Using the Advantage of Being in Between, with the Example of Fuzzy Set Theory: Opportunities for Bosnia

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Abstract: This article analyses how culture, tradition and perception of the science affect the creation and application of techniques used in industry and management. Although it is thought that there are some global rules in business, cultural perspectives have an enormous effect on the application of the theories. This difference can be seen in the early fuzzy set theory applications. Fuzzy set theory has been accepted and applied by the eastern firms earlier than western firms. Despite its usefulness, western corporations met the fuzzy theory very suspiciously at the beginning, and they started utilizing it after its success has been proven. The biggest obstacle for the west for being late in using fuzzy set is their loyalty to the crispness and their crisp way of thinking. Bosnia, as a country which has both west's crispness and east's mystical insight, can use the advantage of this feature. Bosnia can convert this characteristic of being a country between east and west and being familiar with the two different mind-sets into a competitive advantage. Instead of following only one trend, Bosnia can harmonize the characteristics of two sides and enjoy the early application of some promising theories.

Keywords: Fuzzy Set Theory, Cultural difference, perceptions of science, Bosnia

1- Introduction

It has always been a research question how and to what extent culture affects human beings. Does it only affect how to behave in the environment we exist or does it also affect how we think? There are thousands of studies about this issue but there isn't any compromise between the researchers. First of all, there is a debate on the definition and content of the culture. However, one acceptable definition can be made as "a distinctly human means of adapting to circumstances and transmitting this coping skill and knowledge to subsequent generations. Culture gives people a sense of who they are, of belonging, of how they should behave, and of what they should be doing." (Harris et al., 2004). Researchers believe that culture shapes the way we behave, our productivity at work, our values; shortly all human being's behavior. Trompenaars (2003) defines culture as "the contextual environment, defining much of the essence of the relationships between an organization and the environment in which it operates.

In the world, there are more than 200 nations, and Hofstede (1993) offers to focus on cultural factors in separating or uniting nations. In order to understand and differentiate cultures better, many different models have been developed. Some researchers have offered ten different categories to identify the culture (Harris et al., 2004). Some others claim that firms will be able to limit imitation and create competitive advantage if they concentrate on retaining the relationship between their corporate culture and their national/regional culture (Moran et al., 2007). We should also understand national culture to explain differences in international operational decision making (Pagel et al., 2005), because managers make their decisions and manage their resources under the shadow of their culture.

In an interesting cross-cultural research, Kirkman et al. (2006) review empirical studies that have used the cultural values framework of Hofstede for the years between 1980 and 2002. They identify 180 studies in which culture has the main effect or moderator. 148 of these studies out of 180 cases, examine culture as a main effect, 32 of them as a moderator. Hofstede (1991) claims that national culture explains 50% of the differences in managers´ values, beliefs and attitudes.

Culture shows its effect on many different areas of business and industry. For example, due to the cultural differences various types of Computerized Numerical Control (CNC) use have been seen in Japan and UK. Britain preferred to utilize CNC tools by operators with previous experience, but Japanese tried to use their CNC tools with no previous experience of machine tool operation. Moreover, British firms appointed one worker per machine, while Japanese were attempting to achieve multi machine operation (Kambayashi, 2004). This example explains individualism in the UK and collectivism in Japan with the cultural values framework of Hofstede.

According to the Hofstede (1980)´s research, German and Anglo-Saxon worlds specifically and western world in general are less uncertainty avoidant than eastern countries. Moreover, western countries have been less open to new experiences, sceptical about new theories such as Total Quality Management (TQM) and Fuzzy Logic. They applied these theories only after the success of these theories have been proven. The more interesting thing is, Deming´s ideas about total quality management hadn't been accepted by Americans, but welcomed by Japanese businessmen first. Bensaou and Earl (1998) compare the Japanese and Western "mind-sets" and approaches to the management of IT. Westerners use IT to have the smartest and cheapest result and to improve performance, while Japanese use IT to reach their goals after identifying performance goals.

