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Fuzzy linguistic approach to quality assessment model for electricity network infrastructure

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ABSTRACT

In the modern service economy, the consumer satisfaction is one of primary objectives that a company aims at achieving. Successful companies offer high quality of products or services in order to meet the consumers' expectation, and, at the same time, they safeguard their own profits and increase market competitiveness. The consumer satisfaction is an indicator to estimate how likely a customer will make a purchase in the future and it is used as a metric very useful in managing and monitoring the company businesses. To address this issue, we present QuAM (*Qu*ality *A*ssessment *M*odel), a model for evaluating the overall quality and value of services supplied by a company, through the analysis of the consumer satisfaction. The quality is measured indeed, by the definition of some subjective criteria that are collected through a question form filled in by the consumers. The consumers' judgments about the supplied items/services allow evaluating the reputation as well as the success of a company. In this work, QuAM has been applied in the electricity network domain, in order to assess an electricity company. In this domain, the overall evaluation of the organization is based on measuring service quality in terms of response times and cost. The quality of service often comes at a cost, with a concern that the pursuit of profit incentives by utilities may have a negative effect on the quality of service. The role of customers is crucial to estimate a market demand curve for service quality, and maximize the customers satisfaction means increasing profitability, productivity and the corporate image. QuAM has been designed by exploiting a fuzzy linguistic approach along with the Computing with Words (CWW) paradigm: the customers feedbacks are modeled through linguistic labels, which naturally fit to describe human judgments; then a linguistic operator LOWA (Linguistic Ordered Weighted Averaging) allows aggregating all the collected judgments into a synthetic linguistic expression. Finally, heuristic measures enable a comprehensive company evaluation.

1. Introduction

In the present-day business world, the main challenge a company must face is to find business opportunities and strategies that raise the market value above the cost of capital needed to finance the business choices. Then, a company must maintain a productive workflow, that is, more effective, more efficient and more capable of adapting to the changing environment; moreover it must optimally plan and dispatch the available resources [1]. Efficiency and effectiveness are two sides

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of the same coin: the balancing of this two indexes allows assessing and measuring the performance of an organization, even though the company's success is often measured in term of efficiency rather than effectiveness in a business network [15]. To achieve objectives such as Customer Satisfaction and maximum resource utilization, it is important to have adequate means of efficiently managing the company and assuring that the produced plan always gives a better choice at marketing strategy level. Particularly, the Customer Satisfaction with the service on-site, as well as on the Web, is a subjective assessment of service effectiveness, and can be considered the fulcrum of the success in today's high competitive world of business [9]. Companies should continuously assess their services quality to ensure that they are managing the customers' expectations effectively. Service quality (QoS) is the key to measure Customer Satisfaction [14]: as service effectiveness improves, the probability of Customer Satisfaction also increases [6]. Another measure that recently has been widely used in the on-line communities, is the Quality of Experience (QoE) [27,28]. It is strongly correlated to the Customer Satisfaction. It enables the service evaluation by means of objective psychological variables in addition to subjective variables of more traditional measures. QoE is frequently used in a technical context and "refer(s) to the overall acceptability of an application or service, as perceived subjectively by the end user" [27].

This paper introduces QuAM (*Qu*ality *A*ssessment *M*odel). It is a model for the quality assessment that is based on the assumption that "only customers judge quality; all other judgments are essentially irrelevant" [3,4]. It is inspired by an existing service quality tool, called SERVQUAL (SERVice QUALity), developed to assess customer perceptions of service quality in service and retail businesses [13]. SERVQUAL defines five factors which describe the service quality and models service quality as the gap between a customer's expectations for a service supplied and the customer's perceptions of the service received.

Similarly, our model QuAM aims at evaluating the quality of the services supplied by a company, by analyzing the consumers' judgements, in response to the provision of the services. The quality is measured by defining some subjective and specific criteria that are collected through a questionnaire, completed by the consumers. The consumers can express personal opinions about the provided item/service. QuAM evaluates the Customer Satisfaction (CS) and the Service Productivity (SP). These two measures provide a wider view of the well-being of the company, based on the quality of the services supplied. It can be considered a proficient support for the business process and the workforce management in order to increase the profits and market competitiveness of big companies, with the consequent boosting in the corporate brand and consumers' fidelity.

Our model has been applied in the electricity network domain. The complexity of the electricity network infrastructure needs constant maintenance and the asset management is cumbersome and expansive. Thus it is required a highly-productive management to deliver continuous services which meet the customer requirements and standards. For electricity providers, the nature of the product delivery can require a high level of service response time [2]. Since the electricity networks are key infrastructures of the modern life, their failure will probably paralyse a whole area. Thus, in case of the emergency, the electric power must be immediately re-established. In an idealized competitive electricity market, customers would choose a network provider offering a level of service quality that matches their expectation and mainly their willingness to pay for it. The role of customers is crucial for determining a market demand curve for service quality and maximize the customers satisfaction means increase profitability productivity and the corporate image.

To address this issue, QuAM has been used to evaluate the services productivity of the electricity company through the analysis of the customers' satisfaction; specifically, it provides the information that would allow us to evaluate:

- Customer Satisfaction: described as a gap between the perceived and desired quality. The model achieves this evaluation, by the answers provided in the questionnaire by the consumers. Due to the subjective nature of the customers evaluations, the typical cardinal scale is replaced by fuzzy linguistic variables that better represent the imprecise nature of the human language.
- Service quality and productivity: two strongly interrelated measures of good performances in service companies, respectively from the customer and provider stakeholder perspective.
- Corporate image: described by the customer global expectations and the perceived value of the supplied services.

The paper is organized as follows: Section 2 gives a brief literature review; Section 3 introduces QuAM, by describing the whole the model process; then Sections 4–6 describe each stage that compounds the comprehensive process, along with the associated theoretical background; Section 7 is devoted to show an example of scenario in the electricity network domain. Experimental results, discussion and conclusion close the paper.

2. Related work

The assessment of the service quality is strongly affected by two well-known variables: the expected (desired) service and the perceived service [30]. Perceived service quality is the user's evaluation of the performance of the received service and its comparison with the expected one. These evaluations are objective and not based on service attributes, because they reflect the users' perceptions and feelings [31].

Service quality has been defined by considering mainly two schools of thought [37]: one described service quality using categorical terms and divided the construct into different dimensions [32]: the technical dimension (what), the functional

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dimension (how) and the corporate image. The other, more widespread school characterized the service quality by descriptive terms also divided the construct into different dimensions: Tangibility, Reliability, Responsiveness, Assurance and Empathy [13]. SERVQUAL was the result: the first service quality assessment tool and then it has been widely accepted as a robust categorisation of the dimensions of service. Based on the customers' answers to questions about both their expectations and their perceptions, SERVQUAL models service quality as the gap between a customer's expectations for a service offering and the customer's perceptions of the service received. The SERVQUAL scale does not measure the technical quality of a service, but only its functional quality [33].

In [34], the technical quality (referred to as the pivotal attribute or output of the service) assumes a crucial role, that is comparable to the functional quality of a service; really, both aspects should be considered to get an accurate evaluation of the service quality.

The widespread of Web and then, the e-services (whose only difference wrt the traditional services is the method of service delivery), yields a web-oriented quality assessment models. In [14], a multiple-item scale for evaluating the service quality delivered by Web sites on which customers shop online is presented. In order to capture the e-service quality, the authors define two scales: the basic E-S-QUAL scale, which considers four model dimensions: efficiency, fulfilment, system availability and privacy; these dimensions are decisive in the service quality evaluation; the second e-recovery service quality scale E-RecS-QUAL that allows measuring the quality of recovery service supplied by Web sites. In [6] E-S-QUAL scale is applied to internet banking services to measure the e-service quality perceived by internet banking customers and study customer loyalty relationship.

