Paraconsistent Method of Prospective Scenarios (PMPS)

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Abstract: This work presents the Paraconsistent Method of Prospective Scenarios (PMPS) in order to support organizations in their strategic planning, being a useful tool, as it serves a noble task. The method is based on non-classical logic, called the Paraconsistent Annotated Evidential Logic Eτ (Logic Eτ), this logic is excelling in the fields of research and it's main characteristics are set by the thought of experts, generating input parameters and been consolidated by the collective way that translates into mathematical terms. Logic Eτ is not trivial and has the capacity to manipulate imprecise and conflicting information.

Keywords: Prospective Scenarios; Paraconsistent Annotated Evidential Logic Eτ; Method.

1 Introduction

This study aims to present the paraconsistent method of prospective scenarios, proposing a new way of constructing based on non-classical logic with technical and operational criteria, in such way that future studies can take the contradictions into consideration and can be not only reliable but also operationally efficient.

This method presents numerical output generated by the model, so that they are easily understood by the decision makers. It shows results of strategic topics between truth and falsehood, answering the following question: is it possible to develop future prospectives scenarios with conflicting and paracomplete data?

The paraconsistent method was developed with Paraconsistent Annotated Evidential Logic Eτ (Logic Eτ). The main advantages of using the Logic Eτ are due to the fact of the input parameters are set by the structure of the thinking of experts, consolidating a collective logic translated into mathematical terms.

2 Literature Review

Throughout history many philosophers incited debates about the future. The medieval philosopher Augustine of Hippo who lived between 354-430, also known as St. Augustine, approached the so-called "problem of time", he considered it impossible to forecast the future [1]. The nature link between past, present and future, according to Kant, makes the story to be deterministic [2]. Hegel states that "man's immediate action can contain something beyond what is in the will and consciousness of the author" [3] and also that "reason rules the world, and, therefore, the universal history is also a rational process" [3]. Philosophy, therefore, does not give us a definitive answer about the future.

Help companies make decisions in the present with eyes on the future is the large role of prospective scenarios. The reflection on how future situations can impact the production management is a way to prepare for the future.

Godet says that currently "the Futurists have exaggerated scenarios and poorly built projects" [4]. Ringland argues that prospective scenarios have two key roles in supporting the organizations strategy in an uncertain environment, "mental models and serve as a methodology to allow exploration of the future" [5].

Scenarios should represent a set of internally consistent pictures of futures and nature states based on logic and rationality [6]. Scenario construction may be used to valuable functions in companies. "Scenarios refer to narratives of possible futures that might arise beyond the control of the company" [7].

To Schoemaker, scenarios should reflect a wide range of viewpoints from inside and outside the organization, so that, together they represent a broad spectrum of future possibilities. Milestad, Svenfelt and Dreborg assert that "the central element of scenarios is the focus on conditions beyond the control of the main actors" [8].

For Ramirez and Wilkinson prospective scenarios have value greater than a mathematical matrix. The challenge of the purpose and use of scenarios is often overlooked when choosing method of scenarios construction: "Given the diversity of the different thought traditions and methods of scenarios construction, the potential for methodological confusion and misunderstanding is considerable" [9].

We observe, therefore, that the subject conquer room and meaning in academic and professional circles, especially when it comes to the future of organizations. The emphasis on the matter is due to environmental instability and the issue of competitiveness.

The first logician to build a system of paraconsistent propositional calculus, between 1948 and 1949, was the Polish Stanislaw Jaskowski (1906-1965), following the suggestion of £ukasiewicz [10]. He called his system of Discussive logic (or Discursive).

But who is acknowledged as the inventor of Paraconsistent Logic is the Brazilian Newton Carneiro Affonso da Costa [11]. This is due, mostly, to the independent manner in which, since 1958, developed the ideas that led to the construction of several paraconsistent systems, not only in propositional level but also at the level of predicates (with and without equality).

A logical (or calculation) is called paraconsistent if it can be the underlying logic of paraconsistent theories (inconsistent but non-trivial) [11]. Therefore, in paraconsistent theories exist A formulas such that, from A and $\neg$A, does not follow any formula B, in other words, there is always a B formula from a set of all sentences such that B is not theorem of the theory. The Paraconsistent Annotated Logic allows handle subjective real-world data in precise data with numeric outputs [12]. One of its advantages is to perform the translation of natural language (linguistic terms) used in daily communications in mathematical expressions. This is achieved through the properties of the lattice of annotations. According to Da Silva Filho and Abe [13], benefits in the development of paraconsistent systems are: how quickly the system construction is carried out in relation to those based on "fuzzy" (common or Boolean) logic models and to make no longer necessary the knowledge or development of a mathematical model.

