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A Fuzzy Model to Organizational Structure Design According to Mintzberg's Taxonomy of Organizational Forms

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Abstract: In this paper a fuzzy expert system for selecting a suitable organizational structure is introduced. This approach has four stages. In the first stage, a fuzzy system is presented that whose inputs are contextual dimensions. These dimensions are technology, strategy, environmental uncertainty and organization size. The system's outputs are type of organizational structures based on Mintzberg's Taxonomy of Organizational forms. In the second stage, inputs and output are fuzzified. To do so, the triangular function is applied. Rules (inference engine) are developed in third stage. The fourth stage is defuzzification stage. In the fifth stage the model is tested.

Key words: Fuzzy set theory % Organizational Structure % Organization theory

INTRODUCTION

Organizational structure is one of the most important issues in the management literature. Certain structures undoubtedly are more conductive to realizing particular corporate goals and strategies [1]. Although the thinkers of classic school in management tried to pinpoint an ideal structure for all organizations, because of the complexity of an organization's situation, it is difficult to identify a single ideal structure. Dynamic changes in organizational goals and resources as well as its environment may preclude a static ideal structure [1]. The need for organizational flexibility to accommodate a changing world is well understood [2]. The value of quickness in business is supported by evidence suggesting that a time-based strategy positively affects firm performance [3]. For such reasons, thinkers are trying to design the contingency theories and models. The contingency approach seeks no one right structure for all organizations. Instead, "right" structure depends on contingency factors. By matching an organization's contingency factors with those prescribed by management theorists the ideal structure for an organization could be found [1]. The major contingency or situational factors may include strategy, environmental uncertainty, organization size, technology. The contingency perspective states that structure will change to reflect changes in strategy, size, technology and environment [4].

We need a model to identify the suitable structure form. There are several approaches for modelling. Here a fuzzy expert system approach is selected. Expert system is a software that operates as an expert. It is a branch of Artificial Intelligent (AI). In AI, natural intelligent (knowledge, inference, etc) is simulated in software form. When there is high complexity applying expert system will be useful.

The classic work on the relationship between an organization strategy and its structure was done by Harvard historian Alfred Chandler and published in the early 1960s [4]. According to Chandler, organizational structure has to change based on product diversification strategy. Organizational structure has to be simple whit low diversification strategy and it will be divisional whit high diversification. In intermediate diversification functional structure is right. According to more researches such as Miles and Snow [5-7], it seems that most of organizations use the cost-minimization, innovation or imitation strategy [8]. When strategy is cost-minimization, the result is a structure made up of high horizontal differentiation, centralised control and an elaborate formal hierarchy for communications.

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Innovators are almost the opposite of cost-minimization. Organizations whit imitation strategy, takes the successful ideas of innovators and copy them. These organizations seek both flexibility and stability.

New organizational forms emerge in response to environmental conditions [5]. Empirical research in macro-organizational behaviour suggests that a firm's organizational structure should be dependent on the environmental characteristics which surround the firm [9]. Environmental uncertainty can be defined as the unpredictability stemming from the lack of clarity in information, the time span for feedback and the nature of causal relationships [10]. Specifically, uncertainty arises from the unpredictability of various groups (e.g. suppliers, competition, customers) that make up the external environment of a business unit [11]. The more certain environment; the more likely the firm's organizational structure will have a centralized hierarchy with formalized rules and procedures [12]. Conversely, an uncertain environment requires organizational flexibility and more autonomy for the product manager if he/she is to maximize the firm's potential to adapt [9]. Burns and Stalker [13] believed that the most effective structure is one that adjusts to the requirements of the environment, which means using a mechanistic design in a stable, certain environment and an organic form in a turbulent environment. Mechanistic structures were characterized by high complexity, formalization and centralization [9]. Characteristics of organic structures are opposed to mechanistic structure's ones.

Type of technology is another factor which can determine the form of organizational structure. The initial interest in technology as a determinant of structure can be traced to the mid-1960s and the work of Joan Woodward [14,15]. Her research, which focused on production technology, was the first major attempt to view organization structure from a technological perspective [5]. Woodward categorized the firms into one of three types of technology: unit, mass, or process production. She treated these categories as a scale with increasing degrees of technological complexity, with unit being the least complex and stage the most complex. Several studies have supported Woodward's findings. The mass-production technology firms were highly differentiated relied on extensive formalization and did relatively little to delegate authority. Both the unit and stage technologies, in contrast, were structured more loosely. Perrow [16] looked at knowledge technology rather than at production technology. Perrow introduced four types of technology based on two underlying dimensions of knowledge technology.These dimensions were task variability and problem analyzability. The technologies consist of routine technologies, engineering technologies, craft technologies and nonroutine technologies. Perrow also proposed that task variability and problem analyzability were positively correlated so four technologies can be combined into a single routin-nonroutine dimension. According to Perrow's studies, it seems that the degree of three structural dimensions in routine technology is more than that of nonroutine technologies.

