ABSTRACT:
Information risk management in the marketing function will play a significant role in the decision-making process of any modern business. With the development of computer science and technology, innovative ways have been introduced to process information. At the same time, it is realized that the different ways of comprehending information used by humans can be very misleading, since all information contains error or noise and the human reasoning and senses are very limited. Therefore, marketing managers must recognize that mathematical calculations use data as input - not information, as some seem to believe. Information can only be obtained by providing attributes or relevance and purpose to data. Numbers by themselves do not constitute information, which is why information technology (IT) is not really information-oriented by default but data-oriented. Only the human mind can provide purpose and hence relevance to data, which of course can subsequently be built into data systems to provide information systems. For this reason we introduce Marketing Analytics [MA], a new concept that stresses the raising issue of accountability in the marketing literature. We strongly believe that a marketing analytics' philosophy will contribute significantly at the empowerment of the accountability of marketing decisions. But in order this philosophy to be empowered; information risk management systems must be incorporated in the marketing decision-making process. We believe that these systems in order to work effectively, a classification of consumers' informational uncertainties are needed. So, the research scope of this work is to classify consumers' informational uncertainties, in terms of efficient management of incomplete information in consumer markets. In terms of this research try, based on our proposed fundamental formula of "information utility" we will express, mathematically, grey and fuzzy information (relative concepts of "information uncertainty"). We strongly believe that the incorporation of concepts from mathematics in marketing planning will contribute significantly to the accountability of marketing decisions. According to the literature review, accountability in marketing planning is not only a matter of ineffective decision tools, but also a matter of culture.

Key words: Accountability, marketing analytics, marketing data, consumers' informational uncertainties, mathematic expressions and marketing budgeting.
1. Introduction:
Many concepts evolved in the 20th century and could be used as describers of the development of the society. One of the most drastic changes is related to the information revolution. But in the era of information revolution, the protagonists of marketing decision-making seem not to understand the distinction among the following meanings: data, information and knowledge. Such a misconception explains the problem of the lack of making marketing decisions accountable.

All mathematical calculations use data as input - not information, as many marketing managers seem to believe. Information can only be obtained by providing attributes or relevance and purpose to data (Joia, 2000). Thus, numbers by themselves do not constitute information, which is why information technology (IT) is not really information-oriented by default but data-oriented. Only the human mind can provide purpose and hence relevance to data, which of course can subsequently be built into data systems to provide information systems.

The next step is to turn information into knowledge, where knowledge is defined as "information combined with experience, context, interpretation and reflection" (Davenport et al., 1998). Furthermore, Kock and McQueen (1998) point out that information is "descriptive and historical, relating primarily to the past and present whereas knowledge is predictive and associative and unveils hidden facts". Thus, no MA can provide knowledge or insight directly, and often will the information derived from MA require further work. In other words, BAs are more attention directing instruments than knowledge generating instruments.

But knowledge by itself is also not enough - we must truly understand an issue to be able to act upon it wisely.

Interestingly, there are not many definitions of "understanding" in the business literature. It is as if everybody assumes that once we know something we understand it by default and hence can act accordingly. Knowledge can be defined as "information combined with experience, context, interpretation and reflection" (Davenport et al., 1998). The definition of knowledge offered by Senge (1999) as "the capacity for effective action" is essentially a definition of "understanding" (McKelvey et al., 1999). Another useful definition of understanding is "to perceive the meaning of" something (Webster, 1989, p.1854).

With these distinctions between data, information, knowledge and understanding in mind, we realize that during all the efforts of marketing analysis constantly remind ourselves what is the purpose, the context, possible alternative interpretations, experience and so on.

1.1. Background Study
1.1.1. The emergence of the culture of accountability and the increasing need of Marketing Analytics
The cultivation of managerial support for organizational effectiveness activities has become a major priority for the entire array of modern competitive (profit and non profit) organizations. Primarily driven by reporting requirements of the top management and the stakeholders in the nowadays organizations are under considerable pressure to develop programs that collect and use information to document and improve organizational performance. Based on Alexander’s (2000) call of the latest trend: "the changing face of accountability", we observe that there is an increasing need of viewing data-driven improvement processes as the primary policy levers to ensure that the business respond appropriately to stated top management's expectations.

