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A NOVEL FRAMEWORK FOR MODELING VALUE FOR THE CUSTOMER, AN ESSAY ON NEGOTIATION

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This paper proposes a novel framework for modeling the Value for the Customer, the so-called Conceptual Model for Decomposing Value for the Customer (CMDVC). This conceptual model is first validated through an exploratory case study where the authors validate both the proposed constructs of the model and their relations. In a second step the authors propose a mathematical formulation for the CMDVC as well as a computational method. This has enabled the final quantitative discussion of how the CMDVC can be applied and used in the enterprise environment, and the final validation by the people in the enterprise. Along this research, we were able to confirm that the results of this novel quantitative approach to model the Value for the Customer is consistent with the company's empirical experience. The paper further discusses the merits and limitations of this approach, proposing that the model is likely to bring value to support not only the contract preparation at an Ex-Ante Negotiation Phase, as demonstrated, but also along the actual negotiation process, as finally confirmed by an enterprise testimonial.

Keywords: Customer perceived value; modeling value; collaborative network; value network; negotiation.

1. Introduction

Any business activity is intrinsically about value exchange. It is about delivering some tangible and intangible good or service and having its value accepted and rewarded by one's peer/customer, either within or outside one's company. Value has been defined in different theoretical contexts as need, desire, interest, standard/criteria, beliefs, attitudes, and preferences. Value is, therefore, very dependent on perception. Many researchers have studied customer perceived value from different perspectives. Some have studied the influence of customer perceived value on loyalty[1];

others have studied the influence of perceived value on customer satisfaction[14]; still others follow Zeithaml's approach,[2] in line with Lapierre,[3] who studied customer perceived value in an industrial context, dividing this into benefits and sacrifices.

In this context, it is our objective to provide firms with a model that builds the bridge between Value for the Customer,[4] customer perception of value and enterprise usage and building of both tangible and/or intangible assets that can be either internal or external to business unit under analysis.

This model comprises the understanding that time has a direct impact on customer perceived value, and that the suppliers' and customers' perceptions change from the pre-purchase to the post-purchase phases.[4] We therefore break down every value component, as well as every built-and-used asset, into their endogenous and exogenous perspectives along different time positions.

The research presented in this paper combines results from three distinct areas areas: (a) from the Marketing area, the concept of Value for the Customer[4]; (b) from the collaborative networks area, the ARCON Reference Model for Collaborative Organizations Networks[5]; (c) from the Intellectual Capital area, the concept of "Value Network", introduced by Ref. 6 whose purpose can be summarized in her own words,[7,8] as "How do we convert intangible assets such as human knowledge, internal structures, ways of working, reputation, and business relationships into negotiable forms of value?" In this context, this paper derives the so-called Conceptual Model for Decomposing Value for the Customer (CMDVC) and its mathematical formulation in the context of an exploratory case study.[9] The paper further illustrates the usage of this Conceptual Model in the preparation of a contract in a pre-negotiation setting. It concludes with the application of the formal mathematical model of the CMDVC using the Fuzzy AHP (analytical hierarchical process) method in the context of the case study and the final discussion of the results.

2. A Novel Framework for Modeling Value

2.1. *Literature review*

Customer Perceived Value

Long lasting relationships can help supplier and customer in the process of creating higher value that can be mutually beneficial. In business markets, few firms have the knowledge to assess value, and therefore need to understand how this is decomposed into its components and "what drivers create value for the customer"(see Ref. 3, p. 122) in order to obtain an equitable return for the value they deliver to the customer. Moreover, customers' "purchase decisions are often guided by a careful assessment of what benefits they obtain in exchange" (see Ref. 3, p. 123) such as expenses in acquiring and consuming products/services and costs of ownership.

From the point of view both of customer and supplier, it is essential to know how to create and deliver value in the relationship, "particularly as the product itself may end up becoming a commodity (see Ref. 10, p. 594).

Value creation is a concept that is difficult to achieve, understand, model and/or conceptualize. Some authors consider value creation a trade-off between benefits and sacrifices perceived by customers during a supplier's offering.[11] Lindgreen and Wynstra[12] consider creating and delivering customer value as a concept and illustrate its complexity. They consider it important to distinguish between two major research streams: (i) the value of goods and services; and (ii) the value of buyer−seller relationships, also mentioned in Allee's research as an exchange of tangible and intangible assets.[13] Goods and services or buyer−seller relationships can be related to as benefits and sacrifices, in the exchange of either tangible or intangible assets.

In marketing literature, the term "customer value" is used to illustrate a scenario derived by the customer from the supplier, and also by the supplier from the customer. Different customers perceive different value for the same products/services. In addition, organizations involved in the purchasing process can have different perceptions of customers' value delivery.[14] Lindgreen and Wynstra[12] further stress this statement by saying that value, as perceived by the producer, means something different from the value perceived by the user, i.e., the producer is less sensitive to price, whereas the consumer is more sensitive to the product quality. It is therefore necessary to establish models to support buyer−seller relationships where emphasis can be placed on improving supplier performance with a view to its effect on perceived value for the customer.[14] As result, there is a clear need for a balance between the proposed value of product/service and the actual value perceived by the customer or end-user.

Zeithmal[2] has suggested that "perceived value is the consumer's overall assessment of the utility of a product based on perceptions of what is received and what is given". This complexity and multidimensional nature of the conceptualization of perceived value can be seen in Ref. 15.

Subsequently Woodruff[16] defines customer perceived value as: "(...) preference for and evaluation of those products attributes, attribute performances, and consequences arising from use that facilitate (block) achieving the customer's goals and purposes in use situations".

Customer perceived value normally focuses on a buyer's evaluation at the time of a product purchase. From a longitudinal perspective, Huber *et al.*,[17] Parasuraman[54] and Woodall[4] state that customers are not able reliably to predict what they will value in the future and different types of value are experienced by the customer from the pre-purchase phase to a later post-purchase phase. To understand how customers determine/perceive value in a sequential activity of a value proposition, Woodall[4] divides Value for the Customer (VC) into four value temporal positions:

- Pre-purchase — a phase of trying to predict how people perceive their services,[17]
- At the point of trade — which implies a sense of VC experienced at the point of trade; e.g., Acquisition Value plus Exchange Value,
- Post-Purchase — a phase that delivers results of experiments based on customers'/suppliers' choices; e.g., Use value; Received Value,[17]

- After/use experience — a phase that reflects the point of disposal/sale.
- Furthermore, but linked to the above, Woodall classified Value for the Customer into different forms of value,
- Net VC — "balance of benefits and sacrifices" to provide the best or the worst VC,
- Marketing VC — "perceived products attributes",
- Sale VC — primarily concerned with the price,
- Rational VC — "difference from the objective price",
- Derived VC — users' experiences.

Measuring value for the customer and predicting how customer and supplier will perceive a value proposition is a strategic tool for clarifying a company's propositions to its customer and creating a value offer superior to that of its competitors.

The perspectives "Value for the Customer" and "Perceived Value" were explored in depth in Refs. 4 and 15, but the decomposition of value is not dissected and broken down into its components, namely the firm assets used and build in the construction of the exchanged value, whether internal or external to the company or organization. For this reason we seek the integration of the above definitions with concepts that stem from research areas such as value networks and collaborative networks.

Value Networks

The topic of value networks has been an interesting field for researchers and practitioners.[18–20] In the eighties Sveiby introduced the concept of intangible assets and in 1997 he stated that: "People are the only true agents in business. All assets and structures — whether tangible or intangible — are the result of human actions. All depend ultimately on people for their continued existence." Allee[13] further stresses that "intangibles are at the heart of all human activity, especially socio-economic activity," and goes on to argue that "intangibles go to market as negotiable in economic exchanges" and that "intangibles act as deliverables in key transactions that take place in any given business model." The understanding of intangible value and how it is exchanged is, therefore, of the utmost importance in a discussion of how value is exchanged and perceived and, ultimately, in the construction of the product/service Value Proposition.

Collaborative Networks

A Collaborative Network (CN) is a network of autonomous entities that might be either people or organizations, geographically distributed and heterogeneous, which collaborate in order to better achieve common or compatible goals, whose interactions are supported by a computer network.[5] CNs are complex systems whose understanding encompasses several scientific areas ranging from engineering to social sciences such as management and law. As CNs "focus on the structure, behavior, and evolving dynamics of networks of autonomous entities that collaborate to better achieve common or compatible goals,"[21] the density of the whole concept has to be modeled in order to reduce complexity and allow for the adequate handling of

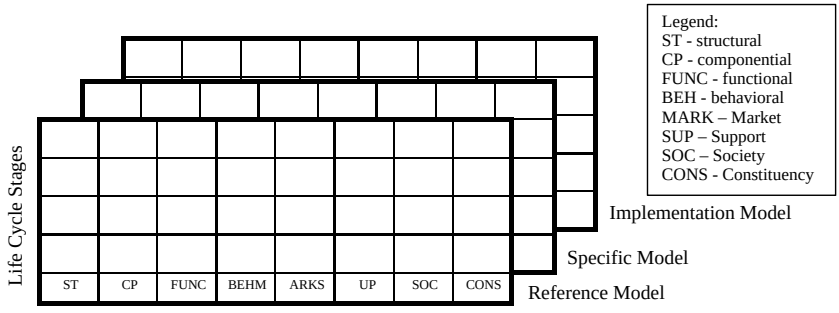


Fig. 1. ARCON through the perspectives of Value Network.

consistent subsets of the whole problem domain. To this end, Camarinha and Afasarmanesh[5] proposed the ARCON modeling framework.

The Reference Model for Collaborative Network Organizations (ARCON)[5,22] provides a generic and abstract representation that enables the understanding of all involved entities and the relationships between all of them. This model comprises three perspectives (Fig. 1): (1) the life cycle perspective, illustrating from the lowest row the CN phases (Creation, Operation, Evolution, Metamorphosis and Dissolution), (2) the modeling intent (general representation, specific model and implementation model), and (3) the endogenous and exogenous components of each of the phases.

Within the scope of our research we focus on the collaborative network daily activities that comprise both the operation and the evolution phases. Figure 1 also illustrates the so-called endogenous elements that capture and represent Collaborative Network Organizations (CNOs), under the following four dimensions: Structural (ST), Componential (CP), Functional (FUNC) and Behavioral (BEH). On the other hand, the outside perspective is captured by the exogenous elements that reveal the interaction with the surrounding environment and are divided into four dimensions: Market (MARK), Support (SUP), Societal (SOC), and Constituency (CONS).

2.2. *Research question & methodology*

The structure of this research work follows the "Design Science" approach proposed by Hevner *et al.*[23] that "seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artefacts". This paper further builds on an Exploratory Case Study, following the "design criterion in exploratory case research" (see Ref. 9, p. 604), as we seek the first validation of the proposed Conceptual model for Decomposing Value for the Customer. It was in this context of looking at both the literature review and the business environment that the following research question was tuned and designed:

1. *How can the Value for the Customer be modeled*?
   1.1 *How is this value built on top of assets endogenous and exogenous to the organization*?

1.2 *How do endogenous and exogenous assets influence the Value for the Customer*

2. *Can we derive a formal mathematical model that provides for the quantitative handling of the proposed model?*

As we conduct our research we are aware that, in this context, "although early identification of possible constructs can be helpful, it is equally important to recognize that it is tentative in theory building case research" (see Ref. 9, p. 607). In this context and in order to validate a proposal model constructs and their relationships, an Exploratory Case Study was conducted at a Small and Medium Enterprise (SME). According to Ref. 55, small enterprises have from 10 to 49 persons employed, whereas medium-sized enterprises have 50−249 persons employed. The selected company operates in the Occupational Safety and Health Services sector. It has a permanent staff of 20 employees and 10 external regular collaborators. Reference 55 further states that SMEs employ 37.7% of Europeans and are responsible for 36.8% of all value added. The remaining share of persons employed is divided into 33.3% and 29% respectively in large and small enterprises. This company is therefore representative of an important group for enterprises for the European economy. This was the main drive to select Centro Preventivo de Medicina do Trabalho (CPMT) to be our Unit of Analysis[9] for our exploratory Case Study.

