Use of Paraconsistent Logic Evidential Annotated Eτ in Logistic Systems

Angel Martinez, Liliam Sayuri Sakamoto, Jair Minoro Abe, Luiz Lima, Jonatas Souza, Nilson Souza

Use of Paraconsistent Logic Evidential Annotated Eτ in Logistic Systems

Liliam Sayuri Sakamoto[1[0000-0001-8636-0100]], Jair Minoro Abe[1[1111-2222-3333-4444]] , Luiz Antonio de Lima[1[0000-0003-4228-2387]] , Jonatas Santos de Souza[1[0000-0002-0052-0132]] , Nilson Amado de Souza[1[0000-0003-1092-4314]], Angel Antonio Gonzalez Martinez [1[0000-0003-1012-9812]]

[1] Paulista University, 1212, Dr. Bacelar Street, São Paulo SP, BRAZIL
liliam.sakamoto@gmail.com,

Abstract. Traditional Logistic Systems related to the modules of routes and vehicle tracking were observed, which use classical logic. In this study, whose main objective is a proposal for digital transformation with the implementation of the use of Paraconsistent Logic Evidential Annotated Eτ for optimization and reduction exposure to the risk of the cargo transport process in these types of systems. The methodology used para-analyzer algorithm, with selection of specialists in decision-making issues to improve the safety of the routes and minimize the risks exposed in the cargo's path from shipment to the destination. An exploratory research was used surveys through applied logical questionnaires. The main results were compared to the Case Study of the Volkswagen Modular Consortium - Trucks and buses, from a logistical point of view, in which the three main factors resulting from this study can prove an alignment regarding the implementation of this innovation. In addition, data on incidents occurred at the Agrobusiness Company regarding the Routes and Tracking Systems were presented, proving the risk of the loads and the need for digital transformation in these types of systems.

Keywords: *Non-Classic Logic, Annotated Evidential Paraconsistent Logic , Tracking Systems, Route Systems.*

1 Introduction

1.1 General Context

The objective of this study is to analyze the traditional Logistics Systems in the use of vehicle tracking modules that use processes based on classical logics, with a proposal to implement the use of the Paraconsistent Logic Evidential Annotated Eτ for the optimization and reduction of exposure to the risk of the cargo transport process.

In many areas, many companies have not yet realized how the digital transformation paradigm provides a profound change in the layers of the business, in which companies that wish to obtain a competitive advantage will need to adapt themselves in the implementation of innovations. There is no doubt that a “digital gap” has been growing among those that have become stagnant and those that are adapting. [1]. And in the field of Logistics this could not be different, as most of these companies use Logistics Systems with tracking models, some with the support of mobile applications to define routes for the transportation of various loads. These routes can be designed manually or automatically, but these route models are quite predictable [2], mainly because they use models based on classical logic. The support or monitoring tools generally consider only the classic approach, that is, they are based on the duality of whether it is a risky situation or not, however there is no study that involves the contradictions and the doubts that in most times are despised.

This dependence also causes the need for the digital transformation of this resource, which can be of its own IT structure or for a service provision by a specialized company. As [3] approaches, information technology and innovation help supply within a Value Chain.

The use of the Paraconsistent Logic Evidential Annotated Eτ with the practical application of the Para-Analyzer algorithm for decision making, that is, with the implementation of artificial intelligence can be one of the important points for innovation and digital transformation of logistics.

The study is structured starting with a bibliographic review of the Paraconsistent Logic Evidential Annotated Eτ and the Logistic Supply Chain, after presenting the methodology of the Para-analyzer algorithm, and in the discussions, comparisons were made with the Volkswagen Modular Case Study - Trucks and buses from the point from a logistical point of view, presented by [3] and with real situations of Tracking Systems and Route System of an agribusiness cargo transport company.

2 Background

2.1 Paraconsistent Logic Evidential Annotated Eτ in Logistic

The Paraconsistent Logic Evidential Annotated Eτ belongs to the class of non-classical evidential logics that arose specifically in logical programming, according to [4].

Paraconsistent Logic Evidential Annotated Eτ is a family of non-classical logics that emerged in the late 90s of the last century in logical programming [5]

Annotated logics constitute a class of paraconsistent logic. Such logics are related to certain complete lattices, which play an important role. A knowledge specialist on the subject to be addressed issues a quantitative opinion ranging from 0.0 to 1.0. These values are respectively the favorable evidence that is expressed by the symbol μ and the opposite evidence by λ.

