IDENTIFICATION OF SOURCES OF TRANSACTION COSTS – A FUZZY APPROACH FOR THE EVALUATION OF ANALYTICAL CATEGORIES

Identificação das fontes dos custos de transação - uma abordagem fuzzy para a avaliação das categorias de análise

ABSTRACT

This work intends to assess the evaluation of analytical categories related to the identification of transaction costs. Assuming an analytical model for the identification of the transaction costs proposed by Arbage (2004) in which categories are discussed in terms of which analyses to be made and how to evaluate them. Amongst these categories, 'opportunism' is assessed in terms of patterns of behavior and measured in terms of confidence. The work supports the use of the fuzzy theory for measuring this category in particular. Through the fuzzy theory, there is the possibility of modeling and manipulate vague and inexact information mathematically, natural of the human language and, therefore, also the information supplied for the specialists when characterizing the considered processes.

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RESUMO

Este trabalho pretende analisar a avaliação de categorias analíticas ligadas à identificação dos custos de transação. Assume-se o modelo analítico para a identificação dos custos de transação proposto por Arbage (2004) em que as categorias são discutidas em termos de que análises podem ser realizadas e como avaliá-las. Entre essas categorias, o 'oportunismo' é avaliado em termos de padrões de comportamento e medido em termos de confiança. O trabalho baseia-se na utilização da teoria fuzzy para medição desta categoria em particular. Através da teoria fuzzy, há possibilidade de modelar e manipular informações vagas e inexatas matematicamente, natural da linguagem humana e, portanto, também as informações fornecidas por especialistas na caracterização dos processos considerados.

Palavras-chave: custos de transação, categorias analíticas, teoria fuzzy.

Key words: transactions costs, analytical categories, fuzzy theory.

1 INTRODUCTION

The context of society and organizational forms in the exchange relations motivate economic agents to the creation of a control structure that makes possible the identification and attainment of the solutions of the problems (MENDONÇA and BATALHA, 2003). Concomitantly, it is possible to recognize the increasing interest for scientific inquiries that has as purpose the generation of knowledge that make possible the decision making in the "time" of its planning or optimized implementation.

Directly related to these research are the processes that allow the mathematical modeling, as problems of resolution of ordinary differential equations, resolution of systems of algebraic, linear or not linear equations, numerical integration and adjustment of curves (AMENDOLA, SOUZA and BARROS, 2005).

Nevertheless, significant part of the socioeconomic processes is not subject of handling through these processes. Amongst the possible approaches to handle these processes is the fuzzy theory. The potentialities of the use of the Fuzzy Theory are manifested for the study of social phenomena, in particular the problems involved with exchanges and commercial arrangements.

Through the Fuzzy Theory, there is the possibility of modeling and manipulate vague and inexact information mathematically, natural of the human language and, therefore, also the information supplied for the specialists when characterizing the considered processes. This

manipulation is carried through the arrangement of predetermined variables to shape mathematically the event problem, when the implication of the independent variables in the dependents is introduced by a set of linguistic rules based on the knowledge of specialists (AMENDOLA, SOUZA and BARROS, 2005).

In fact, it is perceived the increasingly use of the theory of fuzzy sets in diverse areas of application. Currently, fields of the knowledge as the biomathematics, agricultural engineering and production engineering make use of the techniques of this the theory (BARROS (1997), RIBACIONKA (1999) and ORTEGA (2001).

The present article discusses the use of the Fuzzy Theory to the study of social sciences, considering as unit of analysis the relations of economic exchanges. Anchored in the New Institutional Economy (NIE), it is intended to develop applications of the Fuzzy Theory, in order to identify the determinants of the transaction costs, the sources of uncertainties and risks between the diverse links of the productive chains.

The article presents some considerations on the origins and basic concepts of the theory fuzzy, in the sequence we try to demonstrate the applicability of these concepts in socio-economy in general and, in particular, in the study of transaction costs, using the categories proposed for Arbage (2004).