As mentioned so far culture is an important factor for the development and application of new theories. However, in some cases it can be misleading to consider the entire region as the basis for analyzing the culture. For example, the culture of UK is closer to the culture of USA even though UK is geographically closer to the European countries. The same is true for Mexico and USA as well. Although they are neighbors, they have different management cultures. In this case, besides cultures of the nations and similar culture of the regions, the perception of science of the cultures is another important factor in the development and application of new theories.

Although TQM and Fuzzy Logic have enormous applications and benefits, western world was late to accept and to utilize these theories. As mentioned above, culture might be one reason but cannot explain the whole story alone. At this point looking at the science perception of the cultures might be helpful.

The structure of the paper is as follows. Section 2 discusses fuzzy logic, the possible reasons why it has been accepted by the eastern world earlier than the western world, applications of fuzzy logic in commercial and industrial products and historical development of it. Section 3 analyzes the differences between eastern and western logic and connects these differences with the developments of fuzzy logic. Section 4 concludes.

2- Fuzzy Logic

2.1. Why fuzzy logic has been exploited in the east before the west?

McNeil and Thro (1994) suggest two possible reasons for western nations for being late on accepting fuzzy logic. One reason is traditional cultures of west which rely on Aristotelian either-or-approach. Western people avoid uncertainty and risk. In the West, individual competitiveness is the main force of technological progress, whereas in the eastern cultures strength and success is achieved through consensus and group work which was also explained by the Hofstede's (1980) analysis. As easily seen, eastern characteristics are more compatible with the fuzzy logic than mathematically oriented western attitudes. Another reason they suggest is Japan may be more open to new ideas than management- and bottom-line oriented western firms.
Lotfi Zadeh, the founder of fuzzy logic, says that one important reason for Japan for being so advanced in fuzzy logic is that they are really consumer oriented. Japanese can immediately adapt new ideas and technologies which have a potential to serve the consumers (Blair, 1994).

"When the only tool you have is a hammer, everything begins to look like a nail"(Zadeh)

According to Zadeh, in Aristotle's day people tried to be as precise as possible. This Aristotelian or Cartesian tradition makes people to look at everything as being totally white or black. As Zadeh states, sometimes people may perceive things as being bad at the beginning, but then they turn out to be good or not so bad as people thought originally. One failure of classical logic is paying so little attention to approximate reasoning and perceiving things only in absolute terms. This allows solving many problems in real life but prevents us from solving many other everyday problems which are not crisp, subjective or have many possible solutions. He says that: "When the only tool you have is a hammer, everything begins to look like a nail. Classical logic simply doesn't provide the means to solve the problems. They concerned themselves with models of precise knowledge. But such models are so far removed from the real world that they don't do you any good" (Blair, 1994).

2.2. The Differences between Crisp Sets and Fuzzy Sets

The difference between conventional dual logic and fuzzy set theory is that in conventional dual logic a statement can be either true or false; in set theory, an element can either belong to a set or not. However, real world situations are very often uncertain. Lack of information may cause the future state of the system to be unknown or unpredictable. This type of uncertainty has been handled by statistics and probability theory sofar. Fuzziness is possible to be found in many areas of life such as meteorology, medicine, engineering, manufacturing etc. where it is possible to define one situation in different ways or it is possible for an element to belong to different sets. In daily life, the meaning of words is often imprecise. Fuzzy set theory provides a

mathematical framework to study vague phenomena precisely. It is defined as a modeling language for fuzzy relations, criteria and situations (Zimmerman, 2001).

