

FUZZY MODEL OF RELATIONSHIP AMONG ECONOMIC PERFORMANCE, COMPETITIVENESS AND BUSINESS ETHICS OF SMALL AND MEDIUM-SIZED ENTERPRISES

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Abstract

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The objective of this article is to study the relations among financial indicators, competitiveness and business ethics of comparable small and medium-sized enterprises. A sample of 59 SMEs from the South Moravia region was chosen. All selected companies either produce or service electronics. This research is based on the application of scientific analysis, synthesis, induction, fuzzy logic and modeling. Information for this research was obtained from secondary information sources – Amadeus database, accounting statements and information from the register of companies. Each company is described by a set of 10 variables. Fuzzy sets and reasoning are ideal tools to cope with vague, ill-structured and uncertain scenarios which can be found frequently in business and economics. This is the main reason why fuzzy logic was used in this research. The paper is self-explanatory and no a prior knowledge of fuzzy reasoning is required.

SMEs, performance, business ethics, discrimination, fuzzy logic, competitiveness

This paper discusses the relation among business ethics and the economic performance of a business enterprise. Several scientific studies have been conducted in the past to research this relationship but these studies focused on Great Britain and the USA. In the Czech Republic this relationship is researched by several authors including (Koráb, 1998; Markesová *et al.*, 2003). Their research focuses mainly on small to medium sized enterprises. Results of these past studies indicate that there is a positive correlation between business ethics and economic performance to a certain degree. If moral principles are not ignored by the managers and employees the business company has better results.

Ethical issues are very complex and the relationship among business ethics, economy and competitiveness are very vague, inconsistent and also difficult to observe and measure. Ethical phenomena, relationships and interdependencies which characterize the ethical behaviour

of businesses, economic performance and competitiveness on the market are very special and unique. It is difficult to analyse the business ethics with classical mathematical and statistical methods, the results are often not reliable or inconclusive.

As a suitable data and knowledge mining calculus to integrate this type of knowledge, expert systems could be used. Expert systems represent different algorithms developed as results of some artificial intelligence activities. One type of expert systems is based on some kind of fuzzy logic. To apply fuzzy logic, which can be used successfully to solve a broad spectrum of problems, it is necessary to formalize the obtained knowledge and then input it into expert systems (Zimmermann, 1991).

This paper presents findings of a research aimed at the identification of factors that positively influence the competitiveness of small to medium-sized enterprises manufacturing or servicing electronics in the South Moravia.

This topic is very relevant and important because it is closely related to the national strategy of international competitiveness of the Czech Republic for years 2012–2020. The objective of this strategy is to get the Czech Republic into a group of twenty world's most competitive countries.

Majority of scientific studies agree that the small and medium-sized enterprises (SMEs) have a great influence on the overall economic performance of whole countries and job creations. According to the study conducted by the EU about 85% of new jobs were created thanks to SMEs however the total share of jobs in SMEs is only 67%. The conclusion is that SMEs create more jobs than any other type of business. Each year about 1.1 million of new jobs are created (Business Info [online] 16. 01. 2012 [cit. 2012-01-15]).

In the Czech Republic 99.84% of all businesses are SMEs. The total output of SMEs in 2010 was 3 996 314 million CZK which is more than in 2009 by 102 305 million. The total share on GDP was 51.24% in 2010. A slight decrease of 1.47% can be observed when compared to 2009 (MPO [online] 12. 07. 2011 [cit. 2012-02-12]).

European-wide survey about female entrepreneurship and the current eurobarometer survey contain more information items about management of businesses broken down by gender. The objective is to obtain information on economic sectors in which women entrepreneurs operate with a special focus on science and technology. A focus group with women innovators, entrepreneurs and stakeholders dealing with innovation policy and female entrepreneurship should be organized at European level in order to explore possible ways of dealing with the gender gap in a joined up way. The findings from the focus group should be disseminated to all stakeholders at national and European level (European Commission [online] 25. 07. 2008 [cit. 2011-04-28]).

Medium-sized enterprise is defined by (Czechinvest.org [online]. 15. 11. 2010 [cit. 2011-03-08]) as a business employing either less than 250 employees or its equity are not higher than the equivalent of 43 million EUR and the total turnover does not exceed 50 million EUR. Small enterprise employs less than 50 employees or its equity does not exceed 10 million EUR. The number of employees, information about equity and turnover are determined from the accounting statements.