2 ORIGINS OF THE FUZZY THEORY

Fuzzy sets were introduced by Zadeh (1965) in the analysis of complex systems but some of the key ideas of the theory were envisaged by Max Black using the term ´vagueness´ to refer to uncertainty and introducing the notion of membership function (BLACK, 1937, cited by KLIR and FOLGER, 1988). In the sequence, the basic concepts of the Fuzzy theory will be explored during the presentation of some definitions.

Definition 1: (fuzzy set) let X be a nonempty set. A fuzzy set A in X, the universal set, is characterized by its membership function μA defined as μA: X→[0, 1],where μA is interpreted as the degree of membership of element x in the fuzzy set A for each x∈ X and [0,1] denotes the interval of real numbers from 0 to 1, inclusive. In this way, the value zero is used to represent complete non-membership and the value 1 is used to represent fully membership, and values in between are used to represent intermediate degrees of membership.

For example, one can define a possible membership function for the fuzzy set of real numbers close to, let us say, 511.16 as follows:

$$\mu_A(x) = \left(\frac{1}{1 + 0.1(x - 511.16)^{1.2}} \right) \quad (1)$$

Equation (1) is a possible membership function representing the proximity of the real number 511.16. The shape of the curve in Figure 1 can be choose in terms of the flexibility of the parameter in question, that is, is it the difference between \$R 511.16 (μ A(x) =1) and R\$ 508 (μ A(x) =0.7) important to the research?

Following, two different evaluations of an affordable forested land to settlers and farmers are depicted in the Figure 2 represented as a fuzzy set on a universe of prices per hectare.

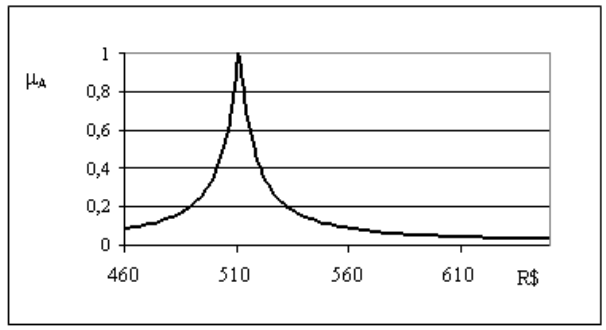

FIGURE 1 – A possible membership function of the fuzzy set of real numbers close to 511.16

In Figure 2, below 700 R\$, land is considered as cheap and between 700 R\$ and 800 R\$, a variation in the price induces a weak preference to farmers and a clear discordance to settlers. Between 1,000 R\$ and 1,200 R\$ costs are too high to farmers and even less affordable to settlers. Beyond 1200, the costs are too high for both groups.

Another example of application and type of membership function could be the evaluation of market insertion (Figure 3). We can represent the market entry aggregating values of produced and sold products in the market. The following membership function intends to depict market entry:

$$\mu(x) = \begin{cases} 1 & if \quad x \geq 0.5 \\ 1 - \dfrac{0.5 - x}{0.4} & if \quad 0.1 \leq x \leq 0.5 \\ 0 & otherwise \end{cases} \quad (2)$$

Each farming system, in general, has a characteristic tendency in terms of market entry. However,

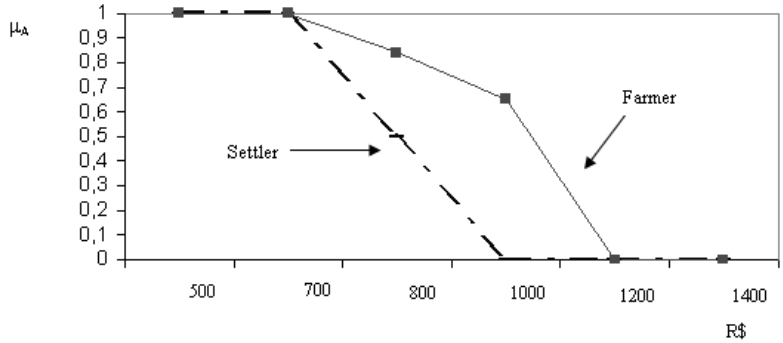

FIGURE 2 – Different evaluations of affordable forested land.

the agents (families) could have different values according internal and external influences. In this case, for example, a value of say 40% (μ A (40%) =0.75) could be considered quite a good entry point in the market, to a determined family.

