Designing a Compromising Strategy for Reverse Supply Chain Performance: Case Study of Electrical and Electronic Equipments Industry

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Abstract— **Wastes of the Electrical and the Electronic Equipments (WEEE) have been a major danger because of their hazardous composition to the environment and to the human health. Today, their valorization within a reverse supply chain is a reality and it is a good thing. However, stakeholders are often divided on the issue and their positions and decisions about performance enhancement are sometimes ambiguous. A new strategy should look for collective decisions for improving sustainable performance of the economic, the environmental and the social responsibility aspects. It became necessary to develop an interactive decision making that considers the conflicting opinion to select the best compromise strategy. Nevertheless, ambiguity and collaboration decision modalities of different decision-makers are not considered in the real case. In this paper, a compromising strategy has been undertaking using an entropic analyze, ambiguity notions and cooperative theory. The proposed model has been applied in a Tunisian industry of Wastes of the Electric and the Electronic Equipment (WEEE).**

Keywords-Reverse Logistics; Compromise strategy; decision making model; WEEE; sustainable performance

I. INTRODUCTION

One of the most significant changes in the supply management is the growth of the environmental interest and more recently the corporate social responsability. Thus, due to the technological development of the Wastes of the Electric and the Electronic Equipment WEEE are increased [1]. The WEEE must be taken back to reduce its effect on the environment, the social and the economic consciousness. With integrating the sustainability into reverse supply chain, the treatment of WEEE can improve the environmental image by removing the growing waste [2]. However, reverse supply chain generally involves a complex returned flows due to the growth of kinds and the number of the returned products and decision makers. The process of reverse logistics have to based on three main sustainable development pillars: economic, environmental and social. Each of these three pillars constitutes an important objective used to determine an adequate strategy which satisfies all decision makers in the supply chain. This can increase the number of decision making in different entity the supply chain (supplier, manufacturer, distributor, costumer…) which differ in their choice of strategy considering the criteria of sustainability performance. Generally, a set of indicators can be used to measure performance providing relevant information on the state of system in order to make an effective decision. These indicators are measured by one evaluator based on their position in the assessment. Evaluators should be assigned to an evaluation to satisfy partners of supply chain. Thus, a meaningful strategy provides the choice of evaluators for such indicator to satisfy decision makers.

A reverse supply chain management needs to integrate all part or decision makers to improve the sustainability with integrating a collective decision to get a compromising strategy. It involves more formal relationships, objectives and actions which are mutual, compatible and common, not necessary a centralized authority [3]. Thus, different agents in reverse supply chain such as supplier, producer and distributors, have conflicting opinions which must be considered to select a suitable strategy. Providing a collective decision which allows managers to choose a compromising strategy that offers an improvement in performance. Measurement of this is an essential element of the effective planning and control, as well as decision making [4]. The performance evolution in the supply chain is very important to sustain its effectiveness and its efficiency [5]. Consequently, the supply chain management has strategic implications which identify the required performance measures on most of the essential criteria and it should be an integral part of any strategy [6]. However, this criteria used in evaluating performance can be referred to conflicted objectives.

As far as we know, the implication of the interactive decision-making is not considered literature to select the best strategy which improves the sustainability. In this study, an aided-decision model is proposed to highlight the collective solution that indicates the global strategy of the different preferences of decision makers according to the sustainable performance. This paper is organized as follows: in section 2, literature review presents the different strategies of supply chain management. Section 3 describes the importance of the sustainable performance in reverse Supply Chain. Section 4 introduces our method. In section 5, we present a real case to explain the proposed method. In section 6, we interpret the result. Finally, we present our conclusion and potential further works.

II. LITERATURE REVIEW

With growing interest to focus on the competitiveness and the effectiveness in the business organization, supply chain is one of the important challenges which can improve the value of the manufacturer. The rise of management process in the supply chain is not only depending on the deployment of resources, but also by finding the performance of the whole supply chain. A large number of publications are often regarded to improve the organizational management or inter-organization which addresses the lean supply chain, the agile supply chain and the performance supply chain. These paradigms may be combined to enable highly competitive supply chains capable of winning a volatile and cost-conscious environment [7]. The common objective of academics and practitioners is to determine how a firm can achieve a sustainable competitive advantage [8]. In doing so, we seek to identify a suitable strategy to offer a sustain benefit which its implementation differ from the supply chain especially and the reverse supply chain, inasmuch as we consider to tack a variety of agents and decisions. To complete the supply chain level, firms must adopt an appropriate supply chain management strategy [9].

