ROUGH SETS APPROACH TO HUMAN RESOURCE DEVELOPMENT OF INFORMATION TECHNOLOGY CORPORATIONS

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Abstract: It is essential for IT corporations to improve competitive advantage and increase organizational performance. Employees are a key factor for a company's success. It is crucial to find or create a brand-new model in dealing with human resource and customer relationship management, as well as to recognize which employees' characteristics are influential in building relationships with customers. The objective of the paper is to clarify what kinds of features and behaviours of the employees can create a good relationship with customers. In the paper, rough sets model is used to deal with vagueness/ambiguity and uncertainty in the analysis of human resource and human relationship management, and can change a qualitative problem into a quantitative one. The model will give useful information by natural language and can provide guidelines to a decision maker. The rough sets approach differentiates between the two groups, and in the end we suggest some policies to improve the quality of human resource management, customer relationship management and the development of them. The proper management of employees and customers will ensure the success of a project and the good performance of a corporation.

Keywords - human resource development, rough set theory, customer relationship management

1. INTRODUCTION

Many researches underline providing important methods for human resource management. Since in 80s people were product-oriented; most employees just needed skills to product, which is the idea of job-based human resource management. Then Harvard University psychology professor McClelland in 1973 first challenged the idea of "work as the center" evaluation. He pointed out utilizing competence sets instead of intelligence as assessment criteria, which emphasized the evaluation idea and technology of "work as the center" [Richard, 1997], the concept of competency-based evaluation has led a revolutionary change in a modern evaluation system. This idea regards an organization as a polymer of competence sets and its focus on competence sets expansion and its growth, especially suite to high dynamic and people-oriented features in the era of knowledge economy [Yan *et al*., 2006]. So today employees do not need to pursue only their jobs but also have to keep good relationship with customers.

When a company has a good relationship with customers, it can increase the revenue, market share of the company, quick response of the market opportunity, customer loyalty to the company, and collect information easily to ensure the corporation resources that are used in a suitable way. For this goal, a manager will arrange employees to the right place in the right time for satisfy company's customers. But when there is a quarrel between employees and customers, this becomes a trade-off problem that means the company cannot satisfy both employees and customers at the same time. Manager often sacrifices employees' right and satisfaction. Nowadays it is not correct any more.

The objective of this research is to find out a compromising solution that satisfies both of employees and customers, and finds out what kinds of features and behaviours of employees who can build good relationships with customers. The results of this research will be used to guide organizations as they are useful in providing a good strategy for human resource management and customer relationship management

This paper is organized as follows: Section 2 reviews research efforts. The mathematical model employed here is briefly illustrated in Section 3. Section 4 is spent to explain the problem tracked in this paper. Its results are discussed in Section 5. At the end several remarks of this paper is given in Section 6.

2. RELATED RESEARCH EFFORTS

2.1. Human Resource Management

Storey (1995) gave a good definition of human resource management (HRM) as it is a distinctive approach to employment management which seeks to achieve competitive advantage through the strategic deployment of a highly committed and capable workforce using an array of cultural, structural and personnel techniques.

In recent years, by connecting HRM with strategic management and corporation performance, researchers emphasized on organizational performance under the positive linkage with HRM promotes to organizational performance [Truss, 2001][Pfeffer and Veiga, 1999]. If the companies have good HRM, then it will have good organization performance, so how to inspire worker's motivation and passion is the key point of a business to survive in an IT industry. The research [Pfeffer, 1994] showed that high motivation and strong commitment of employees will lead to high business performance in the long run. HRM should be influenced to bring effectiveness for an organization, which can be used as a strategy for decision makers to attach work to their staff.

Cascio (1992) suggested that organizations nowadays must gain competitive advantage through the effective utilization of their HRs; the human power of an IT industry is complex, because employees strive with balancing their personal development and loyalty for a company. People change their job frequently, because sometimes they want to receive higher salaries, benefits or statements, but this is a very large loss of the company because the company spent training costs, the time for employees, the business information and the relationship and contact data with the costumers, all of those things will loss when those experienced workers are hired by their company's competitors. So HRM finds out some worker's features which can reduce this problem.

