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A Model for Evaluating Knowledge Sharing Using Fuzzy Inference System (Case Study: Tehran Municipality ICT Organization)

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ABSTRACT: The present paper aimed at developing an approach based on Fuzzy Inference System (FIS) for measuring of knowledge sharing in the organization. In recent years there has been increasing interest in the knowledge sharing by experts and managers in the world, according to increasing importance of knowledge as the key source of competitive advantage, organizations have made serious effort to find effective ways to share knowledge among their employees. It is important to invest in knowledge sharing activities and make innovation and enhance organizational performance. To achieve this elite opportunity, organizations need solutions that are able to evaluate the knowledge sharing. The purpose of the research was to provide a solution for evaluating knowledge sharing. Mined in this research using knowledge sharing model of scientific texts and the appropriate model is designed on the basis of summing up the results of the fuzzy inference system. And finally, knowledge sharing will be evaluated in the case study.

Keywords: *Knowledge sharing, Fuzzy inference system, Knowledge management, Information and communication technology, Human capital, Organizational capital*

INTRODUCTION

Knowledge management efforts typically focus on organizational objectives such as improved performance, competitive advantage, innovation, the sharing of lessons learned, integration and continuous improvement of the organization. Knowledge management efforts overlap with organizational learning, and may be distinguished from that by a greater focus on the management of knowledge as a strategic asset and a focus on encouraging the sharing of knowledge (Sanchez and Heene, 1997). Knowledge sharing remains a challenging issue for knowledge management, and while there is no clear agreement barriers may include time issues for knowledge works, the level of trust, lack of effective support technologies and culture (Jennex, 2007).

Other definitions of knowledge sharing include the exchange of ideas, insights, solutions, experiences to another individuals via knowledge transfer computer systems or other non-IS methods (Turban et al., 2006). Organizations

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have recognized that knowledge constitutes a valuable intangible asset for creating and sustaining competitive advantages (Miller and Shamsie, 1996). Knowledge sharing activities generally supported, by knowledge management systems. However, technology constitutes only one of the many factors that affect the sharing of knowledge in organizations, such as organizational culture, trust, and incentives (Cabrera and Cabrera, 2002). The sharing of knowledge constitutes a major challenge in the field of knowledge management because some employees tend to resist sharing their knowledge with the rest of the organization (Ciborra and Patriota, 1998; Bock and Kim, 2002).

One prominent obstacle is the notion that knowledge is property and ownership thus very important. In order to counteract this, individuals must be reassured that they will receive some type of incentive for what they create (Dalkir, 2005). However, Dalkir (2005) identified the risk in knowledge sharing is that individuals are most commonly rewarded for what they know, not what they share, If knowledge is not shared, negative consequences such as isolation and resistance to ideas occur. Shared knowledge offers different viewpoints and possible solutions to problems. To promote knowledge sharing and remove knowledge sharing obstacles, the organizational culture should encourage discovery and innovation (Dalkir, 2005). This will result in the creation of organizational culture.

Literature Review

Different models have been proposed over the years in the field of knowledge sharing. By searching in books and scientific journals, were extracted from the knowledge sharing model that continues to be mentioned. Many researchers provide conceptual overviews, different references and mature models of knowledge sharing. For instance, Hislope D. (2003) has presented a model about linkage between development of the knowledge management, and human resource management, he has explained how to motivation of worker to share their knowledge may be shaped by their level of organizational commitment. Another paper have been published by Endres et al. (2007), they have proposed a self-efficacy model to compare knowledge sharing activities in the open source community versus those in a traditional organization, they have concluded that the self-efficacy model serves as a useful framework for better understanding the effects of context on tacit knowledge sharing, and that the open source community may provide an ideal set of subjects to whom the model can be applied. One year later Ma et al. (2008) have written an article entitled explore knowledge sharing in a Chinese context and to examine the impact of some key contextual factors which affect knowledge sharing within project teams in the Chinese construction sector, they have believed that within the Chinese context, explicit knowledge promotes knowledge sharing while tacit knowledge creates barriers to knowledge sharing in project teams and trust is positively related to knowledge sharing but justice, leadership style, and empowerment do not influence whether employees will share knowledge among themselves in project teams. Azad and Rashidi (2009) have tried to study the relationship between the supervisors and organizational support with endeavor variable.