Indeed, the lean management as a combination of measuring the intensity levels of agility enable-attributes, while other measuring methods have not under taken into accounts the measuring of the intensity levels [10]. The agile systems rely on flexible to response to customer when there are very short product life cycles. Corresponding to Christopher and Towill [7], an effective management of supply chain is based on the flexibility and the quality, which can be achieved by the dynamic partnerships and the coordination of flows. In the same way, Hang et al. [12] focus on minimizing the total cost in order to implement agile supply chain in scheduling order. To achieve a level of agility, Lin et al. [13] evaluates the supply chain agility on a Taiwanese company which focuses on the application of the linguistic measurement. Aishwarya and Balaji [14] view the point that companies need to be more agile and responsive with its constructed a validated tool which is carried out by matrix transformation to determine the business relationship between supplier and buyer. In the purpose of developing the management process which eliminates all the wastes, lean management offers companies how to emphasize to minimize the cost with high quality and service level and low lead-time. The uses of the fundamentals of Lean management provide an added value for the customer satisfaction. Achieving quality in all steps of production system is the main goal of Sawhney et al. [16], which can be reached by lean focuses on the environment approach. Simpson and power in [17] develop some practices of lean supplier to be adopted in the environmental practices. In the same context, Carvallo [18] applied a collaborative design from all stages of life cycle of products. Further, Dües et *al.* [19] also introduce new practices which have a positive effect on the environment. An appropriate organizational culture is provided by Comm and Mathaisel [20] to change the organizational culture and communication between people. Lean and Agile management provide common elements in the same site and with some of rotation [21], which can meet the need of complex products. Moreover, the researcher and the practitioner look for various challenges from various fields which can be assessed to select the best strategy and to improve performance. Cooper et al. [22] provide coordination between activities and processes that are based on three decision levels: strategic, tactical and operational. Several measuring performance tools are based on economic performance to minimize the cost due to financial piloting indicators. In the same way, Gilmour [23] applied an organizational level to link competences to the information technology and to the organization of chain. Lamouri [24], also in his work, develops a performance model "association for Operations management model" to analyze all the possible-assembly sequences in industrial context. Bou-Lusar *et al.* [25] propose a model which is used as a guide to TQM (total quality management) implementation. Dominique et al. [26] propose adopting Supply Chain Operation Reference (SCOR), which aimed to manage the supply chain practices by improving the performance of each system. Table 1 summarized the well-known management strategy organized by the main objectives. However, the presented research works has involved many limitations for managing the supply chain. In fact, the majority of literature works not cover all the fields of sustainability. Thus, it can not continually improve the processes of supply chains which consider all decision-makers in the supply chain. Hence, the decision maker is not taking into account her conflicting opinion and the ambiguity of judgment.

III. SUSTAINABLE PERFORMANCE IN REVERSE SUPPLY CHAIN

A reverse logistics has been widely tackled because of the importance to protect the environment and to increase the economic profits due to the tack-back obligation [27]. Fleishmann [28] has defined the reverse logistic as: "*the process of planning, implementing and controlling the efficient and the effective inbound flow and the storage of the secondary good and the related information which is opposite to the traditional supply chain direction for the purpose of recovering the value or the proper disposal*". Indeed, a reverse supply chain process allows opportunity to improve its sustainability. The importance of the sustainability criteria in supply chain is evaluated via the performance measurement [29].

Sustainable performance has increased because it represents a new driving strategy for the development of the supply chain related to the economic, environmental and social impact. In the reverse supply chain managing, the returned flow which is extremely complex due to the characteristics of returned products. Sustainable performance has created a positive implication on the reverse supply chain.

TABLE I. DIFFERENT STRATEGIES OF SUPPLY CHAIN

Authors	Lean supply chain	Agile supply chain	Performance supply chain	Main topics
15	*			Using efficient resources to reduce environmental pollution
22			*	Providing a coordination between activities and processes
23			*	Evaluating the characteristics of an organization's supply chain
24			*	Analysing all the possible assembly sequences
7		*		Achieving high responsiveness to the market to get speed of delivery, flexibility and quality
12		*		Inserting and scheduling order in Agile supply chain with minimum cost
17	*			Adopting the environmental management practices tool such as lean supplier development.
20	*			Identifying the suitable system of indicators to focus on appropriate organizational culture
13		*		Developing a fuzzy agility index for each agile supply chain to provide more informative and reliable analytical results
25			*	Using a guide to TQM (total quality management) implementation
26			*	Analyzing cost/performance tradeoffs
18	*			Reducing the environmental pollution in all process in cycle life product
19	*			Implementing the greenery in lean supply chain
14		*		Improving the agile capabilities by relating the business changes to the supplier-buyer relationship

Thus, decision maker seeks to integrate the efficient strategy that promotes the environmental protection, the economic benefits and the social satisfaction. Managing returned products with sustainable issues may be considered as business objectives. Thus, due to the performance indicators one can offer to the manufacturer an opportunity to manage the diversity of objectives and to increase its effectiveness and its efficiency.

