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### RESEARCH ARTICLE

#### HOW TO MEASURE SUSTAINABILITY OF SUPPLY CHAIN.

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#### Abstract

Earlier firms mainly based on financial performance to assess their progress. Thenceforth, maturity of supply chain must be evaluated from a more comprehensive performance including, economic, environmental and social dimensions. The purpose of this paper is on consideration of how to use indicators to monitor sustainable development in supply chain. Integrated information on sustainable development of a supply chain is very essential for decision-making since it is very difficult to evaluate the performance of the supply chain on the ground of too many indicators. The objective of this work is to design a mathematical module for obtaining a global composite index (Ig) in order to track integrated information on economic, environmental, social and global performance of the supply chain with time. Normalized indicators were associated into three sustainability sub-indices and finally composed into a global indicator of a supply chain performance. A case study was used to validate this module for one year (2016), interpretation of results is given and the utility of Ig with its relevance is pointed out.

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#### Introduction:

The main objective in supply chains management was to improve industrial competitiveness by minimizing costs, providing level of service required by customer, effectively allocating activities on actors of production, distribution and transport. Currently, supply chains must integrate two new dimensions in their performance: their impact on society and on environment. Supply chains must develop methods and approaches to consider and measure their impacts on economic, environmental and social levels and analyze interactions between these impacts.

Traditional mechanisms for performance measurement, such as costs, do not give supply chains a clear view on consequences of their management practices. Approaches available today are mainly focused on environmental sphere, when the reality of impacts of supply chain management practices is more complex, integrating the three dimensions of sustainable development (economic, environmental and social). It's true that public institutions encourage firms to make sustainable development a strategic issue. In supply chain, sustainable development is a transversal concept that affects all stakeholders who have different and sometimes conflicting goals. Performance is complex to master given different processes to consider, various stakeholders to integrate and various dimensions in which stakes are declined. To take into account all supply chains impacts, it is essential to develop a comprehensive performance evaluation method. These methods must be consistent with specificities of each stakeholder. The

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difficulty in supply chain is to measure interactions between the three dimensions of global performance. To address this problem of measuring the global performance of supply chain, it is pertinent to ask the following questions: why consider sustainability in supply chains? What are the motivations of supply chains to develop a sustainable approach? What are the specificities of sustainable issues in supply chains?

### **Sustainable Development in Firms and in Supply Chains:**

#### **Criteria of Sustainable Performance:**

Traditionally, criteria taken into account to assess supply chains and firms performance are related to financial aspects, flexibility, responsiveness, quality and reliability [1]. However, taking into account environmental and social concerns in the context of CSR (Corporate Social Responsibility) change performance assessment. This must indeed be extended to consider all three dimensions of sustainable development, in line with the principles of triple bottom. There is still no consensus on what should be environmental and social performances. They depend in fact on several variables as industrial sector, country of location of activities, etc. It is therefore difficult to characterize global performance. Nevertheless, there are several international standards (SCOR repository, GRI (Global Reporting Initiative), ISO 26000, etc.) and works in literature that provide economic, environmental and social criteria more or less common and generic that can be adapted.

#### **Methods for Evaluating Sustainable Performance:**

The most numerous approaches are qualitative, they include literature reviews, conceptual models and case studies. Quantitative approaches are the mathematical models.

#### **Literature reviews:**

Despite international efforts to measure sustainable development, few indexes have a comprehensive approach taking into account the three dimensions of sustainability and in most cases, the emphasis is on one of the three aspects [2]. Interaction between logistic chain and sustainability is intended to optimize total cost, including the impacts of resource depletion and exponential waste production and pollutants, rather than the current cost of a product [3]. Value creation in context of sustainable development comes from the importance of collaboration between players in logistic chain [4].