It is undeniable that practicing marketers have a real world problem with accountability. This is evidenced by the fact that commentary on this issue appears in both practitioner and academic journals. On the practitioners' side, the question has been posed why "safe bean counters, rather than marketing entrepreneurs, get the top jobs" (Matthews, 2002). This
and commentary by Stubbs (2002) take as their source a survey of the profession that suggests that while marketing is viewed as an important business tool, only 20 per cent of UK companies have a marketer at board level. They also report that fewer than 15 per cent of FTSE 100 chief executives would describe themselves first and foremost as marketers. This need to make marketing a boardroom issue has been echoed elsewhere (e.g. Mitchell, 2003) although recent research has revealed that unless more attention is paid to marketing accountability, marketers have only a slim chance of gaining a seat on the board (Simms, 2003; Ambler, 2003).

Much of the academic perspective on this issue focuses on making marketing financially accountable or on bridging the gap between the marketing and finance disciplines. For example, a whole issue of the Journal of Business Research edited by Zinkhan and Verbrugge (2000a) was given over to discussion of the marketing and finance interface on a range of issues including advertising (Graham and Frankenburger, 2000), shareholder returns (Kumar et., 2000) and green marketing (Mathur and Mathur, 2000). Zinkhan and Verbrugge (2000b) point out that marketing scholars rarely address the issue of firm performance or stockholder wealth and "thus the effectiveness of marketing activities is more often assumed than empirically verified". They suggest that some of the large unanswered questions in marketing research remain those such as "does marketing work?" and "do marketing expenditures pay off?" The subject was later returned to in a subsequent special issue of the journal devoted to marketing productivity. Contributions from Sheth and Sisodia (2002) argue that marketing's fundamental problem today is due to low productivity and a lack of accountability while Morgan et al. (2002) make the case for marketing productivity analysis and marketing audits to be considered as subsets of the broader concept of marketing performance assessment.

Other authors also concentrate on the links between marketing and the bottom line (Ambler, 2000a, 2000b; Shaw and Mazur, 1997) and the links between marketing and shareholder value (Doyle, 2000). Doyle (2000), for example, contends that marketing has not had the impact in the boardroom that its importance justifies because marketers have failed to show how marketing activities and costs influence shareholder value. He offers a redefinition of marketing in value terms and advocates the use of shareholder value analysis to demonstrate the importance of marketing, value brands and test marketing strategies. It is not surprising, therefore, that marketing performance measurement and accountability has been one of the top three "gold" priorities for academic research of the Marketing Sciences Institute (www.msi.org).

1.2. Research Scope

Despite the risks of failing to manage them holistically and systematically, records and information risks are not recognized as a distinct area of focus for most marketing managers, therefore, no processes or people are specifically dedicated to them. In most organizations, marketing managers deal with records and information risks, where they address them at all, on an ad hoc basis through other organizational processes such as internal audit and IT or, in some cases, records management. Their approach to managing records and information risks is purely loss avoidance-oriented.

In an increasing number of organizations, however, board-level and management awareness of records and information-related risks and the need to manage the risks is growing. This awareness is likely brought on by recent high-profile cases involving records and information and new laws and regulations, though the awareness of the rationale for records and information risk management still is likely to focus attention on loss avoidance rather than opportunity maximization. In these organizations, personnel typically found within the business continuity planning, IT security, and legal functions perform rudimentary records and information risk identification, assessment, and control. Their focus is likely to be on the types of records and information risks typically addressed by these functions (i.e., disasters, major systems failures, threats to information security, and litigation or new laws).
Other sources of records and information risk, if they are identified, are still dealt with on an ad hoc basis within the marketing department. Ownership of those records and information-related risks that have been identified may or may not be clearly defined at the level of individual business units. In such organizations, the records management function, where it exists, usually still performs a more traditional role concerned with information retrieval or retention and disposition, though recognition of the need to widen its role to engage in records and information risk management may be growing. How should records and information risk management be administered within a marketing department? Generally speaking, it should be fully integrated into the organization's-wide risk management program. This integration means that:

* Records and information risk awareness will be incorporated into the organization's risk management culture and policy.
* Roles and responsibilities for records and information risk management will be clearly identified and will permeate all levels and locations of the organization.
* Records and information risks will be highlighted in all training and development initiatives.
* Records and information risk management will be a component of all operational processes (e.g., the development of new products or services).
* Consideration of records and information risk management requirements will be built into organizational planning processes such as strategy development and budgeting.