According to De Carvalho and Abe say that logics Eτ associates to each proposition ***p***, a pair **(μ,λ)**, representing by the Greek letters *mi* (μ) e *lambda* (λ),

representing by the following way: $p_{(\mu;\lambda)}$. μ and λ varies in the real closed interval [0, 1]. The pair $(\mu; \lambda)$ belongs to the Cartesian product [0, 1] x [0, 1]. Intuitively, μ represents the degree of favorable evidence expressed in ***p***, and μ, the degree of contrary evidence (or degree of disbelief) expressed by ***p***. The pair (μ,λ) is called annotation constant. The logic Eτ atomic propositions are the type $p_{(\mu;\lambda)}$ [14].

One can interpret the pair as follows [19]:

(0; 0) indicates the total absence of favorable evidence or maximum contrary evidence to ***p*** (it translates a logical state called paracompleteness);

(1; 0) means, extreme point of favorable evidence and no contrary evidence to ***p*** (it translates a logical condition called truth);

(0; 1) represents no favorable evidence and maximum contrary evidence to ***p*** (it translates a logical condition called falsehood);

(1; 1) means, simultaneously, maximum favorable evidence and maximum contrary evidence to ***p*** (it translates a logical condition called inconsistency);

De Carvalho and Abe [14] claim that "all the constants annotations (μ; λ) can be represented in Cartesian coordinate system by the unit square [0, 1] x [0, 1], called Unit square in the Cartesian plane (USCP) ".

As a result of the foregoing, it appears that the perfectly defined line (PDL) and a perfectly indefinite line (PIL) divides the USCP into four regions, as shown in the figure below.

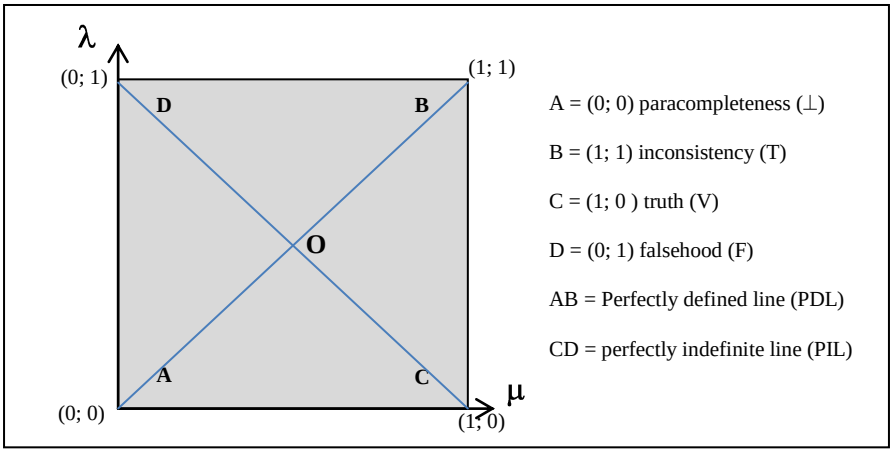

Figure 1. USCP divided in four regions by lines PDL AND PIL (Source: DE CARVALHO and ABE, 2011)

Some initial considerations are required due to the generic use of language, not being separated the concepts of straight line AB, line AB, or segment AB; or line segment AB "connects" to the points A and B; when it "crosses" from point A to point B; or "on" the line BC. Will also be used expressions like "almost true", "maximum truth", "maximum falsehood", etc.

Note that the line segment CD "connects" to points C and D in the figure above, in which there are situations of perfect definition (truth or falsity). Therefore, the segment CD is called a perfectly definite line (PDL). The equation is $\mu + \lambda - 1 = 0$ [14].

De Carvalho and Abe [14] says it is very reasonable to define the contradiction degree of an annotation $(\mu; \lambda)$ as: $G_{contr} = \mu + \lambda - 1$, called perfectly indefinite line (PIL) the line AB of USCP. The equation of line AB is $\mu - \lambda = 0$. Defining this way the degree of certainty (H_{cert}) of an annotation $(\mu; \lambda)$ as $H_{cert} = \mu - \lambda$

It is thus a model of atomic propositions easily understood, without being trivial. Recently, Jair Minoro Abe and other researchers have developed applications for Logic Eτ, highlighting the viability analysis [15] and decision making [16].

In the pioneering work of De Carvalho *et al* [17] makes comparisons with inductive logic by using the statistical method and also with the Fuzzy Logic stating that: "by fixing the same value for the level of demand, the fuzzy decision gets stronger than paraconsistent" [11]. The use of Annotated Paraconsistent Logic, however, is practical and without need of complex math calculations [18].

3 Methodology

This study methodology used techniques and processes on a systematic way to objectively achieve the knowledge of the proposed subject. Research empirically applied, after literature review, with exploratory purpose. The phases of the methodological process used in this study were as follows:

1) Issue formulation:

- How to develop prospective scenarios working with contradictory data?