The logic of the diversity objectives between decision makers in the same manufacture is explained by the number of activities notably in the reverse network. Furthermore, measures or performance indicators are checked in different ways. It's depending on the preference of the expert. In the reality, numerous ambiguities may be exist due to the human judgments.

Generally speaking, numerous actors have composed the reverse supply chain to get valorized products. Each decision makers involved its performance measurement to cover its appropriate purpose. Thus, measuring a sustainable performance which is made more difficult in reverse supply chain to raise three management dimensions that may affect the whole decision, especially that no individual decision since has not been taken in this study. Based on a modified concept of making decision regarding the sustainable performance, a collaborative strategy can be applied to contribute to better decision regarding the conflicting objectives. This paper aims at developing a new model of decision making for compromising the strategy of decision makers. The main contributions of this paper are:

a) The compromising strategy for Collective decision making based on the interactive opinion.

b) The evaluation of the sustainable performance proposed to achieve a process of a continuous improvement considering the weight of indicator which depends on the decision making preferences in the context of reverse supply chain.

c) The problem of selecting the strategy of reverse supply chain coordination has been recovered by group decision makers, which provide a conflicting opinion.

d) A fuzzy method is proposed to solve the problem of ambiguity considered by the human judgment.

IV. METHODOLOGY

This paper proposes an aided decision method that guides decision maker to provide a suitable strategy improving the sustainable performance. The proposed methodology is summarized on three steps. Firstly, a mutual influence analysis for selecting performance indicators done to find the most important indicators. Then, a fuzzy performance index has been determined to get a normalized matrix. The last steps consist on generating the different combination of strategy (evaluators / indicators).

Depending on the interactive decision making, the preferences of experts are taking into account the ambiguity in measuring performance. Thus, it is difficult to directly make a decision in the complex situation of the returned products. A specific opinion for each decision maker considered as a player is influenced by his own decision criteria. According to the preference of each decision maker /player, system will be in an inconsistent situation. Regarding to all these challenges, we propose the various steps of proposed decision system which is given as follows "*Fig.1*":

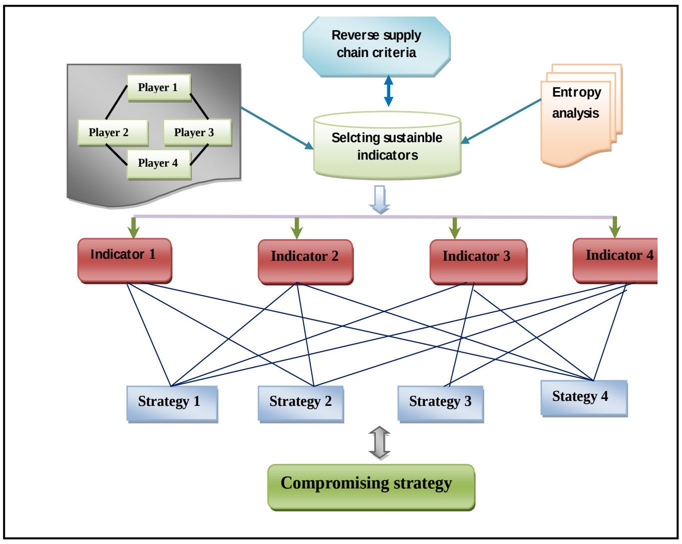

Figure 1. Structure of the proposed model.

A. Mutuel influence analysis for selecting performance indicators

The most essential task of sustainable measurement is to choose the appropriate indicators that cover all the main aspects of the system. To avoid clarity and simplicity, performance system should provide information on overall on outcome [30]. A specific relationship can be defined between performance indicators "IP" and its appropriate event "ID". A cause and effect analysis can prove the degree of relation for an effective the performance couple I (IP, ID). To help evaluator in measuring performance, an entropy analysis provide which the main indicators you should choose to assess performance in the system by the cause and effect relationship between objectives and resources using a logical tool such as "If... then … Otherwise". The entropy analysis is based on the concept of theory of information and it is based exclusively an expertise during the drive. This technique could be employed to select the tangible indicators, which implies the cause and effect relationship between performance couple (IP, ID) [31]. A performance indicator could be described as in (1):

$$U_i::<IP_i>,<type>,<unit>,<field> \quad (1)$$

The objective O_i and the measure are expressed as in (2) and (3):