2.3. *Proposed conceptual model for decomposing the value for the customer*

It is our objective to understand how Value for the Customer could be broken down into component elements or simpler constituents integrating the value perceived by both suppliers and customers. To this end we derived the model in Fig. 2, which illustrates how to project the Value for the Customer of each exchanged deliverable[8] on to the following dimensions:

- The Forms of Value and Temporal Positions. The diagram maps the Forms of Value within their temporal positions, because "not only does each of us value the same things differently, we individually value different things, and at different times in different ways" (see Ref. 4, p. 4),
- The ARCON Endogenous and Exogenous perspectives[22] in the operation phase of the collaborative network life cycle,
- The usage and construction of tangible and/or intangible assets,[7,8] which are going to be projected across the collaborative networks' endogenous and exogenous perspectives.
- The Perceived Benefits (PB) and Perceived Sacrifices (PS), both by the enterprise itself and by the Customer — as seen by the people in the enterprise pictured and as a white diamond — are pictured in the illustration. These PB and PS will

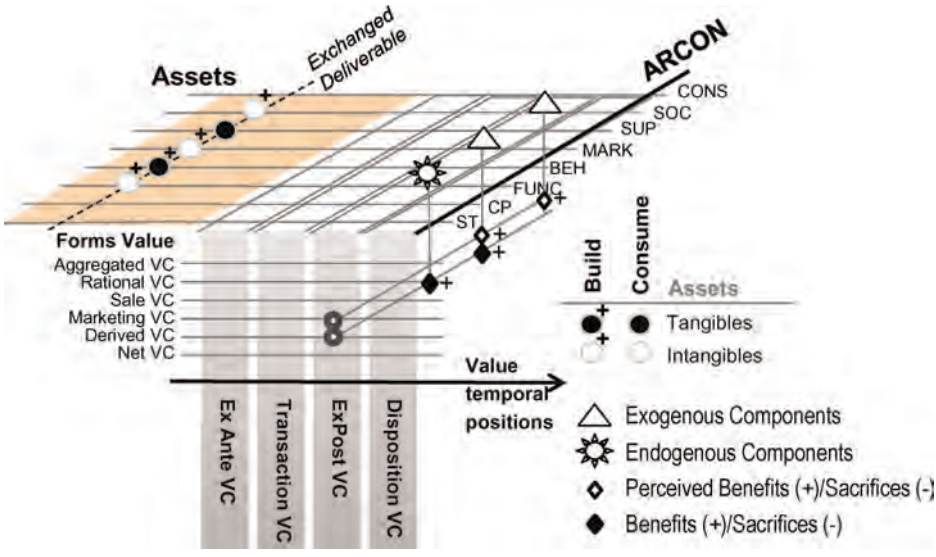


Fig. 2. Conceptual Model for decomposing the Value for the Customer.

provide the means to derive the relative value of each asset and, as a consequence, the relative value of each tangible of intangible exchanged deliverable.

3. Case Study

3.1. *Unit of analysis*

The present Case Study was conducted at CPMT in Porto along the second semester of 2010. Figure 2 illustrates the CPMT value network.[6–8,13,19,24] The roles picture real people in the network, who perform different activities within CPMT. This study will focus on two roles, the Safety Service Manager and the Service Provider Manager and in their interaction with the customer company. As illustrated in the Value Network, transactions begin in one participant and end in another. Solid lines depict the exchange of tangible assets (e.g., process changes to improve safety), and dashed lines the exchange of intangible assets (e.g., improve worker health and happiness). The arrows express the direction of the exchange between two roles. The deliverables are the tangible or intangible assets that move from one participant to another.[7]

Using the information gathered in the interview and following the Business Narrative Modeling Language (BNML) approach, proposed by Oliveira and Pinto Ferreira,[25] the exchange of the deliverables between the CPMT and its customers were modeled and analyzed. In our approach we aimed at understanding how a Service Proposal from CPMT to one of its customers is decomposed as a finite set of deliverables. This analysis resulted in decomposing a Service Proposal into 19 deliverables provided from the CPMT to its customer at the "point-of-analysis" pictured in Fig. 3.

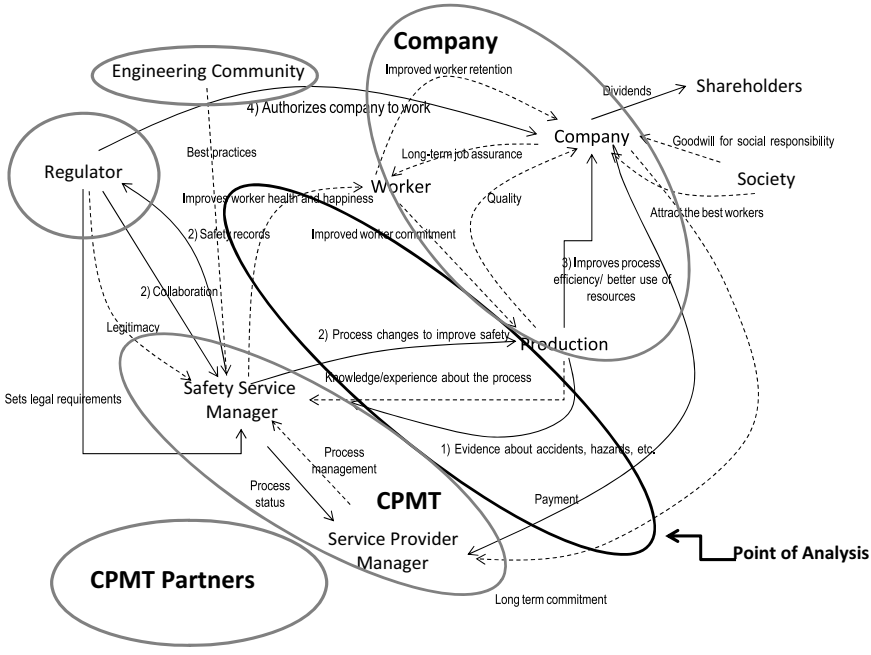


Fig. 3. Value Network for CPMT.

3.2. *Data collection methodology*

This case study was conducted at the company through the personal interview of two enterprise members. We started the process with a recorded interview with open-ended questions to the managers of the "Safety and Industrial Hygiene Services" and "Quality" departments. For the first phase the goal was to have an informal conversation, where they explained their routine and perception of how services unfold within the enterprise. With the support of the interviewee, we could investigate "a phenomenon within a specific natural setting" and using "multiple sources of evidence"[26] to gain experience and perceive certain issues which we aimed to extract in detail. In a second interview round, the interviewees were asked to give a very detailed description of all deliverables exchanges across the point-of-analysis (Fig. 3). These interviews combined with documents provided by the enterprise allowed the triangulation of the collected information.

3.3. *Deliverable exchange at the point of analysis*

We were able to identify three deliverables areas: the one related with the Customer Requirements, the ones that cover to whole value offered by the CPMT to customer companies, under the Value Proposition, and, finally, those related with the actual Service operations. For each of these areas and in the course of the interview, we were

able to identify several deliverables. Their identification and final validation was made in collaboration with both interviewees.

The Requirements area comprises the following deliverables: Customer Company Legal Requirements (DL_1 — Legal Requirements Customer); CPMT Legal Requirements (DL_2 — Legal Requirements CPMT), CPMT legitimacy (DL_3 — CPMT legitimacy); and Best Practices (DL_4 — Best Practices). The DL_1 is, in fact, the reason for the existence of CPMT. Companies need this Health and Safety Audits to get their operating license. The other deliverables are detailed in the context of the following interview excerpts.

Interview excerpts:
Regarding the legal requirements needed for the CPMT (DL_2) the interviewee referred that "(...) *to provide an occupational health service, as well as good safety and hygiene standards, the company must be legally empowered to do so. There is a set of statutes stating that companies must be legally qualified to provide a service.*" "*The terms of the contract may be adjusted at the very beginning of the service and while it is being carried out.*" It was further mentioned that CPMT has to fulfil legal requirements that define "(...) *how [CPMT] should operate. There is a regulation that lays down a mechanism for accreditation. Companies have to be legally accredited to be able to provide this service.*"

Regarding the CPMT legitimacy (DL_3) the interviewee referred: "(...) *in the same way, the CPMT must have a legal entitlement to operate.*" *That is* "*companies must be legally qualified in order to provide the service.*"

In a most relevant remark, it was stated that "(...) *the rules do not define everything, there are good practices in business*". *As an example* "(...) *we have the best practices that we use and that are not specified by law: related with the medical records; Medical Exams Protocols recommended by the Medical Association* ("*Ordem dos Médicos*"); *and other practices such as several protocols for some types of exams, that we use and that are common practice in Spain.*" This means that the Best Practices (DL_4) provided by the CPMT is a most relevant deliverable.

The Value Proposition area comprises the following deliverables: Improvement in Worker Health and Happiness (DL_6), Improve Worker Commitment (DL_7), Health and Safety Audits (DL_8). The Value Proposition (DL_5) was considered itself a deliverable as it allows the instantiation, as a whole, of actual customer value perception of the CPMT service. Value Proposition as defined by Osterwalder and Pigneur[27] is "the bundle of products and services that create value for a specific Customer Segment."

Interview excerpts:
According to the interviewee the Value Proposition (DL_5) "(...) *is evaluated by the customer at the beginning of the negotiation, as soon as the contract is entered into*". It is also evaluated in another phases, because sometimes it could suffer

some adjustment, as "(...) *other additional activities*, *which will be contracted as they appear*."

When talking about the Worker Health and Happiness (DL_6) the interviewee referred that: "(...) *we can identify the point of view of the* customer *gains in service safety and hygiene*, *including*: *legal requirements*; *improved working conditions*; *improved productivity*; *contribution to quality improvement as well as worker satisfaction*."

About Improving Worker Commitment (DL_7), it was mentioned that "(...) *it is an objective of the enterprise improve the worker commitment*" also "(...) *sometimes the CPMT team must be prepared to change the objectives to which they originally proposed. Must face some adversity to get new resources to safety improve*." As an illustration of this dynamic adjustment, CPMT promotes flexibility by allowing the worker check-ups to be made at the best convenience of the actual worker. This becomes very convenient for the customer company workers that travel and are often away from the company headquarters.

Finally, regarding to Health and Safety Audits (DL_8) the interviewee referred that "(...) *usually there is a productive process during which audits are carried out*, *and the company also provides information about that process*." "(...) *by assessing the state of the customer facilities*, e.g., *noise levels*, *the service provider can make a pre-analysis of working conditions*."

The Service area comprises the following deliverables: Process Changes to Improve Safety (DL_9), Process Changes Implementation (DL_{10}), Knowledge/Experience about the Process (DL_{11}), Payment (DL_{12}), Long-term Commitment (DL_{13}), Evidence about Accidents and Hazards (DL_{14}), Service Quality (DL_{15}).

Interview excerpts:
The deliverable Process Changes to Improve Safety (DL_9) is related to the needed flexibility to adjust the service to the customer's company needs. This could involve, as in DL_7, the service provision in another location. This could further involve having particular exams made in particular points in time, or need, the next for unforeseen exam requirements. These changes are made "(...) *to improve safety and hygiene that has effects on* [*the customer*] *production*".

The CPMT has to face with some Changes in the Process Implementation (DL_{10}) because "(...) *there are companies that want to make their workers check-ups outside the seasonal production peaks in order to avoid affecting the productivity*." "*When faced with a situation that is not covered in the original contract*, *we have two situations*: (1) *we propose to provide the service ourselves*; (2) *but we always give our customers the chance to subcontract that service in another company*, *we have this attitude for the sake of transparency*, *and*, *if requested*, *we help in selecting the service provider*."

Knowledge/Experience about the Process (DL_{11}) was implicitly acquired by CPMT along its many years of successful operation in Portugal. This was

accomplished through the systematic gathering of information regarding "(...) *evidence about accidents and about on the products used* (...)" and by keeping abreast with the state-of-the-art in this area.

The Long-term Commitment (DL_{13}) results in having "(...) *customers renew*[*ing*] *their contract*". This also relates with CPMT knowledge about the process that adds value to the whole Value Proposition to the customer.

Evidence about Accidents and Hazards (DL_{14}) is related with the: "(...) *information and evidence about accidents on the products used and on assessments made about levels of noise and fumes* (...)". In face of Evidence about Accidents and Hazards, there are "(...) *legal requirements to be met and there might be accidents that may affect the actual production process that may have to be changed and improved*."

The interviewee has further referred to the CPMT Service Quality (DL_{15}). This customer perception improves "(...) *once working conditions improve*, *the quality of work increases* (...)". For example "(...) *by reducing the noise level and avoiding accidents*, *the quality of work* [*at the customer company*] *increases*." On the other hand, "(...) *if we ensure that the check-ups and exams are performed in less and X hours*, *this becomes a competitive advantage for the customer company*". At this point we would add that CPMT is certified ISO9001:2000.

3.4. *Data analysis methodology*

Data analysis was supported by the so-called BNML proposed by Oliveira and Pinto Ferreira[25] outlined in Fig. 4.

The coding for this research was centered in the following views on the collected data for each Deliverable (*DLi*) exchanged in the point-of-analysis (Fig. 3):

- Business Model Canvas (Storyline view),
- *DLi* projection onto the used and build assets (Storyline view),
- Universe of Analysis
  - — Deliverable identification,[7,8]
  - — Deliverable Value Exchange (perception),[7,8]
  - — Value Temporal Position of *DLi*,[4]
  - — Forms of Value related to *DLi*,[4]
  - — *DLi* projection onto the ARCON Endogenous and Exogenous components,[22]
  - — *DLi* projection onto the Enterprise Ontology.[56]
- Interview evidence.

