Risk Evaluation Model on Enterprises' Complex Information System: A Study Based on the BP Neural Network

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***Abstract*—As modern enterprises' dependence on complex information system is growing, higher risks of using these information systems are thus incurred. This paper firstly made an overview of both the importance of complex information systems in enterprises and the universality of risks. Then proposed and analyzed are eight types of risks of complex information systems in enterprises: infrastructure, systemic projects, system application, information asset, business continuity, information system strategy, information system supplier and outsourcer, external risks of information systems. Finally, these eight risks are introduced to construct a risk evaluation model on the enterprises' complex information system based on the BP neural network.**

***Index Terms*—enterprise complex information system, risks of information system, Evaluation of Information System, BP Neural Network**

I. INTRODUCTION

Information Technology (IT) is another important driving force that promotes the global economic development following the industrial revolution. With the development of information technology, especially the application of internet and its rapid popularization, information system (IS) has taken on the development trend of networking, integration, large-scale and complexity. [1]

Complex information system (CIS) of the enterprise refers to the information system under strong challenging environment and strong constraints, with a variety of functions, requiring dynamic operation and integration, and with fairly good embedding characteristics. [2] From technical point of view, CIS refers to the information system which may runs on different operating systems, adopts many types of communication protocols, developed by many program languages, made up of a number of incompatible applications, and composes of many heterogeneous applications.[3] As the complex information system is fully embedded in various hierarchies of the enterprise or even the entire supply chain, the enterprise has an indispensable relation with the information system and each enterprise problem will be reflected in the information system, so that information system becomes the direct driving force of the enterprise, changing from traditional background support to new business development, and becomes an important basis of the entire enterprise business process, an important element of enterprise products and services, as well as an important factor of enterprise competitive strategy. As modern enterprises' dependence on complex information system is growing, higher risks of using these information systems are thus incurred.

A complex information system will encounter a variety of risks, and the risk formation mechanism varies greatly. [4] Based on exterior and internal enterprise risks and the promoting process of the information system, the author makes a comprehensive analysis of the risks of the complex information system from eight aspects: infrastructure risks, project risks, application risks, information asset risks, business continuity risks, strategic risks of the information system, information service supplier and outsourcing risks, and information system risks of the external enterprise. [5] And these eight risks are introduced to construct a risk evaluation model on the enterprises' complex information system based on the BP neural network.

II. THE IDENTIFICATION OF RISK FACTORS OF COMPLEX INFORMATION SYSTEM

A. Infrastructure risks of the complex information system

Infrastructure is a general designation of a series of concentrated or dispersed computers and network equipment resources. The major problem of infrastructure risks is that the infrastructure reliability is not high. First, once any of the infrastructure components fails, besides replacing the required hardware, the impact of service time on the system will also be considered, at the same time, due to the system compatibility issue, it is necessary to replace the system as a whole. Second, because of the accelerated infrastructure replacement, safely and quickly replacing the original components is also confronted with great difficulty.

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B. Project risks of the complex information system

Information system project is a series of activities that can directly observe the project budget, starting and terminating time, and other factors, therefore information system project has a special status in the whole information system risks. [6]

The project risks of the information system are mainly shown in the following aspects: postponing the finishing date of the original plan, spending more resources and money than the original plan, submitting fewer user functions than the original plan and causing service business interruption during the implementation period, and these will cause the project to be unable to deliver and ultimately make the project a failure. The major factors of failure are time, quality, functions and cost.

C. Application risks of the information system

The project completes in accordance with the time plan and designated budget, at the same time the system also completes all the related testing work, and all deliverables are provided and under reliable operation, then the next job is the application of the information system.