$$O_i<IP_i>=<expression> \quad (2)$$

$$m_i::<IP_i>=<expression> \quad (3)$$

A set of actions with j index could be described as in (4):

$$Vj::<IDj>,<objet>, <impact>,<action>,<type>,<horizon> \quad (4)$$

The average mutual information I (ID_j,IP_i) quantified the correlation between the variable decision ID_j and the performance indicator. This is what we can learn about the decision in (5):

$$ID_j= id_j^{g'} \quad (5)$$

We can obtain as in (6):

$$IPi= IP_i^g \quad (6)$$

The decisional entropy H(ID_j) can be written as follows in (7):

$$H(ID_j) = \sum_{g'} p(id_j^{g'}) \log p(id_j^{g'}) \quad (7)$$

The calculation of mutual information average is also expressed by the following equation (8):

We can generate entropy conditional on the following propriety in (8):

$$0\leq 1(ID_j; IPi \leq \ H(ID_j)\ ) \quad (8)$$

B. Fuzzy Performance Index Calculation

After selecting the relevant indicators (step 1), experts should calculate performance indicators selected. The importance of the expert's judgment differs from an indicator to another. The incorporation of expert's judgment increases the imprecision of decisions. This is as our case which is composed a wide range of views from various internal and external areas (customer, government, recycler…). However, the dimensions of partners (actors) are differing from each other due to the priority of individual objective and strategy. It is necessary to measure the weight of each expert, which can explain his preferences to the indicator. Due to the relative weight of evaluator's opinions derived from interior and exterior decisions maker can be incorporated to provide a suitable decision. The Analytical hierarchy process (AHP) is a classical method [33] is used for comparing the consistency of the decision-makers for determining the weights of criteria by a hierarchy. Based on scale of Saaty (1980) [34] which is numbered from 1 to 9, we can compare the importance of decision makers between them to get decision weights of each decision makers. Decision weight provides the most important actor in supply chain which is used to generate all possible strategy.

Furthermore, the procedure of measuring performance can not be effective due to the lack of visibility, which is essential to provide the real performance index. In order to find the performance of the system, the ambiguity of information will influence the decision making, corresponding to the complex relationship between the entities of the logistic supply chain. These players provide several opinions and preferences that have an effect on performance measurement. Due to the appropriate objectives and strategies of expert, we assume that performance index represent the expert's measurement of each indicator. Based on the measurement scale and performance measures, we can express the ambiguity of human judgment by the fuzzy numbers. In order to quantify the ambiguity in human judgment, we propose the Fuzzy set theory. Zadeh [32] defined the fuzzy theory as an approach for an effectively dealing with the inherent imprecision, vagueness and the ambiguity of the human-decision making process. Some basic definitions of Fuzzy set theory are reviewed [32].

1) Definition 1:

In the universe of discourses of the PG (μ), the membership function of the set G {A, B, C...F}, for each element of $P_x(\mu)$ each x in X. Where $P_x(\mu)$: G→[0,1].Which is described as in (9):

$$P_G(\mu)=\{ (P_x(\mu). \mu) , X = A,B,C....F\} \quad (9)$$

2) Definition 2:

A triangular fuzzy number G= {Ã, B̃, C̃...F̃}.Theses grades are classified from the perfect to the worst in *"Fig.2"*.

All the triangular fuzzy numbers are summarised as follow in (9):

$$\tilde{A}= T(8, 10, 10), \quad \tilde{B}= T(6, 8, 10)$$
$$\tilde{C} = T(4, 6, 8), \quad \tilde{D}= T(2, 4, 6)$$
$$\tilde{E}=T(0,2,4), \quad \tilde{F}=T(0,0,2) \quad (10)$$

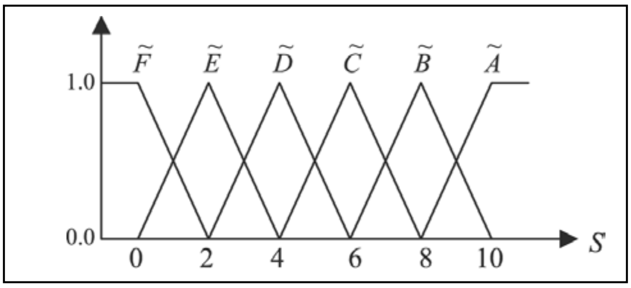

Figure 2. Triangular fuzzy grade .

According to the fuzzy his theory result, we can determine the performance index of each indicators, considering the human judgment. From the scale (figure 2), we can determine fuzzy measurement result ranged from zero to ten. The relative grade of various fuzzy number, provide a fuzzy vector of performance set G= {A, B, C, D, E, F}, to calibrate the performance index into the different intervals.