Competitiveness is defined by the OECD as an ability and performance of a firm to sell and supply goods or services in a given market. Competitiveness can also describe a method in which a state creates the environment which promotes the competitiveness of business enterprises (Skokan, 2004). Competitiveness is closely related to competitive advantage. Competitive advantage is defined by (Porter, 1994) as a strategic advantage one business entity has over its rival entities within its competitive industry. The advantage is created by the value that the business is able to produce

for its customers. The value is higher than the costs required. Value and price of competing products is compared by the customer.

The basics of fuzzy sets and fuzzy modeling are described in (Zimmermann, 1991). Research conducted by Markesová, Dohnal and Putnová in 2003 shows that it is possible to apply fuzzy logic to predict the financial and economic performance of businesses based on a set of parameters. Methods of artificial intelligence and in particular fuzzy modeling can be used as a powerful tool for solving problems where information is vague, ill-structured or uncertain.

According to (Jenkins, 2006) it is possible to improve competitiveness through Corporate Social Responsibility (CSR). Research conducted in the Great Britain shows that small enterprises can implement methods and results of CSR from large corporations. Fuzzy logic allows the identification of interesting possibilities for business cooperation.

Dissertation by (Koráb, 1998) defines a set of variables for evaluation of financial stability of SMEs. This set of variables was created for banking institutions so they could more easily decide which requests for credit should be approved. Variables describing the financial situation of the business were used for the prediction of bankruptcy risk score.

Markesová (2003) used the qualitative modeling and fuzzy logic for analysis of the relation between financial situation and business ethics. The conclusions of this research indicate that the ethical behavior of business enterprises has a long-term positive effect on their economic performance. Managers of the Czech companies analyzed in this research were mostly not aware that their ethical behavior is one of the ways to secure long-term competitiveness of their businesses. According to (Kožená, 2004) the combination of strategic and tactical measures undertaken to create and secure a competitive advantage is a way to be competitive. The internal and external aspects of competitiveness cannot be separated, they have to be analyzed and evaluated together.

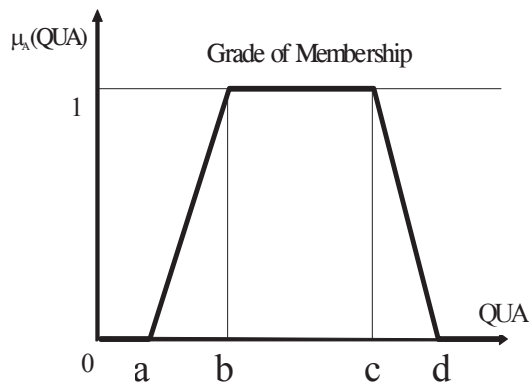
OBJECTIVES AND METHODS

This chapter describes the research objectives and methods used to reach these objectives. The objective of this paper is to research the relations between financial indicators, competitiveness and business ethics. The research is conducted on a sample of 59 comparable small and medium-sized enterprises from the South Moravia region. Selected companies either produce or service electronics. Scientific analysis, synthesis, induction, fuzzy logic and modeling are the scientific methods used in this research. Information for this research comes from secondary information sources – Amadeus database, accounting statements and information from the register of companies. Ethical problems are very complex. Knowledge of ethics and its relations

with economics are vague, inconsistent, partially subjective and sparse. Indeed, ethical phenomena, relations and dependencies which characterize ethical behaviour of companies and their financial performance are quite particular and unique; this makes the application of traditional mathematical and statistical methods in their study very difficult, if not impossible, and little reliable.

The theory of fuzzy sets is based on the premise that the key elements of human thinking are not numbers but words. The most important feature of human thinking is the not yet wellunderstood ability of human brain to extract from a large amount of data sets only such items of knowledge which are relevant to the task at hand. The theory of fuzzy sets allows the existence of a type of uncertainty due to vagueness or fuzziness rather than due to mere randomness. In its most basic sense, a fuzzy set is a set where objects have gradual rather than abrupt transition from membership to nonmembership.