Human resource, in other words, well-informed capable citizenry can improve the total ability of an organization, a society, a government agency and virtually of a country, of a nation [Khan, 2003]. For example, planning and needs based recruitment keep staff costs down; merit-based selection procedures should improve the quality of staff [World Bank, 1997], companies can have quality, effective and low cost employees though HRM at the same time.

2.2. Soft Computing

The hardware and software of computer enable us to deal with large data in a short time. Huge amount of data have been collected and stored in a database, traditional ad hoc mixtures of statistical techniques and data management tools are no longer adequate for analyzing this vast collection of data [Sushmita *et al.*, 2002]. Many businesses need huge collections of data like: financial investment, human resource management, customer relationship management, production and inventory management …etc. But we are faced with another problem, that is, how to analyze such a huge number of data. There are many researches who use data mining and soft computing to find out meaningful information from a large database [Sushmita *et al.*, 2002], collect current data mining practice include the following.

(1) Classification: classifies a data item into one of several predefined categorical classes.

(2) Regression: maps a data item to a real valued prediction variable.

(3) Clustering: maps a data item into one of several clusters, where clusters are natural groupings of data items based on similarity metrics or probability density models.

(4) Rule generation: extracts classification rules from the data.

(5) Discovering association rules: describes association relationship among different attributes.

(6) Summarization: provides a compact description for a subset of data.

(7) Dependency modeling: describes significant dependencies among variables.

(8) Sequence analysis: models sequential patterns, like time-series analysis. The goal is to model the states of the process generating the sequence or to extract and report deviation and trends over time.

Data mining is widely used in many researches, and various soft computing methodologies have been applied to handle different challenges posed by the data mining [Sushmita *et al.*, 2002]. There are many methods such as fuzzy logic, neural network, genetic algorithms, genetic programming and rough sets. Each of them can analyze a problem in its domain, those methodologies can be used together to solve complex problems, and more and more researches combine those methods to find new critical features. That result is more adaptive for our real world as comparing with traditional techniques.

Current researches find conventional data mining methods still have weak points. Those methods focus on discovering algorithm and visualizing techniques. But through data mining it is easy to find out a huge number of patterns in a database, where most of these patterns are actually useless or uninteresting to the user [Sushmita *et a.l*, 2002].

Rough set theory suits to analysis of different types of uncertain data and rough set can deal with large data to reduct superfluous information, we also can find extracting knowledge form the rules.

2. ROUGH SETS

3.1. Researches

Rough sets theory has many advantages. For instance, it provides efficient algorithms for finding hidden patterns in data, finds minimal sets of data (data reduction), evaluates significance of data, and generates minimal sets of decision rules from data. It is easy to understand and offer straightforward interpretation of results [Pawlak, Z., 1996]. Those advantages can make the analysis easy, that is why the rough sets approach is applied widely in many researches.

The rough sets theory is of fundamental importance in artificial intelligence (AI) and cognitive science, especially in the areas of machine learning, knowledge acquisition, and decision analysis, knowledge discovery inductive reasoning, and pattern recognition in databases, expert systems, decision support systems.

Rough sets theory is developed by [Pawlak, 1982; Pawlak, 1984]. It has been applied to the analysis of many issues, including medical diagnosis, engineering reliability, expert systems, empirical study of material data [Jackson *et al*., 1996], machine diagnosis [Zhai *et al*., 2002,], travel demand analysis [Goh and Law, 2003], data mining [Li and Wang, 2004], the research proposal of a general approach for a progressive construction of a rule-based assignment model to solve the linear programs [Azibi and Vanderpooten, 2002]. Based on rough sets theory, the research by Shyng *et al*. (2007) addressed the effect of attributes/features on the combination values of decisions that insurance companies make customers' needs satisfied [Shyng *et al*., 2007]. Rough set theory can unify with fuzzy theory [Lech P., 2003] and is transformed from the crisp one to a fuzzy one, called Alpha Rough Set Theory [Quafafou, 2000].

Another paper discussed the preference-order of attribute criteria needed to extend the original rough sets theory, such as sorting, choice and ranking problem [Greco, S. *et al.,* 2001] and extends previous research by employing a development of rough sets theory, namely the variable precision rough sets (VPRS) model business failure prediction [Beynon and Peel, 2001], The rough sets theory is useful method to analyze data and reduct information in a simple way.