#### **Conceptual models:**

Most conceptual models found in the literature focus on methodologies and frameworks to adopt, to select and develop indicators to measure the global performance. After analyzing the most recognized standards for sustainable development, including GRI and ISO 14301 (ISO 2004), a selection of indicators to measure sustainable performance of production was offered [5]. Then a detailed guide in eight steps of implementation of these indicators was proposed [6]. There is a method for assessing the degree of sustainability of a business operation [7]. The goal of this method is to select a number of indicators that meet four criteria: they must be consistent with the company's business, reflect objectivity, they must be balanced and all indicators selected should represent the concept of sustainable development. More recently the integration of information, other than financial, appeared in the performance measure as a necessity.

#### **Case studies:**

Following an analyzes based on 89 of automotive industries within China, the main motivations for firms to engage in CSR strategy are the regulatory pressures, those of the market and also internal factors of firm [8]. In addition, results of these analyze put forward a slight correlation between implementation of CSR practices and environmental and economic performance but a lack of connection with the financial performances. Many studies based on Chinese [9] and United States [10] firms gave similar conclusions.

#### **Mathematical modules:**

To assess the sustainable performance, many authors present models of aggregation of indicators. In this domain, exist a module to assess the sustainable performance through a comprehensive composite index ( $I_s$ ), which includes three sub-indices corresponding respectively to economic, environmental and social performances [11]. Also there is a method for the development of a composite index of sustainable performance in steel field [12], based on three lasting performances and AHP (Analytic Hierarchy Process) method. Despite international research efforts on assessing the sustainable performance, only a very small number of approaches take into account the three dimensions of social responsibility in firms and supply chains. Indeed, there is not, nowadays, an available module permits to integrate overall assessment in terms of logistics chains management. Social dimension is poorly represented in existing indices.

**Proposal of A Module to Measure Global Performance of Supply Chains:**

To measure global performance of supply chain, and thus facilitate decision making, we propose an analytical evaluation module. We propose to characterize each dimension of sustainable development by a number of indicators (Table 1).

We based our selection of indicators on the three recommended requirements by (Roy, 1985) [13]:

- ❖ Completeness: we must not it has too few indicators; otherwise, it means that some assessment elements were not taken into account.
- ❖ Non-redundant: it should not be some indicators that are duplicated, thus more than necessary.
- ❖ Consistency: global preferences (all indicators) are consistent with local preferences (for a single indicator).

**Correlation of Global Performance Indicators with Supply Chain Decisions:**

We analyze the possible correlations between selected sustainable development indicators and the decision variables of the mathematical module, to build mathematical expressions which formalizes and measures the value of these indicators. Thus the performance evaluation is operationalized so consistently.

**Table 1:** All mathematical module indices [14]

Index	Meaning
E	All entities of supply chain
F	All production sites
i	Production site
R	All employees residential regions
j	Region
f	Supplier
S	All potential suppliers for raw materials
SC	All potential subcontractors for semi-finished products
C	All customers
p	Product
P	All products
RM	All raw materials
MP	All manufactured products
$MP_{sf}$	All semi-finished products manufactured
$MP_f$	All finished products manufactured
$OMP_{sf}$	All manufactured semi-finished products that can be outsourced. $P = RM \cup MP; MP = MP_{sf} \cup MP_f; OMP_{sf} \subset MP_{sf}$

**Table 2:-** All decision variables of the mathematical module [14]

Decision variable	Meaning
$CM_{pi}$	Unit cost to manufacture product p in site i
$X_{pi}$	Quantity of product p manufactured in site i
CL	Unit cost of labor
$Lab_{ji}$	All employees residing in region j and working in site i
$CI_{pi}$	Unit cost of ownership of stock of product p in site i
$I_{pi}$	Quantity in stock of product p in site i at the end of period t
$CA_{pf}$	Unit acquisition cost of product p from the supplier f
$QS_{pfi}$	Quantity of product p purchased from supplier f by site i
$CS_{ps}$	Unit acquisition cost of product p from the subcontractor s
$QSC_{psi}$	Quantity of product p purchased from subcontractor s by site i
$CTU_{pfi}$	Unit transport cost of product p between supplier f and site i
$YSF_{pfi}$	Quantity of product p transported from supplier f to site i
$CTU_{psi}$	Unit transport cost of product p between subcontractor s and site i
$YSCF_{psi}$	Quantity of product p transported from subcontractor s to site i
$CTU_{pii'}$	Unit transport cost of product p between site i and site i'
$YF_{pii'}$	Quantity of product p transported between site i and site i'