The interview segmentation into narrative patterns allows the construction of a Microsoft Excel table where each line establishes the relationship among the different coding scheme terms and the interview evidence that provides the rationale for those relationships. For this Case Study, the narrative pattern is, in fact, the actual

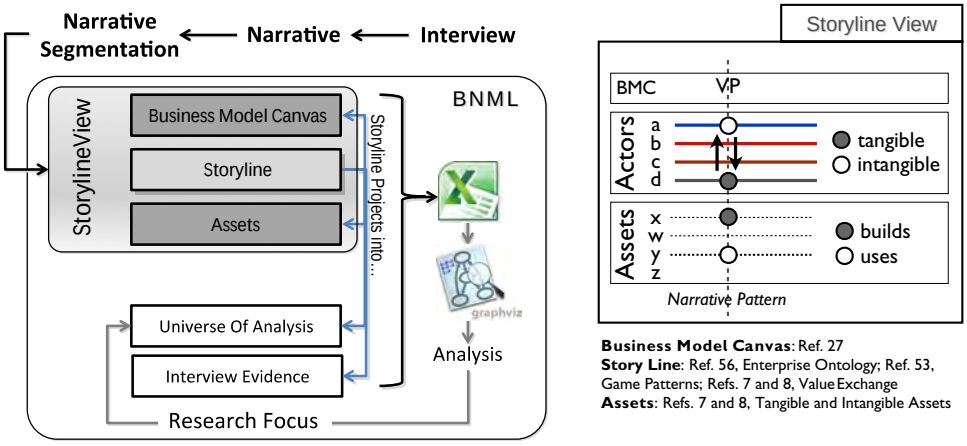


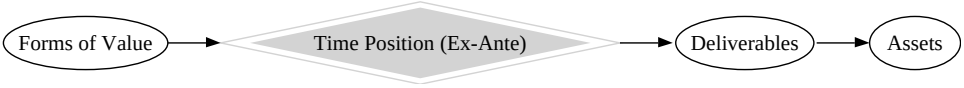
Fig. 4. Business Narrative Modeling Language.[25]

detailed deliverable description. The Excel worksheet is then further processed using "pivot tables" in order to extract the desired perspectives onto the data model. For the sake to limiting the discussion of this Case Study in the context of this paper, we limited the analysis to the Ex-Ante time position, the Pre-purchase phase. In this context, we will be looking into a contract preparation phase and, therefore, at the set of foreseen deliverable exchange belonging to that contract.

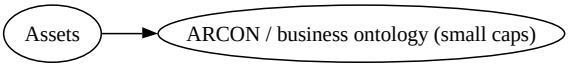
4. Case Study Discussion

4.1. *Perspective of analysis, pre-purchase phase*

The analysis of the Pre-Purchase phase that corresponds to the period before the handing of the contract proposal to the CPMT customer seemed most interesting, as it relates to the perceived Value for the Customer "whenever they contemplate the purchase" (see Ref. 4, p. 10). This phase is related to "a guess about probability of uncertain future consequences," and involves several decisions in order to measure the *Ex-Ante Time Position for the Value For Customer* (EXA_VC) in terms prior to consumption. This is a primary issue in adjusting of the Value Proposition of a product or service. From an Ex-Ante perspective this is fundamentally about whether we will decrease the error and increase relevant information for future funding decisions, by predicting the different scenarios. Since the future of the Value Proposition is unknown and highly uncertain, and the evaluation of the optimum is undetermined, the only objective data is the one collected along historical observations that enterprise (CPMT) has made at their customer's. This phase is, therefore, a point in time for anticipating future predictable occurrences so that we can "make choices to maximize the ex-post happiness" (see Ref. 17, p. 325).



(a) "Forms of Value" -> "Time Position (Ex-Ante)"-> "Deliverables" -> "Assets";



(b) "Assets" -> "ARCON/business ontology (small caps)";

Fig. 5. Analysis Segments of the deliverables for the Ex-Ante Time Position.

4.2. *Data analysis and discussion*

The analysis to the Ex-Ante time position will be made by converting the excel data and implied connections into a graph using Graphviz. To this end, and for the sake to simplifying the discussion, we will break this temporal position view into two segments outlined in Figs. 5(a) and 5(b).

Forms of value, deliverables and assets

Figure 6 illustrates a graph that relates all different perspectives of analysis (for the segment (a) in Fig. 5) to the Pre-Purchase (Ex-Ante) time position. The graph in Fig. 6 illustrates the connections found for EXA_VC (Ex-Ante Time Position for the Value For Customer) relating "Forms of Value", "Deliverables" and "Assets". As explained before, this graph results from a filter applied using Excel "pivot tables" to the coded data. This filter makes the relations for the "EXA_VC" keyword explicit.

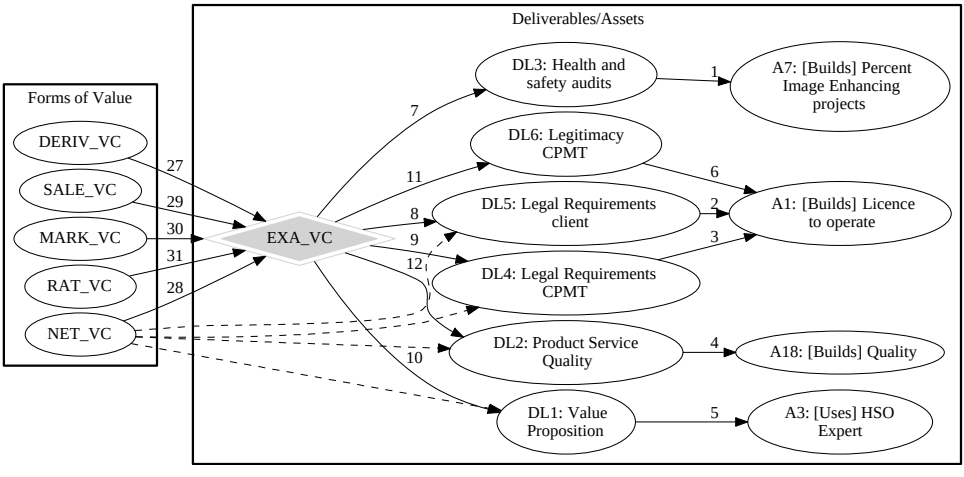


Fig. 6. Graph of the Value Temporal Position — Pre-Purchase (EX-VC) — Segment (a).

Forms of Value

All forms of value emerged from this phase - EXA_VC: the "Derived VC" (DERIV_VC – edge 27), "Net VC" (NET_VC – edge 28), "Sale VC" (SALE_VC – edge 29) "Marketing VC" (MARK_VC, edge 30) e "Rational VC" (RAT_VC, edge 31).

The "balance of benefits and sacrifices", by equating the weight "and/or quantities of benefits and sacrifices" (see Ref. 4, p. 7) emerges at the so-called "Net VC" form of value. In this form of value we want to evaluate "how customers perceive the total value proposition (e.g., products, services, channels, ideas)" (see Ref. 3, p. 124). This form of value is related directly with the following deliverables (dashed lines): Legal Requirements for CPMT, Legal Requirements by the Customer; Product/Service Quality; and Value Proposition. The lines connecting the other Forms of Value and the Deliverables were not included in the illustration to avoid visual overload.

Marketing VC is linked with a "pre-experience zone and can best be associated with an Ex-Ante temporal perspective," because "suppliers can never predict how each consumer will perceive and react to a specific service" (see Ref. 4, p. 17). We can say that this form of value is seen as a "perceived component". It is also imminently linked to the product attributes and "concerned with the way that the organization goes to market".[4]

> *Interview excerpts*:
> Some customers are more concerned with price whereas, in other cases, the CPMT would show that "*the service offers better value.*" For example, "(...) *to have very rapid response times when arranging appointments for temporarily employed workers in other companies.*" Going into further detail, the Marketing VC relates to the following deliverables: Value Proposition (edge 10); Legitimacy (edge 11); Product/Service Quality (edge 12).

Derived VC also appears at this phase, because it relates to expected "uses/experiences outcomes," "derived from the consumption activity that associates the subject with individual social groups favored",[4] helping suppliers fulfil the customer's needs. The Derived VC relates to the deliverables in edges 7 (Health and safety audits) 10 (Value Proposition) and 11 (Legitimacy).

> *Interview excerpts*:
> Expected outcomes demand that "*To provide a service whether for occupational health or safety and hygiene, the company must be legally qualified for the task.*" "(...) *In order to carry out the service, companies have to be legally qualified*" (edge 11, Legitimacy). "*The actual activity of work-based safety and hygiene is related to the legal framework, and is carried out within a complex of legislation which defines what the minimum requirements of safety and hygiene are in accordance with the type and extent of productive activity*" (edge 7, Health and safety audits).
>
> On the other hand, the interviewee referred to the earlier audit preparation by saying that "(...) *when an audit is going to be undertaken there are some already prepared checklists and one must try to make full use of their stipulations, but*

(*this must take place*) *while the service is being rendered*" (edge 7, Health and safety audits).

Mind that "(...) *this is accomplished before contact with the consumer.*" (edge 10, Value Proposition).

Sale VC appears to be linked "primarily on price" and reduction of sacrifice, and is associated "purely upon units of exchange" (money, for example) "and will almost certainly influence perception on VC" at an Ex-Ante temporal position (see Ref. 4, p. 19). The Sale VC relates to the deliverable in edge 10 (Value Proposition).

Interview excerpts:
The interviewee referred that VC means low relative price "*The aim is to provide the service at lowest possible cost while complying with minimum requirements. We have this kind of customer for whom the cost is all that matters.*" On the other hand some customers are more associated with the reduction of sacrifice by saying that "(...) *the lowest total costs might not correspond with the lowest service cost.*"

The Rational VC combines the notions of exchange value with intrinsic value and, as Net VC, it is essentially utilitarian in nature. It is used "in a predictive context and may be seen as being represented primarily in the ex-ante zone" (see Ref. 4, p. 19). This is a phase in which the customer will predict within what acceptable range he is prepared to pay — either much more or much less — depending on what extra product/service features he requires. The Rational VC relates to the deliverable in edge 12 (Product Service Quality).

Interview excerpts:
The interviewee referred that the VC is a clear demand by the customers. Although suppliers can estimate what price difference the market tolerates for doing different exams, the customer makes an evaluation of "what a fair price might be in relation to the benchmark already established" (see Ref. 4, p. 8). In this context interviewee mentioned that "(...) *the customer could be interested in the exams being conducted in a specific place, in whether there are temporary facilities instead of the examinations being conducted on the main site. He can ask for more exams, besides those already specified by law. There's a tendency for ever more companies to conduct ever fewer exams. They might need to contract additional services in order to conduct exams at certain times of year.*"

Net VC recalls a "utilitarian perspective on purchase and consumption," considering an intuitive calculation in dividing benefits and sacrifices. The Net VC relates to the deliverables in edges 10 (Value Proposition), 11 (Legitimacy) and 12 (Service Quality).

Interview excerpts:
As an utilitarian perspective on purchase and consumption, the evaluation of the benefits and sacrifices "(...) *has to be done by the customer.*" However, the CPMT helps the customer balance the involved benefits and sacrifices. Quoting the interviewee "*If the work contributed to customers gains then they will hire CPMT*

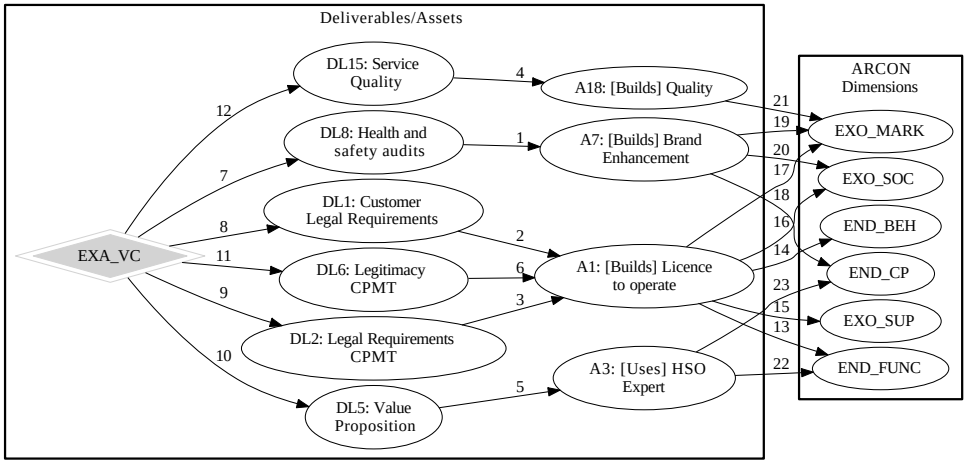


Fig. 7. Graph of the Value Temporal Position — Pre-Purchase (EX-VC) — Segment (b).

again. From the point of view of customer, we can advise some good services in safety and hygiene, including legal requirements, that can improve working conditions, improves productivity, contributing to quality improvement (reduction of costs of nonquality by accident) and worker satisfaction."