In [36], the proposed model focuses on the concept of "impact score": it is the impact of each service quality attribute on global Customer Satisfaction. The attributes play a crucial role in this modeling: based on each attribute, the users can be classified in those who have recently had a problem with the attribute and those who have not had a problem with it. The difference between the two mean satisfaction rates is called "gap score".

In [35], the Customer Satisfaction Index (briefly CSI) is defined: it is calculated using a coefficient of importance of the services. Customers assign a rate of importance (weight) and a rate of satisfaction (score) for each criterion of the service. Each weight is divided by the average of the coefficients by clients. Then, for each attribute is calculated as the product of weighted points score and weighted average. The CSI is the sum of all the weighted scores.

In the literature, there are several quality models that are based on the consumers' view. Library 2.0 [5,12] is a quality evaluation model for digital libraries: it is based on he LibQUAL+ methodology [38] and measures the quality level of the services offered by libraries in Web 2.0. Since users' opinions and evaluation are too related to the subjective human nature, this model replaces cardinal scales with fuzzy linguistic variables which better describe imprecision and vagueness of the natural languages. Our approach adopts a similar fuzzy modeling to reflect the human perception.

In general, SERVQUAL represents one of the reference models that has inspired many service quality tools in specific domains such as restaurant [7] or railway transport [8].

These research methodologies is taking us one step closer in understanding service at the qualitative level: our imprecise approach along with the interpretive orientation seek to study phenomena and to develop theory or build models/frameworks that can be mapped in the real life domain and tested empirically.

3. Quality Assessment Model (QuAM)

QuAM is a model for the service quality assessment designed to build a bridge between the customer and the company (or in general, the service provider) viewpoint. The quality assessment of the company is expressed through two quality indexes: the Customer Satisfaction (*CS*) and the Service Productivity (*SP*). The *CS* index measures how much the service supplied by a company meets the customer expectations. Understanding the customer expectation is crucial for delivering good quality services, since customers evaluate service quality by comparing their perception with their expectation of the service. The *SP* index is instead, a measure of how service complies with the minimum standards envisaged by the company's business and productivity. The Service Productivity is the ability of an organization to provide services whose quality matches the expectations of customers [26]. These indexes contribute to measure the performance of a company in terms of effectiveness and efficiency.

Efficiency and effectiveness are recurring terms in the literature [16,15,17], they are indicators of the welfare of the company. Specifically, the efficiency is the capability to rationally use the resources, then to find the right ratio between used resources and obtained results. Efficiency is not a measure of success in the marketplace but a measure of operational excellence or productivity [15]. Efficiency is therefore, concerned with minimizing costs and improving operational margins. According to [15], the effectiveness instead, is linked to the company capability to generate a sustainable business growth in its surrounding networks. In [16], the effectiveness is considered "not a characteristic of organizational outputs but a continuous process relating the organization to its constituencies; effectiveness is negotiated rather than produced". This definition meets our idea of effectiveness, that is the achievement of the company goals with respect to the consumers' expectation.

Fig. 1 shows the whole QuAM process. It is composed of three main stages: *Opinion Management*, *Service Analysis* and *Business Analysis*. The users' opinions are given as an input to the *Opinion Management*, that filters and arranges them, by the geographic or service-based facet. These data are passed to the *Service Analysis* that elaborates them and yields an aggregated

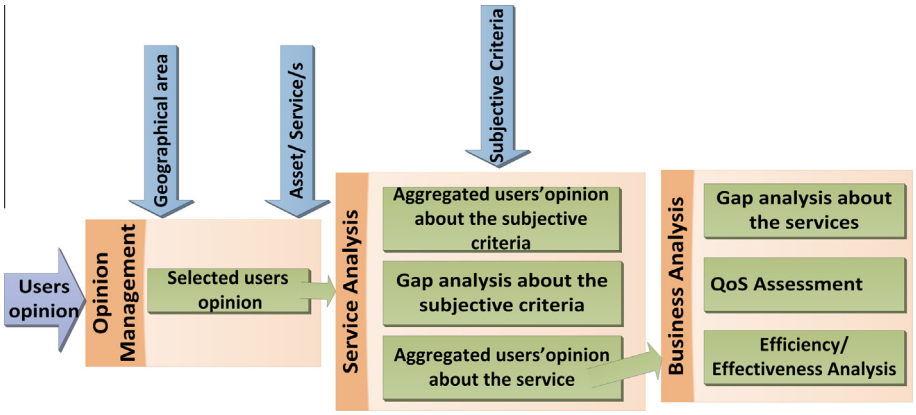

Fig. 1. Quality Assessment Model (**QuAM**) process – overview.

description of the quality of each service. Then, the *Business Analysis* measures the service quality, in terms of how the service performance is far from the desiderata; and finally produces the service assessment from the viewpoint of the company's effectiveness and efficiency. Next sections provide additional details about each stages.

4. Opinion Management

Opinion Management is in charge of the management of the users' opinions. A questionnaire was submitted to the customers in order to collect their opinions and perceptions on the services provided by the company. The opinions are collected and stored in local repositories and then arranged with respect to the two dimensions: the service and geographical area.

More formally, let E is the set of all the customers, S set of services and A is set of the geographic areas, a typical example of a query is to select all the customers from a specific area $a \in A$ with regard to a specific service $s \in S$ is:

$$E_{s,a} = \{\varphi_s(s) \cap \varphi_a(a)\} \tag{1}$$

where $E_{s,a} \subseteq E$ and $\varphi_s : S \to E$ and $\varphi_a : A \to E$ are the transformation functions that return the users, given a service or a specific area, respectively.

According to the dimensions, the possible combinations of them allow the evaluation of the company, based on the users' opinions about (1) a specific service and/or asset provided by the company on a specific geographic area; (2) a specific service and/or asset on the whole territory covered by the company; (3) all the services/assets associated to a specific geographic area and (4) all the services/assets distributed on all the territory covered by the company.

5. Service Analysis

Service Analysis elaborates the selected users' opinions, with the aim of aggregating them in order to have a synthetic description of the quality of the services. The customers assessment of the service quality is based on subjective criteria (represented by the questions in the questionnaire) that are related with the users' judgements or opinions [5]. This assessment comes from the comparison of the service expectation with the actual performance [20] and it is based on three expected service levels: Desired Service Level (*DSL*), Perceived Performance Level (*PPL*) and Minimum Service Level (*MSL*). Briefly, *DSL* is defined as the level of service the customer hopes to receive. *MSL* is lower level expectation, that is the level that the customer accepts. Finally, *PPL* is the level the customer perceives with respect to the actual service performance.

As shown in Fig. 1, the *Service Analysis* may be split into three tasks: *Aggregated users' opinions about the subject criteria* that returns an aggregate evaluation of the customers' opinions, with respect to the answers given on the subjective criteria; *Gap analysis about the subjective criteria* is the subtask that is in charge of measuring the distance (or gap) between the perceived and the expected service levels and finally, *Aggregated users' opinions about the service* that aggregates the users' opinions computed in previous subtask, to obtain a comprehensive evaluation of each service. Next subsection provides some theoretical and computational details that are part of the *Service Analysis* stage.

5.1. Formal approach

The nature fuzzy, imprecise and personal opinions of customers lends itself to the use of words in natural language (linguistic terms) rather than the numeric values. Fuzzy linguistic approach is a technique to model fuzzy and qualitative aspects of an applicative domain. It models linguistic information by means of linguistic terms supported by linguistic variables [21,22]. The linguistic variables are defined by means of a syntactic rule and a semantic rule [5] and their values are not numbers but words or sentences in a natural or artificial language.

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The *Service Analysis* stage embeds the ordinal fuzzy linguistic approach to model the linguistic description and judgement provided by customers. It uses LOWA (Linguistic Ordered Weighted Averaging) [23], a linguistic aggregation operator to get a synthetic description of subjective criteria and/or services.