Records and information risk management should be incorporated into existing risk management administrative structures, processes, and technologies. In addition, roles and responsibilities for functional areas that have traditionally focused on records and information management or dealt with certain types of records and information risk, such as a records management department or the IT department, will need to be redefined in relation to how records and information risk management fits into the organization's-wide risk management program. Finally, just as is the case with other types of risks that cut across organizational boundaries, administration of records and information risks may be aided by the establishment of a committee that focuses specifically on this risk category from a cross-organizational perspective.

Information risk management in the marketing function will play a significant role in the decision-making process of any modern business. But such information risk management systems prerequisite classification of consumers' informational uncertainties. So, the **research scope of this work** is to classify consumers' informational uncertainties. Based on the modern consumer research, we intent to express mathematically grey and fuzzy information (as the most important categories of information uncertainty, based on the modern thrusts of consumer research). We strongly believe that the incorporation of mathematical models in marketing planning will contribute significantly to the accountability of marketing decisions. Through this research try we aim to stress the need of incorporation of marketing analytics in the day-to-day decisions of marketers.

The thesis of this paper is that uncertainty is a real and universal phenomenon in consumers' behavior. The sources of uncertainty are rational and can be identified.

**2. Literature Review:**

**2.1 Information and uncertainty information**

Based on statistics and probability theories, Shannon and Weaver (1949) established the first theory of information dealing with uncertainty. Their theory is based on the concept of Shannon entropy. Based on the concept of fuzzy sets (Zadeh, 1965), a theory of fuzzy information has been constructed (see Klir and Folger, 1988, and references therein). With
the idea of rough sets, the concept of rough information has been introduced (Pawlak, 1991). Based on the concept of grey numbers, a theory of grey information has been widely employed (Deng, 1982; Liu and Lin, 1998). With an understanding of subjective uncertainties existing in understanding information, a theory of unascertained information is established and successfully applied to solve practical problems (Liu et al., 1999). The current situation in the study of information and various uncertainties, existing in information, has brought forward a challenge to the scientific community: is there a unified information theory?

In order to clarify the concept of uncertainty information, we first discuss the intention of information.

2.1.1. Intention of the concept of information

By tracing the development history of information theory, we find that there has not been a definite definition of information accepted by the majority of the scholars in information science. At the very beginning of his book *Information and Information System* published in 1994, Backland put the content "Information is equivocal" as an independent section. He said, "Many problems come immediately out, provided that you discuss the intention of information. The concept of information is significant only when people obtain the information and understand it. It also gives us much food for thought. The word information itself is equivocal and its application is diversified." He divided information into three different kinds according to its applications: information as process, information as knowledge, and information as objects. However, some very established theorists have their objections to the third kind of information. Wiener pointed out emphatically in 1961 that "Information is only information, it is not material or the source of energy". Machlup limited information to the range of communication in 1983, and thought that "Information traditionally has two basic meanings: one is informing about something, another is to be informed of something. All that overstepped the scope of those two meanings is called analogy or figurativeness or is made up by predecessors". In 1954, Faithorne also objected to the idea of describing information as stuff. He thought that "information means the knowledge of acceptance and the explanation of the signal, it does not belong to transmitter or to omniscient observer, even to the signal itself". From the above point of view of information, we can see that the significance of information is different depending on the understanding and circumstances. We can also find some other definitions of information from the available literature:

(1) Shannon defined that "information is eliminated random uncertainty".
(2) Ashby defined that "information is the variation of a thing".
(3) Ou Xiaowei defined that "information is a sequence of space and time of matter and energy".
(4) Liu Changlin defined that "information is an attribute of the thing being reflected".
(5) Lu Chenguang also defined "information is characteristic of the thing being reflected". He also pointed out "characteristic is the latent information, and reflected characteristic is the given information."
(6) Cui Yuanmin pointed out in his book *Modern Enterprises Administration* that "in a narrow sense, information is simply the total sum of news, signals, messages and situations. In a broad sense, information is the mode of existence or state of motion of objective things and their characteristics and exhibition".