Lin W. B. (2008) has focused on the structure of organization theories and the interaction among units of an organization, that study finds that lower formalization of an organizational structure is, the greater knowledge sharing among units of an organization will be, and trust and commitment among units are important for facilitating knowledge sharing among units, and creative and supporting characteristics of organizational culture are beneficial for the implementation of knowledge sharing activities.

Sohrabi et al. (2010) have noted that, for acquiring knowledge sharing advantage requires solutions and approaches that make the organizations capable of measuring their knowledge sharing capabilities, the initial goal of this article is to present an applied model for measuring the knowledge sharing capability through the identification of the most measurement indicators in this area, in the next step, there has been an attempt to statistically validate and localize the indicators and keep those indicators, which are sufficiently able to measure the knowledge sharing capability by the approval of the experts in the field. As well as, Mehregan et al. (2011) have written a paper about designing a conceptual model for knowledge sharing in plans on the basis of their attributes, they have provided knowledge sharing model of state comprehensive tax plan on the basis of attributes of this plan in qualitative section of that research, then they have investigated the level of generalizability of designed model in qualitative part of research in the form of formulated hypotheses, finally, they have identified some relations at the level of state plans and the power of predictive variables for prescription and prediction of criterion variables. Also Pilevari N. (2011) has written an article about crucial role of knowledge sharing in small and medium enterprises (SMEs) in Iran, she has stated about ambiguity of knowledge sharing assessment, and constructed a fuzzy inference system, considering social, organizational and technological conditions.

Table 1 compares the proposed models. At the beginning models focused on human factors, then organizational factors were added and from 2010 onwards ICT factors were also included in some models. This research has more inclusion in terms of the conceptual model, this is due to considering all aspects of the knowledge sharing, and most of the models that had been presented previously focused on specific aspects of factors. As the variables are qualitative in this study, fuzzy inference is a tool used, that is almost new in the field of measuring components and indicators.

Table 1: Comparison of some knowledge sharing model

No.	Authors	Description	Method	Focusing
1	Hislop (2003)	Linking human resource management and knowledge management via commitment: A review and research agenda	Conceptual model	Human
2	Endres *et al.* (2007)	Tacit knowledge sharing, self-efficacy theory, and application to the open source community	Review	Human
3	Ma *et al.* (2008)	Knowledge sharing in Chinese construction project teams and it's affecting factors: An empirical study	Regression analysis	Human
4	Azad and Rashidi (2009)	Knowledge sharing engineering with the help of knowledge management system	Questionnaire	Human
5	Lin (2008)	The effect of knowledge sharing model	Neural network-based nonlinear	Human, Organization
6	Sohrabi *et al.* (2010)	An applied model for measuring the knowledge sharing capability	Descriptive survey	Human, Organization, ICT
7	Mehregan *et al.* (2011)	Providing a model for knowledge sharing in plans on the basis of their attributes	Multiple regression	Human, Organization, ICT
8	Pilevari (2011)	Assessing knowledge sharing in Iranian SMEs using fuzzy logic inference	Fuzzy logic inference	Human, Organization, ICT

RESEARCH METHOD

Conceptual Model Construction

The model is developed based on books, articles, and recent research. This paper used experts' views to refine and finalize the parameters affecting knowledge sharing. The process of access to a conceptual model is presented in figure 1. Table 2 shows attributes of the conceptual model and references. Table 3 shows the sub-attribute of the knowledge sharing conceptual model, references and related codes.

Definitions of Attributes

A. Human capital: the stock of competencies, knowledge, social and personality attributes, including creativity, embodied in the ability to perform labor so as to produce economic value. Many theories explicitly connect investment in human capital development to education, and the role of human capital in economic development, productivity growth, and innovation has frequently been cited as a justification for government subsidies for education and job skills training (Simkovic, 2012).

Training and Learning: the success of any organization is founded on the knowledge of the people who work for it, both of individual and organizational learning and training may promote sharing past successful knowledge sharing experiences or uncovering related skills that can enhance knowledge sharing, such as emotional intelligence, empathy, and active listening skills (Endres, 2007).