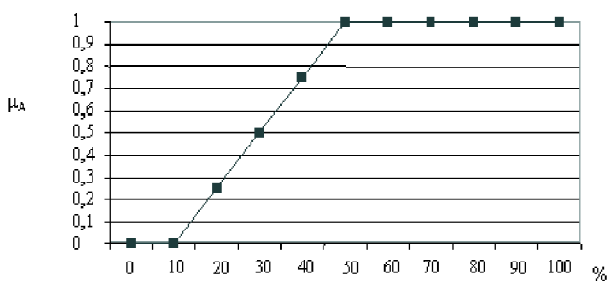

FIGURE 3 – Different evaluations of market insertion.

In general, predicates can be represented by fuzzy sets and basic relations like complement, union and intersection. After the representation, linguistic hedges through fuzzy algebra can modify the predicates. In addition, fuzzy numbers (DUBOIS and PRADE, 1980), in a triangular or other specific form used to describe uncertainties of variables, can be manipulated based on fuzzy arithmetic. In order to explore these concepts even more, we need to introduce some more definitions.

Definition 2: (height and normality) Given a set X and a fuzzy subset A of X, the height of A is the maximum membership value of any xÎX in A. A is called normal iff height (A) = 1.

Definition 3: (convexity) Given a n ∈⊆, a subset A of the Euclidian space ∇n is called convex if :$\forall r, s \in \Re^n \forall \lambda \in [0,1] : \mu_A(\lambda r + (1-\lambda)s) \geq \min\{\mu_A(r), \mu_A(s)\}$

Definition 4: (fuzzy number) A fuzzy subset A of ∇ is called a fuzzy number if A is convex and normal.

Definition 5: A fuzzy set A is called a triangular fuzzy number with centre a, left width α>0 and right width β>0 if its membership function has the following form:

$$A(t) = \begin{cases} 1 - \dfrac{a-t}{\alpha} & if \quad a - \alpha \leq t \leq \alpha \\ 1 - \dfrac{t-a}{\beta} & if \quad a \leq t \leq a + \beta \\ 0 & otherwise \end{cases} \tag{3}$$

A is also denoted as A = (a,α,β). The principles of these manipulation are predominantly semantic in nature and a triangular fuzzy number with centre a may be seen as a fuzzy quantity ´x is approximately equal to a´.

As far as one can estimate with a better precision one of the tails the width α or β differs. There are, however, other possible definitions of a triangular number. It is noteworthy at this point to define some other possible shapes of fuzzy numbers.

One example of proposition depicted by a triangular fuzzy number could be the price estimation, a possibility measure (ZADEH, 1978) based on the historical price. Figure 4 represents A = (15; 2; 1.2). In assuming the fuzzy number A, the decision maker or researcher understands that the price could vary from 13 until 16.2 with a central price as 15. In other words, price is approximately equal to 15, bigger than 13 and less than 16.2.

Some other uncertainties call for an interval in which values are acceptable. In this case a trapezoidal fuzzy number is employed.