Programs can be built using paraconsistent logic, making it possible to treat inconsistencies in a direct way. With this resource, one must apply in big data, expert systems, object-oriented database, representation of contradictory knowledge, with all the implications in artificial intelligence [5].

With the uncertainty and certainty degrees, they can get the following 12 output states (Table 1): extreme states, and non-extreme states. [7].

Table 1. Extreme and Non-extreme states

Extreme States	Symbol
True	V
False	F
Inconsistent	T
Paracomplete	⊥
Non-extreme States	**Symbol**
Quasi-true tending to Inconsistent	QV⟶T
Quasi-true tending to Paracomplete	QV⟶⊥
Quasi-false tending to Inconsistent	QF⟶T
Quasi-false tending to Paracomplete	QF⟶⊥
Quasi-inconsistent tending to True	QT⟶V
Quasi-inconsistent tending to False	QT⟶ F
Quasi-paracomplete tending to True	Q⊥⟶V
Quasi-paracomplete tending to False	Q⊥⟶ F

Some additional control values are:

- V_{scct} = maximum value of uncertainty control = Ft_{un}
- V_{scc} = maximum value of certainty control = Ft_{ce}
- V_{icct} = minimum value of uncertainty control = $-Ft_{un}$
- V_{icc} = minimum value of certainty control = $-Ft_{ce}$

All states are represented in the next Figure (Fig.1).

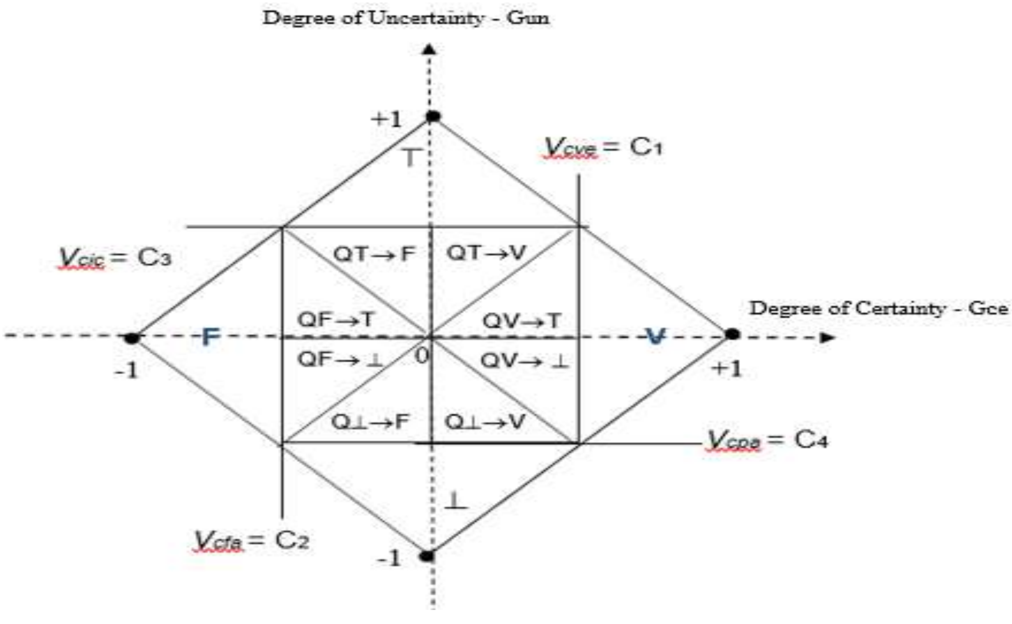


Figure 1: Extreme and Non-extreme states that represent table 1.

Source: [7]

2.2 Logistic Supply Chain

Despite the operational environment of a logistical supply chain, it has the economic limiting factor and not only technological, according to [6], which affirms the need for speed of availability and consistency of delivery.

When assessing Supply Chain management, it is necessary to understand the impacts of decision making on processes, organization, and the social context [3].

In the Transport process, it is necessary to detail the functionalities and characteristics of the participants effectively. In which the transport structure can be rail, road, waterway, pipeline, or air [6]. In this study the focus will be on the type of road transport that can be monitored through routes determined automatically or manually.