The major problems of application risks of the information system lie in the system vulnerability. The non-functional failure of many applications is difficult to distinguish, performance indicators, system capacity (refers to the storage space, computing ability, channel capacity, etc.), and the bulk processing speed etc with response time as the important benchmark will be shown, and the caused impacts may also appear after experiencing a long period of time. For example, the system works very well when dealing with 10,000 records, but it will collapse when records are added to 100,000; the system works very well when facing 100 concurrent users, however, there will be a serious decline in performance in the case of 200 users. [7]

D. Information asset risks

The development and utilization of information assets is a strategic and challenging job, usually including the database, supply chain management system and customer relationship management system of the development enterprise. Developing information assets can bring good economic values to the enterprise, but it is also accompanied by corresponding risks.

The major problem of information asset risks is the failure of protection and preservation. First of all, this kind of risk is relevant to the damage, loss, as well as improper disclosure of information assets loaded by the information system. For example, competitors may see important information of the enterprise. The credit card information of customers may be stolen or used to deceive, or more simply made public. These consequences will cause great harm to the client relationship and company credibility. Second, the risk of information assets will cause the core business process of the enterprise dependent on key information to be seriously hampered, for example, without accurate account balance, the account inquiry functions cannot be used.

E. Business continuity risks

The core and important business process of the modern enterprise are driven by information system service. However, information system creates a successful way for business, and it may also become a source of business failure.

The emergence of business continuity risks is related to a number of factors, but the most prominent is the low service standard and unreliable information system. They may lead to the interruption of business operation, and cause a big influence on end-users and customers. [8]

F. Information service suppliers and IT outsourcing risks

In recent years, outsourcing business has achieved great development. Service suppliers play an important role in project delivery and normal operation of the information system. Now without the involvement of such third parties, it will be very difficult to provide information technology service. Even in some areas where information technology services are not widely popularized, the supply and support of information technology products also need to rely on the third party. [9]

The primary problems of information service suppliers and IT outsourcing risks are the interruption of information system value chain. Once the supplier cannot deliver services or other outsourcing services cannot be put in place, immediate or potential impact will be caused to the information system and service, and the performance of the entire information system will be affected. [10]

G. Risks of external enterprise information system

With the collaborative commerce and comprehensive integration of supply chain, various information system risks of external enterprise will affect the information system of the enterprise. Once risks come, they will have serious consequences on the information assets and system application of the enterprise information system. [11]

H. Strategic risks of the information system

The information system strategy must adapt to overall business strategy of the enterprise, in particular, the business strategy of some companies is driven by the information system. Once the information system of these enterprises cannot support the promotion of the business strategy, the business strategy will be a total failure.

The major problem of strategic risk of the information system is to reduce the implementation capacity of the business strategy, due to the limited capacity of the design of the information system. Although its impact may not appear immediately, it may have a bad influence on objectives and long-term development of the business. [12]

To sum up the analysis above, the combination and relation of CIS risk is shown in Figure 1, and the structure of CIS risk factors is shown in Figure 2.