Deliverables, Assets and ARCON Endogenous and Exogenous Perspectives
Figure 7 illustrates segment (b) of the Ex-Ante Time Position of the CPMT deliverables at the point of analysis. This discussion will be centered in the analysis of the assets used or built, and on their endogenous and exogenous composition. This approach will enable a better understanding of how each deliverable, and as a consequence, its perception of value, relates to components that are endogenous and exogenous to CPMT.

Asset A_1 – [Builds] License to Operate
The construction of this asset is related with deliverables DL_1, DL_2 and DL_6. The asset A_1 is projected through the ARCON at endogenous and exogenous components. Functional endogenous (END_FUNC – edge 13) "shall define the protocols to be followed as well as participants that shall be involved in each phase" (see Ref. 22, p. 96). This is related with how CPMT operates, either as an isolated company or as a collaborative network, whenever a partnership is used to geographically extend their services. In this context, they all have to fulfil the legal requirements to operate so that they become "(...) *legally empowered to provide a service* (...)".

The behavioral endogenous (END_BEH – edge14) dimension "prescribes normative guidelines or rules for the proper behavior of CNO" (see Ref. 22, p. 97). According to the interviewee the CPMT must be legally empowered to work and have the minimum rules to provide the service. This relates to the CPMT stance in relating all aspects regarding the enterprise operation, namely leadership, employee relations, as well as the relations with customers and business partners.

This asset, is linked to the exogenous Support dimension (EXO_SUP – edge 15) since "those entities are entitled to issue certificates of compliance with established regulations or norms" (see Ref. 22, p. 108). In the same way it is related with exogenous Society perspective (EXO_SOC – edge 16) because it "determines the laws that affect or regulate the existence and operation of the [network]" CPMT itself and of its network of partners (see Ref. 22, p. 108). This latter component gives the outside world an indication of what can be expected from the company.

The exogenous Market dimension (EXO_MARK – edge 17) "covers issues related with interactions to customers" (see Ref. 21, p. 11). It is intended for the target market, and offers a range of services, selecting the most relevant opportunities "for achieving its goals and sustainable competitive advantage," including elements such as transactions and established commitment.[22]

Asset A_3 – [Uses] HSO Expert
The usage of this asset is intimately related to the Value Proposition (DL_5) and relates to END_FUNC (edge 22) dimension as resulting from the "consolidation of knowledge acquired" (see Ref. 22, p. 94).

The endogenous Componential dimension (END_CP – edge 23) relates to the "set of documentation/information and assets which inherit from past collaboration cases" (see Ref. 22, p. 93), related therefore with expert acquired experience. On the other hand: "(...) *we have examples of customers*, *such as a Shoe producer*, *with special requirements that result from the usage of special components. This is a case that has to be tough and analyzed against best practices* (...)."

Asset A_7 – [Builds] Brand Enhancement
The construction of this asset is related to the Health and Safety Audits (DL_8). The asset is related to the endogenous Componential dimension (END_CP – edge 18) "in terms of their competencies, profile and potential roles they can perform" (see Ref. 22, p. 93). This means that the way the service is provided by all CPMT human resources, namely the way they use their competencies to perform their roles in the process, is critical to CPMT Brand Enhancement.

The EXO_MARK (edge 19) dimension relates to all "relevant past successful collaboration stories from customer, attesting the level of competence" (see Ref. 22, p. 105).

At EXO_SOC (edge 20) dimension relates "the contribution of CNO activities of benefit to the society in general" (see Ref. 22, p. 108). This gives the society an indication what can be expected from the service. In the case of proposed health and safety service, its mission is to "(...) *improve employee satisfaction*, *improve the image the company decreasing by the aspects related with workplace accidents*."

Asset A_{18} – [Builds] Quality
This asset also related with the EXO_MARK (edge 21) perspective as it "refers to the actions devoted to deliver information about the competencies and products services in order to attract customers" (see Ref. 22, p. 106)

4.3. *Case study conclusion*

The graphs in Figs. 6 and 7, validated through the interviews and then revised with the interviewees, demonstrate the connections proposed in the Conceptual Model for Decomposing the Value for the Customer pictured in Fig. 2. We aimed, at this first step, to validate the rationale for the relationships among the different proposed constructs. These results provide the answer to the first research question "How can the Value for the Customer be modeled?" and also to its refinement in question 1.1 "How is this value built on top of assets endogenous and exogenous to the organization?" The detailed analysis of the exploratory case study demonstrated the proposed connections. It also confirmed the role of endogenous and exogenous assets and their relationships to the exchanged deliverables whose value will, ultimately, be perceived by the Customer.

The other two research questions (1.2 and 2) remain to be answered. To this end, we will go through the second step that corresponds to the mathematical formulation of this model that is discussed in the next section. In this section we will see how value perception, as Perceived Benefits and Perceived Sacrifices, are integrated into this model.

5. Deriving the Mathematical Formal Model for the CMDVC

In this section we derive the formal representation of the CMDVC, based on the "Formal Basis for Negotiation Support Systems Research" by Holsapple *et al.*[28] This author proposed that a negotiation activity can be described as having five variables:

$$N = (E, DL, RU, AR, t).$$

In N the:

"E" stands for the entities participants,
"DL" represents the set of exchanged deliverables,
"RU" stands for the agreed negotiation rules,
"AR" stands for the region of acceptance, and
"t" stands for the time.

In a negotiation decision problem situation, one or more decision makers make a series of choices with interdependent outcomes. However, decisions that are at first glance unrelated to each other, such as DL_7 (Improved Worker Commitment) and DL_7 (Health and Safety Audits), may also be interdependent, casually related to and jointly affecting some common objectives, for example the building of A_{18} ([Builds] Quality) and A_5 ([Builds] Promotion of Long-term Employee Collaboration). The adaptation of this approach to our model does not impose any restrictions to our approach but extends our concepts by making them readily applicable to negotiation scenarios.

5.1. *The deliverable concept*

The work of Holsapple *et al.*[28] was developed in the context of negotiation. In this context, the notion of deliverable is a matter that is in dispute between two or more parties and can involve conflicts/disputes among entities or a cooperative effort to reach a common goal.

Every negotiation is related to a global Value Proposition and may include several deliverables. In the current context, one may define a deliverable (tangible or intangible) as being represented by the set DL_i:

$$DL_i = \{DL_1, DL_2, \ldots, DL_n\},$$

where n is the number of deliverables at stake in the negotiation.

At this point we extend the Holsapple *et al.*[28] model by relating each DL_i with the assets used and/or built up in the context of providing that deliverable. This set is represented by the following formulation:

$$A(DL_i) = \{A_1, A_2, \ldots, A_m\},$$

where m is the number of assets related to each deliverable. Still in this context, and for each asset, we will have to describe the related benefits and/or sacrifices. We have, therefore:

$B(A_i)$ as the set of benefits:

$$B(A_i) = \{PB_1, PB_2, \ldots, PB_q\},$$

where q is the numbers of benefits associated with each asset A_i.

$S(A_i)$ as the set of sacrifices:

$$S(A_i) = \{PS_1, PS_2, \ldots, PS_p\},$$

where p is the numbers of sacrifices associated with each asset A_i.

For example, for the asset A_7 – "[Builds] Brand Enhancement" the sets of benefits and sacrifices in the Componential endogenous dimension are:

$$B(A_7) = \{\text{Operational Benefits; Personal Benefits}\},$$
$$S(A_7) = \{\text{Price; Cost of Repair}\}.$$

5.2. *The concept of entity*

There is a set of entities that have influence on the negotiation of a Value Proposition. An entity can be a person, a group, a computer or a human–machine combination. We assume that entities will be the same during one transaction and use E to represent the set of all the entities:

$$E_i = \{E_1, E_2, \ldots, E_p\},$$

where p is the number of entities involved in the negotiation.

In our case study, Fig. 3, we have five entities in the Value Network. However not all of them will be active during the negotiation:

$$E = \{\text{CPMT, Regulator, Company, Partner, Engineering Community}\}.$$

5.3. *The concept of acceptance region*

The acceptance region (AR) gives us the acceptable points within each deliverable. It can be different in all entities and in time (t) but the intersection for all entities (E) in an acceptance region will form a basis for reaching an agreement.

$$\forall_{E_i} \in E, \quad AR_{it} = AR(DL, E_i, RU, t).$$

The AR is composed by the different scenarios of negotiation. As the negotiation unfolds, according to the rules agreed by the parties involved (these rules can be implicit), the value of each dimension will change and therefore the issue value will change as well, as a result of the consolidation of those dimensions. This region will change as the entities involved in the negotiation modify their individual positions.

There should be an agreement area where all points within this zone are possible solutions, i.e., there must be a nonempty solution.

5.4. *The concept of negotiation rules*

The Negotiation Rules, designated by RU, allow all entities involved to act correctly, and are divided into some several categories:

$$RU(TC, RC, RES).$$

"TC" — Time Constraints, for instance, or the deadlines,
"RC" — Regulation for Coalition Formation,
"RES" — Rules for making Decisions.

5.5. *Conclusion*

This section illustrated how the Holsapple *et al.*[28] Formal Basis for Negotiation Support System Research was extended to comply with the proposed Conceptual Model for Decomposing the Value for Customer. This extension materialized as result of the need to relate Holsapple's Deliverables with the endogenous and/or exogenous Enterprise Assets, used or built in the process of fulfilling that deliverable, and the benefits and sacrifices as perceived by the party being considered. This mathematical model of the CMDVC provides the first step answer towards the answer of research questions 1.2 and 2. The final answer is to be expected at the end of the next section where we will apply the proposed model to the case study and realized the first validation through the exploratory case study.

6. An Essay on a Pre-Negotiation Setting, Applying the Conceptual Model to the Case Study

6.1. *Negotiation*

According to Filzmoser and Vetschera,[29] "negotiations are dynamic processes in which the parties involved communicate to exchange offers, make concessions, raise threats, or otherwise influence each other in order to reach an agreement." The authors De Moor and Weigand,[30] after analyzing several negotiation definitions, stressed that those definitions shared common elements such as the fact that there are two or more participants, each of them with individual goals that may not be totally compatible. They also highlight that in a negotiation: there is usually a process involved, there are alternatives to be investigated, and there is a shared purpose to reach an agreement. Moreover, each negotiation process has its life cycle, depending on the negotiation model used.[30]

Every negotiator must negotiate to win, but there are two ways of winning, the first one being to reach an agreement where the interests of all the involved parties are met; the second being to win at all costs at the expense of the other parties. The possible outcomes of a negotiation can be better understood by studying Fig. 8 (lower-right corner) of a negotiation scenario, which depicts the acceptable ranges within benefits and sacrifices and where "–" indicates a weak negotiating position, while "+" indicates a stronger one. The bold lines represent the very lowest acceptable position for each of the negotiating parties and for each

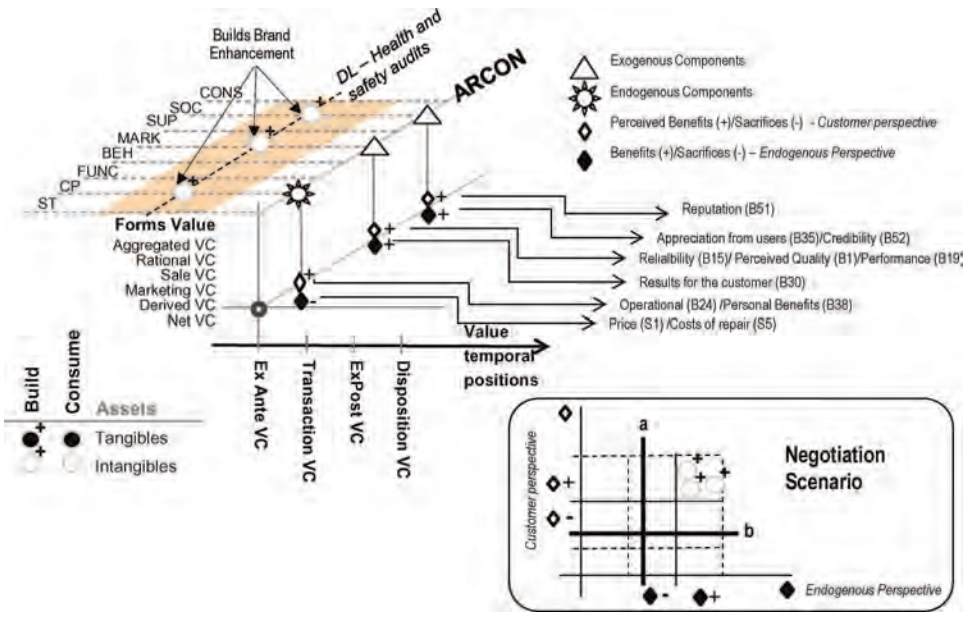


Fig. 8. Decomposing the Value for the Customer of specific *DL* in an Ex-Ante Phase.

particular deliverable. According to Carnevale and Pruitt (1992) there are four ways of reaching a deal: (a) There is no agreement; (b) the agreement favors only one of the parties with no compensation for the other; (c) only one compromises (meaning that only one is in a weak position); (d) there is agreement with a Win-Win result (both parties are in a favorable position "+"). The broken lines give us the tangible or intangible upper and lower value limits (e.g., monetary value, business relationships, internal structures, human competence, environmental responsibility, social responsibility) that each party does not wish to exceed within a transaction.