In addition, the scale measurement is applied to obtain the perfect and the bottom performance value and to quantify the preference of the evaluators. The index of performance is done by the measure the score of each evaluator. For one performance index which T is the indicator number and x is the evaluator number. Thus, we obtained a normalized matrix P_x (μ) that contains a measurement of an appropriate indicator assessed by each evaluator.

C. Best Strategy of compromise: interactive decision making

The behaviors of decision makers are often interactive to improve the sustainable performance, which is characterized by various interests in supply chain such as economics, environmental and social aspects. The objectives of the various agents are conflicting in supply chain need to be considered in selecting suitable assigning evaluators to measure indicators. With incorporating the preferences of the most important players which take into account of other and the matrix of measurement of indicators we can generate the table of all the possible combinaisons ΔF (s1, s2, s3,s4), it can represent a deffuzifed step of P_x (μ) matrix. Each player/actor in this study has vectors of indicators measurement obtained from the index measurement tacked by evaluators (step 2). Based on the concept of the theory game with a 4- player game, this step has been inspired to implement cooperative models that reduce the inconsistence between players. For 4-players and 3 evaluators we obtain 81 interactions as shown in table 3. The calculation of each strategy is based on a mathematical equation. Let $PT_x(\mu)$ is combined matrix by x^{th} evaluators and T^{th} indicators. W_j^T is the vector of players' weight and $\sum_1^4 W_j^T$ is the average of players weight. One player makes the judgment of each evaluator to express the strategy with a relative weight of decisions makers. The strategy function can be expressed as the following:

$$\Delta F (s_1, s_2, s_3,s_4) = P^T_x(\mu)\times \sum_1^4/W_j^T \quad (11)$$

Regarding the importance of the decision criteria, evaluating the performance of supply chain can be obtained by a compromising strategy [35].This study believes to select the most appropriate combinaison strategy to improve performance of supply chain. A balanced strategy is obtained by the convergence value of strategy combinations which represent the most reducer value of calculated startegy. To express the interactive relationship, a mathematical equation is used to extract the most appropriate combinaisons [35]

V. Real case: Tunisian industry Waste of Electrical and Electronic Equipments (WEEE)

The data collected from the environmental ministry of Agriculture and Environment in Tunisia concerning the waste of the Electric and the Electronic Equipment for the implementation of our proposed model. A multiple agent has composed the chain of treatment of Electrical and Electronic Equipment waste presented by: Government, Processor, Recycler, and Consumer. All players can collaborate together despite their divergent objectives, referring to the information collected in the past. Each measure is considered as a judgment strategy to be taken into account in decision making. In order to improve the sustainable performance of supply chain industries of WEEE and in order reduce the inconsistencies between the different agent's purpose considering its preferences and the ambiguity in his judgments.

Tunisian WEEE industries respect the European Union's Directives 2002/96/EC, which aim at obligating the manufacturer to increase the rate of recovery of WEEE. In the same way, it is necessary to measure the rate of satisfaction of the consumer with a measurement interval that is equal to [53, 55] for an average of satisfaction, equal to 54, 4. Thus, we can define the performance indicator IP_i "rate of dismantling product".

We assume $IP_i=IP_{11}$"ratereached" and IP_i=IP12 "rate is not reached". In the disassembly step, all components are in the same condition. Let ID_i=ID2 and ID_i=ID3are two binary variables of action and it corresponds to the dismantling id_{21}= "active destruction".