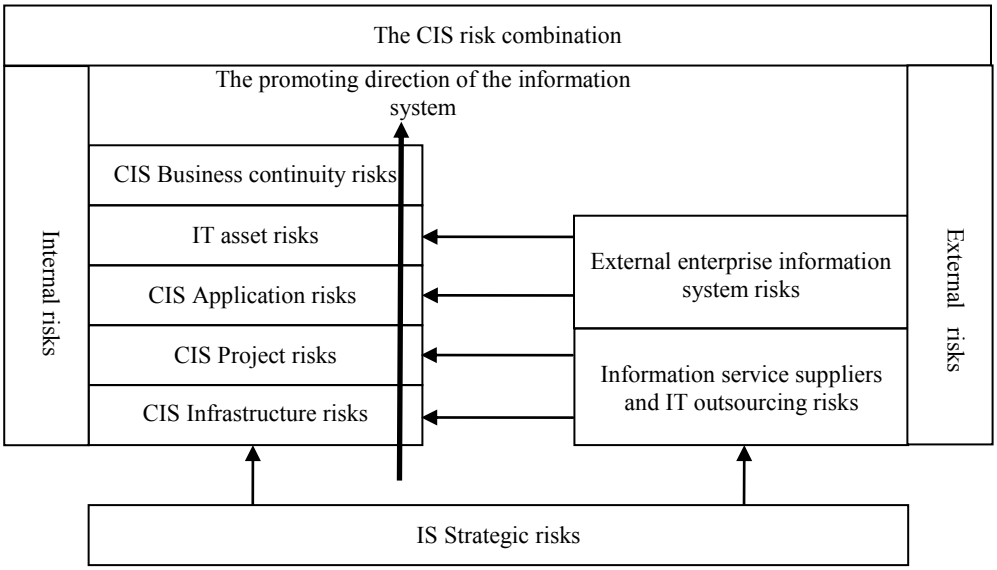

Figure 1. The combination and relation of CIS risk

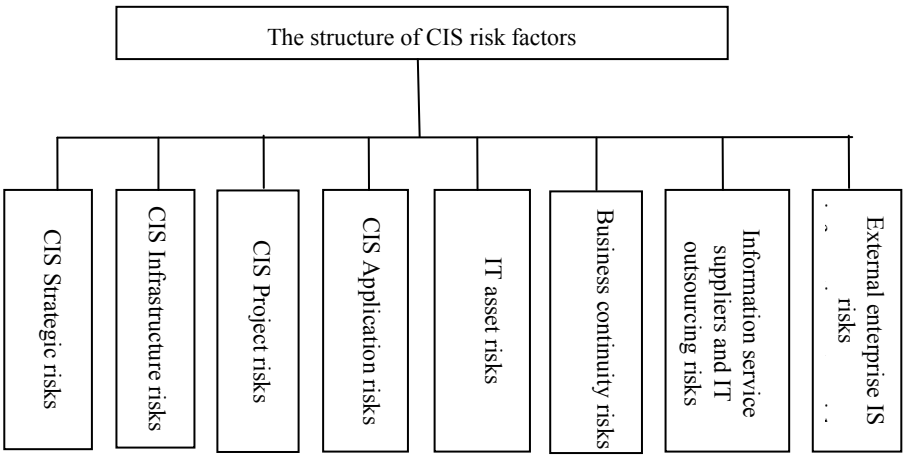

Figure 2. The structure of CIS risk factors

III. THE ANALYSIS ON RELATION OF RISK FACTORS OF COMPLEX INFORMATION SYSTEM

A. The relation of project risks

The relation of project risks is shown in Figure 3.

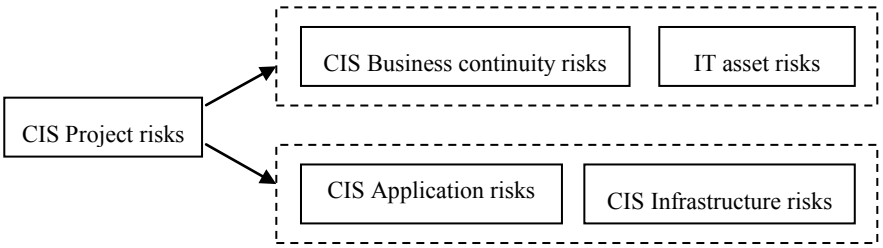

Figure 3. The relation of project risks

Firstly, project risks may conduct to system business continuity risks and information asset risks, and its inappropriate management may easily affect the business service of the enterprise. This kind of risks mainly embody as follows: 1) Postponing or canceling the project may only make us rely on the current and unimproved system continuously. 2) With the implement of new system, new system weakness and fault that differ from the previous ones may be brought. 3) After transferred to the new system, the completeness of

important information assets may be damaged due to the introduction of abnormal and disaccord. 4) The insufficiency of user training may cause the service quality to decrease.

