ALGORITHM APPLIED IN THE PRIORITISATION OF THE STAKEHOLDERS

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Abstract: According to scientific studies, relationships with all stakeholders and addressing all issues related to sustainability in business is neither possible nor desirable. The company should seek to establish an order of priorities for the stakeholders and issues to ensure good management of time, resources and expectations. Based on Stakeholder Theory we discuss the importance of management with stakeholders in the pursuit of sustainability in enterprises. In this paper we will focus our research on the prioritisation of the stakeholders through an analysis of an empirical study by a consulting firm in Brazil. In this case, the company needs to establish priorities for its stakeholders. To achieve this objective, the consultant hired has used fuzzy logic algorithm, applying the P-Latin Composition. To complete the study, we present the contributions, the empirical results and conclusions of our investigation.

1 INTRODUCTION

The stakeholder of a company is by definition any group or individual who can affect or is affected by the achievement of the objectives of the organisation (Freeman, 1984). There is a generic list of stakeholders from business, even for a single company, because they change over time (Mitchell, Agle and Wood, 1997). The groups and individuals affected and affecting businesses rely on the industry, business, geographic location and subject matter. The new business strategies and contextual changes often determine a new set of stakeholders.

Through the constructive engagement of stakeholders, companies can increase external confidence in its intentions and activities, helping to improve corporate reputation and catalyze the diffusion of more sustainable practices in the enterprise system in general (Elkington, 1998). The stakeholders of a firm are individuals and groups who contribute voluntarily or involuntarily, to its capacity and wealth creation activities and therefore, are potential beneficiaries and / or risk bearers (Post, Preston and Sachs, 2002). Interest groups cover a wide variety of stakeholders, including shareholders, employees, customers, local communities, government, NGOs, suppliers. The Stakeholder Theory predicts that sustainability should have a positive impact on financial results because companies benefit from address and balance the claims of the many key stakeholders (Freeman and Evan, 1990). Moreover, the continuing failure to address the concerns and expectations of the groups, ultimately, reduces the confidence of investors in company shares, which affect their cost of funds (weighted average cost of capital) and therefore, opportunities for profit (SAM and PWC, 2009).

To do sustainable business, companies must have good knowledge of all actors with influence in its sphere of activity. This identification of stakeholders is the first step. Once organizations have become aware of the various publics that interact with them, it is important to categorize in terms of expectations, problems, geographical areas, its impact on business activity and vice versa. The result of the identification and segmentation is called mapping stakeholders. To do a map involves identifying stakeholder expectations and influence of each. This helps establish priorities that meet, while allowing an overall view of other possible interactions between groups. Subsequently, companies must establish a hierarchy among them, in order to determine the relevance of their modes of interaction. According to scientific studies, engaging with all stakeholders or on all issues is neither

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possible nor desirable. This would go beyond any available resources, and at the same time make it very difficult to adequately respond to stakeholders, leading to frustration. Therefore, the enterprise should try and prioritise its stakeholders and issues to ensure that time, resources and expectations are well managed (Accountability, UNEP and Stakeholder Research Associates Canada, 2005).

Another item relevant to the topic relates to compliance with the GRI Guidelines for Sustainability Reporting and the requirements of European Standard SGE 21:2008. According to the GRI in subsection 4.15, the organization must submit the procedure for defining its stakeholder groups and for the determination of the groups involved and those not. In subsection 6.1.7, SGE 21:2008 states that organisations must develop a documented relationship with its stakeholders. This model includes criteria for identifying and classifying stakeholders, a methodology to detect their expectations and the establishment and prioritization of action plans and communication.

In this paper we will focus our research on the prioritisation of the stakeholders through an analysis of an empirical study by a consulting firm in Brazil. In this case, the contracting company has gone through the stages of identification and segmentation of stakeholders and needs to establish a priority order for stakeholders.

Because of the importance and complexity that is the prioritisation of the stakeholders for companies is essential to address the analysis with an approach based on complex systems and models that help entrepreneurs in making decisions. For these reasons, it is justified to analyze the prioritisation of the stakeholders using fuzzy logic algorithms, in this specific case; the consultancy contract has applied the P-Latin composition.

We believe that our contribution will serve to support future research on the application of algorithms to business sustainability, a field that has been only scarcely investigated.