Definition 6: A fuzzy set A(t) is called trapezoidal fuzzy number with tolerance interval [a, b], with left width a and right width β if its membership function has the following form:

$$A(t)=\begin{cases}1-\dfrac{a-t}{\alpha} & if \quad a-\alpha\le t\le\alpha\\ 1 & if \quad a\le t\le b\\ 1-\dfrac{t-b}{\beta} & if \quad b\le t\le b+\beta\\ 0 & otherwise\end{cases} \tag{4}$$

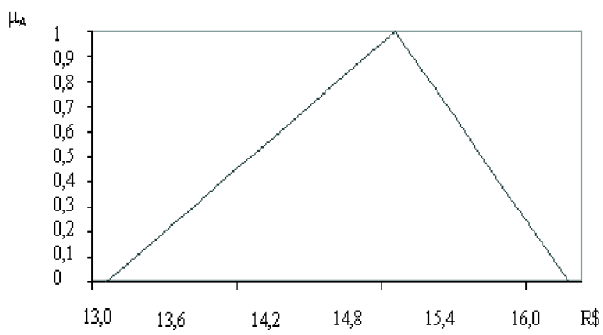

FIGURE 4 – A triangular fuzzy number A = (15; 2; 1.2).

The trapezoidal fuzzy number represents the assertive 'x is approximately in the interval [a, b]. Figure 6 depicted a trapezoidal number describing the possible values of prices between 14.8 and 15.2 and a possible representation of this number is A =[a, b, α, β].

Definition 7: The support of a fuzzy set A in the universal set X is the crisp set that contains all the elements of X that have a nonzero membership grade in A. A special notation for defining fuzzy sets with a finite support is

$$A=\frac{\mu_1}{x_1}+\frac{\mu_2}{x_2}+.....+\frac{\mu_n}{x_n} \tag{5}$$

Definition 8: á-cut of a fuzzy set A is a crisp set A á that contains all the elements of the universal set X that have a membership grade in A greater than or equal to the specific value of α. As, for example, consider the Figure 5. In this case, α = 0.3 is {13,6; 15,9}. And for α= 0.7: low participation0.7 ={14,3; 15,5} or according to Equation 5:

$$A_{0,3}=\frac{0,3}{13,6}+\frac{0.7}{14,3}+\frac{1}{14,8}+\frac{1}{15,2}+\frac{0,7}{15,5}+\frac{0.3}{15,9}$$

$$A_{0,7}=\frac{0,7}{14,3}+\frac{1}{14,8}+\frac{1}{15,2}+\frac{0.7}{15,5}$$

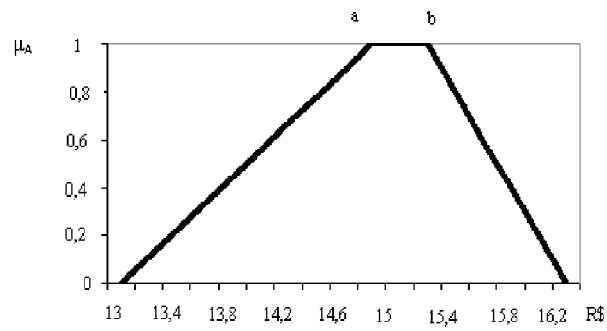

FIGURE 5 – A trapezoidal fuzzy number A = (14.8; 15.2; 1.8; 1.0)

The determination of the matching of input variables with the linguistic terms is referred to as fuzzification (Figure 6), in which the actual degree of membership for input variables is determined for each linguistic term of the corresponding linguistic variable. The fuzzification is normally the first phase of the inference process, in which linguistic terms are treated and manipulated into the fuzzy approach. The inference consists of three sub-functions: aggregation, activation and accumulation. Weighting or not, we could use, for example, the MaxMin inference strategy, which uses the maximum for accumulation and the minimum for the algebraic product for activation where the aggregation determines the degree of accomplishment of the condition from the degree of membership of the sub conditions. Finally, after the inference process that provides a membership function as a result, we can convert this result into a 'crisp' number using one of the techniques for defuzzification and the 'crisp' number generated should provide a good representation of the information contained in the fuzzy set. One possible defuzzification method described in the literature, is to determine the centre of gravity under the membership function and the 'crisp' output is determined as the abscissa value.

