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INTRODUCTION OF SUSTAINABILITY REPORT IN AN ENTERPRISE: DECISION MAKING MODEL BASED ON COMPENSATORY FUZZY LOGIC

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ABSTRACT

Lack of overview of standard requirements; evaluation of the organisation's status quo and appreciation of possibilities to satisfy society's expectations are the most important obstacles when the question "Whether to issue a Sustainability Report or not?" should find an answer. This paper bases on Global Reporting Initiative G3.1 performance indicators and UN Global Compact sustainability principles. It structures decision making activities and offer indexes, assisting beginner organisations, while discussing the option to report on sustainability or not. Compensatory Fuzzy Logic (CFL) with its interpretability through language is basis for the used for knowledge engineering. Another reason for choosing CFL is its good capacity to reflect quantitative and qualitative features of used predicates. The proposed model allows taking into account strategic preferences of organization, its stakeholders and knowledge involved in the problem of sustainability report introduction.

KEYWORDS: Sustainability Reporting, Decision Making, Compensatory Fuzzy Logic

1. Introduction

Sustainability management means successfully facing the environmental, economical and social challenges of an enterprise in long-term perspective. In today's world the issue of sustainability in all its aspects: cultural, social, environmental and economical, continuously gains importance. "Sustainability nears a tipping point" is the conclusion of a research report of the Massachusetts Institute of Technology and the Boston Consulting Group presented in the beginning of 2012. It offers lessons to managers who are either trying to develop a sustainability agenda or wondering whether they should (Haanes K., 2012). It shows that companies elaborating their strategies, following principles of sustainable development (SD) are gaining on competitiveness, improve their image and in general secure their future market place (Haanes K., 2012). It is no longer possible to neglect the sustainability topic, but it becomes a compulsory part for a successful long-term planning.

Consequently, sustainability reporting (SR) gets increasingly attention in today's corporate reporting practice. In their newest survey SustainAbility and GlobalScan point out transparency/ communication with 13% as second highest ranked characteristic after commitment to sustainability values with 31%, when defining a company as sustainability leader. Sustainable products/ services and integration of sustainability in the core business model are following with 11% and 10% respectively (SustainAbility, 2012).

Furthermore, shareholders' proposals to companies, concerning corporate social responsibility issues have increased with 23% in the period 2000 to 2010 (Ernst&Young, 2011). This reflects in the consideration of corporate citizenship in companies' decision making from investment- and purchasing management and supplies chain management professionals to 40% and 44% - respectively as important and 42% for both groups as very important (BrandLogic, 2011). Business leaders worldwide, especially in consumer goods industry, see sustainability as central to their business: 93% of CEOs, and 98% of those in consumer goods, believe that sustainability issues will be important to the future success of their business (UN Global Compact, 2011).

Finally, if resulting from the companies' actions as workflows optimization, investment in research and development, education of employees in understanding and applying sustainability principles and implementation of gained knowledge on stakeholders' demands, laying down SD in the business strategy leads to positive effects in the society and has vital impact on companies' credibility and success (SustainAbility, 2012). Yet, for many enterprises, the decision for communicating their goals and achievements in a sustainability report is impeded by many obstacles.

Steering business towards sustainability, has to be acknowledged as value added for the general company strategy. However, there are difficulties to define the parameters needed, in order to complete the strategy with a sustainability perspective. In the general case, guidelines and prerequisites, which have to be taken into account from companies are often seen as too complex and time consuming issue, therefore perplexed and preferably avoided if possible. Vagueness of the decision making processes, together with the constant striving to better profit, while enrolling principle of sustainability, puts enormous pressure on the top management.

Typically concerns, multinationals and stock exchange listed companies are those implementing SR. This results from legal obligations, but also from being first movers and recognizing opportunities, when mastering modern threads and risks. Limited natural resources, climate change, image and reputation protecting/ improving actions, demand for transparency and active employee participation in company's policy establishment. Confronting such changes in the organizational behavior, despite hard to overcome, can create positive impact on business. They can be an engine for new services- and product portfolio. This can be achieved through research and development in green technology, aware supplier selection, fostering stakeholder

communication as way to recognize and utilize new trends. In the best case, such company actions are taken as a part of its strategy and thus embedding sustainability as core pillar in it. Even when investments and popularization of SD should be carried out with an emphasize from developed nations and businesses in them (UN World Commission on Environment and Development, 1987), it is remarkable that emerging and even third world economies take strong actions towards SD. Brazil for example scores with indisputable leadership in comparison to Russia, India and China in the field of SR. It is possible not only because of legislation, but results as combination of overseas business influence and highly motivated stakeholders driving Brazilian economy towards more efficient and sufficient development (SustainAbility FBDS, 2010).