There are also specialized transport services for: parcel services, intermodal transport, and non-operational intermediaries [6].

Generally, they can be specialized in precious cargo (jewelry, watches, electronic equipment) or valuable (paper money, pharmaceuticals), and these loads are often criminally intercepted and subtracted. Therefore, the need for a digital transformation and optimization of the routing process, which can come from projects focused on big data, IoT - Internet of Things and everything stored in a cloud [2].

In this transport sector, the financial factor is evaluated through the distance of the route, the weight and density of the product, totaling its total cost [6].

The current situation leads to the improvement of cost minimization so that there is a greater demand for product delivery. With the prioritization of a shorter, safer route, with less fuel consumption and less labor time, and with a reduced chance of subtraction or theft, generating implicit value in product delivery, and may even focus on applications furniture too.

The control must be carried out by the Transport Administration area, both in the operational scope and in the management of complaints [6]. Burglary incidents prior to final delivery can lead to financial loss, internal fraud, or theft. With the digital transformation in conjunction with the use of logic, it is possible to optimize results and increase the revenue of these logistics companies, this is a suggested solution that leads to the digital transformation expressly said within a logistics chain.

3 Methodology

In the first phase, a bibliographic review was carried out on the aspects of Logistics and the need for digital transformation, complemented using the Paraconsistent Logic Evidential Annotated Eτ be implemented to aid decision making [7].

The Paraconsistent Logic Evidential Annotated Eτ considers a proposition being represented by annotation values or states (Table 1). According to this concept, an algorithm called para-analyzer was created [5].

The research problem was: How to manage unstable and risky systems for cargo transportation?

The defined proposition was: Do logistics systems need to undergo digital transformation?

Knowledge Engineers - KE, Farms users (foreman, veterinarian), IT analysts and Logistics analysts were selected, each of whom received a form to answer: Degree of favorable evidence μ and Degree of unfavorable evidence λ for each of the factors, within the transport process specifically for the delimitation of routes [8].

Table 2. Chosen factors.

Order	Factors
1	Are the routes standardized within the Logistics Systems?
2	Are routes frequently changed within Logistics Systems?
3	Can Logistics Systems detect blind spots on routes?

Table 3. Average over **μ** and **λ** factors – Part I

KE*		**Factor**	**Weight**	**Favorable degree of evidence μ**	**Unfavorable degree of evidence λ**
Farm user	1	1	1	1.0	0.1
Farm user	2	1	1	0.9	0.2
TI Analyst	3	1	1	0.9	0.3
TI Analyst	4	1	1	0.8	0.2
Logistic Analyst	5	1	1	0.8	0.1
Logistic Analyst	6	1	1	0.9	0.2

* Knowledge Engineers

Table 4. Average over **μ** and **λ** factors – Part II.

KE*		**Factor**	**Weight**	**Favorable degree of evidence μ**	**Unfavorable degree of evidence λ**
Farm user	1	2	2	0.7	0.3
Farm user	2	2	2	0.9	0.4
TI Analyst	3	2	2	0.9	0.1
TI Analyst	4	2	2	0.8	0.2
Logistic Analyst	5	2	2	0.7	0.2
Logistic Anayist	6	2	2	0.8	0.3

* Knowledge Engineers

Table 5. Average over **μ** and **λ** factors – Part III

KE*	Factor	Weight	Favorable degree of evidence μ	Unfavorable degree of evidence λ
Farm manager 1	3	3	0.6	0.5
Farm manager 2	3	3	0.7	0.4
TI manager 3	3	3	0.5	0.5
TI manager 4	3	3	0.7	0.4
Logistic manager 5	3	3	0.7	0.5
Logistic manager 6	3	3	0,5	0,2

* Knowledge Engineers

This Figure 2 present, an algorithm from para-analyzer for digital transformation proposition [5].