2.1 Operations on Fuzzy Sets

The original theory of fuzzy sets extended the classical set theoretic operations from ordinary set theory to fuzzy sets with the following operators:

$$\bar{a}=1-a\cdots\cdots\cdots\cdots\cdots\cdots\mu_{\bar{A}}(x)=1-\mu_A(x)$$

$$a\vee b=\max(a,b)\cdots\cdots\cdots\mu_{A\cup B}(x)=\max\left[\mu_A(x),\mu_B(x)\right]$$

$$a\wedge b=\min(a,b)\cdots\cdots\cdots\mu_{A\cap B}(x)=\min\left[\mu_A(x),\mu_B(x)\right]$$

$$a\Rightarrow b=\min(1,1+b-a)$$

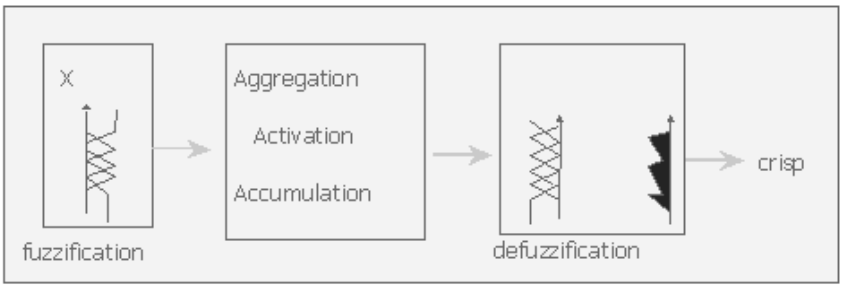

FIGURE 6 – Inference process.

3 THE FUZZY APPROACH IN SOCIO-ECONOMIC PROBLEMS

The force of the Fuzzy Theory comes from its ability in inferring conclusions and generating answers from vague, ambiguous and qualitatively incomplete information. In this sense, it gains prominence its application as a tool for modeling systems which are centered in human decisions (ZADEH, 1972) in general and, in particular, problems of the socio-economy, in which aspects as the imprecision and uncertainties prevail in the communicative language and in collective/individual relations.

Ragin (1992) affirms to exist three special reasons to apply the Fuzzy Theory in social sciences research, generating, in such a way, a profitable dialogue between ideas and concrete reality. First, the author argues that the social scientists interested in research must abdicate of many of the "homogenized presumptions" that conduct the conventional quantitative analysis. The form as the researchers visualizes the cases problems, by means of presumptions and homogenized structures of analysis, determines the limits of the investigation field as well as the examination of the causes and implications of the raised questionings. It defends the investigators must concentrate the research on the existing analytical diversity using strategies that are more common in qualitative inquiries. It is perceived that these techniques, which are guided for the observational diversity, are of simple implementation when the number of cases is small, which is an habitual situation in qualitative inquiries.

One perceives that many of the advances presented for social sciences through the applicability of the Fuzzy Theory take place after the recognition of the limitations of the conventional theory. Although its importance in the academic inquiries, the binary logic presents inefficiencies, as far as it treats, basically, of numerical data, it is based on norms and laws, or then in the purest subjectivism. Also it disrespects many of the behavioral dimensions of the human beings, as questions that intervene with the organizational culture, cultural habits, beliefs and values. Moreover, the construction of instruments on the basis of the fuzzy logic makes possible the representation of the subjectivity and involved questions for emotions, feelings and behaviors, in substitution to the exact quantitative values.

When supplying concepts of randomness for imprecise concepts, fuzzy logic makes possible the development of qualitative tools that allow to analyze the established environment conceptually, evaluating the intensity of the images, the values and the expectations of the individuals and for its representation (RHEINGANTZ, 2002).

According to Jang and Gulley (1997) the fuzzy approach presents the following advantages in relation to the classic approach: the naturalness of its approach becomes it conceptually easy to understand; its flexibility; its tolerance with inexact data; the possibility in modeling nonlinear functions; can be based on the experience of specialists; it can be integrated to the conventional techniques of control; in many cases, it simplifies or it extends the possibilities and resources of the conventional methods of control and; it is based on the natural language.