$CTU_{pic}$	Unit transport cost of product p between site i and customer c
$YFC_{pic}$	Quantity of product p transported from site i to customer c

### Economic Performance of Supply Chain:

Numerous studies focus on the economic and financial dimension for measuring the global performance of supply chains. The modules offer different typologies and classify the indicators and issues according to different categories.

The analysis of this inventory highlights five main criteria, which are *reliability, reactivity, flexibility, quality and financial performance* and nine indicators (Table 3).

**Table 3:** Economic performance indicators of the supply chain

Issue	N°	Indicator I	Symbol	Impact	Unit	Value	I <sub>Inf</sub>	I <sub>Sup</sub>
Reliability	1	Orders reliability	$O_R$	Positive	Digit	$O_R = \sum_{i=1}^{i=E} f_i$	0	All orders delivered
	2	Stocks reliability	$S_R$	Negative	Hour	$S_R = \sum_{i=1}^{i=E} f_{1i}$	0	Total working time
Reactivity	3	Conception reactivity	$C_R$	Positive	Digit	$C_R = \sum_{i=1}^{i=E} r_{1i}$	0	All orders to design
	4	Procurement reactivity	$P_R$	Positive	Digit	$P_R = \sum_{i=1}^{i=E} r_{2i}$	0	All orders to supply
	5	Production reactivity	$P'_R$	Positive	Digit	$P'_R = \sum_{i=1}^{i=E} r_{3i}$	0	All orders to produce
	6	Reactivity of returned products	$R_R$	Positive	Digit	$R_R = \sum_{i=1}^{i=E} r_{4i}$	0	All returned orders
Flexibility	7	Orders flexibility	$O_F$	Positive	Digit	$O_F = \sum_{i=1}^{i=E} f'_i$	0	All changed orders
Quality	8	Percentage of defective products	$P_D$	Negative	Digit	$P_D = \sum_{i=1}^{i=E} q_i$	0	All orders delivered
Financial performance	9	Total cost of supply chain	$T_C$	Negative	M€*	$T_C$	0	Total budget of supply chain

\*: Million euro

$f_i$ : orders delivered in good conditions in entity i

$f_{1i}$ : downtime because of an out of stock in entity i

$r_{1i}$ : orders designed on time in entity i

$r_{2i}$ : orders supplied on time in entity i

$r_{3i}$ : orders produced on time in entity i

$r_{4i}$ : returned orders treated on time in entity i

$f'_i$ : quantity achieved to respond to change orders in entity i

$q_i$ : defective products of entity i

The total cost of supply chain ( $T_c$ ) is calculated as follow ((Equation (1)):

$$\begin{aligned}
 T_c = & \sum_{i \in F} [(CM_{pi} \cdot X_{pi})(a) + (CL \sum_{j \in RS(i)} Lab_{ji})(b) + \sum_{p \in P} (CI_{pi} \cdot I_{pi})(c)] \\
 & + [ \sum_{f \in S; p \in RM} CA_{pf} \sum_{i \in F} QS_{pf} ](d) + [ \sum_{s \in SC; p \in MP_{sf}} CS_{ps} \sum_{i \in F} QSC_{ps} ](e) \\
 & + [ \sum_{f \in S; i \in F; p \in RM} CTU_{pf} \cdot YSF_{pf} ](f) \\
 & + [ \sum_{s \in SC; i \in F; p \in OMP_{sf}} CTU_{ps} \cdot YSCF_{ps} ](g) \\
 & + [ \sum_{i, i' \in F; p \in MP_{sf}} CTU_{pii'} \cdot YF_{pii'} ](h) + [ \sum_{i \in F; c \in C; p \in MP_f} CTU_{pic} \cdot YFC_{pic} ](i) \quad (1)
 \end{aligned}$$