According to [12], the ordinal fuzzy linguistic approach fits well to model the linguistic aspects in several real-world applications, because it simplifies the definition of the semantic and syntactic rules. It is defined by considering a finite and ordered label set $S = \{s_i\}\ i \in \{0, \ldots, \tau\}$ in the usual sense i.e., $s_i \geqslant s_j$ if $i \geqslant j$ and with odd cardinality for S (i.e. 7 or 9 labels). The mid term represents an assessment of approximately 0.5, and the rest of the terms being placed symmetrically around it.

A ordinal fuzzy linguistic model for computing with words is defined as follows [12]:

- Negation operator: $Neg(s_i) = s_j \mid j = \tau - i$
- Comparison operators:
  1. Maximization operator: $MAX(s_i, s_j) = s_i \ if\ s_i \geqslant s_j$
  2. Minimization operator: $MIN(s_i, s_j) = s_i \ if\ s_i \leqslant s_j$
  3. Distance operator:

$$D(s_i, s_j) = s_k \ where\ k = |i - j| \tag{2}$$

- Aggregate operator: Linguistic Ordered Weighted Averaging (LOWA).

The LOWA is an operator which aggregates non-weighted ordinal linguistic information. More formally [10,11]:

Definition 1. Let $A = \{a_1, \ldots, a_m\}$ be a set of labels to aggregated, then the LOWA operator ϕ is defined as:

$$\phi(a_1, \ldots, a_m) = W \cdot B^T = C^m\{w_k, b_k, k = 1, \ldots, m\} = w_1 \odot b_1 \oplus (1 - w_1) \odot C^{m-1}\{\beta_h, b_h, h = 2, \ldots, m\} \tag{3}$$

where: $W = [w_1, \ldots, w_m]$ weighting vector where $w_i \in [0, 1]$ and $\sum_i w_i = 1 \beta_h = \frac{w_h}{\sum_2^m w_k}$. $B = \{b_1, \ldots, b_m\}$ is the permutation of A defined as $B = \sigma(A) = \{a_{\sigma(1)}, \ldots, a_{\sigma(m)}\}$ where $a_{\sigma(j)} \leqslant a_{\sigma(i)} \forall i \leqslant j$. C^m is convex combination of m labels and if $m = 2$:

$$C^2 = \{w_i, b_i, i = 1, 2\} = w_1 \odot s_j \oplus (1 - w_1) \odot s_i = s_k \tag{4}$$

such that $k = \min\{\tau, i + round(w_1 \cdot (j - i))\}$ and $s_i, s_j \in S, (j \geqslant i)$, and the *round* function is the rounding operator and $b_1 = s_j,\ b_2 = s_i$. If $w_j = 1$ and $w_i = 0$ with $i \neq j \forall i$ then the convex combination is defined as follows: $C^m\{w_i, b_i, = 1, \ldots, m\} = b_j$.

The weighting vector W is important, because it affects the behavior of LOWA. Among the possible approaches to compute the weight vector W, in [12,10], W describes the concept of fuzzy majority by means of a fuzzy linguistic non-decreasing quantifier Q defined as follows:

$$w_i = Q\left(\frac{i}{m}\right) - Q\left(\frac{i-1}{m}\right) \ \forall i = 1, \ldots, m; \tag{5}$$

whose memberships function of Q is defined as follows:

$$Q(r) = \begin{cases} 0 & \text{if } r < a \\ \frac{r-a}{b-a} & \text{if } a \leqslant r \leqslant b \\ 1 & \text{if } r > b \end{cases} \tag{6}$$

where $a, b, r \in [0, 1]$. The concept of fuzzy majority is a generalization of the concept of majority (that is described as the unanimous consensus reached by a group of individuals). It is expressed by non-decreasing quantifier Q are: "most" (0.3, 0.8); "at least half" (0,0.5) and "as many as possible" (0.5,1). When a fuzzy linguistic quantifier Q is used to computer the weights of LOWA operator ϕ, it is symbolized by ϕ_Q.

Fig. 2 gives a closer look at the *Service Analysis*. Specifically, it shows a snapshot of the process model for the j-th service: m subjective criteria (associated with the questions in the questionnaire) are associated with the j-th service. According to the SERVQUAL and LibQUAL+ methodology, customers express their judgment for each subjective criterion, considering the three service levels DSL, PPL and MSL. These levels are described by linguistic labels. In general, each question represents a criterion and a customer can express its opinion through one of possible linguistic terms in a set S composed, for instance, of 7-labels: S = {N = None, VL = Very Low, L = Low, M = Medium, H = High, VH = VeryHigh, T = Total}.

Aggregated users' opinions about the subjective criteria: this task collects the customers' answers, corresponding to the subjective criteria of a service. More formally, let $Q = \{q_1, \ldots, q_m\}$ be a set of m questions about j-th service and $E = \{e_1, \ldots, e_l\}$ be the users group that have answered. Each user answers to the question associated with the k-th subjective criterion on the j-th service, selecting a linguistic label from S. Each answer is a triple composed of three labels from S, with regard to the three expected service levels MSL, DSL and PPL. Given the j-th service, the synthetic evaluation relative to the k-th subjective criterion $sc_{j,k}$, is a triple $(MSL_{j,k}, DSL_{j,k}, PPL_{j,k})$ calculated by applying the LOWA operator ϕ_Q on the collected user opinions for $sc_{j,k}$ as follows:

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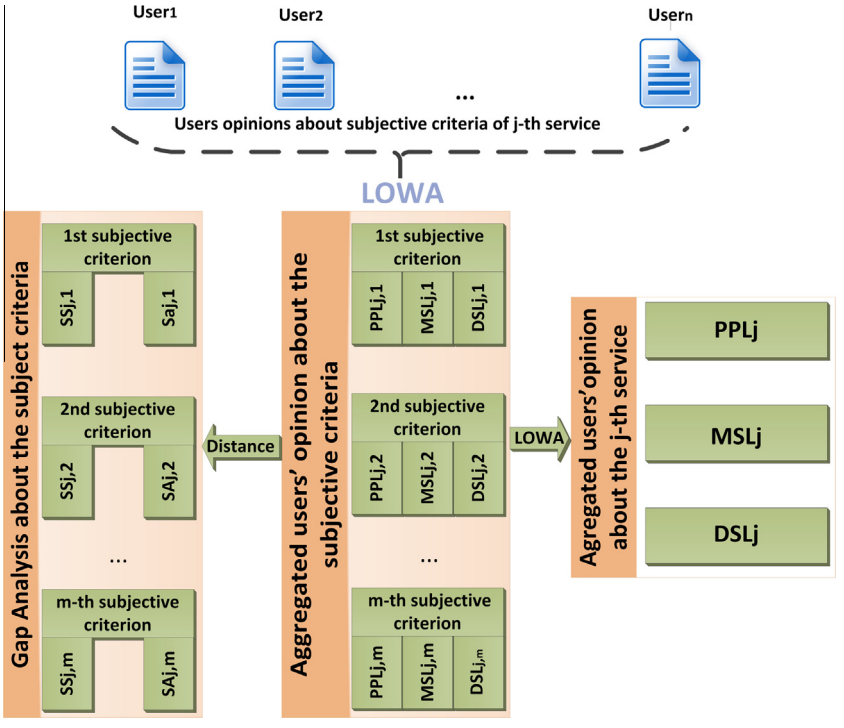

Fig. 2. Logical view of the *Service Analysis* task considering the *j*-th service.

$$DSL_{j,k} = \phi_Q(e_1(q^{DSL}_{j,k}), \ldots, e_l(q^{DSL}_{j,k})) \tag{7}$$

$$PPL_{j,k} = \phi_Q(e_1(q^{PPL}_{j,k}), \ldots, e_l(q^{PPL}_{j,k})) \tag{8}$$

$$MSL_{j,k} = \phi_Q(e_1(q^{MSL}_{j,k}), \ldots, e_l(q^{MSL}_{j,k})) \tag{9}$$

where $e_i(q^O_{j,k}) \in S$ is the answer provided by the user e_i (with $i = 1 \ldots l$) for the subjective criterion $sc_{j,k}$ (described by the corresponding question $q_{j,k}$), considering the service level $O \in \{DSL, PPL, MSL\}$.