A verbal value is a "value" that is given by words, e.g. high, low. The variable Profitability of equity, chosen by us among others to characterize the present state of SMEs, could be described by the following set of verbal values (i.e. dictionary): Unknown, low, medium, high and very high. Each verbal value is then transformed into a fuzzy set by the grade-of-membership function given in Fig. 1. It is necessary to specify the grade of membership of all sets. The numerical values corresponding to points a , b , c and d are established by a team of experts.



1: Grade of membership in a fuzzy set Medium POE

For example, a typical medium (M) POE (Profitability of Equity) is:

$$b < \text{POE} < c. \quad (1)$$

The grade of membership of POE to the fuzzy set M is

$$\mu_M(\text{POE}); \text{POE} \in U, \quad (2)$$

where U is the universe of the POE variable. The values of POE described in (1) belong to the fuzzy set medium POE fully, i.e. their grade of membership

equals to 1. Therefore they are typical medium POE. Then there are two fuzzy intervals, namely:

$$a < \text{POE} < b; c < \text{POE} < d. \quad (3)$$

These intervals represent POE numerical values which belong to the fuzzy set medium POE partially. A fuzzy model is a set of conditional statements:

$$\begin{aligned} &\text{if } A_{1,1} \text{ and } \dots \text{ and } A_{1,n} \text{ then } B_1 \text{ or} \\ &\text{if } A_{2,1} \text{ and } \dots \text{ and } A_{2,n} \text{ then } B_2 \text{ or} \\ &\dots \\ &\dots \\ &\text{if } A_{m,1} \text{ and } \dots \text{ and } A_{m,n} \text{ then } B_m, \end{aligned} \quad (4)$$

where fuzzy sets

$$A_{i,j}, B_i; i = 1, 2, \dots, m \quad j = 1, 2, \dots, n \quad (5)$$

are onedimensional fuzzy sets and can be easily specified or/and modified using points a, b, c, d (see Fig. 1) for each set. A onedimensional fuzzy set R is an answer to a given (chosen) n -dimensional fuzzy query Q :

$$Q = Q_1 \text{ and } Q_2 \text{ and } \dots \text{ and } Q_n, \quad (6)$$

where Q_i is a one-dimensional fuzzy set. The similarity s of two n -dimensional fuzzy sets V, W is

$$s(n, V, W) = \min_{1 \leq j \leq n} \{ \max_{X_j} [\min [\mu_{V_j}(X_j) \mu_{W_j}(X_j)]] \}, \quad (7)$$

where $\mu_{V_j}(X_j)$ is the grade of membership of X_j in the set V_j and n is the dimensionality (see (4)). The i -th statement is activated by the n -dimensional fuzzy query Q (6) if the fuzzy set r_i

$$r_i = A_{i,1} \text{ and } A_{i,2} \dots \text{ and } A_{i,n} \quad (8)$$

and Q are fuzzy similar (see (7)):

$$s(n, Q, r_i) > 0. \quad (9)$$

Set $w(Q)$ of those statements which are activated by the query Q is:

$$w(Q) = \{ i \mid s(n, r_i, Q) > 0 \}. \quad (10)$$

Answer R of fuzzy model (4) to query (6) is the following fuzzy union of B sets (see (4))

$$R = \bigcup_{i \in w(Q)} B_i. \quad (11)$$

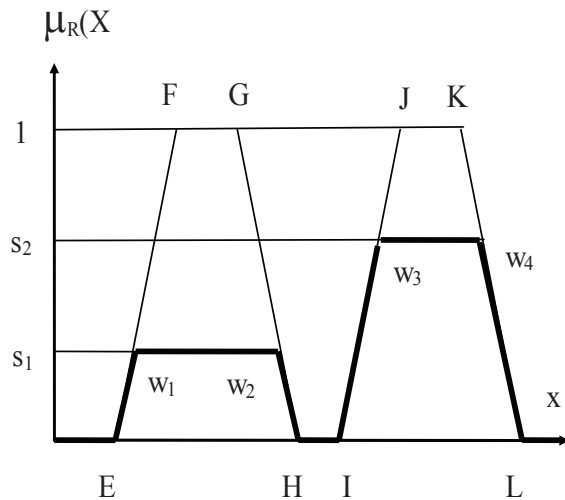
Let us suppose that only two statements out of m statements (4) are activated by query Q . To be specific, let the first and the second statements be activated. Therefore, see (10),

$$w(Q) = \{ 1, 2 \}. \quad (12)$$

Let the similarities s (9) be

$$s_1 = s(n, r_1, Q) = 0.2; \quad s_2 = s(n, r_2, Q) = 0.7 \quad (13)$$

Let $B_1(Y)$ be EFGH and $B_2(Y)$ be IJKL. The fuzzy “answer” R (11) of the model (4) is represented by the fuzzy set $EW_1W_2HIW_3W_4L$ (Fig. 2).