- (a): Production cost; (b): labor cost; (c): stock cost
- (d): cost of raw materials
- (e): cost of semi-finished products
- (f): transportation cost of raw materials between supplier and production sites
- (g): transportation cost of semi-finished products between subcontractors and production sites
- (h): transportation cost of semi-finished products between production sites
- (i): transportation cost of finished products to customers

**Environmental Performance of Supply Chain:**

we can define an environmental impact as a change in the environment, due to the intervention known or suspected of man, direct or indirect, that could have a potentially adverse effect (from simple nuisance to destruction) on lasting quality the natural environment and ecosystems, and consequently, on human health. Decisions and activities of firms have an impact on the natural environment, regardless of the implantation site thereof. These impacts can be associated with the use of biological and non-organic resources by the company, with the generation of pollution and wastes and with the impact of its activities (products / services) on natural habitats. So to reduce their environmental impact, it is that companies adopt an integrated approach that takes into account the wider implications of their decisions and activities from an environmental point of view. The inventory analysis of environmental criteria met in the very abundant literature allows us to isolate three environmental criteria, which are *environmental management, use of resources* and *pollution* and nine indicators (Table 4).

**Table 4:** Environmental performance indicators of supply chain

Issue	N°	Indicator I	Symbol	Impact	Unit	Value	I <sub>inf</sub>	I <sub>sup</sub>
Environmental management	1	Environmental budget	E <sub>b</sub>	Positive	M€	$E_b = \sum_{i=1}^{i=E} b_i$	0	Total budget of supply chain
	2	Environmental certifications	E <sub>c</sub>	Positive	Digit	$E_c = \frac{\sum_{i=1}^{i=E} c_i}{E}$	0	Total number of environmental certifications
Use of ressources	3	Energy consumed	E <sub>c</sub>	Negative	Joule (J)	$E_c = \sum_{i=1}^{i=F} e_i + \sum_{i=F, j=R} e_{ij} + \sum_{k,l \in \{F,S,SC,C\}} e_{kl}$	0	Maximum of energy consumed by supply chain during the last 10 years.

	4	Water consumed	$W_c$	Negative	(m <sup>3</sup> )	$W_c = \sum_{j=1}^{j=E} e_j$	0	Maximum of water consumed by supply chain during the last 10 years.
	5	Raw materials consumed	$RM_c$	Negative	(kg)	$RM_c = \sum_{j=1}^{j=E} m_j$	0	Maximum of raw materials consumed by supply chain during the last 10 years.
Pollution	6	Liquid pollutants	$L_p$	Negative	(m <sup>3</sup> )	$L_p = \sum_{j=1}^{j=E} pl_j$	0	Maximum of liquid pollutants generated by supply chain during the last 10 years.
	7	Solid pollutants	$S_p$	Negative	(kg)	$S_p = \sum_{j=1}^{j=E} ps_j$	0	Maximum of solid pollutants generated by supply chain during the last 10 years.
	8	Greenhouse gas	$G_g$	Negative	(kg)	$G_g = \sum_{i=1}^{i=F} g_i + \sum_{i=F, j=R} g_{ij} + \sum_{k,l \in \{F,S,SC,C\}} g_{kl}$	0	Maximum of greenhouse gases generated by supply chain during the last 10 years.
	9	Noise pollution	$N_p$	Negative	(dB)	$N_p = \sum_{i=1}^{i=F} ps_i + \sum_{i=F, j=R} ps_{ij} + \sum_{k,l \in \{F,S,SC,C\}} ps_{kl}$	0	Maximum of decibels generated by supply chain during the last 10 years.