According to Reys (2003), Fuzzy theory was also found to be a reliable tool for improving the link between theory and data analysis, for calibrating and fitting theoretical knowledge into membership function using a diversity-oriented approach. With regard to resource analysis, Fuzzy theory offers tools for focusing on the main problems involved in defining an ideal level of satisfaction. It also addresses problems inherent in quantification and qualification of goods and services on the one hand and consumption needs and restrictions on the other.

The intrinsic subjectivity of variables, although used in our daily life, transmitted and perfectly understood linguistically between interlocutors, has invariably remained outside of the traditional mathematical treatment (BARROS, 2001). This is the case, for example, of the concepts of onerous, concentrate, risky, etc, which are typical examples of sets whose borders can be considered uncertain, defined for subjective properties, and that usually are part of problems of socio-economy.

A methodological proposal to formalize mathematically, for example, the set of options of a risky transaction, could have at least two approaches. First, the most classic one, determines the value (risk), in which a business option/transaction is considered risky. In this situation the case is sharply defined and the set is clear-cut. Second, less conventional, it is given thus all the business-oriented options/transaction are considered risky with more or less intensity, that is, there are elements that would belong more to the class of the risky ones than others.

This means that the lesser the risk associated to a determined element, the smaller will be its degree of membership to this classroom. In this sense, it can be affirmed that all the elements belong to the class of the risky options of business/ transaction, with greater or minor intensity and this is the proposal that we intend to explore to follow.

4 THE ECONOMY OF THE TRANSACTION COSTS (ECT)

It is intended, from the theoretical referential of the Economy of the Transaction Costs (ECT), to examine the role of the uncertainty, frequency, informational structure and specificity of the assets in the processes of decision making that are part of the transactions between and intra productive chains. Based on the work developed for Coase (1937), the ECT is inserted in the context of the New Institutional Economy and is considered an important branch of the economy, which searches, beyond evaluating the production costs, to analyze the costs associates to the transactions.

Considering that the firms act in an environment full of uncertainties, the approach affirms that these use in its transactions normalization tools, the contracts, which objectify to protect them in case of the non-execution of the terms or profits happened in the operation

Dutra and Rathmann (2008) reinforce that the ECT intends to explain the different and dominant organizational forms in the market. Amongst its presumptions, it is emphasized that the firms are immersed in an environment of limited rationality, characterized for the uncertainty and imperfect information. Thus, from these characteristics, the transaction costs emerge, whose minimization will explain the distinct contractual arrangements, which play with the objective of to co-ordinate the economic transactions in an efficient way (ZYLBERSZTAJN, 1995).

Generally speaking, the productive chain, through its components, aims at to diminish the costs necessary to move the economic system and, also, the transaction costs. Carry out between economic agents, the transactions can in such a way be carried through for the exchange of good as for the exchange services (RATHMANN et al, 2008).

Willianson (1985) affirms that the transactions have three essential characteristics: the Frequency, related to the amount of times that two agents carry out certain transactions. Associates to this characteristic are the reputation and the confidence, which play crucial roles in the course of the transactions. Another characteristic Uncertainty, associate to facts or effects which are not predictable, and that it can lead to the disruption of a contract in a non opportunistic way and; the Specificity of the Assets, which concerns to the loss of value of the involved assets in a determined non fulfilled transaction.(RATHMANN et al, 2008).

Other important concepts for the understanding of the phenomenon of the transaction and, consequently of the theory of the ECT, make reference to the characteristics of the involved economic agents: the limited rationality and the opportunism. According to Zylbersztajn (1995), the limited rationality originates from the complexity of the environment which involves the decision processes of the agents, as well as of the cognitive limitation of human beings. In the other hand, the opportunism, according to Williamson (1985), defined as “the search of the auto-interest with avidity”, is the behavioral characteristic for the definition of the architecture of contracts.