2. Outline of the problem

Sustainability has great number of facets and this makes it difficult to get an overview. For beginners, especially small and medium enterprises, it can become an overwhelming task. The steps needed to extract the useful information from guidelines, trends, methods are highly time and resources consuming. The C management level is aware that on a long term sustainability has to be tackled in the strategy of the companies they lead, nevertheless for many of them postponing is still the typical "action". For speeding up this process, a standardized, but still tailored to particular company's conditions pattern is needed.

Two of the most applied SR schemes are Global Reporting Initiative (GRI) and United Nations Global Compact Communication on Progress (GC). In 2009 GRI in version G3 was used when publishing 1400 reports worldwide – mainly large companies and GC was adopted as a framework in more than 6000 companies – many of them SMEs (Wensen, 2011).

GRI has three standard disclosure parts: profile, management approach and performance indicators (PI). For achieving most actual results GRI G3.1 launched in 2011 is used as basis. In its performance indicators part it includes 81 PIs divided in core (52) and additional (29) distributed in six dimensions. In addition to the general PIs are created sector supplements indicators, covering: Airport operations, Construction and real Estate, Event Organizers, Electric Utilities, Financial Services, Food Processing, Media, Mining and Metals, NGOs, Oil and Gas. If applicable, they are also regarded as core indicators. GRI G3.1 can have three levels of application, as shown in Figure 1.

GC has solely 10 principles grouped in four topics – human rights, labor, environment and corruption (GlobalCompact, 2000). Their fulfilling may vary from brief addressing to comprehensive sustainability report. Yet, there is a linkage between GRI and GC, since the latter can be produced using GRI PIs (UN GlobalCompact, 2007). The so elaborated report, as far as it fulfills the more detailed GRI requirements, can be listed than under both frameworks.

The multidimensionality of strategic management decision making process demands methods looking for preferences in decision making. Simultaneously, it requires inclusion of complexity of strategic thinking and involved knowledge, present in the company. This can't be covered using models, which norm or describe the reality with classic approaches of decision theory e.g. basing on normative thinking. Proper approach for solving this problem is the usage of knowledge engineering, which allows 'capturing' and transformation of knowledge from literature and experts in a formal model. (Espin, Vanti, Marx Gómez, & Racet Valdés, 2011). Such knowledge engineering method should reflect decision making model, strategic preference knowledge involved and specific knowledge about the problem, including standards for sustainability report.

Figure 1. GRI 3.1 Application Levels (GRI, 2011)

This paper will use wide adoption of the two described SR guidelines. Utilizing established merge, a guideline suitable for organizations new to the topic (beginners) will be proposed. Finally tree indexes for readiness, usefulness and convenience of SR for a certain company will be derived. The novelty of the approach is in the adoption of CFL in the mathematical description of the problem. Fuzzy logic interpretability when using language is known. CFL is a new approach, which belongs to mathematical fuzzy logic and improves that property. Henceforth, CFL as a way of knowledge engineering is a good approach for solution of the problem discussed here. Since the method could be applied to NGOs, enterprises, institutions, etc. the common term used in the mathematical description will be 'organization'.

3. Fuzzy Logic and Compensatory Fuzzy Logic

Fuzzy logic is a multi-valued logic having wide range of applications (Dubois et al., 2007). An essential property is its ability to model the "vagueness" mirroring natural language and uncertainty.

The notion of T-norm and T-conorm are not adequate to solve problems in decision making; however, it is the most used approach of all, even though empirical studies prove that some compensatory operators are closest in representing real human thinking than any T-norm or T-conorm system (Mizumoto, 1989).

Compensatory operators have been studied in the literature (Detyniecki, 2001), yet as single operators and not as integrated operators' system of compensatory operators. Maybe, the only exception in the literature is CFL (Espin et al., 2011). CFL consists of set of axioms, some of them inspired by logic, others by Decision theory, grouped in a coherent way.

CFL is designed for calculations, using complex sentences expressed in natural language, and not the usual simple statements used till now in Fuzzy Logic. The conception of this new tool is to reaffirm Zadeh's idea to compute with words rather than with numbers (Zadeh, 2002). This characteristic can be used to link CFL with Artificial Intelligence branches like *Knowledge Engineering*, the *Expert System*'s methodology (Bucharan and Shortliffe, 1984).