For each negotiation the overall real value and the perceived value should be positioned within an agreement area of the negotiation utility space,[31] such that all players involved feel that they achieve an overall real benefit (win-win) from the negotiation. The two bold lines (a) and (b) give the value limits that each party does not wish to exceed in the value proposition. For example the line (a) could be the internal cost of a particular asset that the company does not wish to exceed and line (b) the cost that the company does wish to maintain in their customer relationships, as this could be an asset whose perceived value is comparatively high.

In this context, this section aims at illustrating the usage of the previously presented mathematical formulation of the CMDVC in the context of a negotiation. As mentioned earlier we will only look at the Ex-Ante phase, meaning, the preparation phase that happens before the contract proposal presentation to the customer and, therefore, before the actual negotiation. This is the point in time where the overall Value Proposition as well as the value of each foreseen deliverable set is weighted against the customer value perception. The mathematical formulation of the CMDVC will enable the fast evaluation of alternative scenarios and support decision making along the whole negotiation process.

6.2. *Applying the CMDVC in an Ex-Ante negotiation scenario*

This paragraph aims at illustrating the detailed instantiation of a deliverable into CMVDC, enabling therefore an easier understanding of the extension of the formal mathematical model and its application to the case study model at the point of analysis to be analyzed in depth in Sec. 6.3.

This section makes a detailed analysis of one of deliverables analyzed in Fig. 6. DL_8 – "Health and Safety Audits" decomposition in the Ex-Ante Temporal phase is illustrated in Fig. 8. This picture maps the connections featured in the graph of this deliverable presented in Figs. 6 and 7. Moreover, it features the involved benefits and sacrifices in the context of a negotiation scenario. The benefits and sacrifices now emerge as two projections of one sole perspective, the Enterprise Perspective, of: (1) the Endogenous benefits and sacrifices quantified by the enterprise, as they refer to itself; and (2) the Customer Perspective that materializes the enterprise belief of the actual customer perceived benefits or sacrifices. We would add that the error of

this latter quantification can be reduced by integrating the enterprise experience and close customer relationship.

Figure 8 shows DL_8 as building the asset "[Builds] Brand Enhancement" (see Ref. 6, p. 26 Table 2) and how this asset is projected into exogenous/endogenous components of the ARCON, forms of value and value temporal position. Zooming into the detail of DL_8 we can see that this asset is projected on two dimensions of the exogenous components, namely Market and Society, and also on to the endogenous Componential dimension.

Moreover, DL_8 is associated with the benefits and sacrifices for enterprise itself and to the customer perceived benefits/sacrifices, as also seen by the enterprise (CPMT). These benefits/sacrifices arise from multiple factors and problems involving the different parties' nonoverlapping objectives, as well as conflicting criteria to which we could further add risk perception, along with behavioral[32] and organizational environmental issues.[33] In his publication, regarding the decision-making perspective in negotiation, Tsay and Bazerman[34] further refers to Raiffa's research, which mentions that negotiators' behavior should not always be considered rational. Moreover, negotiators sometimes tend to aim at a particular objective, such as acquiring a particular share of the total deal, thus missing opportunities for mutually beneficial exchange. The point is that value is also perceived and therefore valued differently, and failing to consider the opponent's perspective may lead to missed opportunities. As a result, contract proposal preparation should have in mind these most relevant issues.

In the example of Fig. 8, the asset is projected into the ARCON Market Dimension. This dimension looks at Customers, potential Beneficiaries and Competitors. This is, therefore about customers perceived benefits such as reliability (see Ref. 3, p. 125) and perceived quality and performance (see Ref. 4, p. 12 Table 2). On the other hand, from the company perspective we have the benefit "results for the customer" (see Ref. 4, p. 12 Table 2), as these results may induce new and more projects. The asset "Builds Brand Enhancement" is also projected onto the Society ARCON Dimension as reputation and credibility (see Ref. 4, p. 12 Table 2). This reputation and credibility builds on a good public image that is likely to be the evidence of technical competence in the provision of adequate solution to existent problems in customer companies.

6.3. *Applying the CMDVC mathematical model — using the fuzzy AHP method in an Ex-Ante perspective on negotiation*

6.3.1. *The CMDVC mathematical model*

The next few paragraphs build on the CPMT case study in a pre-negotiation scenario (Ex-Ante perspective on Negotiation), comprising the usage of set of deliverables belonging to a contract proposal to be exchanged at the Point-of-analysis. We will work with those Deliverables and related Assets and Benefits, from now on referred to as variables. In this example we intentionally excluded the Sacrifice quantification.

Table 1. Deliverables, assets and benefits in an Ex-Ante perspective.

Deliverables	Assets	Perceive benefits
DL_3 : Legal Requirements CPMT	A_1 : Builds License to operate	PB_{20} : Functional Benefits
DL_1 : Legal Requirements Customer	A_3 : Uses HSO Expert	PB_{24} : Operational Benefits
DL_2 : Legitimacy CPMT	A_7 : Builds Brand Enhancement	PB_{48} : Image
DL_8 : Healthy and Safety audits	A_{18} : Builds Quality	PB_{51} : Reputation
DL_5 : Value Proposition		
DL_{15} : Service Quality		

This does not impose any limitations on the results and makes the actual demonstration easier to understand.

Building on the variables listed in Table 1, we now outline the detailed Mathematical formal model for applying the Fuzzy AHP method to the CPMT Case Study.

In a value temporal position $t = \{\text{Ex\_Ante}\}$ we have the following deliverables:

$$DL_i = \{DL_1; DL_2; DL_3; DL_5; DL_8; DL_{15}\}.$$

For each DL_i we have to describe the assets used/built, as:

$$A(DL_1) = \{A_1\}; \quad A(DL_2) = \{A_1\}; \quad A(DL_3) = \{A_1\};$$
$$A(DL_5) = \{A_3\}; \quad A(DL_8) = \{A_7\}; \quad A(DL_{15}) = \{A_{18}\}.$$

For each asset we will have the related benefits:

$$B(A_1) = \{PB_{20}; PB_{24}\}; \quad B(A_3) = \{PB_{20}; PB_{24}; PB_{48}; PB_{51}\};$$
$$B(A_7) = \{PB_1; PB_{15}; PB_{19}; PB_{20}; PB_{24}; PB_{51}\};$$
$$B(A_{18}) = \{PB_{20}; PB_{48}; PB_{51}\}$$

and, also the sacrifices:

$$S(A_1) = \{PS_1; PS_5\}; \quad S(A_3) = \{PS_1; PS_{10}; PS_{11}; PS_{13}\};$$
$$S(A_7) = \{PS_7; PS_{10}; PS_{24}\}; \quad S(A_{18}) = \{PS_5; PS_{13}; PS_{24}\}$$
$$(\textit{As stated, the sacrifice quantification was excluded from this example.})$$

The entities involved at time t are:

$$E = \{\text{CPMT}(E_1);\ \text{Regulator}(E_2);\ \text{Company}(E_3)$$
$$= \text{Partner}(E_4);\ \text{Eng Commt}(E_5)\}.$$

As expected, only E_1 will be active at the Ex-Ante time position. This is the point in time when the CPMT is preparing the contract proposal before the actual negotiation takes place.

The acceptance region is given by:

$$\forall_{E_j} \in E, AR_{it} = AR(DLi, E_j, RU, t), \quad j = 1, 2, 3, 4, 5; \;\; i = 1, 2, 3, 4, 5, 6.$$

For example we have:

$$\begin{aligned}
&AR_{1\text{Ex_Ante}} = AR(DL_5, E_1, RU, t)\\
&AR_{2\text{Ex_Ante}} = AR(DL_{15}, E_1, RU, t); \quad AR_{2\text{Ex_Ante}} = AR(DL_{15}, E_2, RU, t)\\
&AR_{3\text{Ex_Ante}} = AR(DL_8, E_1, RU, t);\\
&AR_{4\text{Ex_Ante}} = AR(DL_2, E_1, RU, t)\\
&AR_{5\text{Ex_Ante}} = AR(DL_1, E_1, RU, t); \quad AR_{5\text{Ex_Ante}} = AR(DL_1, E_3, RU, t)\\
&AR_{6\text{Ex_Ante}} = AR(DL_3, \mathrm{E}_3, RU, t).
\end{aligned}$$

As the negotiation rules are not relevant for the discussion of the proposed model they were not included in the demonstration.

6.3.2. *Applying the fuzzy AHP method in the VC evaluation*

In this section we want to understand the weight of each deliverable in the Value for the Customer and the role that it may play in the future negotiation with the CPMT customer. This value is related with the actual tangible and intangible assets that are used and/or built in the deliverable exchange, and how their value is perceived.[7]

The valuation and measurement of tangible and intangible assets is a difficult task, since it brings together qualitative and quantitative variables. We must weigh the "value-based drivers" (term set by Lapierre[3]) identified by benefits and sacrifices, of each assets in the enterprise. This involves multi-criteria decision analysis (MCDA), where we have several conflicting criteria in a setting where their importance is not easily determined.[35] In this sense, the AHP is a systematic decision-making tool which combines both qualitative and quantitative techniques. AHP has been eagerly developed for application in various areas over recent years.[36–40]

However, this traditional AHP method "is problematic in that it uses an exact value to express decisions maker's opinion in a comparison of alternatives" and this makes it unable to adequately handle the inherent uncertainty and imprecision in the pairwise comparison process.[41]

A theory proposed for Zadeh's, in 1965 creates a fuzzy environment, which is used by decision makers to give interval judgments rather than fixed value judgments to measure relative weights for evaluating the critical factors.[42] In this study we use Triangular Fuzzy Numbers (TFNs)[43,44] for a pairwise comparison and use the "extent analysis method for the synthetic extent value"[45] for the fuzzy pairwise comparison of a fuzzy number in order to derive the weight vectors. The application of this AHP-Fuzzy method enabled the construction of a computational model for the mathematical formulation of the proposed CMDVC. The background concepts for this method are detailed in the annex.

As in the AHP method, the Fuzzy AHP also has: a set of p criteria; a set of n alternatives; a set composed by the perception of two decision makers and the perception of the customer (as seen by CPMT). In this context the decision maker defines the weights that relate criteria and alternatives by using the Saaty's scale (see Table A.1 in the annex). We then cluster the data by using the TFNs for a pair wise comparison of fuzzy AHP. Then, using the "extent analysis method for the synthetic extend values" (Chang's[45]) (S_i) of the pairwise comparison and by applying the arithmetic operations on fuzzy numbers, we perform evaluations on the decision makers and the customer perception (as seen by CPMT), on the alternatives set with respect to each criteria. There are many applications for Fuzzy AHP in literature. For instance, Cebeci and Ruan[46] applied the Fuzzy AHP to compare the best consultant that provides the most customer satisfaction (Ref. 46, p. 191). A recent study by Nazari-Shirkouhi *et al.*[47] proposed the fuzzy AHP to find the priority and ranking of each information system project with seven criteria. Still others, presented a Fuzzy AHP in a wide variety of problems areas.[48,49]

As illustrated in Fig. 9, the CMPT criteria correspond to the different Assets A_1, A_3, A_7 and A_{18}. The alternatives available for each criteria are the different possible combinations of Perceived Benefits (PB_q): Functional Benefits (PB_{20}), Operational Benefits (PB_{24}), Image (PB_{48}) and Reputation (PB_{51}). The list of perceived Benefits and Sacrifices used in the analysis was compiled from both Lapierre[3] and Woodall.[4] The quantification of that perception combines inputs from two CPMT decision makers (D_1, D_2), as well as their opinion on how the customer (C_3) perceives each PB_q. The outcome is the hierarchical structure pictured in Fig. 9. In this context, Table 2 outlines the perceived benefits associated with each asset. The Perceived Sacrifices are also presented although not used in the following

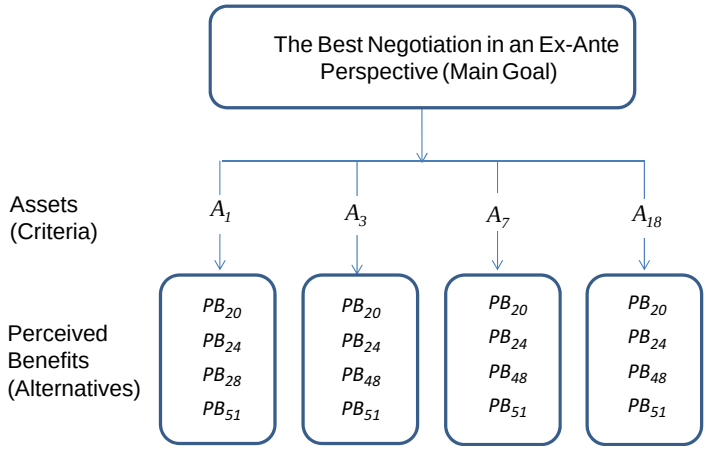


Fig. 9. Decomposition of the case study problem into criteria and alternatives.