3.2. Method

In IT corporations, human resource is an important issue, and how to manage employees and customer relationship is full of incompletion and uncertainty.

Human resource management is about people, including a manager, staff and customer. Much of human knowledge is expressed in natural language and a natural language is basically a system for describing perceptions. Perceptions are intrinsically imprecise, which reflect the bounded ability of sensory organs, and ultimately the brain, to resolve detail and store information [Zadeh, 2005], those perceptions are hided in the human language. The traditional research methods are difficult to measure the real meaning of the human perception.

Fuzzy set and rough set theories turned out to be particularly adequate for the analysis of various types of data, especially, when dealing with inexact, uncertain or vague/ambiguous knowledge [Walczak and Massart, 1999]. Both the fuzzy set and rough set theories deal with the indescribable and perception knowledge. The most difference between them is rough set theory does not have membership function so that it can avoid pre-assumption and subjective information in analysis.

Rough set theory provides a new different mathematical approach to analyze the uncertainty, and with rough sets we can classify imperfect data or information easily. We can discover the results in terms of decision rules.

So in this research, we use rough set theory to analyze the human resource problem.

3.2.1. Information system: Generally, an information system, denoted by *IS*, and defined by *IS* = (*U*, *A*, *V*, *f*), where *U* consists of finite objects and is named a universe and *A* is a finite set of attributes $\{a_1, a_2, \ldots, a_n,\}$. Each attribute *a* belongs to a set A, that is, $a \in A$. $f_a : U \to V_a$, where V_a is a set of values of attributes. It is named a domain of attribute *a*.

Example 1.

	Attributes			decision
objects	a1	a2	a3	D1
object1	3	1	3	1
object2	1	2	3	2
object3	3	1	3	1
object4	1	2	3	2
object5	2	2	4	2
object6	1	2	2	1
object7	2	2	4	1
object8	1	2	2	2
object9	1	2	3	2
object10	2	2	4	2

U= {object1, object2, object3, object4, object5, object6, object7, object8, object9, object10}
A= {a1, a2, a3}
a1= {1, 2, 3}
a2= {1, 2}
a3= {1, 2, 3, 4}
D1= {1, 2}

3.2.2. Lower and Upper Approximations: A method to analyze rough sets is based on the two basic concepts that are lower and upper approximations of a set as shown in Figure 1. These are two crisp sets.

In Figure 1 some squares are included in the circle, while the others are not. The squares included completely in the circle are called a lower approximation, whereas the squares partially and completely included in the circle are called an upper approximation.

Let X be a subset of elements in universe U, that is, $X \subset U$. Now we consider a subset P in V_a, i.e., $P \subseteq V_a$. The low approximation of P, denoted as $\underline{PX}$, can be defined by the union of all elementary sets x_i contained in *X* as follows:

$$\underline{PX} = \left\{ x_i \in U \mid [x_i]_{ind(p)} \subset X \right\}$$

where x_i is an elementary set contained in *X*, $i = 1, 2, ..., n$.

The upper approximation of P, denotes as $\overline{PX}$, can be defined by a non-empty intersection of all elementary sets x_i contained in *X* as follows:

$$\overline{PX} = \{xi \in U | [x_i]_{md(p)} \cap X \neq \emptyset\}$$

The boundary of *X* in *U* is defined in the following: $PNX = \overline{PX} - \underline{PX}$

Figure 1 shows conceptually low approximation and upper approximation.