Fig. 2 shows a sketched view of this situation: the opinions (associated with the three service levels) are collected for each subjective criterion. Then the LOWA operator aggregates the opinion of all the users for each criterion, calculated for each service level. The result is a set of triples for each criterion (*Aggregated users' opinions about the subject criteria*) that are given as input to *Gap analysis about the subjective criteria* and *Aggregated users' opinions about the j-th service*.

Gap analysis about the subjective criteria: this task provides an assessment of the criteria, related to a specific service. It measures the gap (viz, the distance) existing between what the user would want and what he gets (through the service levels, described by the linguistic terms). According to [12,20], the minimum (MSL) and the desired level (DSL) establish the boundaries of an area called zone of tolerance' within which the perceived level (PPL) should desirably float.

Two are the indices defined for estimating the gap analysis: *Service Superiority* (*SS*) and *Service Adequacy* (*SA*). They are computed for each subjective criterion. *SS* gap describes the difference that exists between the desired service level and the perceived performance level. *SA* gap is the difference between the perceived performance level and minimum service level requested by users. Then, for each subjective criterion $sc_{j,k}$ ($\forall k = 1 \ldots m$), relative to the *j*-th service, the two indexes are defined as follows:

– Service Superiority gap about the subjective criterion $sc_{j,k}$ ($SS_{j,k}$):

$$SS_{j,k} = D(DSL_{j,k}, PPL_{j,k}). \tag{10}$$

– Service Adequacy gap about the subjective criterion $sc_{j,k}$ ($SA_{j,k}$):

$$SA_{j,k} = D(PPL_{j,k}, MSL_{j,k}). \tag{11}$$

Aggregated users' opinions about the j-th service: this task accomplishes the aggregation operation of the level triples obtained in the *Aggregated users' opinions about the subjective criteria* task for all m subjective criteria. The result is a comprehensive evaluation of the service. More formally, the customers' assessment of the j-th service quality is expressed by the triple (DSL_j, MSL_j and PPL_j), computed as follows:

– Desired service level about j-th service (DSL_j):

$$DSL_j = \phi_Q(DSL_{j,1}, \ldots, DSL_{j,m}). \tag{12}$$

– Perceived Performance Level about j-th service (PPL_j):

$$PPL_j = \phi_Q(PPL_{j,1}, \ldots, PPL_{j,m}). \tag{13}$$

– Minimum service level about j-th service (MSL_j):

$$MSL_j = \phi_Q(MSL_{j,1}, \ldots, MSL_{j,m}). \tag{14}$$

These triples will be the input of the *Business Analysis* stage.

6. Business Analysis

Fig. 3 shows the *Business Analysis* stage. It aims at providing some metrics to evaluate the performance of the whole company with respect to the provided services. Specifically, the aggregated customers' opinions relative to the all company's services (coming from to the *Service Analysis* stage) are given as input to the *Business Analysis*.

Business Analysis is composed of three main tasks: *Gap analysis about the services*, *QoS Assessment* and *Efficiency/Effectiveness Analysis*.

Gap analysis about the services is a task very similar to the task *Gap analysis about the subjective criteria* (see Fig. 2): it measures the gap between the expected service performance and the perceived one.

QoS Assessment yields a service quality evaluation from the customer and the company viewpoint through two additional quality indexes, named *Service Productivity* (*SP*) and *Customer Satisfaction* (*CS*).

Finally, *Efficiency/Effectiveness Analysis* task allows evaluating the organization performance in terms of efficiency and effectiveness of the company.

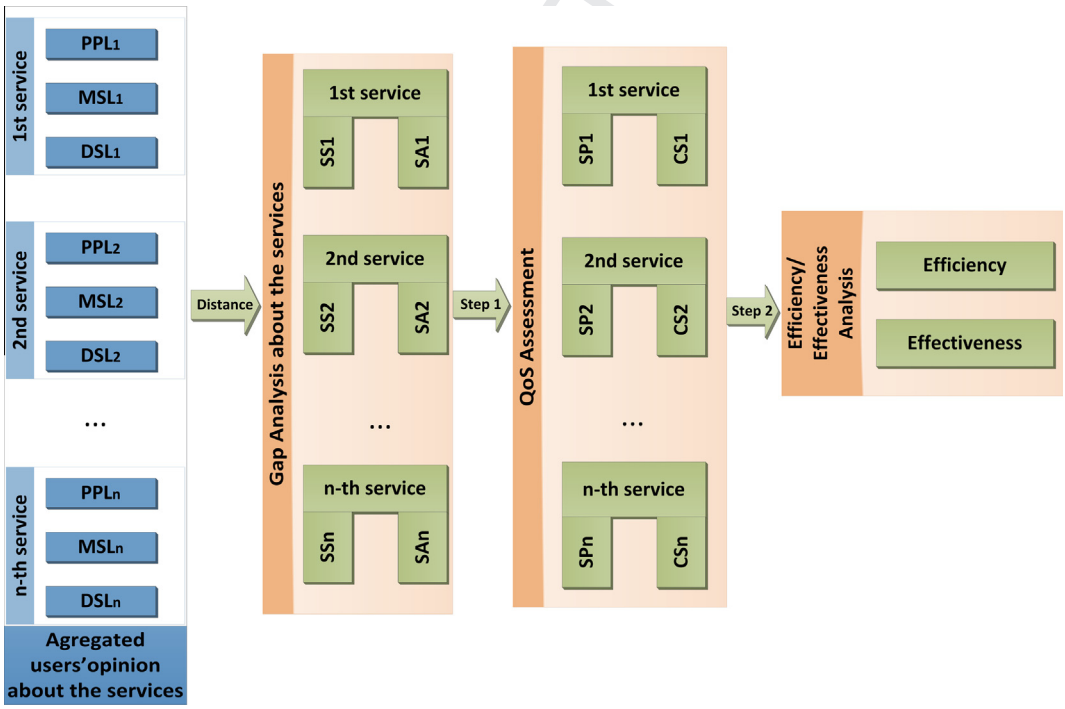

Fig. 3. Business Analysis schema.

6.1. Formal approach

For each service, the gap analysis task achieves the calculation of two indexes: *Service Superiority* (*SS*) and *Service Adequacy* (*SA*) gaps. Formally, given the *j*-th service, the *SS* and *SA* are defined respectively as follows:

– Service Superiority about *j*-th service (SS_j):

$$SS_j = D(DSL_j, PPL_j). \tag{15}$$

– Service Adequacy about *j*-th service (SA_j):

$$SA_j = D(PPL_j, MSL_j). \tag{16}$$

Similarly to the two homonym indexes defined on the subjective criterion (Eqs. (10)), *SS* gap expresses the distance that exists between the desired service level and the perceived performance level about the service in exam. *SA* gap is instead, the difference between the perceived performance level and minimum service level requested by users for the service. According to [12], there are three possible cases could be occur for the gaps *SS* and *SA*. The first case happens when the perceived level is in the zone of tolerance (as stated, i.e., between the minimum and the desired levels).