CFL defines Compensatory Logics as quartets of continuous operators 'c', 'd', 'o', 'n' respectively: conjunction-, disjunction-, fuzzy strict order- and negation operator.

The conjunction operator of CFL could be defined as a quasi-arithmetic mean. The correspondent disjunction operator is quasi-arithmetic's dual. c and d map vectors of $[0,1]^n$ into $[0,1]$, o is a mapping from $[0,1]^2$ into $[0,1]$, and n is a unary operator of $[0,1]$ into $[0,1]$.

The following axiomatic must be satisfied:

i.   Compensation Axiom: $\min(x_1, x_2, \dots, x_n) \leq c(x_1, x_2, \dots, x_n) \leq \max(x_1, x_2, \dots, x_n)$

ii.   Commutativity or Symmetry Axiom:

$$c(x_1, x_2, \dots, x_i, \dots, x_j, \dots, x_n) = c(x_1, x_2, \dots, x_j, \dots, x_i, \dots, x_n)$$

iii.   Strict Growth Axiom: if $x_1 = y_1, x_2 = y_2, \dots, x_{i-1} = y_{i-1}, x_{i+1} = y_{i+1}, \dots, x_n = y_n$
are unequal to zero, and $x_i > y_i$, then $c(x_1, x_2, \dots, x_n) > c(y_1, y_2, \dots, y_n)$

iv.   Veto Axiom: if $x_i = 0$ for one i, then $c(x) = 0$

v.   Fuzzy Reciprocity Axiom: $o(x,y) = n[o(y,x)]$

vi.   Fuzzy Transitivity Axiom: if $o(x,y) \geq 0.5$ and $o(y,z) \geq 0.5$, then
$o(x,z) \geq \max(o(x,y), o(y,z))$

vii.   De Morgan's Laws: $n(c(x_1, x_2, \dots, x_n)) = d(n(x_1), n(x_2), \dots, n(x_n))$

and

$$n(d(x_1, x_2, \dots, x_n)) = c(n(x_1), n(x_2), \dots, n(x_n))$$

The quartet of operators formed by the geometric mean and its dual as conjunctive, the disjunctive operators together with the fuzzy strict order $o(x,y) = 0.5\,[C(x) - C(y)] + 0.5$ and the negation $n(x) = 1 - x$ constitute a Compensatory Logic named Geometric Mean Based Compensatory Logic (*GMBCL*).

The properties of that specific Multivalued Logic are especially good for modeling through language. It satisfies the theorem of the light generalization, allowing very good behavior of the operators' combination, especially important for interpretability of logics' predicates through the language (Espin et al., 2011).

4. Decision Making Model

The goal of this paper is defining most suitable set of criteria for organization – beginner in SR. In this sense, we propose using level C of GRI with compulsory fulfilling of profile and PIs disclosures I and III (Figure 1).

This level requires at least 7 of the demanded 10 indicators to be taken from the listed as obligatory in the original (general) GRI guideline. For that reason the offered model will exclude disclosure on sector supplements. However, if applicable, we recommend strongly their consideration on a later stage when GRI B and A are envisaged.

Obligatory indicators for GRI level C are merged with those describing the principles of GC. In order to achieve full covering of GC, the core indicators are completed with 10 additional ones.