The concept of opportunism assumes that the economic agents can act in a non cooperative form in a transaction but it is waited that the organizations search the alignment amongst the characteristics of the transactions and the agents, in an institutional environment.

4.1 Sources of the Transaction Costs: some analytical categories

Arbage (2004) proposes a model of analysis for identification of the sources of transaction costs, in which he defines analytical categories to be evaluated.

Based on the Economy of the Costs of Transaction, the model is translated in terms of the use of the Fuzzy Theory, since it works with the linguistic interpretation of the words, when trying to perceive and to explain desires, perceptions, opinions, uncertainty and ambiguities. This work will explore the fuzzy tools applied to the category Opportunism.

4.1.1 Category : Opportunism

The opportunism, one of the analytical categories destined to the measurement of the transaction costs, according Arbage (2004), intends to evaluate the behavioral patterns through some quali/quantitative criterion which can measure the confidence between the links of the productive chain.

The confidence can be represented by a fuzzy number (that is, a convex and normalized fuzzy set in R) in which the parts, one about the others, emits its judgment of value, its judgment about the relation between them concerning the confidence. In this way, in a relation between the agents A and B, the agent A can understand it has in the agent B "big confidence".

This linguistic term can be represented, when defining a specific Universe of discourse, Confidence, in which it varies from 1 (very little) to 5 (very big), using the Zadeh (1972) notation:

$$C_{AB} = \int \mu_{AB}(x) = \frac{0}{1} + \frac{0,2}{2} + \frac{0,8}{3} + \frac{1}{4} + \frac{0,4}{5}$$

The same measure, made with agent B on the relationship between B and A, could be answered as "very big confidence", and so represented by:

$$C_{BA} = \int \mu_{BA}(x) = \frac{0}{1} + \frac{0}{2} + \frac{0,2}{3} + \frac{0.8}{4} + \frac{1}{5}$$

These fuzzy numbers can be represented graphically (Figure 7).

It is verified that the curves would be ideal considering two aspects, complementary and not mutually exclusive, which are, first, that its representations were sufficiently similar, that is, the confidence degree between them, in the defined universe of discourse, was similar. In other words, that in such a way the agent A trusts in B as much as B trusts in A, whichever this confidence level is and, second, that alpha-cut of, for example, 0,8, reached both the representations above of value 4 in the scale of the confidence degree.

TABLE 1 – Analytical Model for the identification of transaction costs.

Category\ Aspects	What to evaluate?	How to evaluate?
Opportunism	Behavioral patterns	Confidence
Rationality	Decision making	Share of information
Primary uncertainty	Institutional environment	Adaptation
Secondary uncertainty	Strategic Positioning	Collective strategies
Conductive uncertainty	Profile of the Inter-organizational relationship	Long term Relationship
Geographic specificity	Geography	demand
Physical specificity	Raw material	demand
Specificity of knowledge	Idiosyncratic knowledge	demand

Source: ARBAGE (2004)

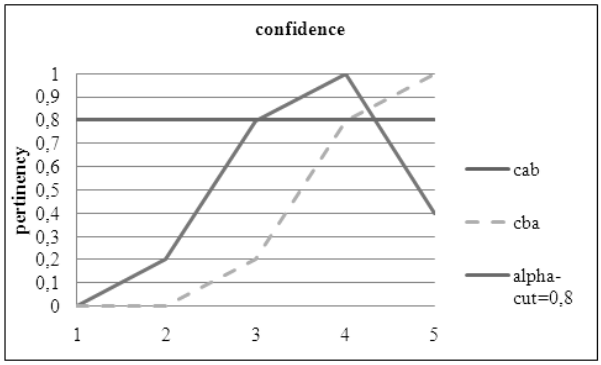

FIGURE 7 – Fuzzy numbers.