Table 2. Benefits and Sacrifices associated to which asset.

	A_1	A_3	A_7	A_{18}
Perceived Benefits(PB)	PB_{20} — Functional Benefits PB_{24} — Operational Benefits	PB_{20} — Functional Benefits PB_{24} — Operational Benefits PB_{48} — Image PB_{51} — Reputation	PB_1 —Perceived Quality PB_{15} — Reliability PB_{19} — Performance PB_{20} — Functional Benefits PB_{24} — Operational Benefits PB_{51} — Reputation	PB_{20} — Functional Benefits PB_{48} — Image PB_{51} — Reputation
Perceived Sacrifices (PS)	PS_1 — Price PS_5 — Costs	PS_1 — Price PS_{10} — Opportunity Costs PS_{11} — Delivery and installation costs PS_{13} — Training and maintenance costs	PS_7 — Perceive costs PS_{10} — Opportunity costs PS_{24} — Effort	PS_5 — Costs PS_{13} — Training and maintenance costs PS_{24} — Effort

computations. Shaded in gray one finds the Perceived Benefits related with the Point of Analysis identified in Fig. 9.

6.3.3. *Evaluation of the criteria*

There are two (D_1, D_2) decision makers and C_3, where C_3 handles the perception of the customer as seen by the CPMT. For each decision maker and customer (C_3), each criterion may have the same or a different importance in the context of the problem. This means that we need that each involved party individually performs the needed pairwise comparison by using Saaty's scale 1-9 for all criteria as illustrated in Eq. (1).

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \quad i = 1, 2, \ldots, n; \quad j = 1, 2, \ldots, n. \tag{1}$$

The result of this pairwise comparison by using Saaty's 1-9 scale.[50] for the four criteria made by D_1, D_2 and C_3 are presented in Fig. 10.

Then, a comprehensive pairwise comparison matrix $(\tilde{D}_p)$ is built as in Table 4 by integrating the values of the evaluations made by D_1, D_2 and C_3 : $\tilde{b}_{jep}$ through the

Pairwise comparisons for the four criteria

D_1 Managment CPMT

D_1	A_1	A_3	A_7	A_{18}
A_1	1	5	1/7	1/9
A_3	1/5	1	1/7	1/7
A_7	7	7	1	1
A_{18}	9	7	1	1

D_2 Technical CPMT

D_2	A_1	A_3	A_7	A_{18}
A_1	1	9	7	1
A_3	1/9	1	1/3	6
A_7	1/7	3	1	1/7
A_{18}	1	1/6	7	1

C_3 Perception of the client

C_3	A_1	A_3	A_7	A_{18}
A_1	1	9	7	2
A_3	1/9	1	1/3	5
A_7	1/7	3	1	1/9
A_{18}	1/2	1/5	9	1

Evaluation of criteria

$A_1 \rightarrow A_3$	*A_1 it is 5 times more important than A_3*
$A_7 \rightarrow A_1$	*A_7 it is 7 times more important than A_1*
$A_7 \rightarrow A_3$	*A_7 it is 7 times more important than A_3*
$A_{18} \rightarrow A_1$	*A_{18} it is 9 times more important than A_1*
$A_{18} \rightarrow A_3$	*A_{18} it is 7 times more important than A_3*
$A_1 \rightarrow A_3$	*A_1 it is 9 times more important than A_3*
$A_1 \rightarrow A_7$	*A_1 it is 7 times more important than A_7*
$A_3 \rightarrow A_{18}$	*A_3 it is 6 times more important than A_{18}*
$A_7 \rightarrow A_3$	*A_7 it is 3 times more important than A_3*
$A_{18} \rightarrow A_7$	*A_{18} it is 7 times more important than A_7*
$A_1 \rightarrow A_3$	*A_1 it is 9 times more important than A_3*
$A_1 \rightarrow A_7$	*A_1 it is 7 times more important than A_7*
$A_1 \rightarrow A_{18}$	*A_1 it is 2 times more important than A_{18}*
$A_3 \rightarrow A_{18}$	*A_3 it is 5 times more important than A_{18}*
$A_7 \rightarrow A_3$	*A_7 it is 3 times more important than A_3*
$A_{18} \rightarrow A_7$	*A_{18} it is 9 times more important than A_7*

Fig. 10. Evaluation of the criteria.

Eqs. (2)–(6).[51]

$$l_{je} = \min(b_{jep}), \quad p = 1, 2, \ldots, t, \quad j = 1, 2, \ldots, m, \quad e = 1, 2, \ldots, m; \tag{2}$$

$$m_{je} = \frac{\sum_{p=1}^{t}(b_{jep})}{p}, \quad p = 1, 2, \ldots, t, \quad j = 1, 2, \ldots, m, \quad e = 1, 2, \ldots, m; \tag{3}$$

$$\mu_{je} = \max(b_{jep}), \quad p = 1, 2, \ldots, t, \quad j = 1, 2, \ldots, m, \quad e = 1, 2, \ldots, m; \tag{4}$$

$$\tilde{b}_{je} = \max(l_{je}; m_{je}; u_{je}), \quad j = 1, 2, \ldots, m, \quad e = 1, 2, \ldots, m; \tag{5}$$

where $\tilde{b}_{je}$ represents the relative importance among each criterion with TFNs.

$$\tilde{D}_p = \begin{bmatrix} \tilde{b}_{11} & \tilde{b}_{12} & \cdots & \tilde{b}_{1m} \\ \tilde{b}_{21} & \tilde{b}_{22} & \cdots & \tilde{b}_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{b}_{m1} & \tilde{b}_{m2} & \cdots & \tilde{b}_{mm} \end{bmatrix}. \tag{6}$$

By this way, the different perceptions pairwise comparison values are transformed into TFNs.

Table 3. The fuzzy evaluation matrix with respect to criteria.

TFN	A_1			A_3			A_7			A_{18}		
A_1	1	1	1	5	7.667	9	0.143	4.714	7	0.111	1.037	2
A_3	0.11	0.14	0.2	1	1	1	0.143	0.270	0.333	0.143	3.714	6
A_7	0.143	2.4286	7	3	5.667	7	1	1	1	0.111	0.418	1
A_{18}	0.5	3.5	9	0.167	2.456	7	1	5.667	9	1	1	1
Total	1.753	7.0686	17.2	9.167	16.789	24	2.286	11.651	17.333	1.365	6.169	10

From Table 3, and following the "extent analysis method for the synthetic extend values," the next step, according to Chang,[45] is to perform the so-called extent analysis (annex — Eqs. (A.9)–(A.15)). After calculating the fuzzy extent synthetic values we have:

$$\begin{aligned} S_{A_1} &= (0.091; 0.346; 1.304), \\ S_{A_3} &= (0.020; 0.123; 0.517), \\ S_{A_7} &= (0.062; 0.228; 1.098), \\ S_{A_{18}} &= (0.039; 0.303; 1.784). \end{aligned}$$

Using these fuzzy values, we can compare them by using Eq. (A.12) (see annex). As an example of comparing S_{A_1} and S_{A_3} we have $V(S_{A_1} \geq S_{A_3})$:

$$\begin{aligned} V(S_{A_1} \geq S_{A_3}) &= hgt(S_{A_3} \cap S_{A_1}) \\ &= \mu_{A_1}(d) \begin{cases} 1, & \text{if } m_{A_1} \geq m_{A_3} \\ 0, & \text{if } l_{A_3} \geq u_{A_1} \\ \dfrac{l_{A_3} - u_{A_1}}{(m_{A_1} - u_{A_1}) - (m_{A_3} - l_{A_3})}, & \text{otherwise,} \end{cases} \end{aligned}$$

where d, the ordinate of the highest intersection is point D between μ_{A_3} and μ_{A_1} (see Fig. 11).

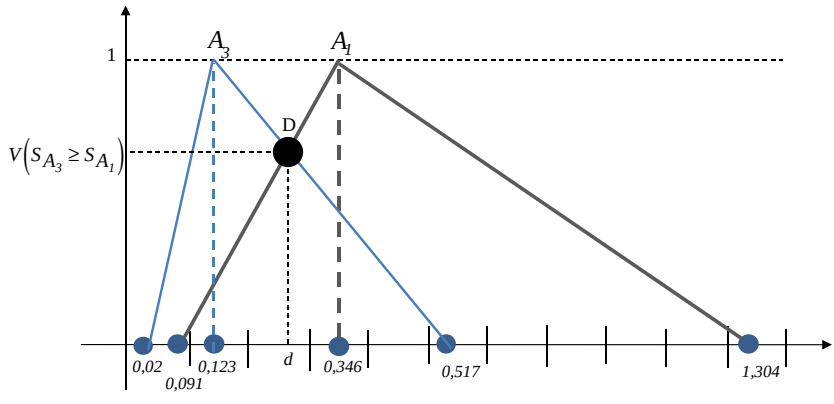


Fig. 11. Comparing both value A_1 and A_3.

To compare A_1 and A_3, we need the values of $V(S_{A_1} \geq S_{A_3})$ and $V(S_{A_3} \geq S_{A_1})$.

According to asset A_1 and Fig. 11, the value 0 is assigned to the membership function when it is lower than 0.091 and greater than 1.304, i.e., there is no possibility of occurrence of these values. Values between 0 and 1 are assigned to the membership function when they fall in the two intervals $[0.091; 0.346]$ and $[0.346; 1.304]$. Also for the asset A_3, the value 0 is assigned to the membership function when it is lower than 0.02 and greater than 0.517. Values between 0 and 1 are assigned to the membership function when it is in the intervals $[0.02; 0.123]$ and $[0.123; 0.517]$. The comparison of these two fuzzy values is achieved using the $\min V(S_{A_1} \geq S_{A_3})$ and $V(S_{A_3} \geq S_{A_1})$ In this case the minimum between A_1 and A_3 is $V(S_{A_3} \geq S_{A_1}) = 0.656$.

The comparison of the all fuzzy values $S_{A_1}; S_{A_3}; S_{A_7}; S_{A_{18}}$ is as follows:

$$\begin{aligned}
&V(S_{A_1} \geq S_{A_3}) = 1; \quad V(S_{A_1} \geq S_{A_7}) = 1; \quad V(S_{A_1} \geq S_{A_{18}}) = 1;\\
&V(S_{A_3} \geq S_{A_1}) = 0.656; \quad V(S_{A_3} \geq S_{A_7}) = 0.812; \quad V(S_{A_3} \geq S_{A_{18}}) = 0.727;\\
&V(S_{A_7} \geq S_{A_1}) = 0.895; \quad V(S_{A_7} \geq S_{A_3}) = 1; \quad V(S_{A_7} \geq S_{A_{18}}) = 0.934;\\
&V(S_{A_{18}} \geq S_{A_1}) = 0.975; \quad V(S_{A_{18}} \geq S_{A_3}) = 1; \quad V(S_{A_{18}} \geq S_{A_7}) = 1.
\end{aligned}$$

Then the priority weights are calculated by using Eq. (A.13).

$$\begin{aligned}
d'(A_i) &= \min V(S_{A_i} \geq S_{A_k}) \quad \text{for } k = 1, 2, \ldots, n; k \neq i,\\
d'(A_1) &= \min(1; 1; 1) = 1,\\
d'(A_3) &= \min(0.656; 0.812; 0.727) = 0.656,\\
d'(A_7) &= \min(0.895; 1; 0.934) = 0.895,\\
d'(A_{18}) &= \min(0.975; 1; 1) = 0.975.
\end{aligned}$$

Then the assets weight vector $(\mathrm{W}'_{\mathrm{A}})$ is given by the equation

$$\begin{aligned}
W' &= (d'(A_1); d'(A_2); \ldots; d'(A_n))^{\mathrm{T}},\\
W'_A &= (1; 0.656; 0.895; 0.975)^{\mathrm{T}}.
\end{aligned} \tag{7}$$

After the normalization of these values priority weight respect to main goal is calculated as by the equation

$$\begin{aligned}
W &= (d(A_1); d(A_2); \ldots; d(A_n))^{\mathrm{T}},\\
W_A &= (0.284; 0.186; 0.254; 0.277)^{\mathrm{T}}.
\end{aligned} \tag{8}$$

We now have to quantify the meaning of the linguistic values (see annex) using "membership function" (see annex — Eq. (A.2)). The μ function gives us the relationship between assets by quantifying the degree of certainty of that asset relevance being greater than the others. We can say, therefore, that:

- $\mu_{\tilde{A}_1} = 0.284$ — Shows the degree of possibility for a fuzzy convex number to be greater than A_3, A_7, A_{18} is 0.284;

- $\mu_{\tilde{A}_3} = 0.186$ — Shows the degree of possibility for a fuzzy convex number to be greater than A_1, A_7, A_{18} is 0.186;
- $\mu_{\tilde{A}_7} = 0.254$ — Shows the degree of possibility for a fuzzy convex number to be greater than A_3, A_1, A_{18} is 0.254;
- $\mu_{\tilde{A}_{18}} = 0.277$ — Shows the degree of possibility for a fuzzy convex number to be greater than A_3, A_7, A_1 is 0.277.