Motivation: the psychological feature that arouses an organism to action toward a desired goal and elicits, controls, and sustains certain goal directed behaviors, in knowledge sharing context, consists of all the actions that help spreading knowledge in organizations. We can design incentives in order to have the staff share their knowledge. In short, the more motivated the employees are, the more sharing of knowledge (Pilevari, 2011).

Interest in Participation:
The willingness of employees to participate in knowledge sharing programs. Participation of all employees in an organization from top management to every employee has a direct impact on knowledge sharing. Increase interest of employees to participate in knowledge sharing programs, leads to higher levels of knowledge sharing in organizations.

B. Organizational capital: the ability of an organization to mobilize and sustain the process of change required to execute strategy (Kaplan and Norton, 2004) organizational capital can be thought of as any procedures according to which cooperating individuals perform tasks, it can include work techniques, accounting practices, and management procedures.

Relation between Strategy and Knowledge:
In order to reveal the link between strategy and knowledge, organization should define its strategic objectives, needed to identify knowledge strategies and comparisons with existing knowledge and thus reveal their strategic knowledge gaps.

Formalization and Centralization:
Formalization means the limitation that internal regulations, rules, procedures, and other formal norms of an organization impose on working and activities. And centralization means the distribution of decision making power within an organization (Robbins, 2009).

Partnership-oriented Organizational Culture:
Is based on trust. It is a key element to ensure the flow of vital information and knowledge in organizations. Knowledge sharing requires to languages, standards, norms or common agreements.

C. Information and Communications Technology (ICT):
The integration of telecommunications, computers as well as necessary enterprise software, middleware, storage, and audio visual systems, which enable users to access, store, transmit, and manipulate information. Knowledge management is more than a technology or product, it is a methodology applied to business practices. However, information technology is crucial to the success of knowledge management systems (Turban et al., 2006).

Communication Technologies:
Allow users to access needed knowledge and to communicate with each other (Turban et al., 2006).

Collaboration Technologies
Provide the means to perform group work (Turban et al., 2006).

Storage and Retrieval Technologies
Database management systems to store and manage knowledge (Turban et al., 2006).

Figure 2 shows completed conceptual model of knowledge sharing. In order to examine the conceptual model, a questionnaire was designed and completed by experts. In this section the research objective was to assess the validity of the model that is why statistical dispersion and location parameter such as mean were used. Due to the acceptance of all indicators by average more than 60 percent of experts' opinion, the designed conceptual model was validated for evaluating knowledge sharing.

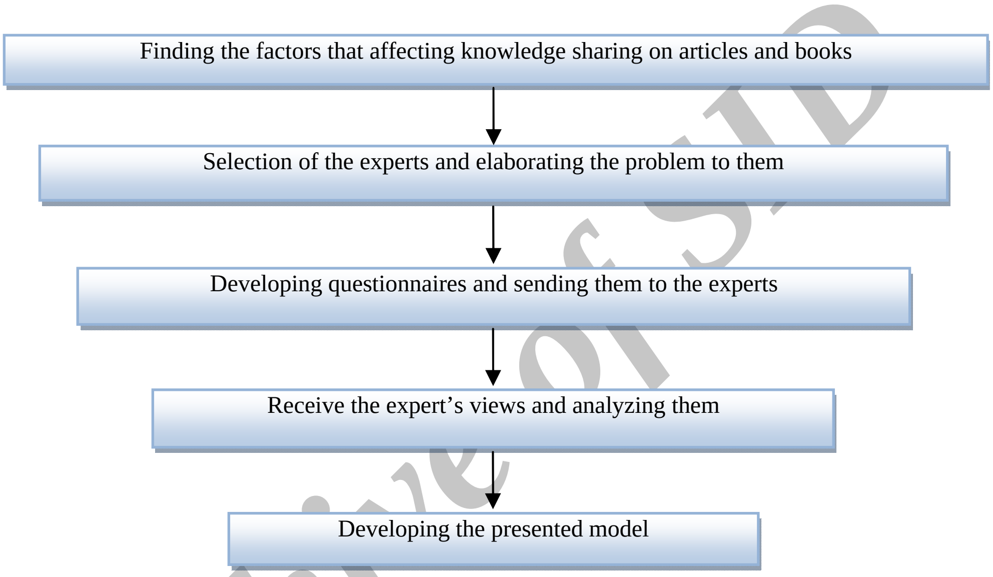
Finding the factors that affecting knowledge sharing on articles and books
Selection of the experts and elaborating the problem to them
Developing questionnaires and sending them to the experts
Receive the expert's views and analyzing them
Developing the presented model

