
- (2) Select DMU. Select DMU is essentially determining the reference set. Therefore, the selection of DMU should meet the following basic characteristics, that is having the same goal, task, external environment and input and output index. The selection of decision-making units is to have certain representativeness.
- (3) Collect and organize of the data has the availability.
- (4) According effectiveness analysis of the target and the actual background to select the appropriate DEA model to calculate.

c. The results of analysis stage

This stage needs to be done the following work:

(1) On the basis of the above work, the calculation result is analyzed and compared, find out the cause of the invalid unit is invalid, and provide further ways to improve.

(2) According to the result of qualitative analysis and forecasting to examine the rationality of evaluation results, DEA model can be used when necessary to take several schemes evaluation respectively, comprehensive analysis of the result, it can also be combined with other assessment methods or reference other methods provide the information for comprehensive analysis.

All in all, as a kind of effective system decision analysis method in recent years, DEA evaluation method is widely applied to technology and productivity advance, technical innovation, the problem about the cost-benefit profit, resource allocation, financial investment, performance evaluation and other fields. It opens up a new prospect and provides a new means for evaluation and decision-making problem of multiple input multiple output cases.

INFORMATION SYSTEMS' BUILDING OF SMALL AND MEDIUM ENTERPRISES BASED ON DATA ENVELOPMENT ANALYSIS

Using the concept of life cycle method we make an introduction. The design is divided into five parts like: feasibility studies and planning system; requirement analysis and general design; detailed design; system operation and system test; maintenance and evaluation.

a. Feasibility studies and planning system

The object of the design is an enterprise. The enterprise analyzes and sorts the vast amounts of data every day. They convey a lot of information. In order to improve its management information system, increase the operation efficiency, management level and economic benefit, which can provide customers with quick and high quality service, enhance competition ability. We can implement information management for the whole enterprise. In the development process we use different development methods to carry on the design, we can find their features and differences.

b. Requirement analysis and general design

The main task of enterprise should be covered in this system so as to make the management and business personnel timely and accurately entry and access to relevant units and departments of operation status information, and it can be controlled and managed effectively. We should extract the relevant data to be processed, auxiliary the interface prototype, clear requirements through acquainting the business.

c. Detailed design

(1) The target of system implementation. Management information system is a combination of human and machine. With the improvement of the system, the goal of the construction of the system is also constantly improved, so we must consider the development strategy of enterprises and the development of computer and conditions. The construction goal of the enterprise management information system should be also put forward at a high level to ensure the integrity advancement and science of the system.

(2) The structure of the system design. Data processing work of each profession have corresponding functional departments, and is performed by the corresponding professionals. The existing institutions and various functional departments are gradually formed in the process of enterprise development, which has its certain rationality and limitations in some respects, which cannot adapt to the requirements of modern management. Therefore, in the construction of the enterprise MIS, we should straight out the relationship between information resources fully, and carry on the reasonable division of subsystems in order to improve the data processing efficiency and quality.

(3) System module partition. Based on the above described process and data class incidence matrix method, we conducted the division of subsystem. The specific steps are as follows: First, relational table about process and data class will be built. The process of the system analysis should be arranged by executive order from the top to down, and data classes related to the process will be arranged from left to right. The relationship between the process and data class fill in the table: fill C when the relationship is generate relationship, fill U when the relationship is use relationship, be blank when no relationship. We call it U/C matrix. Second, adjust the U/C matrix. Pool together the similar function in order of process; meanwhile adjust the arrangement of the data classes. Through the gradual adjustment, make C pooled together as far as possible, and adjust the arrangement of data classes, and form the strongly connected matrix.

(4) System operation and system test. Based on the above analysis and design the subsystem. According to the

logical model system as a whole, following function relatively independency and considering the principle and combining with the actual needs of the enterprise, its management information system can be divided into twelve subsystems. Encoding process can be handled using object-oriented programming language.

DEA module function of sales market subsystem: The efficiency of different sales department; the efficiency of different times compared the same sales department. DEA module function of production subsystem: Each product manufacturing workshop's production efficiency; job scheduling scheme's effectiveness. DEA module function of supply subsystem: The choice of raw material suppliers; the choice of material distribution plans. DEA module function of personnel management subsystem: Management of employee performance; evaluation of each departments' manpower arrangement efficiency.

THE EFFECTIVENESS OF ENTERPRISE MANAGEMENT INFORMATION SYSTEM BASED ON DEA

Understanding the nature characteristics of the information systems, we can targeted discover its advantages to applied to the realistic environment. Information systems is contribute to the current environment in our country, the core task is provide the additional efficiency bonus for transcendence development of Chinese enterprise. The efficiency of bonus has three levels: institutional level, management level and operation level.

This paper is a preliminary study the DEA's application in the enterprise management information system, it has played an advantage of DEA in dealing with multiple input multiple output. How DEA applied to each company's management information systems also require specialized developers in-depth study. Such as DEA decision-making unit and evaluation index system need to do further specification; DEA application design of other model: the efficiency of the algorithm and so on.

CONCLUSION

The basic idea of data envelopment analysis is using mathematical programming model to compare the relative efficiency between the decision-making units, to make a quantitative comprehensive evaluation of decision-making units. It is considered to be a multi-objective decision-making method in dealing with multiple inputs multiple output problems. In the process of analysis, it does not need to determine the weights of input, output artificially in advance, its main characteristic lies in objective and comprehensive of evaluation. Enterprise operation is a multiple input multiple output complex system, and there are a lot of problems which need to be objective and comprehensive analysis, combined with enterprise information construction is the key point of effective competition an enterprise factor, so this method in the enterprise information management system has a broad application prospect.

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