2) Hypothesis formulation:

- To use logic that does not exclude contradiction in prospective scenarios.

3) Literature review:

- Theoretical background of prospective scenarios and Logic Eτ;

4) Data gathering:

- Specialists systems, invited randomly, six (06) of which have volunteered and were divided into three groups:
    - A: 02 (two) economists;
    - B: 02 (two) executives;
    - C: 02 (two) professors.
- extensive direct observation through measure of specialists opinion.

These specialists identified 50 (fifty) Future Facts Carriers, which are actual facts existing at present and will continue to impact our environment in the future.

After identifying these facts, brainstorming sessions were conducted to identify three (03) strategic topics to trial. After identifying the topics was built the strategic proposition which is a hypothesis of future occurrences of events identified based on a strategic issue. The proposition is for setting strategic goals, organizing a Delphi survey and identify future alternatives. The topics and propositions are presented in the board below.

Board 1. Topics and Strategic Propositions

Factors	Strategic Topics	Strategic Proposition
F1	Public Finances	Reduction of indebtedness as a proportion of GDP, so that the net public debt stays below 30% of GDP

		by 2022.
F2	Higher Education	Expansion of Higher Education System, to include, by 2012, about 40% of the population, aged 18 to 24.
F3	Brazilian Exportation	Increase in exports, so that Brazil will respond, in 2022, for about 2% of the world's exports value.

This phase of prospective analysis was made in two (02) Delphi rounds that sought to: identify the sure of the topic occurrence the consultation was conducted by a form via e-mail - in two rounds. The major difference between them is that, in the second round, was informed the answer's results of each question in the first round, giving the answerer an opportunity to revise their earlier answers, if he so wished.

The query was organized in three (03) strategic topics, and for each one there was a brief ambiance about the subject and a proposition about the future (p): "the issue occurs in 2022".

4 Application

Regarding the factors must be reason that they are independent of each other. Therefore, we attempted to assign degrees of favorable evidence (μ) and contrary evidence (λ) according to the specialists, as below.

Table 1. Database of specialist's evidences

FACTORS	GROUP A				GROUP B				GROUP C			
	Specialist 1 (E1)		**Specialist 2 (E2)**		**Specialist 3 (E3)**		**Specialist 4 (E4)**		**Specialist 5 (E5)**		**Specialist 6 (E6)**	
	μ_1	λ_1	μ_2	λ_2	μ_3	λ_3	μ_4	λ_4	μ_5	λ_5	μ_6	λ_6
F1	1,0	0,0	0,5	0,3	0,0	1,0	0,2	0,7	0,3	0,6	0,6	0,3
F2	0,1	1,0	0,1	0,7	0,3	0,7	0,2	0,8	1,0	0,0	0,9	0,1
F3	0,5	0,6	0,6	0,3	0,3	0,3	0,2	0,1	1,0	0,0	0,0	0,0

Based on the database of the specialist's evidence (Table 1), we can extract the opinions of specialists about the prospective scenarios. They are shown in Table 2 using OR and AND rules.

4.1 Maximization (OR) and minimization (AND) rules

The next step was to apply the rule of maximizing (OR) and minimization (AND) from Logic Eτ to the opinions of specialists for each one of the strategic topics. the rule of maximizing the intra-group favorable evidence is applied so that the connective (OR) is used in the favorable evidence and the connective (AND) in contrary evidence within each group, and the rule of minimizing favorable evidence between the groups is applied using the connective (AND) for favorable evidence and the connective (OR)

for contrary evidence for the results obtained at both groups (betwen groups), clustered according to table 2, in other words:

[(Specialist1) OR (Specialist 2)] AND [(Specialist 3) OR (Specialist 4)] AND [(Specialist 5) OR (Specialist 6)]

4.2 Results analyses

We analyze these final results, after applying the rules of maximization and minimization, by the device para-analyzer. Therefore, it is necessary to plot it in USCP, in which, to have more accuracy in conclusion, was adopted as the limits of truth and falsehood the lines determined by degree of certainty H_{cert} = 0,6 and as limits of paracomplete and indeterminacy, the lines determined by the degree of contradictions G_{cont} = -0,6. Thus, there is a scenario of evidence favorable or contrary the certainty of occurrence of topic, if there is a module degree of certainty equal to or greater than 0,6.

In short, the division criterion is:

a) Hcert ≥ 0,6 → Truth (V), the topic happens;

b) Hcert ≤ -0,6 →Falsehood (F), the topic does not happen;

c) -0,6 < Hcert < 0,6 → Area between Truth and Falsehood.

The database was treated with OR and AND connectives and the results of the three topics are shown in the table below.