2 METHODOLOGY

The Fuzzy Sets Theory (Zadeh, 1965) is a mathematical theory in the field of multivalent logics. Its origin is in the work done by Professor Lotfi A. Zadeh and is the starting point for a mathematical theory currently expanding in all scientific disciplines and built with the entire rigor that enables the treatment of subjectivity and / or uncertainty (Gil Lafuente, 2001).

At first, the Fuzzy Sets Theory has been applied in the field of formal science, but in the last 45 years, researchers around the world have published many papers and studies with applications in various fields. It should be noted, the pioneering and important contribution to science of the teachers Kaufmann and Gil Aluja who published the first book in the world dedicated exclusively to the processing of financial and management problems with the mathematics of uncertainty (Kaufmann and Gil Aluja, 1986). It included very diverse studies (investments, renewal of equipment, inventory management and product distribution).

Currently, the use of fuzzy logic takes place in practically every field of science studies. It is in the business management, engineering, biology, medicine, geology, sociology, phonetics, and even in music, among others. Every problem is located in the area of uncertainty is likely to be treated by the theory of fuzzy subsets and that as time passes it is becoming increasingly feasible to introduce in formal schemes, mechanisms of thinking, such as sensations and numeric views. To highlight the large potential of new operational techniques of management in relation to decision theory, Kaufmann and Gil Aluja (1991) proposed the method of the P–Latin composition.

The path is tackled that has as its starting out point the so-called Latin matrix. To follow this path, at least initially, we must resort to the matrix form. The use of adequate operators, mainly the maxmin convolution, leads to the method of the P-Latin composition. The requirement of a specific property (that of the elemental path) allows for the establishment of the enumeration of the elemental paths of a graph, which are, in themselves, an immediate source of order. The algorithm emanating from this does the rest (Gil Aluja, 1999).

According to (Gil Aluja, 1999), what is known as "the latin sequence of property P" or simply "P-Latin" is a finite sequence of vertices (a_1, a_2,…, a_n) which forms a path that possess a property P in the graph $G = (E, \Gamma)$. Let us assume two paths, one of longitude p and the other of longitude q, which possess property P and are represented respectively by the P-latin sequences:

$$s_1 = (a_1, a_2, \ldots, a_p, b) \quad (1)$$

$$s_2 = (c, d_1, d_2, \ldots, d_q) \quad (2)$$

We then consider a binary operation * such we that we arrive at:

$$s_1 * s_2 = (a_1, a_2, \ldots, a_p, b, d_1, d_2, \ldots, d_q) \quad (3)$$

if: b = c
and if: the sequence is P-latin.
=Ø,
if it is not.

With the object of enumerating the paths, we start out from the notion of latin matrix $[L]^1$, the elements of which are formed by the description of the latin letters corresponding to the row and column that define each element. By construction, this latin matrix $[L]^1$ enumerates the paths, obviously elemental in this case, of a longitude of 1. Likewise matrix $[L´]^1$ is defined as the previous matrix which has been deprived, to element of each box, of its respective initial letter. The composition $[L]^1$ o $[L´]^1$ provides $[L]^2$, which enumerates the elemental paths of a longitude of 2 when the property required, is that of an elemental path. By carrying out successive compositions we arrive at:

$$\begin{aligned} &[L]^2 \text{ o } [L´]^1 = [L]^3 \\ &[L]^3 \text{ o } [L´]^1 = [L]^4 \\ &\quad \ldots\ldots\ldots\ldots\ldots\ldots \\ &[L]^{r-1} \text{ o } [L´]^1 = [L]^r \end{aligned} \qquad (4)$$

This allows us to enumerate the elemental paths of a longitude of 1, 2,..., r, without omission or repetition. For this it is necessary that the fundamental relation is complied with.

$$s_1 * s_2 = s_1 . s´_2 \text{ , if } s_1 . s´_2 \qquad (5)$$

is an elemental path

=Ø, if the contrary is true.

We now move on to present the corresponding algorithm.

1) The latin matrix $[L]^1$ is constructed from the binary relations matrix, or associated arrow form graph.
2) Based on the latin matrix $[L]^1$ we arrive at the latin matrix amputated of its initials $[L´]^1$.
3) By means of the latin convolution of matrix $[L]^1$ and of the amputated matrix $[L´]^1$ the latin matrix $[L]^2$ is arrived at where property P is the "elemental path". The elemental paths arrived at are of a longitude of 2.
4) By means of the latin convolution of the latin matrix $[L]^2$ and $[L´]^1$ we arrive at matrix $[L]^3$ which gives us the elemental paths of a longitude of 3.
5) We continue in this way until arriving at $[L]^{r-1}$, r being the cardinal of the reference set E, as long as the latin matrix is not empty, in which case the process is halted.
6) We now find $[L]^r$ in order to verify the non-existence of circuits.