2: Comparison of two fuzzy sets EFGH and IJKL

The numerical representation is the centre of gravity C_G of the corresponding area (see Fig. 2)

$$C_G(EW_1W_2HIW_3W_4L). \quad (14)$$

Two fuzzy “sub sets” B_1 (EFGH) and B_2 (IJKL) represent the level of knowledge inconsistency. If the interval HI is too broad, then the fuzzy answer gives a clear signal that the statements 1 and 2 (see (4)) are unacceptably inconsistent. This inconsistency level is amplified if the absolute values of similarities s_1 and s_2 are high and their difference is not too significant. There are many different fuzzy reasoning algorithms. However, the most important feature of an algorithm is its transparency and simplicity. Some simple algorithms are described in (Dubois, 1991).

Fuzzy expert system requires definitions of the set of conditional statements, see (4). With reference to our SME problems, e.g. the influence of ethical

behaviour on companies’ financial performance, the following relevant variables were identified:

Financial indicators and variables

- Profitability of equity (POE)
- Liquidity (LIQ)
- Payment morale (PAY)
- Total liabilities (TLI).

Variables related to business ethics

- Number of employees (NUE)
- History (HIS)
- Changes ownership structure (COS)
- Discrimination against women (DAW).

Market related variables

- Competitive environment (COE)
- Sector conjuncture (SEC).

Profitability of equity is a term denoting a fraction of absolute profit per a single unit of equity. Liquidity is a degree to which an asset or security can be bought or sold in the market to cover liabilities. Payment morale variable in the designed model characterizes the ability to pay liabilities before due date. Variable called total liabilities records the amount of liabilities from the balance sheet.

Next group are variables related to business ethics. Number of employees records the average number of employees during the observed period. It was necessary to record the total number of employees because it would be too vague to divide firms only between small and medium-sized enterprises. Firms with fewer than 10 employees were excluded from the set of selected firms. Variable called history records the number of years for which the firm was active since its founding. Changes ownership structure records the total number of major changes in the ownership structure of the firm. Variable called discrimination observes if there are women in the management of the company. Market related variables include two variables. Competitive environment variable tells us if a firm is in a sector which is highly competitive. Sector conjuncture

I: Sample of input variables

Identification number	4	5	6	7	8	9
Profitability of equity	0.041	0.1388	0.0192	0.5356	0.0532	-0.0454
Liquidity	5.4318	1.6274	1.6196	16.9015	0.42	16.8225
Payment morale	0	0	0	0	2.8	127
Total liabilities (in thousands of CZK)	11 127	51 874	17 266	1 730	44 798	3 512
Number of employees	78	67	21	21	51	34
History	12	20	13	11	18	15
Changes ownership structure	n.a	0	3	1	2	n.a
Discrimination	0.6	0	0	0	0	0
Competitive environment	2	2	4	2	2	2
Sector conjuncture	H	H	L	H	L	H

Source: own work

variable contains information about the past development on the market.

Every variable has to be characterized by a set of verbal values i.e. by the relevant dictionary. As an example, the POE dictionary is presented by five values. To simplify the presentation all values are normalised, it means that the scale 0–1 is used. A numerical value 0.2 is interpreted as Low. The reason is given in the following table where max and min values for each verbal values are given:

II: Individual fuzzy sets of the POE variable

Interpretation	Minimum	Maximum
Unknown	0	1
Low	0	0.3
Medium	0.3	0.5
High	0.5	0.8
Very High	0.8	1

Source: own work

Nine variables were described by 5 verbal values: Unknown, Low, Medium, High and Very High. One variable (SEC) was described by 2 verbal values: Low and High. Next step in the creation of the fuzzy model is the definition of a fuzzy set for every value from each dictionary. Each verbal quantifier is attributed an interval of numerical values (i.e. a fuzzy set). This is done by a team of experts.