Schematically presented procedure in nine steps for supporting decision making towards SR is proposed (Figure 2). To ease the understanding, all statements to be used are gathered in a notation list. Using the assets of CFL predicates are proposed.
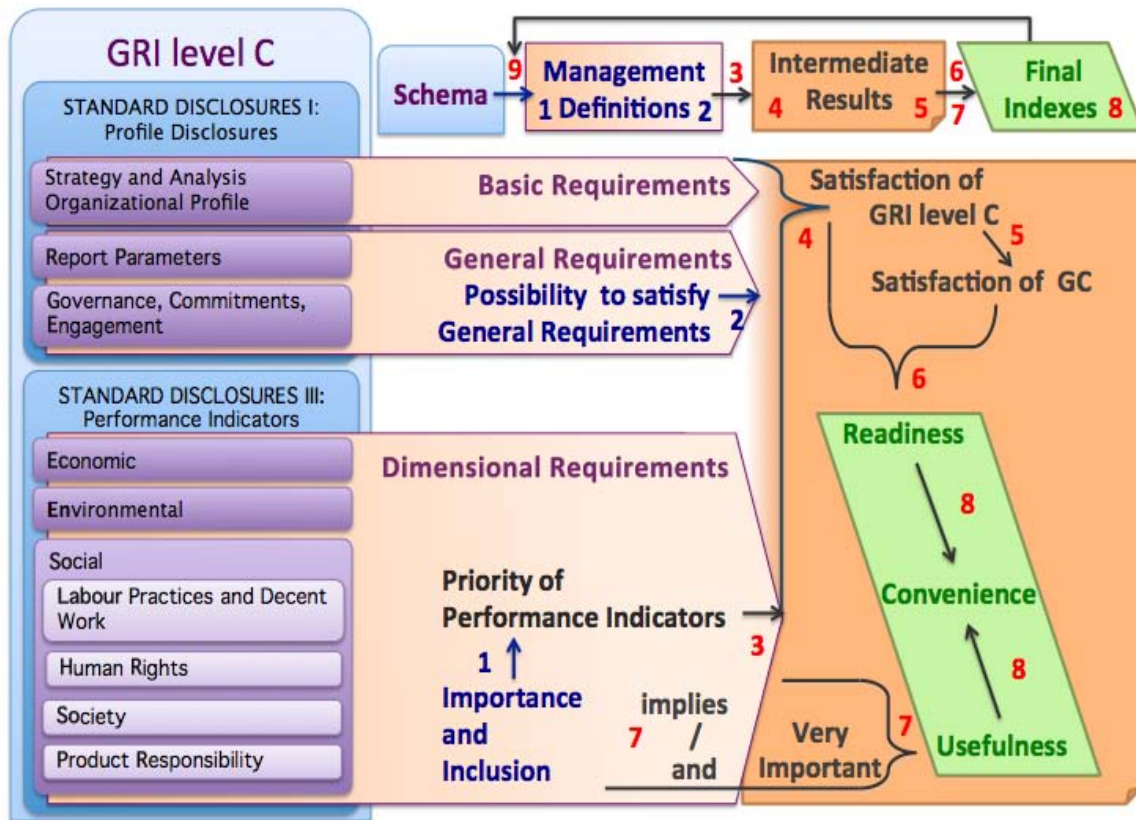
Figure 2 Procedure for decision making process for implementing Sustainability Reporting

Notation used:

$P(i)$	*Priority of PI i for the company*
$I(i)$	*Importance of PI i*
$InSR(i)$	*Inclusion of indicator i in the SR*
$I_C(i)$	*Importance of PI i for the company*
$I_S(i)$	*Importance of PI i for the stakeholders*
$GB(i)$	*Good behavior of organization according to PI i*
$PO(i)$	*Possibility to obtain PI i*
$GRI\_C(x)$	*Satisfaction of GRI level C from organization x*
$GRI\_GR(x)$	*GRI general requirements for organization x*
$GRI\_DR(x)$	*GRI dimension requirements for organization x*
$GRI\_DR\_sum($	*Sum of applicable GRI dimension requirements for organization x*
$GRI\_RP(x)$	*GRI general requirements – report parameters part satisfaction for*

organization x

$GRI\_GCE(x)$	*GRI general requirements – governance, commitment and engagement satisfaction part for organization x*
$GRI\_EcR(x)$	*GRI economical requirements for organization x*
$GRI\_EnR(x)$	*GRI environmental requirements for organization x*
$GRI\_SoR(x)$	*GRI social requirements for organization x*
$RPi(x)$	*Possibility to satisfy disclosure profile i of the report parameters part for organization x*
$RRPi(x)$	*Possibility to report profile disclosure i of the report parameters part for organization x*
$JRPi(x)$	*Possibility to justify omission of profile disclosure i of the report parameters part for organization x*
$GCEi(x)$	*Possibility to satisfy profile disclosure i of the governance, commitment and engagement part for organization x*
$RGCEi(x)$	*Possibility to report on profile disclosure i of governance, commitment and engagement part for organization x*
$JGCEi(x)$	*Possibility to justify omission of the profile disclosure i of the governance, commitment and engagement part for organization x*
$GC(x)$	*Satisfaction of GC*
P_j	*GC principle with number j*
$GBj(i)$	*Good enough behavior of the indicator i corresponding to the principle j*
$POj(i)$	*Possibility to obtain the indicator i corresponding to the principle j*
$\bigwedge\limits_{j}$	*Conjunction over all aspects*
$\bigvee\limits_{i\epsilon A_j}$	*Disjunction over all PIs, which belong to aspect j*
$RSR(x)$	*Readiness of organization x for making a sustainability report*
$U(x)$	*Usefulness of SR for organization x*
$I(i)$	*Important indicator i*
$VI(i)$	*Very important indicator i*
$C(x)$	*Convenience for SR elaboration for organization x*