The intension of information in the above six different definitions is not always the same, and the range of the extension is sometimes wide, sometimes narrow. But, they all have a common original intention: they all have the purpose to discriminate the nature of matter. Based on this idea, we prefer the definition of information in a broad sense as introduced by Cui Yuanmin. In order to make the intension of information clearer, we will next analyze the objective and significance of why humans should understand nature. In order to exist, humans must understand nature, adapt themselves to the nature and possibly change its nature. First of all we should understand nature. There exist many things that are different, complicated and multicolored in the natural world. In order to distinguish different characteristics of various things and comprehend and grasp their laws of motion, humans must subjectively establish some criteria and some scales, then recognize and measure these
different things, and finally organize the observed results into rational knowledge and form a certain set of concepts. What we really talk about is the process by which humans understand nature. Everything in the natural world exists objectively, and does not depend on human wills. The reason humans can understand it is that it has potential energy or latent energy. The essential characteristics existing in the thing itself emit outwards under the influence of the latent energy. The results observed by humans, through criteria and scales obtained through practice, are the reappearance of the essential characteristics of matters. This is what we call informational behavior.

2.1.2. Intention and classification of uncertainty information

Because source information exists in matters, no matter however complicated it may be, source information is always the essential characteristic of matters. That is, source information is definite. On the contrary, destination information reflects information through an information path. Because the extent of the reflecting path is different and the capability of the observer is limited, there always exists the phenomenon of distortion from the source information to the destination information. Distorted information cannot reflect the essences of relevant matters comprehensively.

"In the process of information's appear, transfer and being received, due to noisy interference, there exists a distortion. In the process of recognizing and describing information characteristics of a system, due to complexity of nature things, limitations of man's ability and uncertainty of languages, there exists a phenomenon of distortion that cannot reflect the real characteristics of things" (Ni and Wang, 1992). Therefore, the emergence of the concept of uncertainty information is inevitable.

At present, we have known four kinds of uncertainty information:

1. Random information: owing to accidental interference and insufficient knowledge of conditions, the trial's outcome is uncertain. This is randomness. We call the destination information that contains randomness random information.

2. Fuzzy information: owing to the complexity of things, their boundaries may be ambiguous and their concepts cannot clearly be identified. This indefinite nature is called fuzziness; the information that contains fuzziness is called fuzzy information.

3. Unascertained information: "When making decisions, the required information may be neither random nor fuzzy. But due to the limitations of the policymakers' own conditions, they have a distorted understanding of the information. That is, the information, grasped by the decision makers, is not sufficient to make a wise conclusion on the state of the matter so that quantity relations can be effectively derived. We call the uncertain information that is complete subjective knowledge unascertained information" (Wang, 1990).

4. Grey information: owing to noise interference and limit of the receiving system, we can only in part acquire the information of a system and the rough range of the information quantity. This kind of information is partly known and is partly unknown to humans, and is called grey information.

Strictly speaking, these four kinds of uncertainty information are different in their essences. Four kinds of mathematical systems have been developed to study this uncertain information. These mathematical systems are probability, fuzzy mathematics, unascertained mathematics and grey mathematics. But, the four kinds of uncertainties may occur simultaneously in one system. Therefore, we should consider overall uncertainty information contained in the system in order to study uncertainties, and form two kinds of systems: uncertainty mathematics (Wang et al., 1993) and uncertainty system theory (Wang and Xu, 1997).
2.2. Grey and Fuzzy Information: A Modern Thrust in Consumer Research Literature?

2.2.1. Grey Information & Accountability

In the past 20 years, both the theory and practical applications of grey systems have achieved splendid results. As a new research with strong capabilities to transact and permeate into various traditional scientific fields and disciplines, the theory of grey systems has made astonishing progress in the world of learning. This theory has been widely employed in scientific areas such as life sciences, electric power, IT, agriculture, economics, economic development, energy, transportation, geography, geology, meteorology, hydraulic power, ecology, environmental studies, medicine, education, military science, finance, etc. (Most of the published works were in Chinese and not known outside China.) Social and economic benefits have been materialized in all different areas of human endeavor. Through over 20 years of studies, the theory of grey systems has been recognized as a powerful tool for both qualitative and quantitative systems analysis.