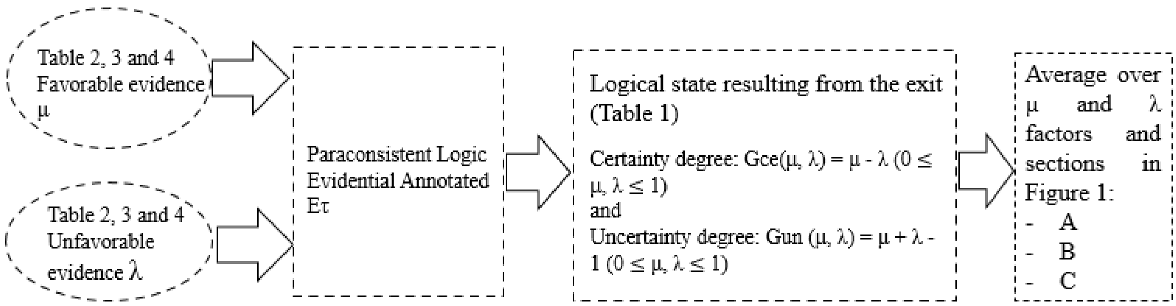


Figure 2: Para-analyzer algorithm function

Source: Adapted from [7]

4 Analysis and Discussion

The algorithm is composed of a set of information collected through a research form for analysis of decision making.

It is observed the practical application of the para-analyzer algorithm and the proposal of this study, compared Case Study of the Volkswagen Modular Consortium - Trucks and buses from the logistical point of view presented by [3] which were addressed:

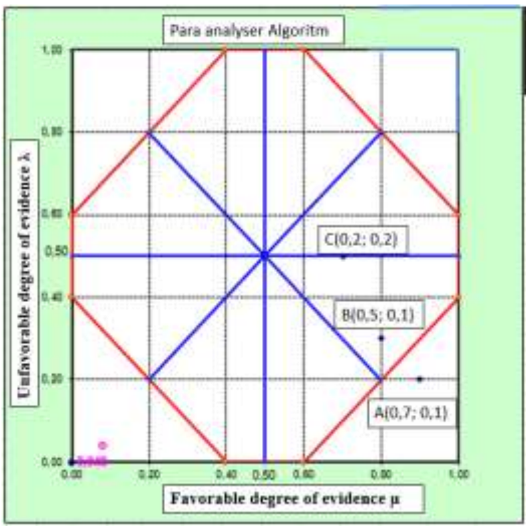


Figure 3: Graphical representation of table 2, 3 e 4.
Source: Authors.

Figure 3 - A: represents the analysis carried out by the specialists regarding the appropriate scenario factor. For in this section, prove the proposition. For the average of favorable evidence is 0.7 and favorable evidence 0.1, in this case the result is real since it already exists in the current context.

Comparing with the Case Study of the Volkswagen Modular Consortium - Trucks and buses from a logistical point of view, presented by [3], where the strategy was to combine all aspects developed in the automobile industry between the years 1995 and 1996 and the Supply Chain mainly with respect to relative Computing Systems.

Figure 3 - B: represents the analysis carried out by the specialists regarding the appropriate scenario factor. For in this section, check the proposition as well. For the average of favorable evidence is 0.5 and favorable evidence 0.1, in this case the result is viable, since it already exists in the current context.

In the Volkswagen Case Study [3], the use of routes in three categories was approached according to the value of the parts for the specific storage areas, implying that there is a change in routes in the logistics system, thus remaining as well according to Factor 2.

In Figure 3 - C: it represents the analysis carried out by the specialists regarding the appropriate scenario factor, in which case the chosen one was the need for digital transformation. For in this section, where there is no definition of when and how to prove that this functionality can be implemented. For the average of favorable evidence is 0.7 and favorable evidence 0.4, in this case the result is inconsistent since this context should have been more detailed.

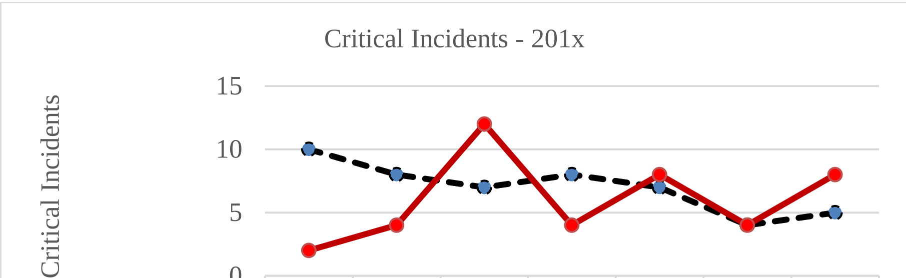
In the Volkswagen Case Study [3], it was commented on the need for greater investments for innovation and technology, due to the increase in cargo theft and costs related to these occurrences. This indicates that Factor 3 agrees and must be followed up for a longer time for a result to be effectively assertive, since it was inconsistent, especially if it occurs many times.