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	Disjunction of elements
	Conjunction of elements
	Numerical value
	Fuzzy value

After selection of experts in the organization step 1 in fulfilling the process is made. Experts have to answer on following questions upon each GRI PI:

- How important the PI is for the company?
- How important the PI is for the stakeholders?
- How good enough is the company behavior in relation to the PI?
- How true is that each PI is possible to be obtained from the company?

The answers are expressed through true value between 0 and 1. The scale used for receiving viable answers from experts and managers is as follows: 0- absolutely false; 0.25- more false than true; 0.5- as true as false; 0.75- more true than false; 1- absolutely true. An illustration of its implementation is shown in Table 1.

Performance Indicator	$I_C(i)$	$I_S(i)$	$GB(i)$	$PO(i)$
1	0.75	0.25	0.5	0.5
2	0.25	0.5	0.75	0.75
…	…	…	…	…
62	1	1	0.75	0.75

Table 1. Value of performance indicators

Thus obtained information is processed through set of predicates, modeling the correspondent statements with Fuzzy Tree Studio. This software was chosen for its intuitive handling, comprehensive performing of different types CFL calculations and last, but not least very good abilities for visualization of the predicates' tree structure (Fig.3).

4.1. Importance of performance indicator for the organization – is observed if the indicator is important for the organization itself, or for its stakeholders. In order to disclose according i, $I(i) > 0.5$

$$I(i) = I_C(i) \vee I_S(i) \tag{1}$$

4.2. Inclusion of performance indicator in the SR – can succeed, if it is possible for an indicator to be obtained and organization has good enough behavior in it. In order to disclose according i, $InSR(i) > 0.5$

$$InSR(i) = PO(i) \wedge GB(i) \tag{2}$$

The results of (1) and (2) are achieved through calculation of the management definitions stated in table 1 and fulfill step 1 of the proposed process.

4.3. Priority of a performance indicator for the organization – described through importance of the indicator for the organization, possibility to obtain it and good behavior of the organization towards it. In order to disclose according i, $P(i) \geq 0.6$, so defined priority of PI

fulfills step 3 of the process.

$$P(i) = I(i) \wedge InSR(i) \tag{3}$$

4.4. Satisfaction of GRI level C – is observed, if organization satisfies the general and dimensional requirements – listed in standard disclosure I and III accordingly, plus fulfilling the condition the sum of the dimensional requirements to be at least ten. $GRI\_C(x)$ describes in details step 4 of the process.

$$GRI\_C(x) = GRI\_GR(x) \wedge GRI\_DR(x) \wedge GRI\_DR\_sum(x) \tag{4}$$

It is assumed that the first two groups in the profile disclosure (strategy and analysis and organizational profile) are crucial basic requirements when taking decision for SR (Fig.2). For that reason organization's strategic management has to fulfill, but will not be questioned on them. $GRI\_GR(x)$ are met, if the report parameters plus government, commitment and engagement parts are accomplished (4a) and (4d).

GRI level C is satisfied when the general requirements (standard disclosure I – profile disclosures) and dimensional requirements (standard disclosure III – PIs) are satisfied. Dimensional requirements have to achieve a sum of ten - $GRI\_DR\_sum(x)$. This is the case, if at least one, but maximum eight of the economic, environmental and social indicators accordingly are disclosed.

$$GRI\_GR(x) = GRI\_RP(x) \wedge GRI\_GCE(x) \tag{4a}$$

Fulfilling of general requirements is defined from strategic managers. They have to state ability of the organization to disclose (report) on all profile disclosures, or give justification for those, which will be omitted. This assessment mirrors step 2 of the proposed procedure.