$b_i$ : environmental budget of entity  $i$   
 $c_i$ : number of environmental certifications of entity  $i$   
 $e_i$ : energy consumed by entity  $i$ ;  
 $e_{ij}$ : energy consumed by moving between entity  $i$  and residence of employees  $j$ ;  
 $e_{kl}$ : energy consumed by moving between entity  $k$  and entity  $l$ ;  
 $e_j$ : quantity of water consumed by entity  $j$   
 $m_j$ : quantity of raw materials consumed by entity  $j$   
 $pl_j$ : quantity of liquid pollutants generated by entity  $j$   
 $ps_j$ : quantity of solid pollutants generated by entity  $j$   
 $g_j$ : amount of greenhouse gases generated by entity  $i$   
 $g_{ij}$ : amount of greenhouse gases generated by the movement between entity  $i$  and residence of employees  $j$ ;  
 $g_{kl}$ : amount of greenhouse gas generated by the movement between entity  $k$  and entity  $l$ ;  
 $p_{di}$ : number of decibels generated by entity  $i$ ;  
 $p_{dij}$ : number of decibels generated by the movement between entity  $i$  and residence of employees  $j$ ;  
 $p_{dkl}$ : number of decibels generated by the displacement between entity  $k$  and entity  $l$ ;

### Social Performance of supply chain:

Social responsibility also led to evaluate social performance. It measures the social consequences of the company's activity for all of its stakeholders who are mainly employees (working conditions, remuneration level, no discrimination, ...), suppliers, customers (security and psychological impacts of products), local communities (nuisances, respect of cultures) and society in general. The analysis of the inventory of social criteria found in the recent literature allows us to isolate five social criteria, which are **labor rights, working conditions, health and safety, community involvement and consumers** and twenty indicators (Table 5):

**Table 5:** Social performance indicators of supply chain

Issue	N°	Indicator I	Symbol	Impact	Unit	I <sub>Inf</sub>	I <sub>Sup</sub>
Labor rights	1	Staff number who are submitted to case of no respect of free competition	N <sub>FC</sub>	Négatif	Number	0	Total staff number
	2	Staff number who are submitted to case of injustice caused by hierarchical power	N <sub>HP</sub>	Négatif	Number	0	Total staff number
	3	Staff number who are submitted to case of discrimination	N <sub>D</sub>	Négatif	Number	0	Total staff number
	4	Staff number representatives	N <sub>R</sub>	Positif	Number	0	Total staff number×0.02
	5	Staff number who has a forced labor	N <sub>FL</sub>	Négatif	Number	0	Total staff number
	6	Staff number who are children	N <sub>Ch</sub>	Négatif	Number	0	Total staff number
	7	Staff number participated in professional elections	N <sub>PE</sub>	Positif	Number	0	Total staff number
	8	Staff number who are submitted to case of violations of privacy	N <sub>VP</sub>	Négatif	Number	0	Total staff number
Working conditions	9	Ratio of lowest wage / cost of local life	R <sub>LW/LL</sub>	Positif	%	0	1
	10	level of salary retention in case of illness	N <sub>RI</sub>	Positif	%	0	1
	11	Number of services offered to staff (nursery, gym, canteen, ...)	N <sub>S</sub>	Positif	Number	0	20*
Health and security	12	Staff number who are victims of occupational accidents	N <sub>OA</sub>	Négatif	Number	0	Total staff number
	13	Staff number who are victims of diseases caused by work	N <sub>D</sub>	Négatif	Number	0	Total staff number

Community involvement	14	Number of jobs created	$N_J$	Positif	Number	0	Sum of local active population of each entity
	15	Staff number with CID	$N_{CID}$	Positif	Number	0	Total staff number
	16	Staff number with CDD	$N_{CDD}$	Négatif	Number	0	Total staff number
	17	Number of CDD transformed to CID	$N_{DI}$	Positif	Number	0	Total number of CSD
	18	Number of layoffs	$N_L$	Négatif	Number	0	Total staff number
	19	Budget destined to promote social activities	$B_{SA}$	Positif	Euro	0	Total budget of supply chain
Consumers	20	Number of products / services subject of claims following a non-compliance issue	$N_{N-C}$	Négatif	Number	0	All products / services