In fuzzy set theory, normal sets are called crisp sets to be differentiated from fuzzy sets (Driankov et al., 1996). Let C be a crisp set and F a fuzzy set defined on the universe U. For any element u of U, either $u \in C$ or $u \notin C$. However, in fuzzy set theory it is not necessary that either $u \in F$ or $u \notin F$. In fuzzy set theory, a membership function μ_F is assigned to every $u \in U$ from the unit interval [0, 1], instead from the two element set {0, 1} as in crisp sets. If an element belongs to a fuzzy set with certainty, it has a membership value of 1. If this element does not belong to a fuzzy set, its membership value will be 0. On the other hand, an element can take the membership values of 0.9, 0,8, 0,7 or 0,2, 0,1 according to the degree at which it is near or far away from the target value which can be inferred from the definition of fuzzy set.
According to Zimmermann (2001), major objectives of fuzzy set theory are to model uncertainty and to relax or generalize classical methods based on dual logic from a dichotomous to a gradual feature. Furthermore, it aims to reduce the complexity of data to a reasonable degree via linguistic variables. Computational units use these linguistic expressions and membership functions of fuzzy sets and finally retranslate the fuzzified result into the words via linguistic approximation and produce the output for the crisp world.

2.3. Advantages and Disadvantages of Fuzzy Systems

Fuzzy logic has been used and become quite popular in different fields due to its advantages (McNeill and Thro, 1994). In fuzzy logic, linguistic variables are used instead of numerical ones which makes it similar to the way human beings think. Another advantage is that fuzzy logic needs fewer values, rules and decisions than conventional models. However, it is hard to develop a model from a fuzzy system. Even though they are cheaper, easier to design and faster to prototype than conventional systems, fuzzy systems may face cultural bias in some countries who favor mathematically crisp systems and linear models. This may be the reason why Japanese firms exploited fuzzy systems before the United States and European countries. Moreover, as the complexity of system increases, it becomes more difficult to specify the correct set of rules and membership functions to describe the behavior of the system appropriately (Aliev et al., 2004).

2.4. Fuzzy Set Mathematics

In classical or crisp sets an element either belongs to a set and has a membership value of 1 or this element does not belong to the mentioned set and has a membership value of 0. However, an element of a fuzzy set may have various degrees of membership value between 0 and 1.

Definition (Zimmermann, 2001)**:** If X is a collection of objects denoted generically by x, then a fuzzy set $\tilde{A}$ is a set of ordered pairs: $\tilde{A} = \{(x, \mu_{\tilde{A}}(x) \mid x \in X\}$

$\mu_{\tilde{A}}$ is called the membership function of x in $\tilde{A}$ that maps X to the membership space M. The range of the membership function is a subset of the nonnegative real numbers whose supremum is finite. The membership function is the crucial component of a fuzzy set. Therefore, operations with fuzzy sets are defined with their membership functions.

2.5. Historical Development of Fuzzy Logic

Fuzzy Logic was developed in the 1960s by Lotfi Zadeh claiming that this new paradigm will be able to model the own uncertainty of human reasoning. He believed that computer logic didn't have to be restricted to only 0 and 1. However, the acceptance of this technique by the “highly deterministic scientific society” has taken some time (Dualibe et al., 2003). The earliest supporters of fuzzy set theory were Japanese scientists and engineers (McNeil and Thro, 1994). Another country, which has the highest number of fuzzy-oriented scientists and engineers is China. The theoretical studies and practical applications on fuzzy theory have been caught in the US and in Europe later than eastern nations. Once it has been proven that fuzzy logic can be applied in the productions of commercial and industrial products quite successfully, western nations started to use and develop it. Nowadays, Germany has quite a lot of fuzzy oriented researchers and applications, and can be counted as the second country in fuzzy related developments after Japan.

2.6. Fuzzy Business and Industrial Systems

Fuzzy systems have been used heavily in industrial production (McNeil & Thro, 1994). For example, Fujitsu Laboratories developed a neuro-fuzzy system for rating the investment safety of bonds. A method of data analysis has been developed at a German company, INFORM, which is used for many purposes such as for the design of automobile and truck parts by Mercedes-Benz and to determine creditworthiness. Furthermore, at Los Alamos Scientific laboratory an experiment was conducted to design the best techniques for improving the recovery of oil from the ground which was a complex optimizing problem. A Portuguese company has implemented a fuzzy based digester management system and achieved a higher degree of automation (Driankov et al., 1996). The main advantages of this system were the consistent control strategy, up to 60% reduction of the variation of product quality, and a significant reduction in energy and base material consumption.