For the report parameters the formula is:

$$GRI\_RP(x) = \forall_i(RPi(x)) = \forall_i\big(RRPi(x) \vee JRPi(x)\big) = \bigwedge_i \big(RRPi(x) \vee JRPi(x)\big) \tag{4b}$$

Governance, commitment and engagement are expressed as:

$$GRI\_GCE(x) = \forall_i GCEi(x) = \forall_i\big(RGCEi(x) \vee JGCEi(x)\big) = \bigwedge_i \big(RGCEi(x) \vee JGCEi(x)\big) \tag{4c}$$

Dimensional requirements are described as follows:

$$GRI\_DR(x) = GRI\_EcR(x) \wedge GRI\_EnR(x) \wedge GRI\_SoR(x) \tag{4d}$$

The predicates $GRI\_DR\_sum(x)$, $GRI\_DR(x)$, $GRI\_EcR(x)$, $GRI\_EnR(x)$, $GRI\_SoR(x)$ are modeled by sigmoid membership functions, according with the requirements of GRI level C, having PIs number with truth value of the predicate $InSR(i)$ greater than 0.5.

Visualization of satisfaction of GRI level C, achieved through Fuzzy Tree Studio software is given below in Fig.3. For reasons of the figure simplification for $RRPi(x), JRPi(x), RGCEi(x), JGCEi(x) - i$ is represented only with its 1 and n values.

4.5. Satisfaction of GC – organization satisfies indicators listed for GC, if there are indicators corresponding to each GC principle, with good enough performance and possibilities to be obtained. This completes step 5 of the process and is expressed with the following predicate:

$$GC(x) = \forall_j \left(\exists_{i \epsilon P_j} (GBj(i) \wedge POj(i)) \right) = \overset{\wedge}{_j} \left(\overset{\vee}{_{i \epsilon P_j}} (GBj(i) \wedge POj(i)) \right) \tag{5}$$
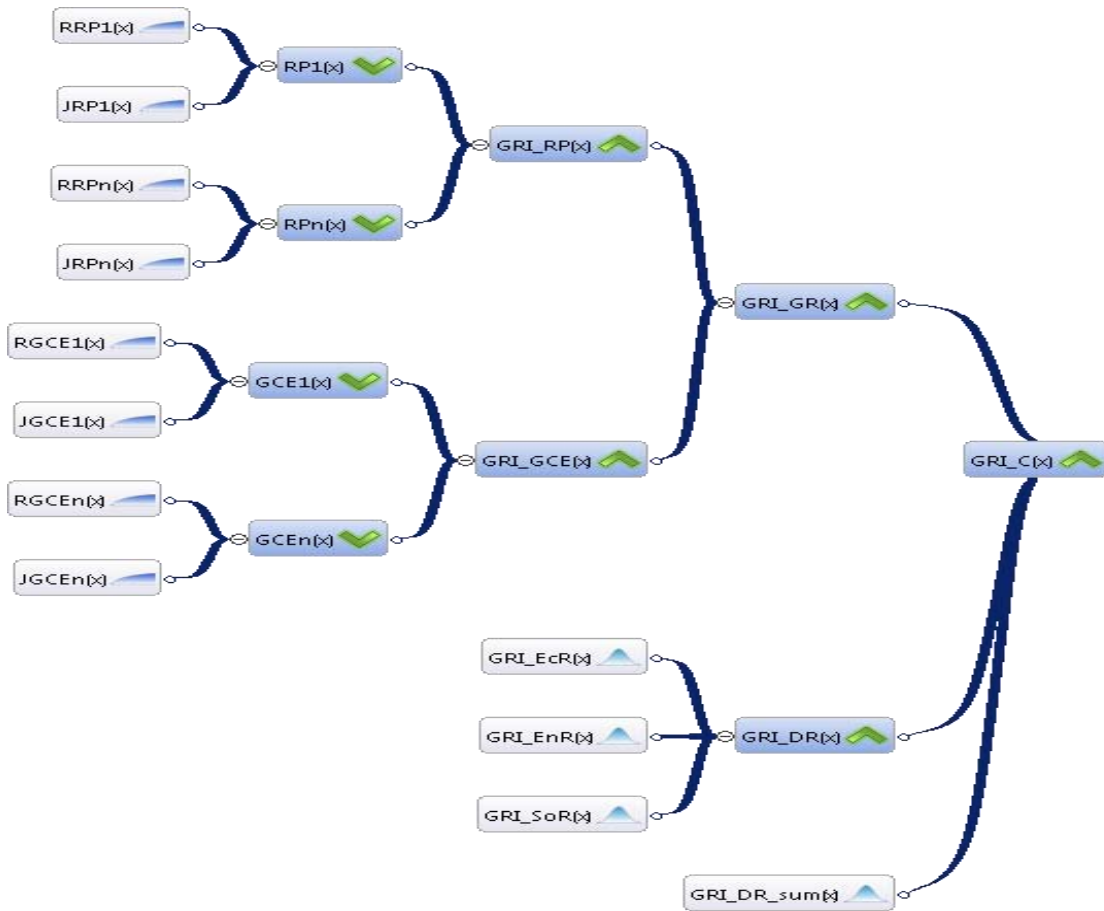