Table 2. Resulting evidence degrees by application of the OR and AND rules

Factors	**Group A**		**Group B**		**Group C**		**Betwen Groups**		**Strategics topics: 03 (three)** **Requirement levels: ≥ 0,600** **Conclusion**		
	μ_{OR}	λ_{AND}	μ_{OR}	λ_{AND}	μ_{OR}	λ_{AND}	μ_{AND}	λ_{OR}	H_{cert}	G_{contr}	**Decision**
F1	1,0	0,0	0,2	0,7	0,6	0,3	0,2	0,7	-0,5	-0,1	almost (F), tending to ⊥
F2	0,1	0,7	0,3	0,7	1,0	0,0	0,1	0,7	-0,6	-0,2	(F) doesn't happen
F3	0,6	0,3	0,3	0,1	1,0	0,0	0,3	0,3	0,0	-0,4	almost (⊥), tending to V

Observing the degrees of favorable and contrary evidence resulting from the application of the rules of maximization (OR) and minimization (AND) the opinions of specialists in the study of future, we note that the degree of certainty (H_{cert}) of F1 (public finances) and F3 (Brazilian exportations) are below 0,6 as established in the criteria for certainty of occurrence. For example, though the specialist 1 of F1 and the specialist 5 of F3 assigned evidence ($\mu_{1,0}$; $\lambda_{0,0}$) which is a statement of (V) truth, namely, certainty of occurrence, when taking into account other evidences of other specialists, the result is neither (V) truth nor (F) falsehood of occurrence's certainty of the strategic topic for 2022. However, it can be said in which region of certainty they are, as shown in the figure below. The F1 topic are plotted in ($\mu_{0,2}$; $\lambda_{0,7}$) at area OHTI= Almost (F) falsehood, tending to (⊥) paracompleteness and the F3 topic are plotted in ($\mu_{0,3}$; $\lambda_{0,3}$) at area OEMK= Almost (⊥) paracomplete, tending to (V) truth. F2 (higher education) has its collective evidence in the region (F) falsehood, that is, the proposition of the strategic topic will not occur in 2022, as shown below.

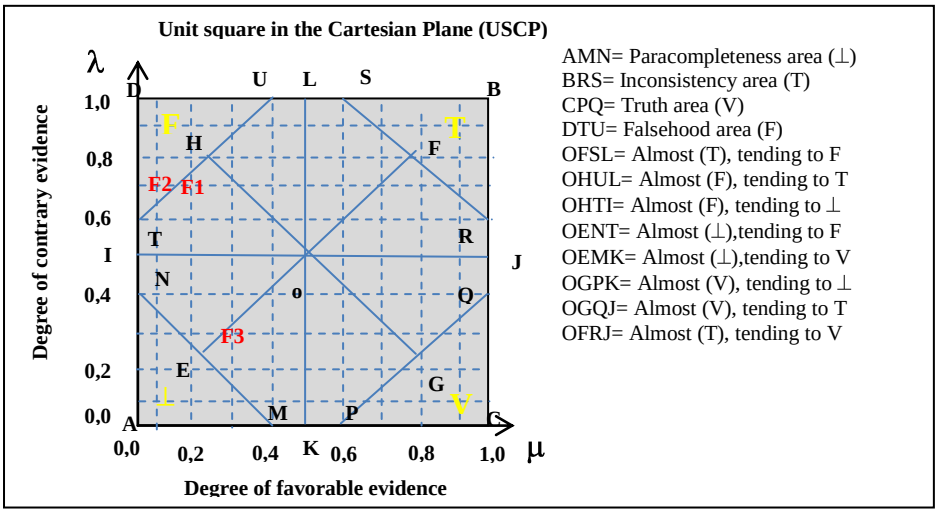

Figure 2: Application of para-analizer device at USCP.

If there is need of a more stringent criteria for decision making, for a more reliable, safer decision, it is necessary to increase the requirement level by approaching the lines PQ and TU from C and D points, respectively, also may be used a larger number of specialists, or even to consider the evidence assigned depending on the weight of each specialist.

So, the development of prospective scenarios with the Paraconsistent Annotated Evidential Logic Eτ allows to determine possible data inconsistencies and verify to what extent they are acceptable or not in decision rules.

5 Final Considerations

A major advantage of this method is its great versatility. The specialists may suffer influence, but in general it is not the same for everyone. Certainly, in a moment of depression, the specialist tends to disbelieve the future and more than believing and the opposite can happen as well in moments of euphoria or joy, but hardly all specialists will be experiencing the same emotions. Finally, virtually all problems where uncertainty, ambiguity or the natural language of human being is relevant are favorable situations for the method application. This method has many advantages, among which we reaffirm briefly: versatility, precision, reliability and trustworthiness, and allows dealing with contradictory data.

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