TABLE II. Diffrent Combinaisons of strategy

		Player 2								
		I			II			III		
player1	I	ΔF (I,I,I,I)	ΔF (I,I,I,II)	ΔF (I,I,I,III)	ΔF (II,I,I,I)	ΔF (II,I,I,II)	ΔF (II,I,I,III)	ΔF (III,I,I,II)	ΔF (III,I,I,II)	ΔF (III,I,I,III)
		ΔF (I,I,II,I)	ΔF (I,I,II,II)	ΔF (I,I,II,III)	ΔF (II,I,III,I)	ΔF (II,I,II,II)	ΔF (II,II,II,III)	ΔF (III,I,II,II)	ΔF (III,I,II,II)	ΔF (III,I,II,III)
		ΔF (I,I,III,I)	ΔF (I,I,III,II)	ΔF (I,I,III,III)	ΔF (II,I,III,III)	ΔF (II,II,I,II)	ΔF (II,II,I,III)	ΔF (III,I,I,I)	ΔF (III,I,I,II)	ΔF (III,II,I,III)
	II	ΔF (I,II,I,I)	ΔF (I,II,I,II)	ΔF (I,II,I,III)	ΔF (II,II,I,I)	ΔF (II,II,I,III)	ΔF (II,II,I,III)	ΔF (III,I,I,I)	ΔF (III,I,I,II)	ΔF (III,II,I,III)
		ΔF (I,II,II,I)	ΔF (I,II,II,II)	ΔF (I,II,II,III)	ΔF (II,II,II,I)	ΔF (II,II,II,II)	ΔF (II,II,II,III)	ΔF (II,II,II,I)	ΔF (III,II,II,II)	ΔF (III,II,II,III)
		ΔF (I,II,III,I)	ΔF (I,II,III,II)	ΔF (I,III,I,III)	ΔF (II,III,I,I)	ΔF (II,II,III,III)	ΔF (II,II,III,III)	ΔF (III,II,III,I)	ΔF (III,II,III,II)	ΔF (III,II,III,III)
	III	ΔF (I,III,I,I)	ΔF (I,III,I,III)	ΔF (II,III,I,I)	ΔF (II,III,I,I)	ΔF (II,III,I,II)	ΔF (II,III,I,III)	ΔF (III,III,I,I)	ΔF (III,III,I,II)	ΔF (III,III,I,III)
		ΔF (I,III,II,I)	ΔF (I,III,II,II)	ΔF (I,III,II,III)	ΔF (II,III,II,I)	ΔF (II,III,II,II)	ΔF (II,III,II,III)	ΔF (III,III,II,I)	ΔF (III,III,II,II)	ΔF (III,III,II,III)
		ΔF (I,III,III,I)	ΔF (I,III,III,II)	ΔF (I,III,III,III)	ΔF (III,III,III,I)	ΔF (II,III,III,II)	ΔF (II,III,III,III)	ΔF (III,III,III,I)	ΔF (III,III,III,II)	ΔF (III,III,III,II)

The second decision variable represents the reversed action of destruction id_{22}= "disabled destruction". In order to determine the location of the returned products to the appropriate center, which is represented by id_{31}= "assignment on" and the conversely action id_{32} = "assignment off". The main criteria of the studied supply chain are described in details in "*table 3*".To identify the rules of the mutual influences, we seek to define the logical rules between indicators (PIs) and variables of action (DV) for an entropy analysis to prove the effective relationship between objectives and resources. This criterion represents the main preference of the processor. To define other indicators, in order to develop the sustainability in the field of WEEE industries after a discussion with an expert.

1) CO2of the emissions: it refers to carbon dioxide emitted during the treatment of WEEE from collected center to the final part in the chain of the valorization of waste. This criterion has a significant impact on the environment. The governmental organizations in Tunisia represented by the National Agency for Environmental Protection are responsible for not only to focusing on the effect of Co2 emission in the health of society , but they guide for the future strategic decision makers Government organization has a direct intervention by measuring the rate of CO2 emitted which is "reached" or "not reached".

2) Disassembly products: The waste of the Electric and the Electronic equipment refers to the unused products (broken, obsolescent, under grantee...) that will be recovered for disposal alternatives. In Tunisia, WEEE must be treated by three waste treatment strategies: reuse, recycle and disposal. Before orienting products for treatment, the processor should control dismantling operation of returned product by the rate of disassembly, in which the processor measure the product if it is able for reprocessing "Enable" or" disabled"

3) Recycle products: It refers to the recovery of the materiel from the returned products to generate energy to reusing for another product. A product collected for recycle should be speared depending on the composition of the waste. Therefore, the recycle is generally taken into account to the capacity of resources, which should be decided if there is "Enable or "disable" for recycle.

4) Customer satisfaction: One of the main objectives and which represents a social indicator improves the rate of the customer satisfaction. Thus, this indicator is depending on the quality of the valorized product in the context of WEEE, if the best quality is reach or not.

TABLE III. TABLE REVERSE SUPPLY CHAIN OF WEEE

Returned products	**Center type**	**Dismantling type**	**Rate of reusable material**
Under warranty damaged Products	Recycling center Remanufacturing center	Total dismantling Partial dismantling	85% recycled material 0% landfill
hazardous Products	Re-distrubution Collect Centre	No dismantling	90% reusable material

VI. RESULTS AND DISCUSSION

Our first step is based on the analysis of the mutual information, which we can determine the logical rules between indicators and decision variables. The validation of the recovery rate of material indicator is based on the present rules that validate the consistence between performance indicator IP and action variable ID such as in (12):

$$\begin{aligned}&\text{If } ID_2=id_2^1 \text{ and } ID_3=id_3^1 \text{ so } IP_1=IP_1^2\\&\text{If } ID_2=id_2^2 \text{ and } ID_3\neq id_3^1 \text{ so } IP_1=IP_1^1\\&\text{If } ID_2\neq id_2^2 \text{ and } ID_3= id_3^2 \text{ so} IP_1=IP_1^2\\&\text{If } ID_2\neq d_2^1 \text{ and } ID_3= id_3^1 \text{ so} IP_1=IP_1^2\end{aligned} \quad (12)$$

In the second step, we can determine the other indicators related to the supply chain agent by the same rule, which we can define by the players and their preferences via the selected indicators in the WEEE industries.