Another interesting fuzzy product, an automated storm-sewage pumping station for Shanghai, was developed by a Chinese scientist Hong Chen. It aimed to correct the deficiencies of crisp pump controllers which either start too late to prevent backflow, run too long or stop too soon. Fuzzy system can easily determine when the pumps should be started and stopped according to the water level, change in water level and also to the weather. Moreover, fuzzy insulin infusion system for diabetics, some consumer products such as vacuum cleaner, washing machine, fuzzy air conditioner, dishwasher, video camera-recorder, heater, rice cooker, and clothes dryer can be counted how fuzzy theory is applicable and useful in practice. These machines arrange their own speed, water level and when to work and when not by easily adapting to their environments and save a lot of energy. In Japan, a home appliance which has the label “fuzzy-controlled” raises a positive sense of modern, high quality and user friendly machine (Driankov et al., 1996).

On the other hand, the use of fuzzy logic is not restricted only to home appliances (Karray et al., 2004). Nissan, Subaru and Mitsubishi use the fuzzy control transmission systems which sense vehicle speed and acceleration, throttle opening, the rate of change of throttle opening, engine load, and driving style. Fujitec and Toshiba use a fuzzy scheme in elevator control which is said to reduce waiting time and improve the efficiency and reliability of operation. Even a subway train is being used in Sendai, Japan which determines the speed and stopping routine. Ride comfort and safety are performance requirements of this train.

However, it is not so simple to implement fuzzy control in the production immediately; it requires well-trained personnel in the industry as well as researchers at the universities and laboratories. This is seen one of the bottlenecks that prevents a broader exploitation of fuzzy technology by European countries at the end of 1990s by Driankov et al. (1996).

By 2002, Japanese firms who utilize fuzzy logic were Canon, Hitachi, Matsushita Electric, Minolta, Mitsubishi Electric, Ricoh, Sanyo and Sharp. In the USA, General Electric, Texaco and US Air Force Office of Scientific Research were the main users of fuzzy logic. At the same time in Europe, AEG, Bosch, Cerberus, Viessmann, INFORM, Endress and Hauser and DASA were utilizing fuzzy logic in their products (Kazemian, 2002).

3. Analysis

Fuzzy logic is a very important and beneficial theory which is subject to change the electric, electronic and computer sciences deeply. Surprisingly, this theory was introduced by someone (Professor Zadeh) whose roots are in the east and was developed by the eastern nations firstly; but not by the western world which has been industrialized and developed before all other nations. Fuzzy logic has been started to be used by the western world first after it has been developed to some extent in the east and its usefulness has been proven. With this characteristic, it shares the same destiny with the Total Quality Management. These examples show one important fact: the invention and development of new ideas is not only dependent on the development level of countries. Culture and the perception of science play the key roles in inventing or accepting new theories. Western world which follows the paths of Aristo, Newton and Renaissance has been pioneers of many developments in the world but could not go beyond perceiving the world as crisp. However, we cannot understand and solve all the problems of human beings and of the world only with crisp theories. On the other hand, eastern way of thinking perceives the world not only with “0 and 1” or “true and false” concepts. This way of thinking makes the east luckier in solving the problems that cannot be solved by the crisp theories. The examples from the past prove these ideas. It is also possible to see new examples in the future as well.

When we analyze the situation of Bosnia, we see that if Bosnia can concentrate on its national/regional culture and follow western and eastern world closely, it will be able to follow the latest trends in the industry and become more competitive in the region. Bosnia like the founder of fuzzy logic Professor Zadeh, witnessed different cultures (Catholics and Orthodox Christian culture, Muslim culture, Austria-Hungarian Culture, Ottoman Culture) and belongs to the western world from one perspective and also is a part of the eastern world from another perspective. For example, Bosnia has adopted western education system, and at the same time is familiar with the eastern philosophy, and mind-set. All these features offer Bosnia big chances for the future developments.