The P-Latin composition can be applied in management processes and provides a useful model in making decisions, for example, the prioritisation of the stakeholders into consideration criteria of sustainability in business.

3 THE PRIORITISATION OF THE STAKEHOLDERS

There are a range of frameworks, standards and codes, which organisations can draw on to provide guidance for the process of stakeholder engagement and which aim to improve the sustainability performance of the organisation (Accountability, UNEP and Stakeholder Research Associates Canada, 2005). These include the GRI Sustainability Reporting Guidelines (on reporting), SA8000 (on labour standards compliance), the AA1000 Series (on systematic accountability, including engagement), and the EFQM Excellence Model (on quality management). At the national level various bodies have issued guidance and standards on social responsibility, for example the SD21000 in France, SIGMA in the UK, AS8003 in Australia and Standard SI 10000 in Israel. At an international level, these will be complemented by the current ISO process to develop international guidance on social responsibility, in which stakeholder engagement will feature prominently. There are also a number of useful resources from organisations including The World Business Council for Sustainable Development, Business for Social Responsibility, CSR Europe, The Future 500 Initiative, the UK Environment Council, the South African Calabash Project, the Brazilian Institute Ethos, the Indian Development Alternatives Group and the International Association for Public Participation.

To establish priorities among the stakeholders is important to define the criteria for this process (Accountability, UNEP and Stakeholder Research Associates Canada, 2005). The level of influence, dependency or willingness to participate is good starting points, but you may need to use other criteria. According to the concept of impact and relevance to the company (Olcese, Rodríguez Ángel and Alfaro, 2008) could be established priorities in different types of stakeholders:

- Critics are those who, for example, have a key impact economic, strengthen the reputation or influence, or grant licenses or limited access or create the future of the sector.

- Basic: those with an average impact on business results, which may partially affect the reputation, but somehow affecting key processes in the company.
- Complementary: are those that have minimal economic impact, had little impact on the reputation and can provide complementary services or products.

4 FUZZY LOGIC APPLIED TO SUSTAINABILITY

In relation to the fuzzy logic applied to sustainability, the review of the literature, we find authors who have used it in many ways, as in models for analysing purchase decision in consumers of ecologic products (Gil Lafuente and Salgado Beltrán, 2005) and (Gil Lafuente, Salgado Beltrán, Subirá Lobera and Beltrán, 2006), in environmental principles applicable to green supplier evaluation by using multi-objective decision analysis (Lu, Wu and Kuo, 2007), in selection process elements that contribute to sustainable growth of the company (Barcellos Paula and Gil Lafuente, 2009a) and in applied algorithms in the sustainable management of human resources (Barcellos Paula and Gil Lafuente, 2009b). However, the application of fuzzy logic to sustainability in business, mainly addressing the prioritisation of stakeholders, yet has been little investigated.

In this context, the consultant hired has chosen to prioritize the stakeholders at the discretion of impact and relevance to the company. The aim is to establish a priority order for stakeholders by applying fuzzy logic through the P-Latin composition.

The methodology has the following advantages: it helps in making decisions in a changing environment, conflict and uncertainty, allows interaction between different stakeholders in finding a consensus among themselves on a specific topic, the analysis helps complex systems such as the prioritisation of stakeholders, provides flexibility to model various scenarios ongoing business, among others. The limitation of the methodology is given when we confirm the existence of a circuit that passes through all vertices. In this case, the evidence leads to the impossibility of establishing order.

5 THE EMPIRICAL STUDY

The empirical study was conducted in August 2009 by the Ideas and Solutions Consulting in Brazil. At the request of the contractor, the study data were treated with strict confidentiality. The company belongs to food industry and the objective is to establish a priority order for the following stakeholders: (a) governance, (b) NGOs, (c) local communities, (d) employees, and (e) suppliers. This will include a prioritisation of stakeholders to discuss the issue of CO_2 emissions reduction. Consulting convened a workshop that was attended by five heads of departments who know the stakeholders and subject matter. Once submitted to the directors of the company the subject and the list of stakeholder groups, we ask you to indicate your view with the scale [0,1], considering the impact and relevance criteria for the company, according to which , as the closer estimate 1, the greater the importance of one group over others on the topic under analysis.