Example 2

	a1	a2	a3
{object1, object3}	3	1	3
{object2, object4, object9}	1	2	3
{object5, object7}	2	2	4
{object6, object8}	1	2	2

If we are interested in subset *X* of five objects:
X= {object1, object2, object4, object5, object9}
The elementary sets presented in example2, which are also contained in *X*, are:
{object1, object3}, {object2, object4, object9}
So the Lower approximation is
PX= {object1, object3}, {object2, object4, object9}

To calculate the upper approximation of subset *X*, one has to find all elementary sets in Example 2 which have at least one element in common within the subset *X*, which are:

{object1, object3}, {object2, object4, object9}, {object5, object7}

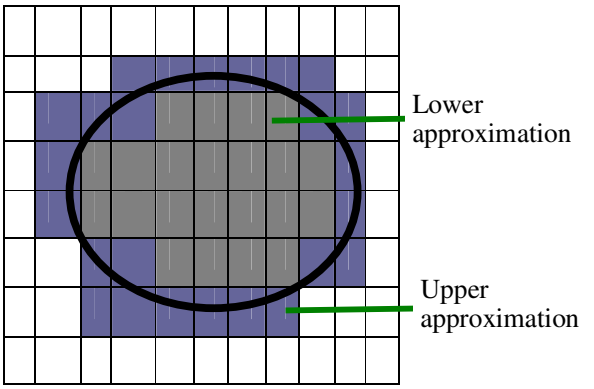

Figure 1. Upper and Lower Approximations of Set *X*.

So the Upper approximation is
PX= {object1, object3}, {object2, object4, object9}, {object5, object7}

Boundary of *X* in *U* is
PNX= {object1, object3}, {object2, object4, object9}, {object5, object7} - {object1, object3}, {object2, object4, object9} = {object5, object7}

3.2.3. Core and Reduct of Attributes: Core and reduct attribute sets are two fundamental concepts of a rough set. Reduct can minimize subset and make the object classification satisfy the full set of attributes. The core concept is commonly used in all reducts [Shyng *et al*., 2007]. Reduct attributes can remove the superfluous attributes and give the decision maker a simple and easy information. There may be more than one reduct attributes. If the set of attributes is dependent, we are interested in finding all possible minimal subsets of attributes which have the same number of elementary sets [Walczak and Massart, 1999].

The reduct attribute set affects the process of decision-making, and the core attribute is the most important attribute in decision-making. If the set of attributes is indispensable, the set is called the core [Walczak and Massart, 1999] , which is defined as

$RED(P) \subseteq A \quad COR(B) = \cap RED(P)$.

3.2.4. Decision Rules: Decision rules can also be regarded as a set of decision (classification) rules of the form: $a_{k_i} \Rightarrow d_j$

where a_{k_i} means that attribute a_k with value *I*, d_j means the decision attributes and the symbol '$\Rightarrow$' denotes propositional implication. In the decision rule $\theta \Rightarrow \phi$, formulas θ and ϕ are called condition and decision, respectively [Walczak and Massart, 1999].

Though the decision rules we can minimize the set of attributes, reduct the superfluous attributes and group elements into different groups. In this way we can have many decision rules, each rule has meaningful features. The stronger rule will cover more objects and the strength of each decision rule can be calculated in order to decide the appropriate rules.

1. 4. AN EMPIRICAL STUDY ON HUMAN RESOURCE DEVELOPMENT OF IT CORPORATIONS

The questionnaires has been built based on the several analysis we provided in IT industry [Toyoura et al., 2004] and in analysis of accidents [Watada et al., 1998]. In this research we obtained answers of 47 questions of 167 employees from IT companies. These questions are named attributes which characterize each employee. When employees have good customer relationship it always help a company earn more profit and realizes a good brand. Nevertheless, it is difficult to find out whether employees will have a good customer relationship. This issue is important in every corporation, but a manager is hard to recognize who has good relationship and interaction with consumers, Therefore, we place a focus on the answer of the question: "do you have a good human relationship with your customers?

Let us denote an answer of employee i to this question $(i = 1,2,...,167)$ as A_i. The objective of this research is to clarify what kind of pattern of other answers to the questionnaires results in some value of A_i, that is, "yes, I have a good relationship with customers" or "no, I have not a good relationship with them." We investigate all the answers of 167 employees of IT companies and find out the latent structure of the answers as managers and companies can provide effective functions to motivate their staffs.

In the analysis, we firstly processed the data that obtained from questionnaires by ROSE [Predki and Wilk, 1999], [Predki *et al*., 1998].