4. Conclusion

As a conclusion, under the shadow of culture and tradition, perception of the science affects the creation and application of techniques used in industry and management. This can be seen in the background of the fuzzy logic founder and by looking at the nations which applied fuzzy set theory first. The reason why western companies were late in accepting and utilizing fuzzy logic can be explained mainly by their science perception. Different than eastern ancient tradition, western tradition and taught teaches to be always precise and crisp. However, many unsolved problems we face are not crisp and cannot be solved by crisp logic. On the other side, the contribution of western nations to the science and technology is not possible to ignore. At this point, Bosnia, as a country which has both west's crispness and east's mystical insight, can use the advantage of this feature. Bosnia can convert this characteristic of being a country between east and west and being familiar to the two different mind-sets, into a competitive advantage. Geographically it is in west, but has experienced both western and eastern cultures in different time periods. Instead of following only one trend, Bosnia is able to observe and understand two traditions, and can enjoy the early application of promising theories.

References

Aliev Rafik A., Bijan Fazlollahi & Rashad R. Aliev (2004). *Soft Computing and its Applications in Business and Economics*. Springer Verlag: Berlin Heidelberg.

Bensaou, M. & Earl, M. (1998). The right mind-set for managing information technology. *Harvard Business Review*, 76(5), 118–128.

Blair Betty (1994). Interview with Lotfi Zadeh: Creator of Fuzzy Logic. *Azerbaijan International*, 2.4, 46-57.

Driankov Dimiter, Hans Hellendoorn & Michael Reinfrank (1996)., *An Introduction to Fuzzy Control*. Springer Verlag: Berlin-Heidelberg-NewYork.

Dualibe, Carlos, Verleysen, M., & Jespers, P. (2003). *Design of Analog Fuzzy Logic Controllers in CMOS Technologies: Implementation, Test and Application*. Kluwer Academic Publishers.

Harris, Philip R., Moran, Robert T. & Moran, Sarah V. (2004). *Culture and its Characteristics, Global Leadership Strategies for the 21st Century*. Elsevier Butterworth–Heinemann: Oxford.

Hofstede, G. (1980). *Culture's Consequences: International Differences in Work-related Values.* Beverly Hills, CA: Sage.

Hofstede, G. (1991). *Cultures, Organizations: Software of the Mind*. London: McGraw-Hill.

Hofstede, G. (1993). Cultural Constraints in Management Theories. *The Executive*, 7(1), 81-94.

Kambayashi, N. (2004). Culture-specific IT Use in Japanese Factories. *Asian Business & Management*, 3, 241–262.

Karray F.O., & de Silva C. (2004). *Soft Computing and Intelligent System Design: Theory, Tools and Applications*. Addison Wesley.

Kazemian H. B. (2002). Fuzzy Logic Applications. *Expert Systems*, 19(4), 189-190.

Kirkman, B. L., Lowe, K. B., & Gibson, C. B. (2006). A Quarter Century of Culture's Consequences: A review of empirical research incorporating Hofstede's cultural values framework. *Journal of International Business Studies*, 37(3), 285-320.

McNeill F. Martin & Ellen Thro (1994). *Fuzzy Logic: A Practical Approach*. Academic Press Limited: London.

Moran, F., Palmer, D.W.,& Borstorff, P.C. (2007). The Relationship between National Culture, Organizational Culture, Causal Ambiguity and Competitive Advantage in an International Setting: An Explanatory Analysis. *Proceedings of the Academy for Studies in International Business*, 7(1).

Pagell M.; Katz J. P; & Sheu C. (2005). The importance of national culture in operations management research. *International journal of Operations & Production Management*, 25(¾), 371.

Trompenaars Fons & Peter Woolliams (2003). *Business Across Cultures*. Capstone Publishing: England.

Zimmermann Hans-Jürgen (2001). *Fuzzy Set Theory and Its Applications*, USA: Kluwer Academic Publishers.