Systems such as social, economic, agricultural, industrial, ecological, and biological systems, are named based on the fields and ranges to which the research subjects belong. On the contrary, the name of grey systems is chosen based on the amount of known information. For example, a "black box" stands for an object such that its internal structure is totally unknown to the investigator. Here, the word "black" represents unknown information, "white" for completely known information, and "grey" for those information which are partially known and partially unknown. Accordingly, systems with completely known information are called as white systems, systems with completely unknown information as black systems, and the systems with partially known and partially unknown information as grey systems, respectively.

In practical situations, we often face with incomplete information. For example, in agriculture, even though all the information, related to the area which is planted, the quality of seeds, fertilizers, irrigation, etc., is completely known, it is still difficult to estimate the production quantity and the consequent annual income due to various unknown or vague variables, such as labor, technology employed, weather conditions, etc.

There are four possibilities for incomplete information: the information of elements (or parameters) is incomplete; the structural information is incomplete; the boundary information is incomplete; and the behavior information of motion is incomplete.

2.2.2. Managing Fuzzy Information & Accountability

As opposed to numerical information processing, where there is a wealth of optimization methods, the area of processing its non-numeric (linguistic) counterpart is still in its early stage of development. The processing of linguistic information is apparently dominant in many areas and will increase in importance over time. This will become essentially vital once we realize that with the steadily increasing amount of data one has to confine oneself to the processing at the lower level of information granularity and embrace linguistic information as a viable alternative. Fuzzy sets are often used as a synonym of linguistic information. The technology of fuzzy sets has already found an interesting niche in the area of instrumentation and measurement (Petriu and Eatherley, 1995), intelligent sensors (Mauris et al., 1994) and signal and image processing (Russo and Ramponi, 1996).

In our discussion of managing efficiently incomplete information in consumer markets, the matter of fuzzy communication systems has a protagonistic role. While on the surface this seems to be slightly restricted, in essence such channels exhibit some general features that are common to most of the constructs of fuzzy information processing.

The theory and practice of communication channels entails a diversity of problems of efficient transmission of information. While this area is extremely well developed and highly advanced in the realm of numeric information and exclusively focused on machine-machine communication, the problems of human-human or man-machine communication are
investigated to a lower degree. One should emphasize that any communication processes between human beings are far less numeric, if not exclusively linguistic. This makes the problem highly challenging. We often use linguistic terms in transmitting messages.

Amazingly, another human being easily comprehends linguistic messages broadcasted in this form. Quite often such linguistic messages form adequate models of imprecise information.

According to the general scheme of a fuzzy communication channel, both the transmitter and receiver are equipped with a codebook composed of some generic terms using which each message becomes encoded and decoded.

Thus the messages received by the receiver are comprehended owing to the existence of the same (or similar) codebook. In fact, the codebook can be regarded as an essential component of the same cultural fabric that allows for a suitable interpretation of any linguistic message. The communication processes between the parties that are not equipped with the same codebook are distorted to some extent and may require some calibration of the codebook (either by adding new concepts or redefining the existing ones).

The mechanisms of encoding and decoding of fuzzy information (these are commonly referred to as fuzzification and defuzzification) can be encountered in the existing literature, however, they are not treated uniformly. Moreover, no coherent and sound design criteria have been considered. Subsequently, as no design criteria have been formulated explicitly, there are no well-developed and systematic design approaches. The objective of this study is to analyze the fuzzy communication channels in a coherent way, review the existing status of research and propose a uniform taxonomy as well as investigate new design avenues.

3. Methodology:

3.1. Theoretical framework

In economic theory it is often assumed that consumers possess perfect information and that their preferences are constant. However, in many applications it is accepted that consumers do not possess perfect information and that new information can change consumers’ preferences. This approach is taken below, following the approach of Smith et al. (1998), inspired by Swartz and Strand (1981).

Informational utility is assumed to depend on the quantities of goods consumed, as well as the consumers’ confidence or expectations about the quality. This confidence depends in turn on the information available to consumers. For example, bad news concerning a product is assumed to affect consumers’ utility in consuming the product. Formally, the consumer’s optimization problem may be stated as:

$$\max_{x_1} U(x_1(q_1(I), x_2) \geq x_1p_1 + x_2p_2 + Ic$$}[1]

where:

- $x_1$: is the good for which quality information is changing,
- $x_2$: is the quantity of all other goods,
- $q_1$: represents the expected quality,
- $I$: is the set of information about the product (including quality and risk information),
- $p_1$ and $p_2$: are prices of $y$ and $x_2$, respectively,
- $c$: is the cost of searching information and
- $y$: is the total consumption budget.