Figure 1: Stages of producing a conceptual model

Table 2: Attributes of the conceptual model

Attribute	Reference List
Human capital	Hislop 2003, Lin 2008, Sohrabi et al. 2010, Glichlee 2009
Organizational capital	Hislop 2003, Azad and Rashidi 2009, Lin 2008, Sohrabi et al. 2010, Pilevari 2011, Skyrme and Amidon 1997
Information and communications technology	Sohrabi et al. 2010, Mehregan et al. 2011, Pilevari 2011, Glichlee 2009, Frappaolo 2006, Turban 2006, Hasanali 2002

Table 3: Sub-attributes of the conceptual model

Code	Sub-attribute	Reference
TL	Training and learning	Endres et al. 2007, Ma et al. 2008, Trussler 1999, Davenport and Probst 2002
MV	Motivation	Hislop 2003, Pilevari 2011, Endres et al. 2007, Sage and Rouse 1999, Trussler 1999
PS	Interest in participation	Hislop 2003, Pilevari 2011
ST	Relation between strategy and knowledge	Mehregan et al. 2011, Glichlee 2009
SC	Formalization and centralization	Lin 2008, Sohrabi et al. 2010, Mehregan et al. 2011, Pilevari 2011, Hasanali 2002
CL	Partnership-oriented organizational culture	Lin 2008, Pilevari 2011, Glichlee 2009, Frappaolo 2006, Skyrme and Amidon 1997, Hasanali 2002
CM	Communication technologies	Pilevari 2011, Turban et al. 2006
CB	Collaboration technologies	Turban et al. 2006
SR	Storage and retrieval technologies	Turban et al. 2006

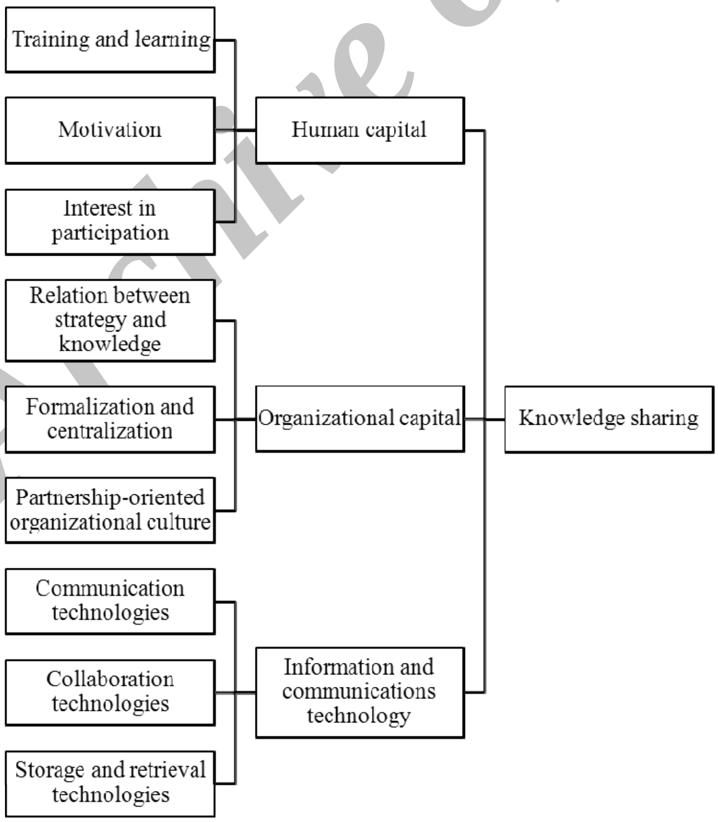
Training and learning
Motivation
Interest in participation
Human capital
Relation between strategy and knowledge
Formalization and centralization
Partnership-oriented organizational culture
Organizational capital
Knowledge sharing
Communication technologies
Collaboration technologies
Storage and retrieval technologies
Information and communications technology