Table 1 shows the lower and upper approximations obtained by a rough set analysis. This result has accuracy 1.000. This means the target set is definable on the basis of an attribute set [Pawlak *et al*., 1998]. Attribute A_i $(i = 1,2,\cdots,167)$ "do you have a good human relationship with your customers?" is named as a decision attribute. The values that A_i $(i = 1,2,\cdots,167)$

Table 1. Lower and upper approximations

Class number	Number of objects	Lower approximation	Upper approximation	accuracy
1	146	146	146	1.000
2	21	21	21	1.000

takes are 1 (yes) and 2 (no). There are 146 YESs and 21 NOs.

Table 1 illustrates that the upper and lower approximations are equivalent. Therefore, there is no uncertainty in the classification of classes $D=1$ and $D=2$. When decision rules are obtained, the decision rules can help a decision maker to get more information about human resource.

4.1. Decision Rules

Decision tables in APPENDIX A show the covering rate and the elements of rules. It helps us to know those features more clearly, and each rule has its own elements. Those elements are the features of these rules. We want to find out the typical rules that can cover most of employees and help decision makers to get the ideal picture of employees' behavior, in this way manager can differentiate features into many groups and each group has its own policies.

Through the ROSE in Figure2 we can obtain the results, which are shown in APPENDIX A, where we find 16 rules. There are 9 decision rules that have good relationship with customers and 7 decision rules that have bad relationship with customers. The total covering rate is 98.8%. So this decision table stands for employees' behaviors in the IT corporations.

APPENDIX A shows that rule1 covers 59.59% of the whole employees. More than half of people in these IT companies have such features when they have good relationship with customers. Rule 10 covers 28.57% of the whole employees. Such behaviors of those employees have their customers who may not be satisfied. Rule 10 covers only 28.57% people because in the databases of 167 employees, only 21 employees do not have good interaction with consumers. The coverage of 28.57% is still meaningful in our result.

5. RESULTS AND DISCUSSIONS

In rules 1 and 4 we can understand when employees in the IT corporations have good relationship with customers. They also have positive thinking and behaviors. They understand a whole system or organization and contact with people of their customer's company, like to join the financial statements and think it is useful to attend a business protocol training, know board members and internal operating rules of the company, and also have good relationships with other members in the same company.

Through those features we can know they are very active in their company. So managers should pay attention to how to make them contribute continually and increase their motivation to make more benefit for their company

In rules 10 and 12 the employees with bad relationship with their customers are those who do not understand the contract, the whole system and organization of their customer company, join in none of scheduled trainings, lectures or seminars and carrier-up, never contact with any board members of customer companies, have no knowledge of databases about customers, and have none of solutions in troubles of the collaboration with a maker. Those negative features mean employees do not care about their jobs and do not want to make achievements. The manager of such employees must find out the reason and push them back to work. Those positive and negative decision rules let us know what kind of features and behaviors can bridge between customers and the company.

Maslow's hierarchy of needs is often depicted as a pyramid consisting of five levels: psychological needs, safety, love/belonging, esteem, and self-actualization. People have good relationship with customers is in the level of love /belonging. So they will want to seek for next level which is more esteemed. People need to engage themselves to gain recognition and have activities that give the person a sense of contribution. As people try to become better, they work hard to find their abilities.

Those people always want to learn new things and know more information about their company, because they have already realised they are one of the team. Therefore, such employees will play a central role in their jobs.

Employees, who have a bad relationship with customers still in the safety level, only care about themselves whether they will be employed or not. It means they think everything for themselves. Therefore, they do not want to work hard because it means nothing to their safety.