This is a best case, i.e., when the service quality is described like a trade-off between the expectation of the customers and the business goals of the company. The other two cases regard the situations when the perceived level falls out of the zone of tolerance. These cases are denoted SA^- and SS^+. SA^- means that the perceived level is lower than the minimum level: in this case the service does not reflect the minimum standard expected by the customers. Conversely, SS^+ represents the case when the perceived level overcomes the desired level, that means that there is a company's overspending: the perception related to the supplied service is superior to the customers' expectation.

Service Superiority gap and Service Adequacy gap about *j*-th service allow us to measure respectively the Customer Satisfaction and Service Productivity as follows:

– Customer Satisfaction indices about *j*-th service (CS_j):

$$CS_j = \mu_{cs}(SS_j) = \begin{cases} 1 & \text{if } SS_j^+ \\ 1 - \frac{k}{\tau} & \text{otherwise} \end{cases} \tag{17}$$

where SS_j^+ is the gap case with the perceived level greater than the desired one, for the *j*-th service.

– Service Productivity indices about *j*th service (SP_j):

$$SP_j = \mu_{sp}(SA_j) = 1 - \frac{k}{\tau} \tag{18}$$

where *k* is computed as in (2).

Fig. 4 shows the fuzzy membership functions associated with the Consumer Satisfaction (4(a)) and the Service Productivity (4(b)). Let us give a closer look to these trends. Notice that on the *x*-axis, the ordered linguistic labels appear. The signs "+" or "−" as an exponent of the labels are associated with SS^+ and SA^- (as stated above), i.e., when the perceived level is out of the tolerance zone.

The Consumer Satisfaction function (μ_{cs}), shown in Fig. 4(a), is described by the distance (or difference) between the perceived performance level and the desired service level, i.e., represents how much the customer's perception about the performance of supplied service meets his expectation. From the graph, it is evident that when the desired service level is closer to the perceived performance level, the service performance can be considered satisfactory, so no action to the business planning is necessary. This aspect is shown by the non-decreasing tendency. When instead, the perceived performance level overcomes the desired service level (i.e, SS^+) means the service performance satisfies (or overcomes) the customers

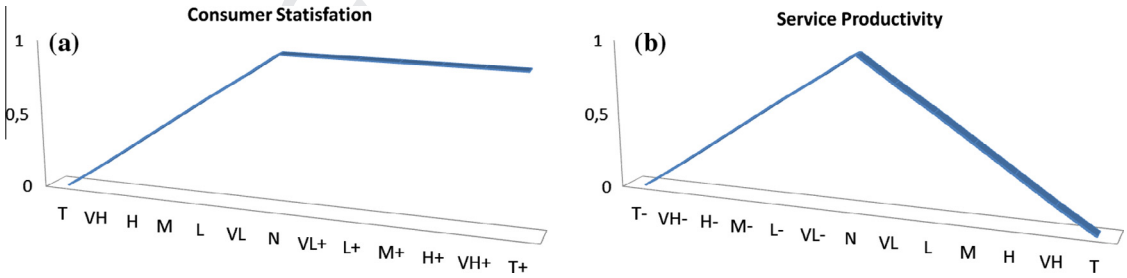

Fig. 4. Fuzzy membership functions of Consumer Satisfaction (a) and Service Productivity (b).

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expectation, but it does not meet the company viewpoint (due to the excessive costs and, in any case, not matching the company business plan). The constant trend and the associated linguistic labels (with sign "+" as an exponent) emphasize this aspect.

The Service Productivity function (μ_{sp}) is shown in Fig. 4(b): it describes the difference between perceived performance level and the minimum service level. This index describes the evaluation of service quality from the company viewpoint: the difference between the two levels indeed, enables the company to assess how the minimum standards of a service are perceived by the customers. If the difference is negative (i.e., SA^{-}) means that the perception of the service performance is below prescribed minimum. When the difference is positive, i.e., the perceived performance level is greater than the minimum standard foreseen for the service, then the service meets to the users' expectations, even though it could not meet the company productivity goals. The better situations happen when perceived performance level is close (or not so far) the minimum service level: it means that the users perception of the service quality is good enough to support the business choices of the company.

The Consumer Satisfaction and Service Productivity calculated for a given service are the input parameters that will be exploited by the *Efficiency/Effectiveness Analysis* task. According to [17], the effectiveness is closely related to the ability of the company to satisfy the customer. A company who is a position to offer services of good quality will have a great chance to satisfy a customer. The customers that have an opportunity to save time, to gain personal advantage or to increase their enjoyment will be more satisfied with the service [18]. These observations emphasize the strong correlation between the consumer satisfaction and effectiveness about a service.

In our opinion, the organizational effectiveness can be expressed as a measure of the effectiveness of the company services. In other words, the consumer satisfaction relative to a certain service supplied by the company gives a method to evaluate the effectiveness of the company.

Similar arguments can be brought forward with regard to the efficiency. Service Productivity concerns indeed, the improvement of the efficiency of service operations [19]. The companies interested in improving their Service Productivity may place more emphasis on minimizing the costs of preparedness and engagement so as to control the overall costs associated with providing the services. For these reasons, the efficiency can be closely related to the productivity of a service and can be interpreted as a function of the Service Productivity of the company.

Let us observe that efficiency and the effectiveness directly influence the corporate image; precisely, they affect the service quality of the corporate image. Corporate image has directly significant effect on satisfaction: the corporate image positively affect the behavioral intentions and loyalty of the customers. At the same time, the corporate image is directly influenced by the service quality and product value. If the perceived values are positive the company gains in customers trust and loyalty. This implies that the customers satisfaction is affected by on the corporate image, besides the service quality.

7. A closer look at the electricity network domain: the case study

Next sections will describe a case study in the electricity network domain. Firstly, the questionnaire is described through the questions associated with the subjective criteria; then, we will analyze the sample data from the questionnaire, related to a particular service by showing the whole QuAM process, along with all its stages (Fig. 1).

7.1. Subjective criteria

A questionnaire has been drawn up in order to collect the users' opinions about the quality of the services supplied by the electricity company. It consists of fourteen questions, each one, associated with a subjective criterion; there are three classes of questions associated with the three corresponding services: s_1) faults service in the electrical networks; s_2) maintenance service in the electrical networks; s_3) electricity supply, described as follows.

- s_1 – Faults service in the electrical networks:
  - *Subjective criterion*$_{1,1}$ ($sc_{1,1}$): The company operates in a timely manner during the occurrence of a fault intervention;
  - *Subjective criterion*$_{1,2}$ ($sc_{1,2}$): The fault intervention is performed in a short time;
  - *Subjective criterion*$_{1,3}$ ($sc_{1,3}$): Its power line undergoes limited interventions caused by failures;
  - *Subjective criterion*$_{1,4}$ ($sc_{1,4}$): The fault intervention causes limited inconvenience;
  - *Subjective criterion*$_{1,5}$ ($sc_{1,5}$): The call center service offers adequate explanations during a fault.
- s_2 – Maintenance service in the electrical networks:
  - *Subjective criterion*$_{2,1}$ ($sc_{2,1}$): The company provides in a clear manner the maintenance intervention procedures;
  - *Subjective criterion*$_{2,2}$ ($sc_{2,2}$): The company operates in a timely manner during the occurrence of a maintenance intervention;
  - *Subjective criterion*$_{2,3}$ ($sc_{2,3}$): The maintenance intervention is performed in established times;
  - *Subjective criterion*$_{2,4}$ ($sc_{2,4}$): Its power line undergoes limited interventions caused by maintenance intervention;
  - *Subjective criterion*$_{2,5}$ ($sc_{2,5}$): The maintenance intervention causes limited inconvenience.
- s_3 – Electricity supply:
  - *Subjective criterion*$_{3,1}$ ($sc_{3,1}$): The electricity supply service is performed continuously and constantly;

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– *Subjective criterion*$_{3,2}$ ($sc_{3,2}$): The maximum duration of service interruption has an acceptable level;
– *Subjective criterion*$_{3,3}$ ($sc_{3,3}$): The service interruption is limited;
– *Subjective criterion*$_{3,4}$ ($sc_{3,4}$): The call center service offers adequate explanations during a service interruption.