Player1: represents the government (G), which promotes the environmental criteria of "CO2 emissions"

Player2: represents processor (PC) that supports the economic criteria "Rate of recovery products"

Player3: represents the Recycler (R) that promotes the economic criteria "Rate of recycle products"

Player4: represents the consumers(C), which promotes social criteria "Rate of customer satisfaction"

In the next stage, weights of important players are obtained using the AHP method. The results provided are show in table 4.The calculated weights shows that government has the most important weight reaches 0.5. Each player's preferences could be calculated to generate all the fuzzy relation preferences. We take the example of the indicator of "customer satisfaction" to determine the matrix of measurement which canbe carried out by three evaluators. The calculated performance index is explained below:

TABLE IV. WEIGHTS CALCULATED OF DECISION MAKERS

	PC	G	R	C	Total	Weight
PC	0,21	0,18	0,18	0,48	1,55	0,26
G	0,63	0,54	0,45	0,36	1,98	0,5
R	0,11	0.11	0,09	0,44	0,34	0,09
C	0,05	0,18	0,27	0,12	0,62	0,16

- Performance score number 1 :

  55-54.4/55-53 × (10-0) =3

- Performance scale1*:*

$P_A(3)=0$, $P_B(3)=0$, $P_C(3)=0$

$P_D(3)=3-2/4-2=0.5$, $P_E(3)=4-3/4-2=0.5$

$P_F(3)=0$

$P_1^1(\mu_1) = (0, 0, 0, ½, ½,0)$;

$P_1^1(\mu_1)$: is the measurement of the judgment of customer satisfaction rate of the first evaluator.

- performance scale *2* **:**

$P_A(0.6)=0$, $P_B(0.6)=0$, $P_C(0.6)=0$

$P_D(0.6)=0$, $P_E(0.6)=0.3$ $P_F(3)=0$

$P_2^1(\mu_1) = (0, 0, 0, 0, 0.3, 0.7)$

$P_2^1(\mu_1)$: is the measurement of the judgment of customer satisfaction rate of the second evaluator

- Performance score 3 :

  55-54.4/55-53× (10-4) =1.8

- Performance scale 3 :

$P_A(1.8)=0$, $P_B(1.8)=0$, $P_C(1.8)=0$

$P_D(1.8)=0$, $P_E(1.8)=0.85$ $P_F(1.8)=0.15$

$P_3^1(\mu_1) = (0, 0, 0, 0, 0.85, 0.15)$

$P_3^1(\mu_1)$: is the measurement rate consumer satisfaction of the third evaluator.

$P(\mu_1)$ =

0	0	0
0	0	0
0	0	0
0,5	0	0
0,5	0,3	0,85
0	0,7	0,15

$P_1^1(\mu_1)$: is the rate of the recycled product measured by three evaluators, which expressed the ambiguity of the human judgment. Similarly, using the proposed method, we obtain the result of rate of: CO_2 emissions, rate of disassembly, recycled products and rate of customer satisfaction which is bellow.

Rate of recycle products

0	0	0
0	0.33	0.27
0.15	0.67	0.73
0.85	0	0
0	0	0
0	0	0

Rate of Co_2emission

0.25	0.3	0.52
0.75	0.7	0.84
0	0	0
0	0	0
0	0	0
0	0	0

Rate of disassembly

0	0	0
0	0.27	0
0	0.73	0.31
0.4	0	0.69
0.6	0	0
0	0	0

In order to raise the sustainable performance decision makers should select the best strategy collected from evaluators dealing with the ambiguity of judgment. Each measurement of the evaluator is considered as a strategy. Interactive strategies are combined that are shown in "table 5" of the most important players to improve the performance. Thus, all players have an appropriate criterion which should be considered in selecting the strategy. The best result is obtained to reach the convergences of players' opinions via all strategies. Performance measurements obtained from previous step are used to compute the opinions of players for selecting the best strategy which can improve the performance of the organization. From "table 5", we can see the green case the consensus of players. The optimal choice for all payers corresponds to I for carbon emission, II for rate of disassembly product, II for rate of recycled product and I for rate of the satisfied costumer, which is founded by the opinion of the first and the second evaluator.