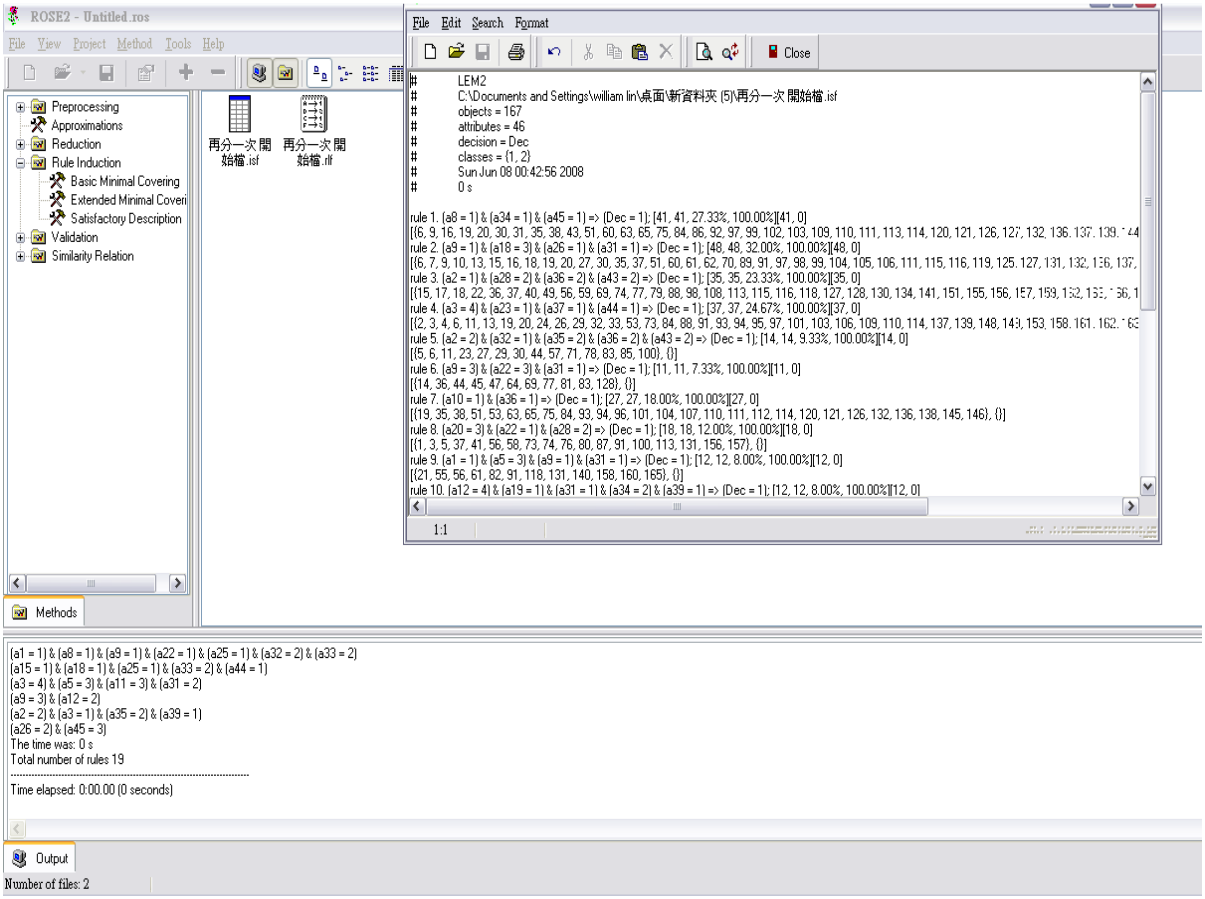

Figure 2: ROSE with the result of decision rule.

They do not think they are company members. Therefore, those people have no interest in doing anything out of their duty. A manager has to assure security of their employment. It means to protect the right of their job and does not mean that the manager fires people easily.

They should be placed into the love/belonging level. In this way, the manager can have effective staff. The manager also has to take care of that people who have good relationship with customers, help them do their work correctly, sometimes give them some challenges and rewards to increase their motivation. No matter whether the employees have good or bad relationship with customers, they are the human resource of the corporation. So Manager can give those two groups with different functions.

But it is always not easy to divide people into groups, so manager can recognize their staffs according to the result of rough set theory. In APPENDIX A when the decision attribute equal to one, it means people have good relationship with customers and they have those feathers: they recognize and understand a whole system and organization of your customer's company, they understand the board members, they like to attend any trainings or seminars for acquiring the knowledge of financial statements, they have a good human relation with their bosses, senior members, and colleagues within a company...etc, those features can give a guild for manager to evaluate the employee.

When the decision attribute equal to two, the staff have those features: they do not understand the contract with the company which they work in, they don't attend scheduled trainings, lectures or seminars for business protocol and carrier-up after joining this company, they can't contact with board members of their customer's company, those negative work attitude will let the manager give them another different way of management. In this research we give a clear function to make staffs differentiable.