7.2. The applicative scenario

Let us show a simple scenario of the electrical network domain, that focuses on the service s_1: "Faults service in the electrical networks". As stated, the entire QuAM process is described, starting from the users opinion given in the questionnaire to the quality assessment of the company with respect to the service and the associated subjective criteria.

7.2.1. Opinion Management

Customers tend to evaluate service quality according to the importance they assign to each criterion. The questionnaire collects indiscriminately all the criteria in the form of questions to which users respond by choosing a linguistic label, selected in the 7-labels set $S = \{N = None, VL = VeryLow, L = Low, M = Medium, H = High, VH = VeryHigh, T = Total\}$ (as described in Section 5.1). Our case study analyzes service quality through the evaluation of the subjective criteria $sc_{1,1} - sc_{1,5}$, associated with the service s_1.

Then, the users' opinions are arranged for geographic areas: for instance, let us consider the area of the city Rome; then according to Section 4, the "filtering" operation returns the set of customers' opinions coming from Rome with regard to the service s_1 = "Faults service".

$$E_{s_1,Rome} = \{\varphi_s(s_1) \cap \varphi_a(\text{“}Rome\text{”})\}$$

The resulting set is composed of twenty-three customers.

7.2.2. Service Analysis

Table 1 shows the actual evaluation provided by the customers of Rome with regard to the service s_1: "Faults service in the electrical networks". In the table, the answers are arranged for the subjective criteria $sc_{1,1} - sc_{1,5}$. Let us notice that each criterion is described by the triple (MSL, PPL, DSL) whose values are expressed by the linguistic labels from the set S. The last row of Table 1 instead, provides the LOWA aggregation ϕ_Q (3) for each triple in correspondence with the subjective criterion. Just to give an example, the LOWA operation computed on the Desired Service Level DSL of the subjective criterion $sc_{1,1}$ is as follows:

$$\begin{aligned} DSL_{1,1} &= \phi_Q(e_1(q_{1,1}^{DSL}), e_2(q_{1,1}^{DSL}), \ldots, e_{23}(q_{1,1}^{DSL})) \\ &= \phi_Q(M, M, VH, VH, VH, L, VH, VH, VH, VH, H, VH, M, M, VH, VH, VH, VH, H, H, H, H, H) = W \cdot B^T = VH \end{aligned}$$

where the weighting vector W is set through the quantifier "at least half" (0,0.5) (see Eqs. (5) and (6)). The rational behind the choice of this quantifier is that it satisfies at least half users opinions. In other words, it considers the first half of user opinions after re-ordering them in the descending order [24].

Once computed the LOWA aggregation, we proceed to estimate to the gap, as stated in Section 5.1. By taking into account the example on the triple ($MSL_{1,1}$, $PPL_{1,1}$, $DSL_{1,1}$) relative to the subjective criterion $sc_{1,1}$, we calculate the Service Superiority gap (see Eq. (10)) and the Service Adequacy gap (see Eq. (11)) respectively, as follows:

$$\begin{aligned} SS_{1,1} &= D(DSL_{1,1}, PPL_{1,1}) = D(VH, M) = L \\ SA_{1,1} &= D(PPL_{1,1}, MSL_{1,1}) = D(M, M) = N \end{aligned}$$

Table 2 shows the linguistic labels computed for the Service Superiority and the Service Adequacy, with regard to the subjective criteria of the service s_1 in Rome area.

The Service Superiority results, shown in Table 2, indicate that the user expectations are not completely satisfied, for all subjective criteria (the linguistic labels are L and VL). The Service Adequacy results instead indicate that the service performance relative to the subjective criteria $sc_{1,1}$, $sc_{1,2}$ and $sc_{1,3}$ meets the minimum level while the quality of the service with respect to the subjective criteria $sc_{1,4}$ and $sc_{1,5}$ are below the minimum level. Recall that the symbol minus as exponent of the linguistic variables indicates that the perceived level is below the minimum level (see Section 6.1). The values obtained for the subjective criteria $sc_{1,4}$ and $sc_{1,5}$ emphasize that the service does not reflect the user expectation, due to the inconvenience caused by the fault service and the unavailability of the call center. In general, the gap analysis outlines the poor performance of the service s_1 (compared with the users desired levels) and then, the urgency of a quality improvement plan.

Fig. 5 shows a radar chart which summarizes Table 1: it gives an overall view of the opinions expressed by the customers for all the subjective criteria in the questionnaire, with respect to the minimum, perceived and desired service level. From this view, the SA and SS gaps are evident for each criterion. The chart evidences the weak quality of the company's services, with respect to the users' expectation.

The radar chart provides also a reading from the company view about the countermeasures to adopt in order to improve the quality of the service in terms of effectiveness and efficiency. As stated, only the subjective criteria $sc_{1,1}$, $sc_{1,2}$ and $sc_{1,3}$ reflect the minimum standards suggested by the users (see SA in Table 2).

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Table 1
The consumers' opinions about the faults service in Rome and the LOWA aggregation.

	$sc_{1,1}$			$sc_{1,2}$			$sc_{1,3}$			$sc_{1,4}$			$sc_{1,5}$		
User	DSL	PPL	MSL	DSL	PPL	MSL	DSL	PPL	MSL	DSL	PPL	MSL	DSL	PPL	MSL
e_1	M	M	M	M	VH	M	VH	M	H	T	M	VH	VH	L	H
e_2	M	M	M	M	VH	M	VH	M	H	T	M	M	VH	M	M
e_3	VH	M	H	VH	H	M	VH	M	H	T	M	M	H	M	H
e_4	VH	VL	M	VH	H	M	M	VL	M	T	M	H	VH	L	H
e_5	VH	VL	M	VH	M	M	M	VL	M	T	M	H	VH	VL	VH
e_6	L	VL	L	VL	M	H	M	VL	M	T	M	H	T	L	H
e_7	VH	VL	M	H	M	H	M	M	M	T	VL	H	L	H	H
e_8	VH	VH	M	H	VL	H	M	VL	M	T	VL	H	T	VL	T
e_9	VH	H	H	H	VL	H	M	L	L	VH	VH	VL	H	T	T
e_{10}	VH	VH	H	M	VL	H	M	L	M	H	H	M	VH	VL	H
e_{11}	H	VH	H	M	H	VL	M	L	M	M	T	VL	M	M	H
e_{12}	VH	M	H	M	VL	VL	VH	L	M	VH	VH	M	M	M	VL
e_{13}	M	L	VL	M	VL	H	VH	VH	M	VH	VH	M	VL	H	VL
e_{14}	M	VL	VL	M	M	M	T	L	M	VH	M	VH	M	M	M
e_{15}	VH	L	H	M	M	L	T	M	M	VH	M	M	VH	M	M
e_{16}	VH	M	M	VH	M	L	T	M	M	VH	M	VH	VL	VL	VL
e_{17}	VH	M	M	VH	M	L	VH	M	M	H	H	VH	H	M	VL
e_{18}	VH	M	VL	VH	M	VL	VH	M	M	H	H	VH	M	M	VL
e_{19}	H	VH	VL	VH	M	VL	M	VL	L	H	H	VH	VH	H	VL
e_{20}	H	VH	VL	H	H	M	VH	VL	H	H	M	VH	H	H	VL
e_{21}	H	VL	VL	H	VL	M	VH	VL	H	H	M	VH	H	M	VL
e_{22}	H	VL	M	H	VL	VL	T	H	H	VH	M	VH	T	H	VL
e_{23}	H	VL	M	H	H	L	VH	VH	H	VH	M	VH	T	M	H
ϕ_Q	VH	M	M	H	M	M	VH	M	M	VH	M	H	VH	M	H

Table 2
Service Superiority (*SS*) and Service Adequacy (*SA*) for the service s_1: "Faults service in the electrical networks" in Rome area.