Over 80 percent of studies using organization size as a variable define it as the total number of employee [17]. Organizations with fewer than fifteen hundred employees tend to be labelled as "small". We define a large organization as one having approximately two thousand or more employees. Aston Group looked at forty-six organizations and found that increased size was associated with greater specialization and formalization. Blau and Child found that as size increases specialization, formalization and vertical span also increase but at a declining rate, whereas centralization decreases but at a declining rate [4].

Since the late 1970s, there has been a growing search to identify some common organizational types or configurations [4]. While there is no universally agreed-upon framework for classifying organizations, Henry Mintzberg's recent work probably gets closet to it [4]. Mintzberg has developed organizational forms and explained the relationships between contextual dimensions and organizational forms. According to Henry Mintzberg, an organization's structure is largely determined by contextual dimensions. In the Structure in fives Mintzberg identifies five types of 'ideal' organizational structure. These are entrepreneurial Startup (the simple structure), divisionalzed structure, Machinery bureaucracy, Professional bureaucracy and adhocracy. To help explain each of the five organizational forms, Mintzberg defines five basic organizational subunits. These subunits and their specifications are:

- Strategic Apex: Board of Directors, Chief Executive Officer
- Techno structure: Strategic Planning, Personnel Training, Operations Research, Systems Analysis and Design
- Support Staff: Legal Counsel, Public Relations, Payroll, Mailroom Clerks, Cafeteria Workers
- Middle Line: VP Operations, VP Marketing, Plant Managers Sales Managers
- Operating Core: Purchasing Agents, Machine Operators, Assemblers, Sales Persons, Shippers [18]

Each of the five organizational forms in Mintzberg's scheme depends on fundamentally different mechanisms for coordination and, in each particular form; different subunits tend to have greater influence. If middle management is in control, you'll find groups of essentially autonomous units operating in a divisional structure. Technocrats standardize procedures and outputs in machine bureaucracy. In professional organization, professionals in the operating core (e.g. doctors, professors) rely on roles and skills learned from years of schooling and indoctrination to coordinate their work. Managers in the strategic apex directly supervise the work of subordinates in entrepreneurial startup. Teams of professionals from the operating core, support staff and technostructure rely on informal "mutual adjustment" to coordinate their efforts in adhocracy.

The simple structure is recommended for small organizations, for those in their formative stage of development, for organizations in environments that are simple and dynamic, as a response to time of crisis, or when those in control desire power to be centralized. The machine bureaucracy is designed to effectively handle large size, a simple and stable environment and a technology that is composed of routine and standardize work. Its professional counterpart is also designed for large organizations with a routine technology. However, the professional bureaucracy's members are technical specialists confronting a complex environment. To effectively operate with these professionals and a complex environment, a decentralized bureaucratic design is necessary. The divisional structure looks a lot like the machine bureaucracy. However, it has been designed to respond to a strategy that emphasizes market or product diversity, where the organization is large, technologies are divisible and the environment tends to be simple and stable. The adhocracy requires top management to give up the most control. In power control terms, therefore, it is the least desirable of the five configurations. When will management select the adhocracy? With diverse, changing, or high-risk strategies or when the technology is nonroutine and the environment is both dynamic and complex. It is also effective in dealing with problems that are typically encountered when an organization is in the formative years of its life cycle. However, since the simple structure is also well designed to deal with the problems in an organization's formative period-while maintaining centralized control-the simple structure is likely to be more widely adopted in an organization's early years.

Though many theories of organizational structure design have been introduced, there is no model that utilizes the findings of these theories in whole framework especially in mathematical form to design the organizational structure. These theories explain the relationship between contingency factors and organizational forms in conceptual forms. In this paper, a model has been introduced to achieve the right structural form according to the contextual dimensions as situational factors using fuzzy mathematics.

MATERIALS AND METHODS

In this paper a model to determine suitable organizational structure form based on fuzzy logic is introduced. This model has five stages.

Developing a System: In this stage, a fuzzy system is developed that its inputs are contextual dimensions and its outputs are Mintzberg's organizational structure forms. Fig 1 illustrates this system.

Second Stage

Fuzzification: In this step we try to fuzzify inputs and outputs. To do so, triangular function was applied.

Fuzzification of Inputs: Here triangular fuzzy number was used to fuzzify the inputs. Table 1 demonstrate linguistic variables of inputs and its fuzzy numbers.

Fuzificaiton of Outputs: A five-point rating scale was used to fuzzify the system's outputs. Table 2 illustrate these fuzzy numbers

Third Stage: Developing the inference rules (inference engine) Fig2. Strategy and size of organization have variable values

In this stage, 54 rules were developed according to review of literature. We have 54 rules because three of inputs have three-point rating scales and one of them has two-point rating scale. So in ideal type we must have (2*3*3*3=54) rules.

Here, developing the expert system was finished. If we feed the value of inputs to expert system (inference engine); it will be produce a value for any outputs. In other words, these values show consistency degree of every one of organizational structure form for an organisation.