Secondly, project risks may conduct to system application risks and system infrastructure risks, and its improper management may also affect the implementation of the system. This type of risk is mainly embodied in: 1) "Quickly but incomplete" engineering approach used in the project may make it difficult to control, support, maintain and guarantee the system. 2) Even if the new solution has been effectively engineered, the solution is still new for operators and any deficiency appeared in the process of system conversion may bring long-term and potential risks for the system. 3) In the project, there will be phenomena like inappropriate selection of products, lacking steady strategy, without enough consultation and etc. 4) The future system application and infrastructure team do not have sufficient capacity, and corresponding risks will be quite big once problems appear.

B. The relation of service suppliers and outsourcing risks

The relation of service suppliers and outsourcing risks is shown in Figure 4.

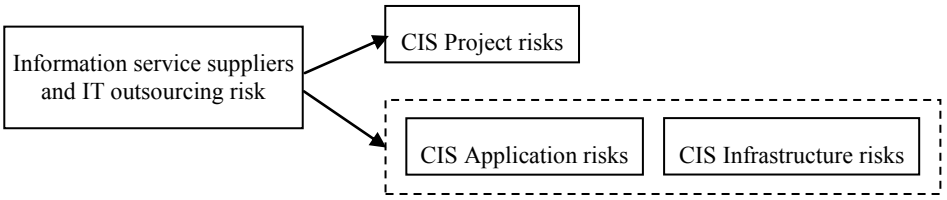

Figure 4. The conduction relation of service suppliers and outsourcing risks

Firstly, service suppliers and outsourcing risks will conduct to project risks, and its improper management will affect the service of delivered projects. Generally speaking, before the development of information system is confirmed, it is required to establish close contractual relationship with each service supplier. The contract itself should be relatively complete, meet the requirements of working process and reach a consensus on how to better manage service suppliers. However, in some projects, this "reached contract" may not be achieved until the project ends. Therefore, in the process of project implementation, if service suppliers and outsourcing risks lack effective management, finally system project risks will appear inevitably. For example, it is asked to make tasks without complete analysis; it often needs to change the scope of the system and project even it has entered the stage of detailed technical design, etc. Meanwhile, the management of multi-supplier will unavoidably result in the sub-contract management, while the potential complexity of sub-contract will also bring risks to the whole project.

Secondly, service suppliers and outsourcing risks will conduct to the system application risks and infrastructure risks, and its improper mismanagement can also affect the operation-delivered services. If information technology services are outsourced, the system is under the control of service suppliers, and various external risks will be entangled together. It is undoubtedly effective for the outsourcing to realize the service contract, transfer the application responsibility, and transfer the management of infrastructure assets to suppliers. But it also needs to share the responsibility to deliver services according to the scheduled performance standards and expense agreement. Even in the case of outsourcing, the risks of system application and infrastructure still remain in the hands of system owners, causing inefficient system application and weak infrastructure. [13]

C. The relation of system application risks and infrastructure risks

The relation of CIS application risks and infrastructure risks is shown in Figure 5.

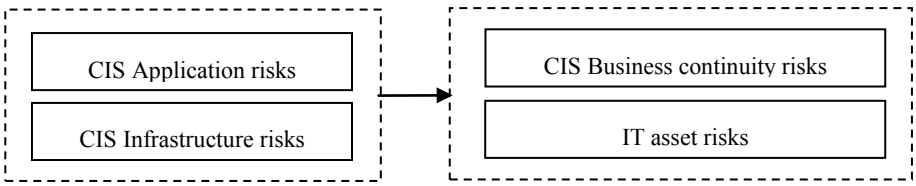

Figure 5. The conduction relation of system application risks and infrastructure risks

The system application risks and infrastructure risks will conduct to CIS business continuity risks and IT asset risks, and its improper management will also affect the operation-delivered service. The system application and infrastructure provides support for information technology services, and also builds a layer of secure guard net for information assets. Once attacked, the deficiencies and shortcomings in system application and infrastructure will result in the interruption of all or partial information system. In many businesses, even temporary halt of the host computer system may also lead to the interruption of business process and cause

significant losses. If there are serious faults like permanent damage of the critical application and data server system, fatal damage might be caused to the business process and information assets. [14]

D. The relation of strategic risks of the information system

The relation of information system strategy is shown in Figure 6.