TABLE V. INTERACTIVE STRATEGIES

		Player 2																	
		I						II						III					
player1	I	0,14	0,21	0,12	0,13	0,12	0,18	0,18	0,24	0,29	0,23	0,29	0,23	0,30	0,21	0,31	0,19	0,35	0,19
		0,18	0,17	0,15	0,18	0,16	0,18	0,25	0,25	0,15	0,2	0,15	0,16	0,14	0,25	0,19	0,13	0,15	0,17
		0,33	0,21	0,32	0,16	0,14	0,22	0,31	0,21	0,31	0,16	0,36	0,13	0,43	0,17	0,33	0,13	0,48	0,1
		0,17	0,28	0,17	0,13	0,14	0,22	0,16	0,21	0,16	0,13	0,2	0,1	0,16	0,17	0,33	0,13	0,48	0,1
		0,36	0,21	0,33	0,21	0,35	0,21	0,31	0,2	0,3	0,5	0,3	0,21	0,42	0,18	0,46	0,16	0,35	0,23
		0,36	0,21	0,17	0,19	0,36	0,22	0,15	0,19	0,15	0,13	0,14	0,25	0,13	0,17	0,15	0,06	0,23	0 ,08
	II	0,36	0,26	0,36	0,26	0,33	0,26	0,37	0,26	0,34	0,26	0,37	0,25	0,41	0,22	0,38	0.17	0,44	0,16
		0,16	0,11	0,15	0,02	0,15	0,11	0,13	0,11	0,09	0,09	0,08	0,11	0,19	0,2	0,18	0,13	0,2	0,1
		0,38	0,3	0,4	0,32	0,39	0,3	0,35	0,3	0,36	0,3	0,36	0,3	0,48	0,27	0,48	0,2	0,4	0,23
		0,3	0,3	0,33	0,08	0,32	0,11	0,31	0,07	0,14	0,08	0,14	0,12	0,28	0,06	0,28	0,09	0,25	0,13
		0,4	0,3	0,4	0,3	0,4	0,3	0,43	0,14	0,44	0,14	0,44	0,14	0,39	0,35	0,33	0,35	0,33	0,3
		0,33	0,08	0,33	0,1	0,33	0,07	0,17	0,09	0,2	0,1	0,2	0,14	0,35	0,03	0,3	0,05	0,3	0,07
	III	0,31	0,25	0,31	0,2	0,31	0,2	0,29	0,25	0,4	0,19	0,41	0,17	0,27	0,25	0,36	0,19	0,47	0,21
		0,29	0,2	0,22	0,08	0,22	0,11	0,29	0,2	0,22	0,11	0,19	0,02	0,3	0,22	0,23	0,18	0,21	0,13
		0,33	0,21	0,33	0,16	0,33	0,16	0,3	0,16	0,33	0,16	0,32	0,11	0,41	0,17	0,36	0,22	0,26	0,16
		0,22	0,16	0,23	0,08	0,23	0,11	0,22	0,16	0,21	0,09	0,17	0,08	0,19	0,09	0,14	0,14	0,18	0,11
		0,44	0,16	0,34	0,16	0,16	0,34	0,3	0,16	0,33	0,07	0,12	0,03	0,43	0,18	0,53	0,16	0,42	0,14
		0,15	0,12	0,16	0,07	0,11	0,09	0,15	0,12	0,16	0,07	0,11	0,11	0,18	0,14	0,21	0,09	0,19	0,1

This paper has provided a decision aided model for improving sustainable performance. To achieve an effective performance, a cause and effect analysis can prove the degree of relation in order to obtain the most appropriate indicators that cover all the main aspects of the supply chain. Nevertheless, the waste of electric and electronic equipment (WEEE) is often characterized by the complexity to take a suitable decision. This complexity is affected by the various flows, of the returned products, of numbers of decision makers returned products. Consequently, a suitable decision that improves performance should be carried out on the collective decision.

This approach relies on selecting an appropriate strategy which takes into account the different partners in the supply chain. According to different preferences of decision makers via decision criteria, a conflicting opinion resulting from the human judgment should be considered. Moreover, the ambiguity is arising from the human judgment.

We propose a fuzzy set theory to calculate the preferences of evaluators without the loss of information. A strong interest to focus on the convergence of opinions of the players from various fields: economic, social and environmental. The combined of interactive relation between supply agents has been addressed to reduce the inconsistence which is inspired from the theory game. Future work could include (a) Comparing our proposed method with other decision aided-methods such as TOPSIS to validate the results (b) Developing more criteria to analyze their interaction on the performance evaluation (c) Varying the number of criteria and players and (d) undertaking the analysis of sensitivity.

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