Fourth Stage: Defuzification: When we feed values of inputs to our system (inference engine) the expert system determines the value of outputs based on inference engine. Value of outputs is in fuzzy form. To simplify the analysis of output we have to convert fuzzy form of

Table1: Linguistic variables of inputs and its fuzzy numbers

Environmental uncertainty		Strategy		Technology		size of organization	
Verbal variable	Fuzzy number	Verbal variable	Fuzzy number	Verbal variable	Fuzzy number	Verbal variable	Fuzzy number
low	(0 0 0.5)	Cost-minimization	(0 0 0.5)	simple	(0 0 0.5)	small	(0 0 2000)
medium	(0 0.5 1)	imitation	(0 0.5 1)	Around simple	(0 0.5 1)	large	(0 2000 2000)
High	(0.5 1 1)	innovation	(0.5 1 1)	complexity	(0.5 1 1)		

Table2: Linguistic variables of outputs and their fuzzy numbers

Linguistic variable	Trimf (*" m$*)
Completely inappropriate	(0 0 0.25)
inappropriate	(0 0.25 0.5)
Relatively appropriate	(0.25 0.5 0.75)
Appropriate	(0.5 0.75 1)
Completely appropriate	(0.75 1 1)

Table 3: Magnitude of inputs and outputs

Inputs		Outputs	
Degree of contextual dimensions		Degree of structure consistency	
Strategy	0.15	Simple	0.65
Environmental uncertainty	0.2	Machinery	0.531
technology	0.2	Professional	0.344
Organizational size	170	Adhocracy	0.285
		Departmental	0.305

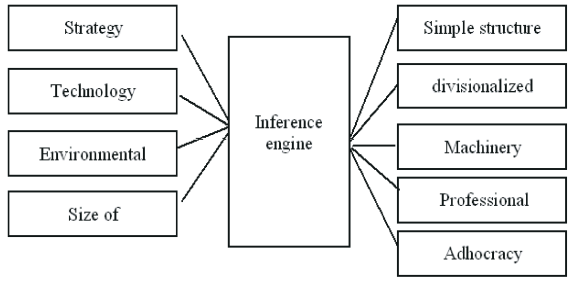

Fig. 1: Fuzzy system

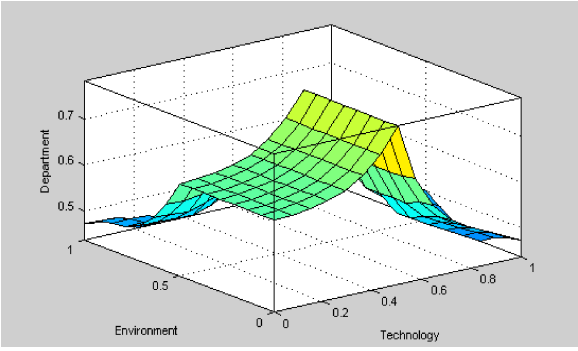

Fig. 2: Strategy and size of organization have variable values

outputs to crisp form. In other words, we have to defuzzify the value of outputs. There are many methods for defuzzification. One of appropriate methods is centeriod method.

Fifth Stage

Testing the Model: In this step, efficiency of expert system was tested by analyzing of outputs' behaviour. To do so, we considered fixed value (0.5) for two inputs and tried to vary the value of other two inputs. Then the value of outputs was calculated based on pair wises of variable inputs. Consequently a behaviour was formed for every output. For example in Fig.2; technology and environmental uncertainty have fixed value (0.5) but strategy and size of organization have variable values. These values fed to expert system so behaviour of any organizational structure forms (Departmental form in this Fig) was obtained.

These behaviours were approved in comparison with research literature. Besides, five experts approved these behaviours too.

Case Study: The organizational model of a private automobile parts factory is considered as the case study. In this section, we describe the model according to this company's data. First the environmental uncertainty, strategy and technology (inputs) were measured by questionnaires. The size of organization was determined by number of employee.

It is obvious that we must test questionnaire's validity and reliability before using them. Questionnaires were revised based on five experts viewpoint. These experts were specialized in designing the organizational structure (validity). Reliability of Questionnaires was measured by Cronbach's alpha.

After approving the validity and reliability of questionnaires, Viewpoints of ten experts were gathered about contextual dimensions. These experts were from company so they had qualification to answer the questions. They were from finance, procurement and production departments..We applied fuzzy average method to summarize these viewpoints. MAX method was used to defuzzify the fuzzy average number. After feeding the inputs' values to expert system, Outputs were obtained by expert system. Table 3 illustrates the value of contextual dimensions and degree of structure consistency.

RESULTS AND DISCUSSION

Appropriate organizational structure is one of the most important factors in achievements of any organization. Though many theories of organizational structure design have introduced, there is no model that utilizes the findings of these theories in whole framework especially in mathematical form to design the organizational structure. In this paper, a model has been introduced to achieve the structural form according to the contextual dimensions as situational factors using fuzzy mathematics. In this paper we consider strategy, environmental uncertainty, technology and size of organization as inputs variable Mintzberg's structural forms as outputs. It is obvious other researchers can consider other forms of structure as outputs and can use other methods to model such as neural network.

The existent limitations in the related theories exist in the introduced models too, so the model is not a conclusive model and to be modified with arising new theories of organizational structural design.

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