4.1 Comparisons with real data

We used information from a agrobusiness company, here as "ABC", which has headquarters in São Paulo and four farms, two in Minas Gerais and two others in Mato Grosso. This company uses Tracking system and Router System. The Tracking system in cargo trucker are monitoring by an outsourcing NOC – Network Operation Center, otherwise Router System is management by Service Desk in headquarters.

There are, on average, 300 employees, its capital is of family origin, and it was requested that its name and period of analyzed data remained secret.

A survey about critical incidents in the analyzed period of 7 months was conducted, starting in January/201x, and finishing in July/201x. According to a chart that summarizes the total analyzed critical incidents (shutdown).



	January	February	March	April	May	June	July
Tracking System	10	8	7	8	7	4	5
Route System	2	4	12	4	8	4	8

Figure 4: Amount of occurrence of Critical Incident in the period of 7 months from Agrobusiness "ABC"
Source: Authors

The Routing System is unable to monitor 100% of the loads during its routes because of the instability of the interface with the ERP Logistics platform developed internally.

While the Tracking System shows a drop in coverage at times when it passes through shady places, a situation reported by the NOC to the Agrobusiness company.

Analyzing Figure 4, we can see that both the Tracking System and the Routing System presented several failures during the analyzed period, which indicates the need for an adaptation so that there is no risk in cargo transportation.

5 Final Considerations

To make an analysis of several factors and make a combination between its varied possibilities for decision making, according to in several areas, as well as in logistics with support of digital transformation and Paraconsistent Logic Annotated Evidential Eτ for optimization of safe routes.

This study presents the three results of the analyzes of the specialists in comparison with the issues addressed in the Volkswagen Case Study and it was observed that there is an alignment between them.

On the other hand, the Agrobusiness company's Tracking Systems and Routing Systems present us with weaknesses that expose cargo transportation to risk due to the need for an update or digital transformation, perhaps with the implementation of Paraconsistent Logic Annotated Evidential Eτ.

All these scenarios bring a greater or lesser degree of risk of evidence for a digital transformation. Where it can be seen, that the greater the degree of granularity presented, the more appropriate the result to be mapped. The Evidential Annotated Paraconsistent Logic Eτ assists logistics with a direction, in which risk contexts can be identified and prevented.

References

1. Sampaio, Rafael Vantagem digital: Um guia prático para a transformação digital.pp. 47-49. Alta Books Editora (2018).
2. Veras, Manoel. Gestão da tecnologia da informação: sustentação e inovação para a transfomação digital. Rio de Janeiro: Brasport (2019).
3. Bertaglia, Paulo Roberto Logística e gerenciamento da cadeia de abastecimento / Paulo Roberto Bertaglia – 3. ed. – São Paulo: Saraiva, 2016. 528 p
4. Da Costa, N.C.A, Abe, J.M & Subrahmanian, V.S. Remarks on annotated logic, Zeitschrift f. Math. Logik und Grundlagen d. Math. 37, pp. 561-570, 1991.
5. Abe, J. M. (2011). Silva Filho, João Inácio da. Celestino, Uanderson. Araújo, Hélio Corrêa de. Lógica Paraconsistente Anotada Evidencial Eτ. Comunicar.
6. Bowersox, Donald J. et al Gestão logística da cadeia de suprimentos. AMGH Editora. (2013).
7. Abe, J. M. (Ed.). Paraconsistent intelligent-based systems: New trends in the applications of paraconsistency. Vol. 94. Springer (2015).
8. Akama, S. Towards Paraconsistent Engineering, Intelligent Systems Reference Library, Germany: Springer (2016).
9. Calado, Alexandre M. F. et al. Alguns dos erros mais comuns na tomada de decisão. Instituto Superior de engenharia de Coimbra. Coimbra. (2007).
10. Banzato, Eduardo Tecnologia da informação aplicada à logística. INSTITUTO IMAM (2016)
11. Rocco, A. et al.. Estimação de estados em Sistemas Elétricos de Potência com técnicas baseadas em Lógia Fuzzy e Paraconsistente. Revista Seleção Documental nº27. Santos: Ed. Paralogike. (2012)