6. CONCLUDING REMARKS

Through this research we can understand human resource management and customer relationship management are important in every corporation. The rough sets theory separates superfluous factors from important elements in our decision table and successfully deals with the human resources and customer relationship management, besides we find out latent logic of features and answers to manage employees and customers. Those useful information can be adopted in IT corporations, to help them to provide right service at right time which satisfies their customers without sacrifices employees' rights, in another word, increases the satisfaction of employees and customers at the same time.

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APPENDIX A

Rule member	Decision attribute	The minimal covering rule		Value	Covering rate
Rule(1) 59.59%	**1**	**Q29**	Do you recognize and understand a whole system and organization of your customer's company?	**Yes**	**0.520**
		Q30	Do you understand the board members?	**Yes**	
		Q33	Do you like to attend any training or seminar for acquiring the knowledge of financial statements	**Yes**	
		Q36	Do you have a good human relation with your bosses, senior members, and colleagues within a company?	**Yes**	
		Q40	Do you understand the internal operating rules of the company?	**Yes**	
Rule(2) 45.21%	**1**	**Q29**	Do you recognize and understand a whole system and organization of your customer's company?	**Yes**	**0.640**
		Q39	Do you understand the contract with the company that you work in? Yes	**Yes**	
		Q2	Is it useful in business that you attended business protocol training?	**Yes**	
Rule(3) 23.97%	**1**	**Q36**	Do you have a good human relation with your bosses, senior members, and colleagues within a company?	**Yes**	**0.700**
		Q4	Did you attend a scheduled training, lectures or seminars for business protocol and carrier-up after joining this company?	**None**	
		Q46	To whom do you consult when you experience any troubles in collaboration?	**The boss**	
		Q48	Are you male or female?	**Male**	
		Q52	How many books do you read in a month?	**About 5 books**	
Rule(4) 10.27%	**1**	**Q18**	Regarding the method to learn skills of software products, how about your general product knowledge level of software products?	**Low**	**0.724**
		Q38	Are you satisfied of the promotion and award programs within the company?	**Yes**	
		Q42	Regarding the contracted rules and collaboration with a computer maker, do you understand the yearly measures and policies of the maker?	**No**	
Rule(10) 28.57%	**2**	**Q39**	Do you understand the contract with the company that you work in?	**No**	**0.880**
		Q4	Did you attend a scheduled training, lectures or seminars for business protocol and carrier-up after joining this company?	**None**	
		Q31	Can you contact with board members of your customer's company?	**No**	
		Q50	What is your job title?	**General level**	
Rule(11) 23.81%	**2**	**Q29**	Regarding the knowledge of the company system and organization, do you recognize and understand a whole system and organization of your customer's company? No	**No**	**0.910**
		Q33	Do you like to attend any training or seminar for acquiring the knowledge of financial statements if you have any chances?	**Yes**	
		Q9	Do you have "my database" about your customers?	**Out of my duty**	
		Q45	Did you find any solutions in these troubles of the collaboration with a maker?	**No**	

Rule(12) 19.05%	**2**	**Q45**	Did you find any solutions in these troubles of the collaboration with a maker?	**No**	**0.934**
		Q5.	How do you find business manners of other employees around you?	**Bad**	
		Q28	Do you follow and backup your proposal with specification and estimation after giving it to a customer? I propose rather estimation.	**I propose rather estimation.**	
		Q43	Do you understand dealing rules (price rate of products) with a maker and the sales promotion program?	**No**	
		Q53	Do you prefer to play a sport?	**Yes**	
Rule(13)	**2**	**Q30**	Do you understand the board members?	**No**	**0.976**
14.29%		**Q33**	Do you like to attend any training or seminar for acquiring the knowledge of financial statements if you have any chances?	**Yes**	
		Q43	Do you understand dealing rules (price rate of products) with a maker and the sales promotion program?	**No**	
		Q12	How about your general product knowledge level of I series?	**Low**	
		Q32	Regarding the knowledge of financial statements, did you learn how to read and analyze the financial statements?	**Yes**	
					Total 0.988

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