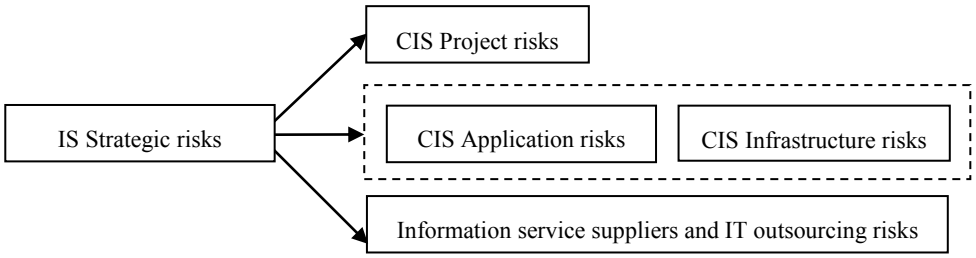

Figure 6. The conduction relation of strategic risks of the information system

Firstly, strategic risks of the information system will conduct to project risks, and the ill management will seriously influence the choice of project and technology direction. 1) Select right projects and avoid the implementation of wrong projects; 2) In the implementation process of information system project, ensure the correct strategic direction, and meanwhile make necessary adjustment to the project based on strategic direction. If there is strategic deviation, no matter how perfect the original imagination is, it is difficult for the project to escape the fate of failure. [15]

Secondly, strategic risks of the information system will conduct to system application risks and infrastructure risks, the mismanagement will exert a serious impact on the selection of system architecture and components. If there is no clear strategic and target system architecture, then strategic decision-making relevant to system application and infrastructure components selection will degrade as tactical decision-making, even the decision will be made simply on the basis of special conditions. This will affect the support to system application operation and process of system development, maintenance and guarantee, and will make the future system change and integration become extremely difficult.

Thirdly, information system strategic risks will conduct to information service suppliers and outsourcing risks and the mismanagement will have a serious adverse impact on suppliers and the outsourcing service quality. Since the influence of information outsourcing decision will last for many years, the information outsourcing decision is actually a kind of information strategic decision. Improper outsourcing strategy and selection process may introduce great risks to the service conversion process, so that the service provided by independent suppliers cannot meet the requirements. When a number of suppliers are needed to coordinate and work together, a set of decisions that can guide this "multi-source" cooperation and arrangement should be made, otherwise situations such as disparity, overlapping as well as out of control may occur at any time, and the delivery of "end-to-end service" will be difficult to be guaranteed.

IV. CONSTRUCTION OF RISK EVALUATION MODEL OF COMPLEX INFORMATION SYSTEM BASED ON BP NEURAL NETWORK

Many researches at home or abroad have addressed the methods of risk evaluation for information systems which mainly include quantitative evaluation, qualitative evaluation, partially quantitative evaluation and etc. [16][17][18] Specifically, major evaluation methods are analytic hierarchy process (AHP), decision tree method, Markov Model and so on. [19][20][21] For different analytic methods, the emphasis, application scope and evaluation results vary. Another important issue is that to evaluate the risks of a complex information system needs, risk evaluation factors need to be selected and weights of each evaluation factor needs to be defined. Only proper definitions of risk evaluation factors and their weights can ensure effectiveness and credibility of risk evaluation conclusions. [22] Adopting 8 types of risks mentioned above as risk evaluation factors, [23] this paper first defined the risk levels of each evaluation factor, and obtained original data through the combination of quantitative and qualitative analyses, then employed the evaluation method based on BP neural network to make risk evaluation of complex information systems with enterprises.