Figure 2: Knowledge sharing conceptual model

Fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic. In this paper, we use fuzzy inference system (FIS) to evaluate knowledge sharing in the organization. By mapping and then provide a basis from which decisions can be made, or patterns discerned. The process of fuzzy inference involves all of the pieces: Membership Functions, Logical Operations, and If-Then Rules. In this paper Mamdani approach has been used for aggregating rules, we have member function in Mamdani approach. A “membership function” is a curve that defines how the value of fuzzy variable is mapped in a degree of membership between 0-1.In this paper to evaluate knowledge sharing, three steps have been done. In steps one, membership functions are used to calculate the degree of fuzzy in knowledge sharing in different values, are expressed by linguistic term such as very low, low, medium, high and very high (figure 3). In this study, a set of Gaussian functions were applied. The reason is that these functions are differentiable functions that are required for each fuzzy inference system. Moreover, these functions can cover most of the values.

IF-THEN expression is the most common way for representing human knowledge. This form generally is referred to as deductive form. It means that if we accept on a fact (premise, hypothesis, antecedent), then we can infer another fact called conclusion (consequent). The fuzzy inference system is a popular way for wide range of science and engineering. In step two, for making rules the verbal options of experts regarding the effects of different factors such as human capital, organizational capital and information and communication technology are gathered and processed for generating a rule base and using them as inputs of our fuzzy inference system. For example following rule has been used: If human capital is A, and organization capital is B and ICT is C then knowledge sharing in the organization will be D. For evaluating knowledge sharing three attribute have been used as proposed inference system inputs, but in most steps there are several rules for evaluating so in the last step we need an algorithm to aggregate the result of the rules to derive a final evaluation. The process of deriving overall conclusion from the individual consequents contributed to each rule in the rule base is known as aggregation of the rules. The proposed methodology has applied to company to evaluate knowledge sharing. In order to carry out the assessment procedure, a committee of experts has been formed. The decision team is asked to determine. The shape of the “membership function” based on subjective judgment about the magnitude of sharing attributes in influence diagram that is shown in figure 2. We have used fuzzy tech software to derive final aggregated result by Mamdani (max min) inference method, and also to find a crisp value for the aggregated output, center of gravity. Mamdani method is the most prevalent and physically appealing defuzzification methods. That is given by algebraic expression:

$$\overline{y} = \frac{\sum_{j=1}^{m} y_j \prod_{i=1}^{n} \mu_{A_i}\left(x_i\right)}{\sum_{j=1}^{m} \prod_{i=1}^{n} \mu_{A_i}\left(x_i\right)}$$

The proposed fuzzy model consists of four main rule blocks and nine inputs (TL, MV, PS, ST, SC, CL, CM, CB and SR), three intermediates (human capital, organizational capital and information and communications technology) and the output of the main fuzzy inference system is the knowledge sharing in the case study (Tehran municipality ICT organization) evaluated and the results have been shown in table 5. Continued model validation was performed by testing in extreme conditions. In this test FIS input variables change in different conditions (very high and very low) and investigate the model sensitivity to changes. An example can be seen in table 4, there is sensitivity analysis of human capital FIS, according to the changes in input variables from very low (0) to very high (1) the model shows a completely rational behavior.

Table 4: Validation using extreme condition test

FIS OUTPUT	FIS INPUT		
Human capital	Interest in participation	Motivation	Training and learning
0.048	0	0	0
0.501	0.5	0.5	0.5
0. 907	1	1	1

Table 5: Fuzzy model's inputs and output values

Knowledge sharing	SR	CB	CM	CL	SC	ST	PS	MV	TL
0.513	0.613	0.563	0.578	0.373	0.51	0.407	0.513	0.378	0.523