Subjective criterion	*SS*	*SA*
$sc_{1,1}$	*L*	*N*
$sc_{1,2}$	*VL*	*N*
$sc_{1,3}$	*L*	*N*
$sc_{1,4}$	*L*	VL^-
$sc_{1,5}$	*L*	VL^-

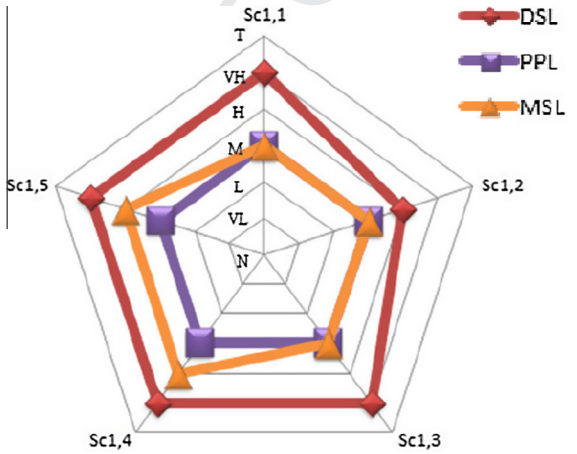

Fig. 5. Radar chart – the customers' replies (expressed as linguistic labels) to the subjective criteria $sc_{1,1}$–$sc_{1,5}$ in the questionnaire.

Let us notice that the subjective criterion $sc_{1,4}$ ("the fault intervention causes limited inconvenience") is connected to the subjective criteria $sc_{1,1}$ ("the company operates in a timely manner during the occurrence of a fault intervention"), $sc_{1,2}$ ("the fault intervention is performed in a short time") and $sc_{1,5}$ ("the call center service offers adequate explanations during a

fault"). Since the subjective criteria $sc_{1,1}$ and $sc_{1,2}$ already meet the minimum standards, a company's business strategy might be to improve the subjective criterion $sc_{1,5}$ (that could be the less expensive for the company) in order to get an indirect improvement of subjective criterion $sc_{1,4}$. In this way, SA could improve (by reducing the distance between the perceived and minimum service level), consequently also the Service Productivity will improve and, finally the service efficiency. As indirect effect, the improvement of Service Productivity could probably affect the users perception and then the Customer Satisfaction, with possible benefits on the effectiveness.

In order to evaluate comprehensively the service s_1: "Faults service in the electrical networks", the triple $(MSL_{s_1}, PPL_{s_1}, DSL_{s_1})$, related to the whole service is computed using the LOWA aggregation ϕ_Q on the service levels related to all the subjective criteria, according to (12)–(14).

$$DSL_{s_1} = \phi_Q(DSL_{1,1}, \ldots, DSL_{1,5}) = \phi_Q(VH, H, VH, VH, VH) = W \cdot B^T = [0.0, 0.2, 0.4, 0.4, 0.0] \cdot (VH, VH, VH, VH, H) = VH$$

$$PPL_{s_1} = \phi_Q(PPL_{1,1}, \ldots, PPL_{1,5}) = \phi_Q(M, M, M, M, M) = W \cdot B^T = [0.0, 0.2, 0.4, 0.4, 0.0] \cdot (M, M, M, M, M) = M$$

$$MSL_{s_1} = \phi_Q(MSL_{1,1}, \ldots, MSL_{1,5}) = \phi_Q(M, M, M, H, H) = W \cdot B^T = [0.0, 0.2, 0.4, 0.4, 0.0] \cdot (H, H, M, M, M) = M$$

Empirical evidence has led us to set the weighting vector W through the quantifier "at most" (0.3, 0.8). This quantifier works by excluding the highest and lowest values of the weighting vector W and gives more importance to the middle values of the input arguments [24]; this quantifier suits well on a few data to aggregate and, in our case, it can approximatively represents the mean value.

7.2.3. Business Analysis

The *Business Analysis* takes as input the triple $(MSL_{s_1}, PPL_{s_1}, DSL_{s_1})$ relative to the whole service and evaluates the gap analysis on the entire service. According to Eqs. (15) and (16), the Service Superiority (SS) and Service Adequacy (SA) for the service s_1 is computed as follows:

$$SS_{s_1} = D(DSL_{s_1}, PPL_{s_1}) = D(VH, M) = L$$
$$SA_{s_1} = D(PPL_{s_1}, MSL_{s_1}) = D(M, M) = N$$

The results, expressed as linguistic terms, confirm the trend about gap analysis seen on subjective criteria: the quality of the service should be improved, re-defining the company business plan. Now, in order to evaluate the QoS Assessment about the service s_1, we measure the Customer Satisfaction (CS) and the Service Productivity (SP), as described by Eqs. (17) and (18), respectively.

– Customer Satisfaction (CS_{s_1}):

$$CS_{s_1} = \mu_{cs}(L) = 1 - \frac{1}{3} = 0.66$$

– Service Productivity (SP_{s_1}):

$$SP_{s_1} = \mu_{sp}(N) = 1$$

As shown in Section 5.1, Customer Satisfaction and Service Productivity are described by the two fuzzy membership functions shown in Fig. 4. The value calculated for CS emphasizes that the service s_1 does not fully reflect the users expectations (i.e., the difference between the desired service level and perceived performance level, in terms of linguistic label, is significant).

Although the CS is not completely satisfying, the Service Productivity results adequate (see Fig. 4(b)): the perceived performance level and the minimum service level are described by the same linguistic label (M). In other words, from the customer viewpoint the service quality is not completely satisfying, but, the overall performance of the service may be considered sufficient, from the company viewpoint: the user perception about the service quality meets the performance of supplied service, that is compliant with minimum standards.

In this specific case, the company should still revise/update the business plan, in order to improve the Customer Satisfaction.

8. Experimental evaluation

8.1. Gap analysis

Our experimentation has been accomplished on a customers sample from four different Italian cities: Rome, Turin, Naples and Milan. The questionnaire, composed of fourteen questions (that characterize to the subjective criteria), refers to the three services shown in Section 7.1.

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Let us remark that the accuracy of the quality assessment of our model is strictly dependent on the questionnaire that the users have to fill-in. This activity could be considered not important or just boring by the users that sometimes refuse to do it. Thus, it happens that users sometimes deliver incomplete questionnaires, with missing answers to some questions. In our experimentation we have discarded incomplete questionnaires. The final customers sample is composed of 200 well-answered questionnaires.

Fig. 6 shows the gap analysis for these three services, evaluated for the four cities. A radar chart is associated with each service and, for each city, the triple of service levels DSL, PPL and MSL is shown. Moreover, the figure shows a comprehensive evaluation, calculated on all the answers of all the cities (see "Total" in the radar chart).

Fig. 6 shows that the service 1: "Faults service in the electrical networks" does not meet the customers expectations: in general the perceived level is equal to or even below the minimum standards (see the cities such as Naples and Turin). Similarly, the service 2: "Maintenance service in the electrical networks", the perceived level is almost always below the minimum level. These results evidence that the services supplied by the company do not satisfy the minimum standards and in this situation the company should intervene to revise the services supplied. QuAM supports the company to find out the deficiencies of their services, directly identifying the subjective criteria that cause a gap. For instance, in the case of service 2, the company should accurately revise its electrical network maintenance plans that seems not reflect the users perception.

Finally, the service 3: "Electricity supply" seems to comply with the minimum standard in all the cities. Particularly, for Turin, the service exceeds the users desires: the perception of the service is far superior to the expectation and the minimum standards foreseen.