Figure 3 Satisfaction of GRI level from organization x

4.6. Readiness for introducing of SR – is observed, if an organization is ready to achieve level C of GRI and simultaneously satisfies the GC principles. A company is ready for GC, if there are indicators corresponding to each GC principle with good enough performance and possibilities to be obtained and respectively included in the report, step 6 of method.

$$RSR(x) = GC(x) \wedge GRI\_C(x) \tag{6}$$

4.7. Usefulness of SR – is present, if all PIs included in the SR are important, or there are some of them very important (7). Very important PI are calculated using the standard way of modeling of modifier 'very' (8) (Espin, 2011), step 7.

$$U(x) = \forall i \big(InSR(i) \rightarrow I(i) \big) \vee \exists i \big(InSR(i) \wedge VI(i) \big) \tag{7}$$

$$VI(i) = I^2(i) \tag{8}$$

4.8. Convenience for elaborating a SR – is present, if the company is ready to introduce SR and it is useful for it, step 8.

$$C(x) = RSR(x) \wedge U(x) \tag{9}$$

When $0.5 \leq C(x) < 0.75$, it should be interpreted as "it is more true than false that the SR is convenient"; if $C(x) \leq 0.75$ convenience of SR should be interpreted as "very true" for the organization.

4.9. Utilization of the results

After fulfilling step 8 of the guideline, decision towards SR could be taken. The literature recommends concentration on four to eight PI in the different dimensions, whereas sector supplements should be also reviewed (SustainAbility FBDS, 2010). In this sense a loop of the decision making process, providing in depth approach on previously envisaged vital for the organization's strategy PI is recommended.

For organizations new to SR exists number of the benefits from the proposed method. Some of them:

- General overview on criteria, whose fulfilling will empower sustainable business;
- Gaining new perspective on the organization's workflows through appreciating its impact in society and environment;
- Accelerated knowledge acquisition for internal and external key factors influencing the organization;
- Developing set of value creation activities implementing thoroughly sustainability principles.

Through step 9 the proposed model can be used as iterative process for self-assessment on achieving internal and external short-, mid- and long-term goals connected with SR

The proposed method enables organizations to assess own status quo according list of profile disclosures developed from international expert panels and seen as essential for sustainable way of doing business, providing services, etc. It gives base for making informed choices, even if organization should appreciate it is still not ready for issuing a SR. Through asking simple questions and merging own comprehension with that of the stakeholders, awareness, hidden potentials can be captured and developed. It can also prove profound sustainability connected activities in specific fields, which were not appreciated till the moment as positive communication worth it assets. Finally, communication on covered GRI G3.1 disclosures and/ or GC principles is highly recommendable. Gained publicity makes the organizations not only more responsible corporate citizen, but pushes through generally further actions while adopting sustainability.

5. Conclusions and Recommendations

Introduction of the SR in a company is strategically important decision for the company's future and relevant for the company's stakeholders. The complexity of the problem recommends modeling using knowledge engineering methods. The selection of CFL for obtaining a model of decision making proves to be very useful and easy applicable for its main characteristic – modeling from linguistic expression of knowledge involved. That allowed to take into account not only organization's interests and standards like GRI and GC, but also enables simple complementing with specially created PI like those in the sector supplements, or such representing specific organization's features particularly for the purposes of SR.

The use of the predicates of CFL allows calculation of three indexes for SR introduction: readiness, usefulness and convenience. They can be seen as a possible part of a semaphore tool, expressing in a useful way level of utilization of SR for the company.

In future research ontology of global indexes can be produced. It can be used as universal tool to estimate level of readiness of a company to incorporate SR. Such add-on could be applied for gathering answers from large number companies. Based on their size (corporations, small and medium enterprises) and field of work (producing, services, logistics, etc.) set of specific "universal" questions can be developed. Through their answers readiness for developing

sustainable business on strategy level will be assessed and recommendation for short, middle or long term SR implementation will be given.

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