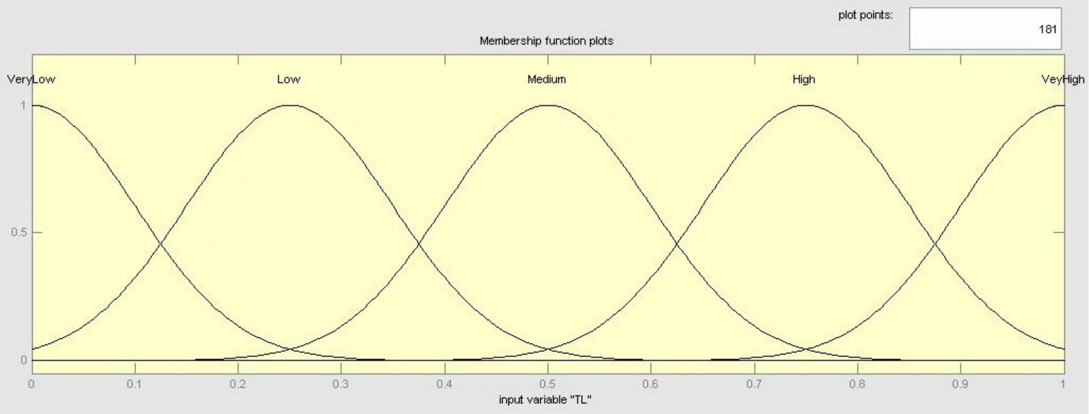

Figure 3: Fuzzy scale for evaluating

CONCLUSION

By following steps that are mentioned in proposed methodology and also by using fuzzy model for evaluating knowledge sharing, knowledge sharing in Tehran municipality ICT organization is evaluated and the results have been shown in table 5. By matching selected membership function for knowledge sharing variable with crisp output (5.13) the knowledge sharing of the organization can be labeled "medium". And also to analyze the system's performance, we can use surface to represent the mapping from inputs to knowledge sharing. Figure 4 shows the output surface (knowledge sharing) with different inputs. Surface is used to display the dependency of output on any inputs.

Then by the sensitivity analysis the effects of input variables and output variables of the model was studied (table 6). According to sensitivity analysis results, to increase knowledge sharing in Tehran municipality ICT organization, more investing must be done on motivation, and managers should pay more attention to the organizational culture and institutionalize partnership-oriented organizational culture in the organization.

This evaluation identifies organizational strengths and weaknesses in knowledge sharing and helps managers to perform gap analysis between existent level and the desired one. This methodology provides more informative and reliable analytical results and also facilitates rapid decision making for managers. The model provides the means for managers to devise an improvement plan, they can identify the right strategy and apply the best methods to increase knowledge sharing and eliminate barriers which reduce sharing of knowledge within the organization. Finally it should be noted that knowledge sharing is an ongoing effort which must be always concerned by the organization.

Table 6: Sensitivity analysis of knowledge sharing model

	SR +0.2	CB +0.2	CM +0.2	CL +0.2	SC +0.2	ST +0.2	PS +0.2	MV +0.2	TL +0.2
Knowledge sharing	0.515	0.516	0.516	0.521	0.514	0.518	0.519	0.524	0.515

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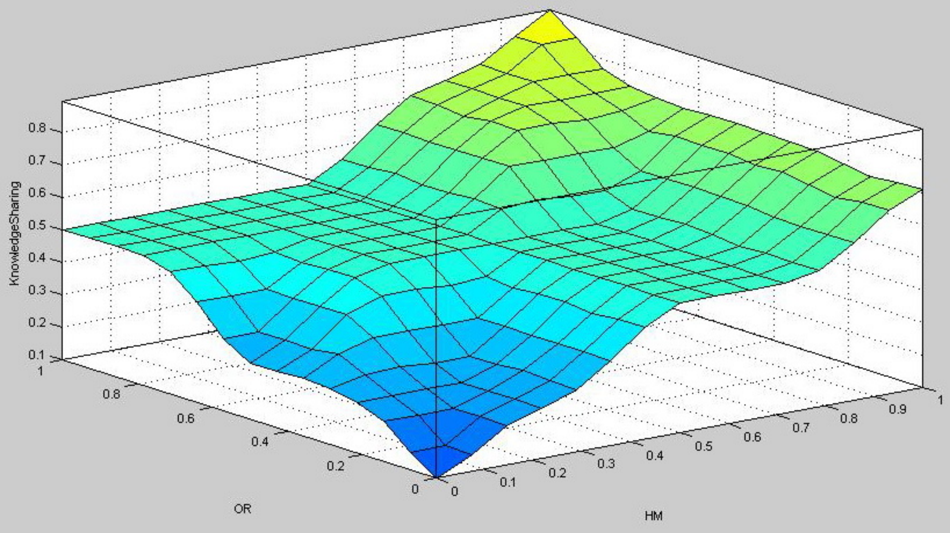

Figure 4: Output surface with human capital and organizational capital as inputs

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