The result (Kaufmann, 1987) is the matrix representing this rating. As with all fuzzy relationship, it's possible to treat their α-cuts. The company decided to perform the analysis level ($\alpha \geq 0.9$) which is considered a high level. As a result, we find the Boolean matrix [$S_{0.9}$] (figure 1).

$[S] =$

	a	b	c	d	e
a	0.7	0.8	0.9	0.8	0.6
b	0.9	0.8	0.8	0.8	0.7
c	0.8	0.8	0.9	0.6	0.9
d	1	0.7	0.8	0.7	0.7
e	0.7	0.9	0.8	0.8	0.8

$[S_{0.9}] =$

	a	b	c	d	e
a			1		
b	1				
c			1		1
d	1				
e		1			

Figure 1: Boolean matrix.

Starting out from matrix [$S_{0.9}$] we construct the latin matrix $[L]^1$. From the matrix $[L]^1$ we find the amputated matrix to the left $[L']^1$ (figure 2).

$[L]^1 =$

	a	b	c	d	e
a			ac		
b	ba				
c			cc		ce
d	da				
e		eb			

$[L']^1 =$

	a	b	c	d	e
a			c		
b	a				
c			c		e
d	a				
e		b			

Figure 2: Amputated matrix.

We do the latin convolution $[L]^1$ o $[L']^1$ and arrive at $[L]^2$. This matrix shows all combinations of factors that affect others in two phases and with a level of 0.9 (figure 3).

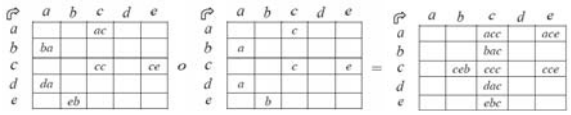

Figure 3: Latin convolution 2.

We now find the latin convolution $[L]^2$ o $[L']^1 = [L]^3$ (figure 4).

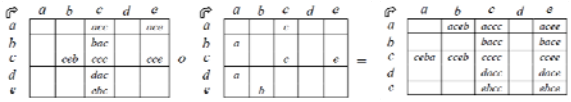

Figure 4: Latin convolution 3.

We then obtain the latin convolution $[L]^3$ o $[L']^1 = [L]^4$ (figure 5).

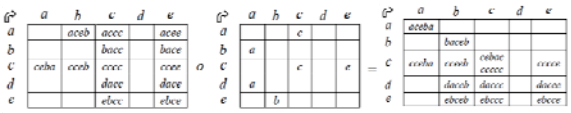

Figure 5: Latin convolution 4.

6 RESULTS

We note that the result found in the matrix $[L]^4$ exposes the presence of circuits. In this case, we stop the process in order to study the last latin matrix that is not empty, in our case $[L]^3$. In it we can see that there are four paths (figure 6):

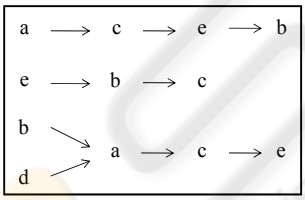

Figure 6: Four paths.

Which leads us to conclude that this is "partial order": (a) governance, (c) local communities, and (e) suppliers. The methodology allows for flexibility in the implementation of algorithms, since under the circumstances, valuations and criteria, valuations can change and consequently the result too.

7 CONCLUSIONS

The study about the stakeholder show that compared with the changes we are living is essential to find models that will help employers in making decisions, especially in an uncertain environment. Because of the importance and complexity that is the prioritization of the stakeholders for companies in our research we try to analyze these complex systems using fuzzy logic. In applying the model through empirical study has been possible to provide a tool based on the use of categorization algorithm that can facilitate decision making by obtaining qualitative data from a dialogue with managers or specialists on a particular topic. This is an innovation and a useful tool to be used in the process of prioritization of stakeholders. The result showed four possible solutions, being that it has demonstrated a strong prioritization (organisation) for the following groups: (a) governance, (c) local communities and (e) suppliers, respectively.

The article's main contribution is the application of algorithms in the prioritization of stakeholders considering sustainability criteria in enterprises, and providing a useful model in making decisions. We believe that our contribution will serve to support future research in the field of application of algorithms to business sustainability in general and particular aspects of it such as environmental management, economic and social, among many other approaches.

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