A. Risk Evaluation Algorithm Based on BP Neural Network

1) Structure of BP Neural Network

BP neural network consist of two parts: positive-going information transition and erroneous opposite-going transition. In the process of positive-going transition, input information is calculated through the input layer, hidden layer and then transited to the output layer; the state of neurons at each layer will only affect that of the next layer's. If no anticipated output is obtained at the output layer, then deviation value of the output layer is thus calculated and transited in the reverse direction, returning the deviation signal through the original passage in the network, then revise the weight values of neurons at each layer until the expected target is reached. [24]

The structure of BP neural network is shown in Figure 7.

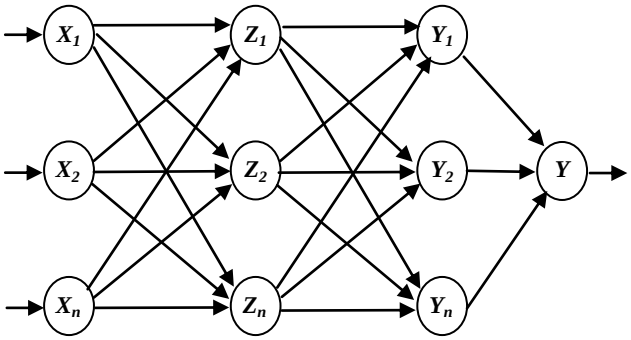

Figure 7. The structure of BP neural

$\{ X_1, X_2, \cdots\cdots, X_n \}$ is at the input layer;

$\{ Z_1, Z_2, \cdots\cdots, Z_n \}$ is at the hidden layer;

$\{ Y_1, Y_2, \cdots\cdots, Y_n \}$ is at the output layer.

Y is the general value of risk evaluation.

The input and output relations between nodes at the hidden layer and output layer are:

$$z = f(\sum w_{ji} x_j - \delta_i) \qquad y = (\sum w_{jk} z_j - \delta_k)$$

$$input: I_i = \sum w_{ji} x_j - \delta_i \quad output: O_i = f(I_i)$$

In the above expression, I_i is the input value of node i; x_j is the input value of node j of last level which is connected to node i; W is the weight that connects nodes i and j; δ is the threshold value of node i; O is the output value of node i; $f(I_i)$ is the function about the mapping properties between input and output layers. [25]

2) Algorithm of BP Neural Network

The algorithm of BP neural network is as follows: first, the calculation is made through the input layer of the network to the output layer; second, revision and adjustment is made on the connectional weight values and threshold values, namely, make calculation and revision through the output layer to the input layer, then revise weight values connected to the output layer according to the deviations of the output layer until all the requirements are fulfilled. Figure 8 shows the flow chart of the algorithm of BP network. As shown in the figure, the algorithmic process of the BP network is dynamic, which means that entry to another step should be allowed only at the fulfillment of last step, otherwise second analysis is required to find the reasons and points of deviation before entering another step.