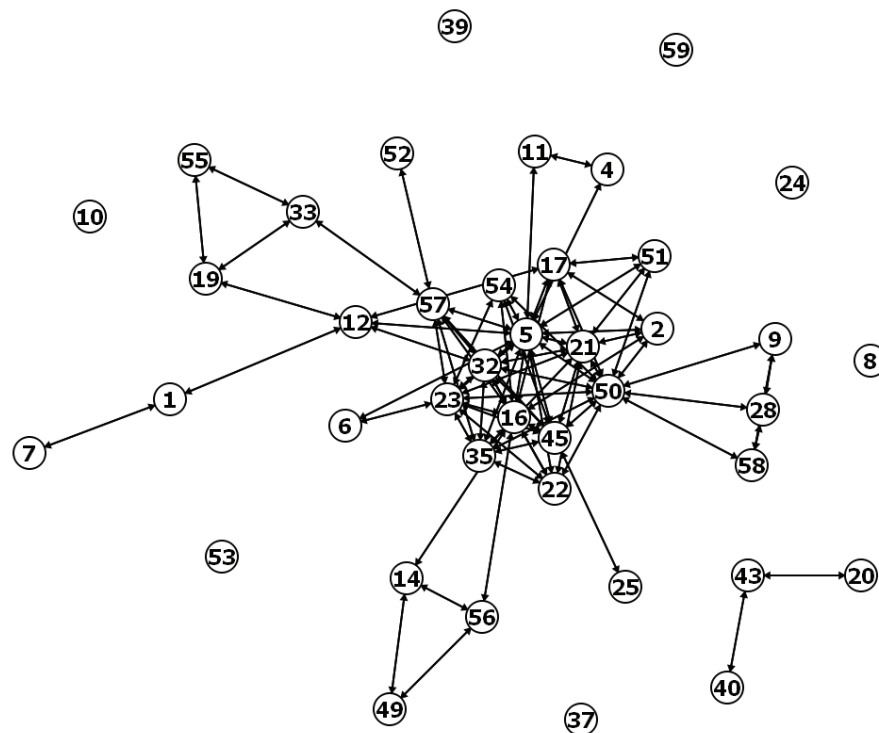
Each firm is described by a set of 10 variables. The resulting knowledge base (4) is a table with 10 columns and so many rows as there are

studied companies. The individual variables have a different importance in the model. The weight of the individual variables is defined by experts. Before the fuzzy model can be used in the real world it is necessary to perform thorough testing. The consistency of the knowledge base and the reliability of the fuzzy model have to be tested. Each individual statement has to be consistent with the remaining statements of the knowledge base. It is very positive if there are many consistent statements in the knowledge base. Expert system does not output results based on a single statement but rather on a group of similar statements. If the model does not pass the testing phase whole procedure has to be repeated. The expert knowledge which is entered into the model is rarely inconsistent.

Fuzzy models can be gradually extended with new expert knowledge. New knowledge can be entered with the trial and error method until the new knowledge base is consistent again. It is the effectiveness with which uncertain knowledge is used, which is very often the main distinction between good and bad models of the same state or process.

RESULTS AND DISCUSSION

The output of the fuzzy model is a file describing the measure of similarity between the individual items of the knowledge base (firms). This file can be visually interpreted as a similarity graph shown at Fig. 3. After performing the test of consistency a comparison of indicators was made in order to



3: Resulting similarities and clusters

find out what kind of correlation exists between the variables. Following hypothesis is tested. If a firm performs well economically and financially, has a long history, does not have large changes in the ownership structure and behaves ethically both to own employees and also to competitors then following statement should be true. If POE = very high; PAM = low; COS = low then the hypothesis is correct.

Consistent fuzzy models can be used for prediction of economic performance and also for estimation of the ability to compete on the market. These predictions can be entered into the fuzzy expert system as queries. When these fuzzy queries are created it is necessary to establish which variables will be dependent and which will be independent. If this cannot be decided a then variable value unknown is used. This means that this value includes whole fuzzy set from low to very high.