The criterion A_1 has the highest priority weight and is likely to be the most relevant asset. By ranking the order of the criteria with the fuzzy AHP method we have $A_1(0.284) > A_{18}(0.277) > A_7(0.254) > A_3(0.186)$. Now that we have the priority weights for each criteria, we have to calculate the priority weights for each alternatives and, as a result, the impact this has in the relative relevance of each Asset (criteria).

6.3.4. *Evaluation of the alternatives*

As in the criteria evaluation, the evaluation of alternatives by D_1, D_2 and C_3 is expressed, as before, through the Saaty's scale. Each matrix of pairwise comparisons must follow the judgment matrix:

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \quad i = 1, 2, \ldots, n; \quad j = 1, 2, \ldots, n.$$

The pairwise comparisons (Fig. 12) of values are then transformed into TFNs on the fuzzy evaluation matrix (Eq. (6)). The results are presented in Tables 4–7.

The priority weights of the Perceived Benefits (alternatives) for each asset are determined by making the same calculations as for criteria.

The weight vector from Table 4 is calculated as $W_{PBA_1} = (0.341; 0.395; 0.263; 0)^{\mathrm{T}}$,
The weight vector from Table 5 is calculated as $W_{PBA_3} = (0.407; 0.392; 0; 0.201)^{\mathrm{T}}$,
The weight vector from Table 6 is calculated as $W_{PBA_7} = (0.264; 0.264; 0.253; 0.219)^{\mathrm{T}}$,
The weight vector from Table 7 is calculated as $W_{PBA_{18}} = (0.253; 0.374; 0.211; 0.163)^{\mathrm{T}}$.

The composite priorities of the alternatives will be determined by aggregating the weights throughout the hierarchy. The final score SC of alternatives can be calculated as follows:

$$SC = M_{PBA} \times W_A^{\mathrm{T}}. \tag{9}$$

Pairwise comparisons for the four alternatives

D 1 Managment CPMT

A_1	PB_{20}	PB_{24}	PB_{48}	PB_{51}
PB_{20}	1	1	7	3
PB_{24}	1	1	5	7
PB_{48}	1/7	1/5	1	1/7
PB_{51}	1/3	1/7	7	1

D 2 Technical CPMT

A_1	PB_{20}	PB_{24}	PB_{48}	PB_{51}
PB_{20}	1	1	9	9
PB_{24}	1	1	7	7
PB_{48}	1/9	1/7	1	9
PB_{51}	1/9	1/7	1/9	1

C 3 Perception of the client

A_1	PB_{20}	PB_{24}	PB_{48}	PB_{51}
PB_{20}	1	1	1/2	1/4
PB_{24}	1	1	9	9
PB_{48}	2	1/9	1	1/3
PB_{51}	4	1/9	3	1

Evaluation of alternatives

$PB_{20} \rightarrow PB_{24}$	PB_{20} and PB_{24} are equally important
$PB_{20} \rightarrow PB_{48}$	PB_{20} is 7 times more important than PB_{48}
$PB_{20} \rightarrow PB_{51}$	PB_{20} is 3 times more important than PB_{51}
$PB_{24} \rightarrow PB_{48}$	PB_{24} is 5 times more important than PB_{48}
$PB_{24} \rightarrow PB_{51}$	PB_{24} is 7 times more important than PB_{51}
$PB_{51} \rightarrow PB_{48}$	PB_{51} is 7 times more important than PB_{48}
$P_{B20} \rightarrow PB_{24}$	PB_{20} and PB_{24} are equally important
$PB_{20} \rightarrow PB_{48}$	PB_{20} is 9 times more important than PB_{48}
$PB_{20} \rightarrow PB_{51}$	PB_{20} is 9 times more important than PB_{51}
$PB_{24} \rightarrow PB_{48}$	PB_{24} is 7 times more important than PB_{48}
$PB_{24} \rightarrow PB_{51}$	PB_{24} is 7 times more important than PB_{51}
$PB_{48} \rightarrow PB_{51}$	PB_{48} is 9 times more important than PB_{51}
$P_{B20} \rightarrow PB_{24}$	PB_{20} and PB_{24} are equally important
$PB_{24} \rightarrow PB_{48}$	PB_{24} is 9 times more important than PB_{48}
$PB_{24} \rightarrow PB_{51}$	PB_{24} is 9 times more important than PB_{51}
$PB_{48} \rightarrow PB_{20}$	PB_{48} is 2 times more important than PB_{20}
$PB_{51} \rightarrow PB_{20}$	PB_{51} is 4 times more important than PB_{20}
$PB_{51} \rightarrow PB_{48}$	PB_{51} is 3 times more important than PB_{48}

Fig. 12. Evaluation of the alternatives.

The weight vector of priority weights (Eq. (8)) of the main criteria (assets) of the goal was

$$W_A = (0.284; 0.186; 0.254; 0.277)^{\mathrm{T}}.$$

Table 4. The fuzzy evaluation matrix with respect to asset A_1.

TFN(A_1)	PB_{20}			PB_{24}			PB_{48}			PB_{51}		
PB_{20}	1	1	1	1	1	1	0.5	5.5	9	0.25	4.083	9
PB_{24}	1	1	1	1	1	1	5	7	9	7	7.667	9
PB_{48}	0.111	0.7503	2	0.111	0.151	0.2	1	1	1	0.143	3.159	9
PB_{51}	0.111	1.4813	4	0.111	0.394	0.143	0.111	3.370	7	1	1	1

Table 5. The fuzzy evaluation matrix with respect to asset A_3.

TFN (A_3)	PB_{20}			PB_{24}			PB_{48}			PB_{51}		
PB_{20}	1	1	1	1	3	7	4	5.667	9	4.00	6.667	9.00
PB_{24}	0.14	0.7143	1.00	1	1	1	5	6.333	9	5.00	7	9.00
PB_{48}	0.11	0.2037	0.25	0.111	0.170	0.2	1	1	1	0.14	0.770	2.00
PB_{51}	0.11	0.168	0.25	0.111	0.151	0.2	0.5	4.5	7	1.00	1	1.00

Table 6. The fuzzy evaluation matrix with respect to asset A_7.

TFN (A_7)	PB_{20}			PB_{24}			PB_{48}			PB_{51}		
PB_{20}	1	1	1	1	1	1	0.11	6.037	9.00	0.14	6.048	9.00
PB_{24}	1.00	1	1.00	1	1	1	0.143	4.714	9	3.00	5.667	9.00
PB_{48}	0.11	6.037	9.00	0.111	2.437	7	1	1	1	1.00	1.333	2.00
PB_{51}	0.11	5.3704	9.00	0.111	0.215	0.333	0.5	0.833	1	1.00	1	1.00

Table 7. The fuzzy evaluation matrix with respect to asset A_{18}.

TFN (A_{18})	PB_{20}			PB_{24}			PB_{48}			PB_{51}		
PB_{20}	1	1	1	1	1	1	5.00	7.667	9.00	3.00	7	9.00
PB_{24}	1.00	1	1.00	1	1	1	3	6.333	9	5.00	36.333	99.00
PB_{48}	0.11	3.1037	9.00	0.111	0.196	0.333	1	1	1	1.00	4	6.00
PB_{51}	0.11	3.1481	9.00	0.010	0.137	0.2	0.167	0.456	1	1.00	1	1.00

The matrix of priority weights of the perceived benefits is M_{PBA} such as:

$$M_{PBA} = \begin{bmatrix} 0.341 & 0.407 & 0.264 & 0.253 \\ 0.395 & 0.392 & 0.264 & 0.374 \\ 0.263 & 0 & 0.253 & 0.211 \\ 0 & 0.201 & 0.219 & 0.163 \end{bmatrix}.$$

The evaluation criteria is obtained by multiplying the matrix M_{PBA} obtained by the weights of alternatives with respect to main criteria with the normalized vector obtained by the weights of the criteria W_A^{T}. We get the normalized ranks for the benefits.

$$SC = \begin{bmatrix} 0.307 \\ 0.353 \\ 0.197 \\ 0.136 \end{bmatrix}.$$

According to the obtained results in the fuzzy AHP method, the alternative PB_{24}, which has the highest priority weight, is selected as the most important benefit that the negotiator may take in account in the decision-making process for the CPMT in an Ex-Ante temporal phase. The ranking order of the alternatives with the fuzzy AHP method is $PB_{24} > PB_{20} > PB_{48} > PB_{51}$. Therefore, PB_{24} (Operational Benefits) would be considered the most relevant benefit in Ex-Ante phase.

6.3.5. *Discussion*

Table 8 summarizes the overall results: (1) the degree of possibility (relevance) of A_i and PB_i being related; (2) the relative importance of A_i — bottom row; and (3) the relative importance of PB_q right column.

Table 8. Results.

	A_1 Builds license to operate	A_3 Uses HSO expert	A_7 Builds brand enhancement	A_{18} Builds quality	*WP* vector of the *PB*
PB_{20} Functional Benefits	0.341[a]	0.407[a]	0.264[a]	0.253[a]	0.307
PB_{24} Operational Benefits	0.395[a]	0.392[a]	0.263[a]	0.374[b]	0.353
PB_{48} Image	0.263	0[a]	0.253[b]	0.211[a]	0.197
PB_{51} Reputation	0[b]	0.201[a]	0.219[a]	0.163[a]	0.136
Weight priority (*WP*) vector of the assets	0.284	0.186	0.254	0.272	

[a]Belongs to the asset. [b]Does not belong to the asset.

This table and its meaning, featuring the quantitative representation of the CMDVC, was discussed with CPMT in an interview from which we would highlight the following comments: "(...) *The results are quite consistent with the company's management perception of the market. The license to operate is clearly the key factor. Nevertheless, it was quite interesting that important factors overlooked in the interviews* (e.g., *image*) *did show up in the results and that quality* (*directly or by brand enhancement*) *were also important assets. This is most important, as often price-based competition is regarded as a suitable strategy in the fiercely competitive market the company operates* (...)." This is explained by the need to rank alternatives using the Saaty's Scale and lead a previously disregarded Perceived Benefit to emerge. This important result is confirmed by the interview testimonial. Moreover, the analysis of the above table combined with Fig. 13, further enables the understanding of how

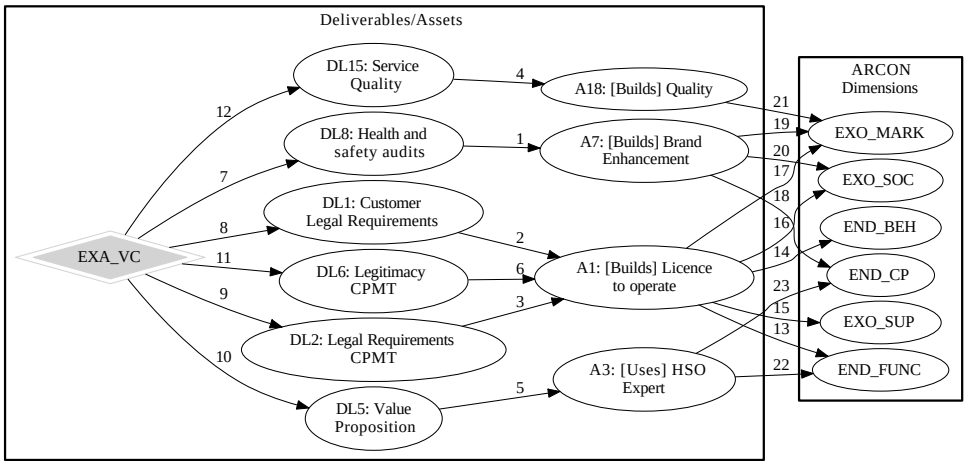


Fig. 13. Deliverables/assets/ARCON Dimensions.

these Perceived Benefits relate to the actual deliverables. In this case, we see that A_7 is also related with PB_{48} (Image), which means that DL_8 also builds CPMT image among its customers with a degree of possibility (relevance) that is comparable to the other PB_i in the same column (Table 8).

It is also interesting to see that A_1 ([Builds] License to Operate) is a very important asset. We could have expected that from the interviews. It was also confirmed that the Operational Benefits for the customer as seen by CPMT (PB_{24}) emerge as the PB_q with the higher degree of possibility. We should also realize that PB_{24} now emerges in A_{18} and was previously not there. In fact, PB_{24}, that was not mentioned in the interviews as related with A_{18}, is now the highest ranked for asset A_{18} ([Builds] Quality). As explained by CPMT, "(...) *The results are consistent with the company's empirical experience in the occupational health services market. Most clients favor the operational aspects of the service, like minimizing the time "lost" by employees in medical exams, over the actual service "quality". The impact of the latter in the client's bottom line usually takes years to be noticed and it is difficult to quantify.*"

The researchers were happy to hear a final comment by the CPMT interviewee regarding the value of this approach: "*This novel approach can be quite useful for CPMT to better manage its service offering and marketing approach, as it provides management qualitative data, instead of relying solely on hunches.* (...)"