8.2. QoS assessment results

Fig. 7 shows the results of the QoS assessment. Analogously to the gap analysis, the three radar charts show Consumer Satisfaction and Service Productivity for the three services supplied. Let us recall that these measures are related to the effectiveness and the efficiency of a company, respectively (see Eqs. 17 and 18). Let us observe that the services 1, 2 and 3 generally exhibits a Service Productivity value greater than the Customer Satisfaction. In other words, the services reflect the pricing strategy of the company but do not always reflect the customers needs. Thus, for these services, the company results more efficient than effective. In this case, the company should improve the quality of the service in order to get the Customer Satisfaction and consequently, increase the company success. The best results are obtained when the two measures tend to become closer. In fact, to have a company both efficient and effective, it is necessary that the Customer Satisfaction and Service Productivity levels tends to overlap to each others for any service supplied.

As seen, the unique exception occurs for the service 3 in the city Turin, where the Customer Satisfaction exceeds the Service Productivity. In this situation, the company should revise business plans and pricing strategy, in order to lower the expenses, while maintaining the Customer Satisfaction.

9. Discussion

QuAM shows some similarities with respect to other well-known models as SERVEQual and LibQual: services quality assessment, gap analysis and linguistic labels to describe customers opinions. Additionally, it uses two measures, relative to the individual services: the Customer Satisfaction (CS) and the Service Productivity (SP), in order to evaluate the effectiveness and the efficiency, respectively of the company. Although we do not give a formal evidence, the experimentation reveals a strong correlation between these measures (see Section 5.1). CS along with SP provide a reading about the possible future actions to do for guarantee the customers' satisfaction and the welfare of the company, with respect to the supplied service.

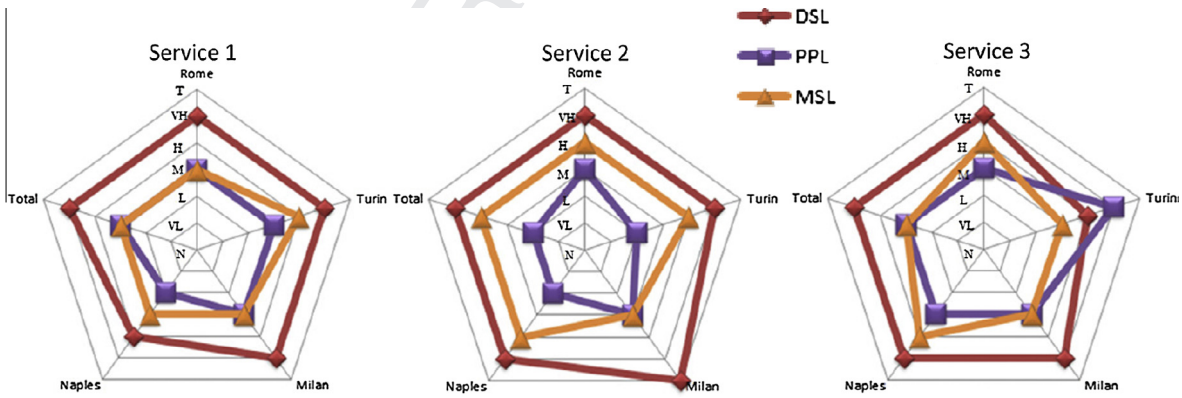

Fig. 6. Gap Analysis for service 1: *Faults service in the electrical networks*, service 2: *Maintenance service in the electrical networks* and service 3 *Electricity supply* evaluated on the individual cities: Rome, Milan, Turin and Naples and a comprehensive view for all the four cities together (Total).

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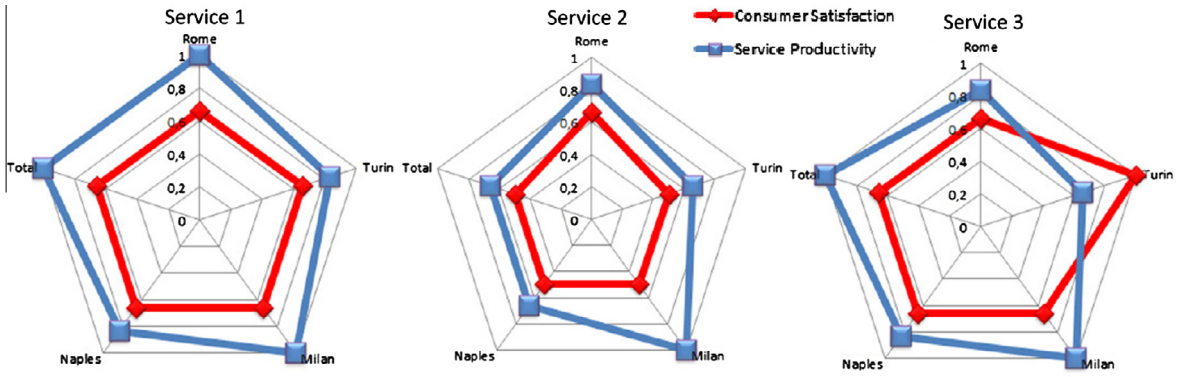

Fig. 7. QoS assessment results.

These measures could support the company in the business strategy and quality improvement plan. At this stage, our model stops to suggest possible business actions to the company, no implementation of them has been carried out, in order to evaluate the accuracy of this approach.

Anyway, let us remark that the quality assessment of our model is based on the questionnaires that the users have to fill-in. As stated in the experimentation, the users could not be interested to fill-in the questionnaire, which often is delivered in an incomplete way. This limit of our approach could be overcome by achieving a different form of "user perception" acquisition. Due to the wide spreading of social technologies in the Web, a challenging application of our model could be on the social networks. The emerging way to share impressions, comments, suggestion, criticism, etc. represents a "silent" data acquisition source that could be better tolerate by the web users. The relevant information about the topic of a specific domain should be collected through Natural Language Processing and Text Mining activities. The identification of relevant expressions requires tricky and complex tasks as the extraction of semantics enclosed in the natural language words, through techniques of Deep Learning.

Moreover, to get a better evaluation of the company in terms of the efficiency, the model should consider a weight to associate with the importance of the service and the subjective criteria. Considering of equal importance to all the services could not be the best choice: a call-center service for instance, is less crucial than the maintenance electricity service. As a possible extension, we would aggregate the opinions, using the aggregation operator LWA (Linguistic Weighted Averaging LWA) [29] that assign different weight to the opinions associated with services of different importance.

To further emphasize the role of users in the overall acceptability of the services provided by a company, as a future work, we would also investigate the Quality of Experience (QoE) beyond to the Quality of Service. This measure that mainly reflects the customers' viewpoints could be analyzed with respect to the QoS, from a technological and social perspectives. The sharing of the overall experience with other users of the net could improve the customers-oriented quality assessment (QoS) and at the same time, allow for estimating the service performance in terms of how well the network meets the users' need (QoE).

10. Conclusions

This paper introduces our model QuAM for evaluating the quality of the services provided by a company. QuAM is a consumer centric approach: it exploits the customer perception to evaluate the services in terms of quality and performance. The model has been applied in the electricity network domain, in order to assess the services provided by an electricity company. The model provides a mechanism to support the service evaluation, keeping the consumer at the center of corporate strategies.

Then, it allows the company to get benefits in terms of improvements in the corporate brand and consumers fidelity. Particularly, the model suggests where to intervene, in order to meet company and customer needs, identifies the services that can be improved and those that are already satisfying.

QuAM can be considered an assessment tool for the effectiveness and the efficiency of the services supplied the company, with meaningful benefits: reduction of the costs, improving of a quality of the services aimed at supporting the customer-company relationship. Our case of study reflects experimental evidence about the validity and reliability of our model QuAM in the electricity network domain. Furthermore, this model lends itself to be adapted to companies of several application domains.

11. Uncited reference

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