The distance between the values in the scale for this alpha-cut (in this case we have $0{,}8_{AB}(x)= 3$ and $0{,}8_{BA}(x)= 4$) offers a distance degree between the confidence of the agents. It can also indicate which part must invest more in this relation (considering the efforts to reach an ideal point where both had the same confidence degree).

Through the inference process, a single measure of the relation between the agent can be gotten considering some criterion of aggregation. Amongst the diverse operators of aggregation, the option for one more simple and conservative is interesting. It can thus be added the representations for operator MIN (a ^ b), given by:

$$C_{AB;BA} = MIN\left(C_{AB}(x); C_{BA}(x)\right) = \frac{0}{1} + \frac{0}{2} + \frac{0,2}{3} + \frac{0.8}{4} + \frac{0,4}{5}$$

Whose graphical representation is given by Figure 8:

The centroid of this area would indicate a crisp (exact) number that it would represent the relation between the agents. Efforts to improve the confidence degree could in such a way thus be monitored, as far as the results of C_{AB} and C_{BA} could concomitantly be raised with the operations and transactions of the agents.

The sources of transaction costs related to the factors which make difficult the establishment of the confidence, or, in other terms, the improvement of the confidence could be, in such a way, related to the advances of this index face to the involved costs. Thus making, a model could be considered indicating a maximum value to be invested (regarding a desired confidence level) or a maximum confidence level waited (regarding a fixed amount to be invested) or still a criterion of minimum cost to be determined in this function of improvement of the confidence versus transaction costs, considering the influence of diverse other variable in this index.

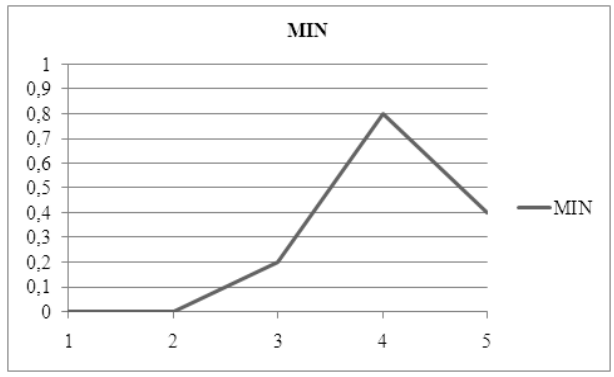

FIGURE 8 – Representations for operator MIN (a ^ b).

Finally, it is noteworthy, that the linguistic representation of the confidence degree not only brings in itself the individual experiences of the companies and its components in its relations with the other company but in its set of relations with other agents. Another important factor is the organizational culture of these companies, its flexibility, objectives and commitment with customers, employees and suppliers, which can influence substantially the confidence degree.

5 CONCLUSIONS

Maturana and Varela (1995), when alleging that the mental act to know produces, essentially, a conditional world for the recursive act of the human language, strengthen the importance of the application of the linguistic variables. In this sense, the semantic quality of the linguistic sentences approximates the mathematics of the mental processes.

The premise of that the key elements of the human thought is not numbers, but labels of fuzzy sets, or classes of objects in which the transition of membership is gradual instead of the abrupt yes or no, justifies the use of the linguistic variables in the determination of degrees of attributes to the elements analyzed in the estimate of performance of the constructed environment (HERDEG, 1996 apud RHEINGANTZ, 2002), and consequently, the application of the Fuzzy Theory to the research in social sciences.

The fuzzy approach applied to the socio economic problems presents many advantages in relation to the binary logic, mainly for its flexibility in the treatment with the available data, its tolerance with vague data and for being based in the natural language.

When used to the study of the transaction costs, through the analysis of the categories opportunism, rationality, uncertainties, specificities of asset etc, which

are presumptive behaviors of the economic agents and characteristics of the transactions, the Fuzzy Theory reveals equally interesting. The interpretation of the sense of the words, when trying to perceive and to explain desires, perceptions, opinions, uncertainty and even though ambiguities related to the transactions and the relations between the different links of the productive chains, allow to the identification and evaluation of the sources of the transaction costs.

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