As information is taken to be publicly available the personal costs of obtaining information is assumed to be zero.

If the utility function satisfies standard regularity conditions, this problem can be solved with respect to the consumed quantities of different goods, yielding the demand function $x_i = f(y,$
where the demand of the good in question depends on the size of the total budget for consumption, prices and the set of available information about the good. Additional information about quality related to one of the goods might affect the consumers’ quality/risk expectation, and thus have an effect on their demand for that good. The demand for other products may also be influenced due to substitution.

Information about products and services comes from numerous sources. As mentioned above, it is useful to distinguish between two categories of information: information with temporary significances and information with permanent implications for consumption. Their impacts on consumption behavior are different: "permanent" news may impose structural breaks in consumption behavior, whereas "temporary" news have short-run behavioral impacts and can be captured within the model structure.

Having made this distinction, the demand function can be respecified: Equation 2 where $I_T$ represents "temporary informational uncertainty" and $I_P$ represents "permanent informational uncertainty". Equation (2) provides the theoretical basis for the empirical analyses below.

$$X_1 = f(y, p_1, p_2, I_T, I_P)$$

4. Proposition: Mathematical expressions of Grey and Fuzzy Information

Based on the fundamental formula ([1]) of informational utility we will try present the mathematical expressions of grey and fuzzy information.

By a piece of tidings, we mean the totality of a special form of objective motions. It is an objective entity, which reduces human’s level of ignorance. For example, a piece of tidings can make a person be aware of a certain thing from the previous state of being unaware of the matter. The statement that "x is a rational number" is a piece of tidings, which improves our knowledge about the number x to a more detailed level: x is not only a number, but also a rational number.

In our informational world, it is often necessary for one to consider many pieces of tidings at the same time. That is, new pieces of tidings can be obtained by operations of known tidings. For example, if from the tidings A, one will naturally obtain tidings B, then A is called sub-tidings of B, written $A \subseteq B$. If $A \subseteq B$ and $B \subseteq A$, then the tidings A and B are said to be equivalent and written as $A = B$. As in the formal logic, if A and B are two pieces of tidings, then $A \cup B$, $A \cap B$, $\bar{A}$ and $A - B$ can be introduced. Here, for example, $A \cup \bar{A}$ means no tidings and $A \cap \bar{A}$ stands for a piece of contradictory tidings.

Let the lower case letters $x$, $y$, $z$,... stand for unknowns and A be a piece of tidings. We write $A \Delta x$ to represent the case that the tidings A can make people know the value of the unknown $x$. Otherwise, $A$ will be called a piece of unrelated tidings of $x$, written as $A \nabla x$.

Let’s assume that $x$ is an unknown, $U$ a piece of tidings, and $S$ a set of the Cantor type (Kuratowski and Mostowsiki, 1976). If the tidings U makes one realize that $x$ belongs to $S$, then U is called $x$-position tidings. Each piece of tidings $A \subseteq U$ is called information regarding the position tidings U or just information for short. The totality of all information of U is called an informational hierarchy. For example, we a marketing manager can classify ages of consumers as follows: consumers in the age group 18-25 are young, in the groups of 17-18 and 25-28 are semi-young, otherwise, not young. Now, let S be the set of all real numbers, U the statement that "x is in S", and A defined as "x is a young person". Then, $A \subseteq U$ and A is a piece of information.

If $A$ is a piece of information of a position tidings, then the inverse information, written $A^{-1}$, of $A$ is defined as: $A^{-1} = U - A$. 

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For example, if \( A \) is defined as "\( x \) is a rational number" as in the previous example, then \( A^\perp = U \setminus A \) stands for "\( x \) is a real, but not a rational number".

Now we can classify the concept of information for consumer markets at least as follows: grey information and fuzzy information.

The so-called grey information is defined as follows: let \( x \) be an unknown, \( S \neq \emptyset \) a set, \( S' \) a subset of \( S \), \( U = \{x \in S \} \) and \( A = \{x \in S' \} \). Since \( A \) implies \( U \), \( A \) is a piece of information, called a piece of grey information. For example, let \( S = \mathbb{R} \), the set of all reals, and \( S' = [2, 3] \). Then, the grey information \( A \) tells the following fact: \( x \) belongs to the interval \([2, 3] \). That is, \( A \) tells the range of the unknown \( x \) without further specifics.