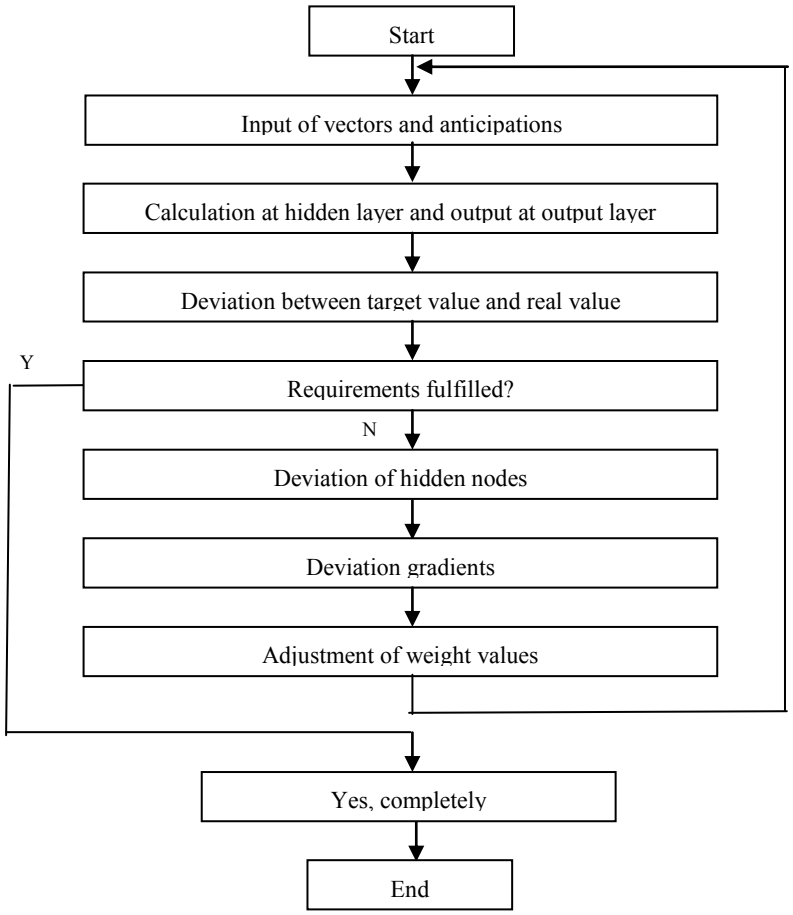

Figure 8. Algorithm of BP Neural Network

B. Definition of Risk Levels of Each Risk Factor

Risk levels of each risk evaluation factor are co-defined by the occurrence possibility of each risk and the severeness of risk occurrence. The occurrence possibilities of each risk can be divided into five levels: negligible, low, medium, high and great; degrees of severeness of risk occurrence generally include five levels: negligible, small, fair, serious and disastrous. Table I integrates these two parameters to evaluate the risk level (1-5) of evaluation factors. [26]

TABLE I.
RISK LEVELS OF RISK EVALUATION FACTORS (X1 ,X2 ,……, X8)

Possibility of Risk Occurrence	Severeness of Risk Occurrence				
	Negligible Influence	Small Influence	Fair Influence	Serious Influence	Disastrous Influence
Negligible	1	1	1	1	1
Low	1	2	2	3	3
Medium	1	2	3	4	5
High	1	3	4	5	5
Great	1	3	5	5	5

C. Definition of the General Risk Evaluation Model on Enterprises' Information System

The fundamental principle for employing BP neural network to make risk evaluation is: risk levels used to describe each risk serve as the input vectors of the neural network; the values of risk evaluation for the systems become the output of the neural network.

In this model, there are 8 risk factors, 8 neurons at the input layer, 3 neurons at the hidden layer, 1 neuron at output layer. Adopting the tool box of neural network in MATLAB software, neural network is able to be trained with convenience; input vectors are X1 , X2 ,. . . . . ,X8 and the output of neural network Y is the general value of risk evaluation. If the risk evaluation value of the system Y<=1.5, the system is low risk-ed while those with risk evaluation values Y for 1.5<Y<=3.5 are medium-risked, and those systems with Y>3.5 are highly-risked.

Before using the neural network, some traditional methods or sample systems with practically successful cases were adopted to train this network in order to make sure all the coefficient of its special weights receive correct internal relations after self-adaptive study. After the neural network is well trained, it can be an effective toll to evaluate information systems of enterprises. This model has been trained with 6 samples of enterprises, and the output values were basically consistent with the evaluation outcomes of successful cases.

V. CONCLUSIONS

Based on BP neural network, this paper constructed the Risk Evaluation Model for enterprises' complex information system and made comprehensive evaluation with living examples. The results of evaluation showed good precision and objectiveness and are thus able to serve as the measurements for risk controlling. Enterprises' complex information system is generally complex and universal. Types of risks of information systems are mutually dependent and interactive, hence to get in hold with all types of influencing factors of complex information system and various method to evaluate risks will be helpful for enterprises to take the initiative in controlling the occurring periods of risks, to avoid external risks, to eliminate internal risks and to solve the potential problems by finding their sources; in this way, information systems and information technologies will become the significant assets of enterprises indeed and thus elevate the investment return and value of enterprises' information systems.

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