We can finally confirm that the CMDVC formal model enabled the quantification of "How do endogenous and exogenous assets influence the Value for the Customer?" (Research Question 1.2). This influence emerges from the relations made explicit between the assets in Fig. 13 and ARCON dimensions, intersected with the results of Table 8 that map the relative value of each asset as the result of weighting perceived benefits. The Research Question number two, "Can we derive a formal mathematical model that provides for the quantitative handling of the proposed model?" is implicitly responded by the validation of the formal quantitative model upon its validation by the interviewees at CPMT.

As proposed by Dube and Pare[9] we followed the exploratory case study approach as a "tentative in theory building case research." The constructs defined for the proposed model revealed both useful and adequate. In this context we would finally highlight the importance of two constructs that seem not to be directly used in the Quantitative CMDVC, the Forms of Value and the ARCON endogenous and exogenous dimensions. In fact, whereas the Forms of Value provide the model user with a comprehensive framework on the nature of the demand-side perceptions of value, the ARCON endogenous and exogenous dimensions make explicit the origin of each asset and, therefore, the level of influence the enterprise has over them.

7. Conclusion

This paper proposed a novel framework for modeling the Value for the Customer, the so-called Conceptual Model for Decomposing Value for the Customer (CMDVC). This conceptual model was first validated through an exploratory case study in

CPMT, and SME in Porto, Portugal, where we were able to both validate the proposed constructs of the model and their relations. In a second step the authors proposed a mathematical formulation for the CMDVC as well as a computational method. This has enabled the final quantitative discussion of how the CMDVC can be applied and used in the enterprise environment, and the final validation from the CPMT interviewees, where we were able to confirm that: "*This novel approach can be quite useful for CPMT to better manage its service offering and marketing approach* (...)."

Upon answering the Research Questions it is useful to reflect on the merits and applicability limits of the proposed model.

The merits of this approach seem evident from the contact with CPMT. The tool, tested on a contract preparation phase (Ex-Ante negotiation perspective), revealed itself useful by providing "(...) *results* [*that*] *are consistent with the company's empirical experience* (...)". Moreover, it enabled the discovery of previously disregarded connections between assets used and/or built in the foreseen exchange of deliverables and perceived benefits.

Along this paper the authors focused on the CMDVC validation and on the validation of the corresponding quantitative model and corresponding computational method. To this end, a pre-negotiation scenario consisting of a contract proposal preparation, was defined where a set of deliverables, belonging to contract proposal, were dissected in a very detailed analysis of the case study. This approach allowed the testing of the proposed model and the discussion of the obtained results. The imposed scenario aimed at limiting the scope of analysis. However, we believe that this does not impose any limits to the applicability of the proposed model, namely as a support tool along the negotiation process. In fact, we would argue that, from the moment the negotiation starts, people at CPMT would likely realize that some of their expectations regarding the customer perceived value may now be wrong and would have to be changed and adapted. This was confirmed by CPMT by stating: "(...) *when we send a contract proposal we always follow-up on the phone and try to feel the customers reaction and understand what is the most important thing for them. In fact, the strict economic context we now live in Portugal may very fast drive the customer stance from a service quality inclination to a severe cost-driven attitude. We try an early evaluation of all these issues in the first contact, but things actually change.*" In this context and along the negotiation process, the existence of a computational model that could rapidly give the new distribution of weights (Table 8) would be of utmost value, as it would help establishing the relationship of what is actually valued by the customer and what is being offered, enabling, therefore, the preparation of a new proposal that best meets the customer needs.

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Appendix A. Introduction to the Fuzzy AHP

The AHP, first proposed by Saaty,[50] is widely used multiple criteria decision-making tool. According to this author, "the most creative task in making a decision is to choose the factors that are important for that decision" (see Ref. 50, p. 9). AHP is based on the representation of a complex problem through a hierarchical structure, which consists in defining criteria, sub-criteria and alternatives in successive levels, and relating them with the goal criteria. The hierarchical sub-criteria are represented in Fig. A.1.

This structure provides "an overall view of the complex situation relationships inherent in the situation; and helps the decision maker assess whether the issues in each level are of the same order of magnitude, so he can compare such homogeneous elements accurately" (see Ref. 50, p. 9). Once the problem has been decomposed and the hierarchy constructed, the prioritization procedure starts and the comparison is used to form the matrix of pairwise comparisons called the judgment matrix A, using Saaty's nine-point scale listed in Table A.1.

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \quad i = 1, 2, \ldots, n; \quad j = 1, 2, \ldots, n. \tag{A.1}$$

Each entry a_{ij} of the judgment's matrix is governed by the three rules:

$$a_{ij} \geq 0; \quad a_{ij} = \frac{1}{a_{ji}}; \quad a_{ii} = 1 \quad \text{for all } i.$$

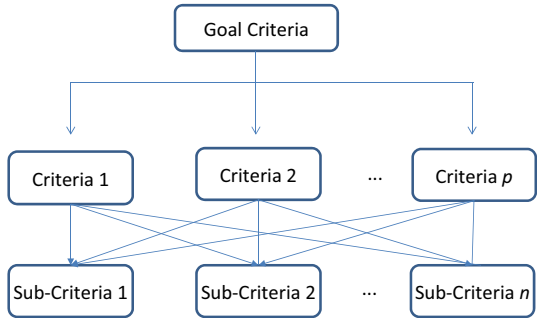

Fig. A.1. Decomposition of the problem in AHP method.

Table A.1. Saaty's 1-9 scale for AHP.[50]

Definition	Saaty's scale	Description
Equal importance	1	Two criteria contribute equally to the objective in the immediate higher level
Moderate importance of one over another	3	Experience and judgment slightly favor one criterion over another
Essential or strong importance	5	Experience and judgment strongly favor one criterion over another
Demonstrated importance	7	A criterion is favored very strongly
Extreme importance	9	The difference between influences of the two decision elements is extremely significant
Intermediate values between two adjacent judgments	2, 4, 6, 8	When compromise is needed

AHP — fuzzy

In this section, some of the theoretical concepts used in this paper are briefly introduced. This includes fuzzy sets, linguistic variables, fuzzy numbers and Fuzzy AHP process.

• Fuzzy Sets

How we can understand the vagueness of human thought with the fuzzy number?

A fuzzy set is a class of objects with continuum grades of membership. Such a set is characterized by a membership function (characteristics) which assigns to each object a grade of membership ranging between zero and one (see Ref. 42, p. 338).

• Linguistic Variables

Linguistic variables are the domain of the fuzzy sets. They are the input and output of the system whose values are words or sentences from natural language, instead of numerical values. As an example, size is a linguistic variable labeled small, medium, tall, rather than the number 0, 1, and 2. Then $S(s) = \{\text{small, medium, tall}\}$ can be the set of decompositions for the linguistic variable size. The concept of a linguistic variable facilitate the expression of rules and facts which are too complex or too ill-defined to be amenable to description in conventional quantitative terms.[52]

• Fuzzy Numbers

According to Deng[41] a fuzzy number $\tilde{A}$ is a convex fuzzy set, characterized by a given interval of real numbers, each with a grade of membership between 0 and 1. Its membership function $(\mu_{\tilde{A}}(x))$ is precise continuous, satisfies the following conditions:

- $\mu_{\tilde{A}}(x) = 0$ for each $x \in]-\infty; \mathrm{a}_1[\cup]a_4; +\infty[$.
- $\mu_{\tilde{A}}(x)$ is nondecreasing on $[\mathrm{a}_1, \mathrm{a}_2]$ and nondecreasing on $[a_3, a_4]$.
- $\mu_{\tilde{A}}(x) = 1$ for each $x \in [a_2, a_3]$ where $a_1 \leq a_2 \leq a_3 \leq a_4$ are real numbers.

It is possible to use different fuzzy numbers according to the situation. "Triangular and trapezoidal fuzzy numbers are used to express the decision makers

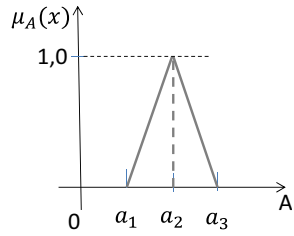

Fig. A.2. Triangular fuzzy number.

assessments on alternatives with respect to each criterion" (see Ref. 41, p. 216). In this study TFNs are adopted in the Fuzzy AHP, because of computational simplicity and easy to interpret. For example a ("value approximately to 50") can be represented by (45; 50; 55) or by (40; 50; 60).

TFNs are a special class of fuzzy number, and can be denoted by $(a_1; a_2; a_3)$. The parameters a_1, a_2, a_3, respectively, indicate the smallest possible value, the most likely value and the largest possible value that illustrate the fuzziness of data evaluated.

A triangular fuzzy number is shown in Fig. A.2:

Their membership functions are usually described as:

$$\mu_{\tilde{A}}(x) = \begin{cases} \dfrac{x - a_1}{a_2 - a_1}, & a_1 \le x \le a_2 \\ \dfrac{a_3 - x}{a_3 - a_2}, & a_2 \le x \le a_3 \\ 0, & \text{otherwise.} \end{cases} \tag{A.2}$$

The algebraic operations of any two fuzzy numbers $A = (a_1; a_2; a_3)$ and $B = (b_1; b_2; b_3)$, used in this study are:

Fuzzy addition

$$A + B = (a_1 + b_1; a_2 + b_2; a_3 + b_3), \tag{A.3}$$

where a_1, a_2, a_3 and b_1, b_2, b_3 are any real numbers.

Fuzzy subtraction

$$A - B = (a_1 - b_3; a_2 - b_2; a_3 - b_1), \tag{A.4}$$

where a_1, a_2, a_3 and b_1, b_2, b_3 are any real numbers.

Fuzzy multiplication

$$A \times B = (a_1 b_1; a_2 b_2; a_3 b_3), \tag{A.5}$$

where a_1, a_2, a_3 and b_1, b_2, b_3 are all nonzero positive real numbers.

Fuzzy division

$$A/B = (a_1/b_3; a_2/b_2; a_3/b_1), \tag{A.6}$$

where a_1, a_2, a_3 and b_1, b_2, b_3 are all nonzero positive real numbers.

Scalar multiplication

$$\forall\, k > 0, \quad k \in R, \quad ka = (ka_1; ka_2; ka_3), \tag{A.7}$$

$$\forall\, k < 0, \quad k \in R, \quad ka = (ka_3; ka_2; ka_1). \tag{A.8}$$

• Fuzzy AHP

The systematic steps for evaluating relative weights using Fuzzy AHP process is utilized, which was introduced by Chang's.[45]

Let $X = \{x_1, x_2, x_3, \ldots, x_n\}$ an object set, and $G = \{g_1; g_2; g_3, \ldots, g_n\}$ be a goal set. Then each object is taken an extent analysis for each goal performed, respectively. Therefore, m extent analysis values for each object can be obtained, with the following notation:

$$M_{gi}^1, M_{gi}^2, \ldots, M_{gi}^m, \quad i = 1, 2, \ldots, n \quad \text{where } M_{gi}^j \; j = (1, 2, \ldots, m) \quad \text{all are TFNs.}$$

According to extent analysis synthesis values with respect to main goal are calculated according to the steps of Chang's, such as:

Step 1: The value of fuzzy synthetic extent with respect to ith object is defined as:

$$S_i = \sum_{j=1}^{m} M_{gi}^j \times \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j\right]^{-1}. \tag{A.9}$$

The fuzzy addition of M_{gi}^j values is performed such as:

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i\right). \tag{A.10}$$

Then the inverse of the vector above is:

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j\right]^{-1} = \left(1 \Big/ \sum_{i=1}^{n} u_i, 1 \Big/ \sum_{i=1}^{n} m_i, 1 \Big/ \sum_{i=1}^{n} l_i\right). \tag{A.11}$$

Step 2: The degree of possibility for $M_2 \geq M_1$ of two TFNs $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ can be defined as:

$$\begin{aligned} V(M_1 \geq M_2) &= hgt(M_1 \cap M_2) = \mu_2(d) \\ &= \begin{cases} 1, & \text{if } m_2 \geq m_1 \\ 0, & \text{if } l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & \text{otherwise.} \end{cases} \end{aligned} \tag{A.12}$$

In general, the priority weights are calculated by using

$$d'(A_i) = \min V(S_i \geq S_k) \quad \text{for } k = 1, 2, \ldots, n; \;\; k \neq i \tag{A.13}$$

that are the pairwise comparison of the M TFNs. Then the weight vector is given by

$$W' = (d'(A_1); d'(A_2); \ldots; d'(A_n))^{\mathrm{T}}. \tag{A.14}$$

Finally we normalized the weight vector

$$W = (d(A_1); d(A_2); \ldots; d(A_n))^{\mathrm{T}}. \tag{A.15}$$

where W is a nonfuzzy number.

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