If for an unknown \( x \) and a non-empty set \( S \), \( U = \{x \in S \} \) and \( A = \{x \in S' \} \) and the degree of membership for \( x = e \in S \) is \( a_e \), \( 0 \leq a_e \leq 1 \), then \( A \) is a piece of information of the position tidings \( U \), called a piece of fuzzy information. To see why \( A \) is a piece of fuzzy information, one can:

- Assume that the non-empty set \( S \) is the universal set of a study. Then, the information \( A \) defines a membership function: \( \mu_A : S \rightarrow [0, 1] \) with \( \mu_A(e) = a_e \).

This end proves that our definition of fuzzy information coincides with that of fuzzy sets (Zadeh, 1965; Klir and Folger, 1988).

- Assume that the non-empty set \( S \) is \( p(X) \), the power set of the universal set \( X \). Then, the information \( A \) defines a fuzzy measure (Sugeno, 1977; Klir and Folger, 1988) as follows: \( \mu_A : S = p(X) \rightarrow [0, 1] \) with \( \mu_A(e) = a_e \).

Similarly, the concept of measures of fuzziness is also a special case of our concept of fuzzy information (Knopfmacher, 1975; Loo, 1977).

Now, let us go back to our concept of fuzzy information. If for any \( e \in S \), \( a_e = 1 \) or 0, then \( A \) is called a piece of ascertained or white information. We should see the difference between the concepts of stochastic and unascertained information and that of fuzzy information. The former deals with the possibility \( a_e \) for "\( x = e \in S \)" while the later with the degree \( a_e \) of membership "for \( x = e \in S \)". Even though the two cases read roughly the same, they are fundamentally different, since the degree \( a_e \) of the membership \( e \in S \) implies that \( a_e \) portion of the element \( e \) belongs to \( S \), which is not limited by the condition \( \Sigma_{e \in S} a_e \leq 1 \), while the possibility \( a_e \) for \( x = e \in S \) only tells the possibility for \( x \) to be in \( S \) without any guarantee. For example, even though we may know that the possibility for the outcome \( x \) to occur is 0.99 when a specific experiment is conducted, it does not mean that when the experiment is conducted, 99 percent of the possible outcome \( x \) will surely happen.

5. Discussion:
In general, marketing is an area, which is not well understood and can be characterized as involving high uncertainty, loose casual structure and incomplete and dispersed knowledge (Wilson and McDonald, 1994). The exploration of international marketing activity on the Internet and the associated emergence of the global information superhighway have a profound effect on the conduct of international business in the new millennium. Levy and Yoon (1995) introduced a model for global market entry decision by using fuzzy logic, while Li (2000a, b) developed a hybrid intelligent system for developing marketing strategy.

In 2001, Li and Davies (2001) produced a new intelligent hybrid system, called GloStra for developing global marketing strategy and associated Internet marketing strategy. This system is constructed to integrate the strengths of expert systems, fuzzy logic and artificial neural networks. Its knowledge base contains fuzzy rules and facts for intelligent reasoning. Two strategic analysis models are stored in this knowledge base in a transformed form of fuzzy
On the other hand, Moscato (1996) proposed an approach for the application of fuzzy logic to budgeting, while in 1998 he presented a risk analysis methodology using fuzzy logic (Moscato, 1998). With this methodology the analyst is able to have his beliefs of differing loss values reflected, via belief graphs, in the total risk analysis. In addition, Kuo and Xue (1998) developed a DSS for sales forecasting by combining fuzzy logic and artificial neural network technologies and Paliwal et al. (1999) proposed a fuzzy logic-based hedonic model to determine the revealed willingness to pay for landmass of different suitability classes, based on landmass functional characteristics obtained through subjective assessments. Byrne (1995) studied the application of fuzzy logic in real estate analysis and Friedlob and Schleifer (1999) presented the application of fuzzy logic for audit risk.