Fuzzy model can then generate the requested answers from the knowledge base. There are several atypical companies identified by the oriented graph, see Fig. 3. One of them will be used as an example and described in details. The company was incorporated as a Ltd. 11 years ago. The ownership was changed just once during its history. Two owners sold their shares to a stock company and stayed as managing directors. The company is active in development and manufacturing of electronic speed meters. The company is profitable in the long-term and expands its activity into European Union. It got the ISO 9001:2009 in 2010. It employs approximately 20 employees and pays attention to long-term education of its employees via a motivation program. The company has no debts and state authorities have not discovered any problems. This company was evaluated as follows: POE = high, LIQ = very high, PAY = low, TLI = low, NUE = medium, HIS = very high, COS = medium, DAW = low, COE = high, SEC = low.

This evaluation indicates that the company is stable, liquid, behaving ethically to its employees and its environment i.e. state authorities, suppliers. This makes the company rather atypical and the evaluation result can be interpreted that the company has definitely competitive advantages.

The cluster of companies 2, 5 16, 17, 21, 22, 23, 32, 35, 45, 50, 51, 54, 57, see Fig. 3 consists of companies which have in average, the following evaluations: POE = low, LIQ = medium, TLI = low or medium, HIS = very high, COS = low or medium, DAW = low, COE = medium, SEC = low or high, PAY = very broad spectrum of fuzzy values covering nearly all values in the dictionary, NUE = very broad spectrum

of fuzzy values covering nearly all values in the dictionary. This fuzzy description can be briefly characterised as companies with high debts but liquid, active 10 and more years on the markets and active in manufacturing. However, additional research is required to discover if the company has some marketing advantages.

The cluster of companies 4 and 11 represents companies which have the following values that are identical: POE = low, LIQ = low, TLI = high, NUE = high, HIS = very high, COS = high, SEC = high. Both companies are active on the market of planar desks. They are medium-sized companies and are of approximately of the same age. Both are located outside of the main centre of the studied region and both were hit by the 2008–2009 crises. But both were able to recover and achieve some profit during 2010. The companies invested into machinery and managed to expand the spectrum of their products in spite of the decrease of income due to the crisis. High quality standards are kept from their incorporation. Both companies participate in European Union projects. The company No. 4 took part in the ecological project – Minimization and Decontamination of Industrial Waste Water.

Fuzzy expert system delivered consistent results and its graphical interpretation makes it easy and user friendly to see the mutual company similarities which can be accompanied by verbal description. When thinking about business ethics the payment morale is currently not very good but the firm has good liquidity, long history and it is in a sector which is growing faster than other sectors. It safe to assume, that the firm will achieve better results in the future.

When considering the limitations and implications of this research following conclusions can be made. The application of fuzzy model makes it possible to predict the future development to a certain degree. Although the answers received from the fuzzy model are sometimes not consistent. For example many statements can have the value low but the center of gravity can be the value medium. Correct interpretation of results in this case is the task of the user of the fuzzy model. If a conflict is detected in the knowledge base it is possible to continue the fuzzy dialogue with a different fuzzy query. Application of fuzzy modeling in economics is a very progressive method which allows to estimate and even to predict the financial stability and performance of a business company. This method is also useful for investors who are determining the suitability of the investment alternatives. And also banks can use it to determine which applications should receive credit.

SUMMARY

The results of this research indicate that even small and medium-sized enterprises just like larger enterprises perform better and are more competitive if they did not have many changes in the ownership structure and ethical principles are important for the management. The results of the study (Jenkins, 2006) were confirmed. If there are positive relationships between the management, employees and external environment the firm has a foundation it needs for growth and success. Performance of SMEs in this study ranges from medium to very high and profit per employee for some companies is very high (exceeding hundreds of thousands of CZK per single employee). All of observed SMEs fulfill the prerequisites for applying business ethics Putnová *et al.* (2011). Ethical behavior inside a company is positive for the investors, satisfies suppliers and customers and also motivates employees.

Fuzzy logic is an efficient tool for work with information which is vague, uncertain, ill-structured or incomplete. This paper confirms the conclusions published by Markesová *et al.* (2003) – the results of the fuzzy model are dependent on the quality of the information entered into the fuzzy expert system. The fuzzy model does not allow users to gain information which is not present in the input data but makes visible the information and relationships that would remain hidden when other methods are used. The designed fuzzy model cannot be used for other firms with different focus and conditions without the modification of the set of variables. The methods based on the application of fuzzy logic in economics are progressive and allow the analysis of relationships and correlations in areas where precise information is not available.

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