According to the top three "gold" priorities for academic research in Marketing (see Marketing Sciences Institute), the present work aims to express, mathematically, consumers' information uncertainties. This research try is focused on the case of classifying consumers' informational uncertainties, in terms of information risk management systems. Our intention is to stress the need of incorporation of marketing analytics in the day-to-day decisions of marketers. This means that accountability in marketing activities prerequisites a new way of thinking and acting. A significant part of this "new way" is related to the skills and knowledge of marketers to work with mathematical calculations and approach the inputs of these mathematical frameworks as data and not as information. So, truly marketing analytics, as a concept that stresses accountability in marketing activities, should be approached as an issue of culture. In such a direction concepts from mathematics can contribute significantly to the accountability of the marketing decisions.

**5.1. Implications for Practitioners**

Fuzzy marketing budgeting, put simplistically, is to use fuzzy versions of the neo-classical capital budgeting methods and real option valuation. It needs to be observed that the fuzzy versions of the methods are original constructions, and not fuzzifications of the existing methods. This means that the mathematics is that of possibility, not of probability. It is not in the interest of this paper to elaborate further on fuzzy logic and possibility mathematics, we suggest the reader looks at Zadeh (1965), Dubois and Prade (1988), and Carlsson and Fuller (2002), for further reference on these issues.

To elaborate on what fuzzy mathematics can add to marketing budgeting, the thing that springs first to mind is the intuitive way of a marketing manager to think about future cash flow estimates of a marketing program. Intuitively when asked to estimate such a cash flow the answer is often an interval. For example, "The marketing program will produce a cash flow between 100,000€ and 120,000€, in three years from now". This is a fuzzy statement, and includes the intuition of the marketing manager about the real uncertainty of the marketing program, as he/she sees it. If the manager giving the statement is the best expert around, then the statement is the best available estimate of the future cash flow. With fuzzy capital budgeting methods these estimates can be used as they are, without having to typify them into one number, as is done with the more common approaches. It is evident that as the uncertainty, as understood by the marketing manager, is included in the estimate and carried directly into the profitability calculation, there is no loss of information, and the picture given is not that of exaggerated precision. Most of the commonly used capital budgeting methods have their fuzzy counterpart, for example Buckley (1987) and Kuchta (2000). There is also fuzzy real option valuation models built in (Carlsson and Fuller, 2000).
The following formula, based on the original formula presented in Black and Scholes (1973) and extended in Merton (1973), for computing fuzzy real option values is suggested in Carlsson and Fullér (2000): (see equation I), where: (see equation II), (see equation III) $E(S_0)$ denotes the possibilistic mean value of the present value of expected cash flows, $E(X)$ stands for the possibilistic mean value of expected costs and $(S_0)$ is the possibilistic variance of the present value of expected cash flows.

$$C_0 = \hat{S}e^{-rT}N(d_1) - Xe^{-rT}N(d_2), \quad \text{[I]}$$

$$d_1 = \frac{[\ln(E(S_0)/E(X)) + (r + \delta + \sigma^2/2)T]}{\sigma\sqrt{T}} \quad \text{[II]}$$

$$d_2 = d_1 - \sigma\sqrt{T}. \quad \text{[III]}$$

In addition to including more representative estimates for future cash flows into mathematically correct constructions of marketing budgeting methods, fuzzy numbers give a possibility to include qualitative information into the budgeting process, in a very straightforward way. The fuzzy sets presenting the cash flow estimates can be adjusted dynamically to reflect the future trends that are revealed by a foresight process, and are in a qualitative form. A simplistic method to achieve this is presented in Collan and Majlender (2000). In the method, market analysts to reflect the information about the future adjust sides of fuzzy cash flow estimates.

Finally, we would like to stress that advanced marketing decision methods such as future consuming patterns trends open the chance to explore the value of flexibility inside and outside a marketing program and give further insight into the real uncertainty of large investments. As they offer both a framework and tools to assess the possibilities and the risk that projects carry, it makes sense to take full use of them, and pursue the (pro-)active management of investments with them.

**5.2. Future Research Tries**

Based on the wise research priorities, as Marketing Sciences Institute have stated them, we believe that future research tries must be focused on the development of mathematical frameworks for a series of decisions in all marketing activities, in order to achieve higher levels of accountability. A strong research implication is related to the establishment of marketing analytics as a culture. So research propositions, especially from the field of marketing education, will contribute significantly to the promotion of scientific knowledge and the empowerment of marketing performance.
6. References List:
34. Matthews, V. (2002) Have fun but forget the boardroom. The Times (June) 12, 28.