\* : approximate number

**Global Performance of Supply Chain:**

We specified in tables 3, 4 and 5 indicators respectively measuring the goals of economic, environmental and social performance of supply chain. To measure the global performance of supply chain and thus facilitate decision making, indicators should be aggregated into a single index ( $I_g$ ). The aggregation is done at two levels:

1. Aggregation of indicators within each dimension of sustainable development. We obtain three sub-indices that measure each one economic, environmental and social performance of supply chain.
2. Aggregation of the three sub-indices of sustainable development. We then get the global composite index which measures the global performance of supply chain.

When aggregating we face two difficulties. The first concerns the heterogeneity of units of indicators measurement, hence the need to normalize thereof. The second touch to inequality of indicators importance, suggesting weighted indicators to express their relative importance. To do this, we use the principle of weighting of AHP method [15], which was used to calculate the composite index of sustainable performance [16], [17].

We propose an aggregation of indicators as follows:

- **Step 1:** identification and classification of indicators  $I_{ijt}^+$  et  $I_{ijt}^-$

$I_{ijt}^+(I_{ijt}^-)$ :the value of indicator i of dimension j of sustainable development, at the time t, which improves (deteriorates respectively) the performance of dimension j when its value increases:

$$I_{ijt}^+ \in [I_{ijt, inf}^+, I_{ijt, sup}^+]$$

$$I_{ijt}^- \in [I_{ijt, inf}^-, I_{ijt, sup}^-]$$

$I_{ijt, sup}^+(I_{ijt, inf}^-)$  : the target goal to reach by indicator  $I_{ijt}^+(I_{ijt}^-)$  respectively).

- **Step 2:** normalization of indicators  $I_{ijt}^+$  and  $I_{ijt}^-$

$I_{Nijt}^+(I_{Nijt}^-)$ :the value of normalized indicator i of dimension j of sustainable development, at the time t, which improves (deteriorates respectively) the performance of dimension j when its value increases:

$$I_{Nijt}^+ = \frac{I_{ijt}^+ - I_{ijt, inf}^+}{I_{ijt, sup}^+ - I_{ijt, inf}^+} \quad \text{with } I_{Nijt}^+ \in [0,1] \quad (02)$$

$$I_{Nijt}^- = 1 - \frac{I_{ijt}^- - I_{ijt, inf}^-}{I_{ijt, sup}^- - I_{ijt, inf}^-} \quad \text{with } I_{Nijt}^- \in [0,1] \quad (03)$$



- **Step 3:** indicators Weighting  $I_{ijt}^+$  et  $I_{ijt}^-$ .

For each  $j \in \{Eco, Env, Soc\}$ , we build a matrix  $A_j = (P \times P)$  where indicators of each  $j$  dimension are compared 2 by 2 by the decision maker. The comparisons are made by posing the question which of two indicators  $i$  and  $i'$  is more important. The intensity of preference is expressed on a factor scale from 1 to 9 (Table 6).

**Table 6:** Comparison scale of AHP method [18].

Preference factor, p	Importance definition
1	Equal importance
3	Moderate importance of one over another
5	Strong or essential importance of one over another
7	Very strong or demonstrated importance of one over another
9	Extreme importance of one over another
2,4,6,8	Intermediate values
Reciprocal, 1/p	Reciprocal for inverse comparison

The value of 1 indicates equality between the two indicators while a preference of 9 indicates that one indicator is nine times more important than the one which it is being compared. This scale was chosen, because in this way comparisons are being made within a limited range where perception is sensitive enough to make a distinction. In the matrix  $A_j$ , if indicator  $i$  is “p-times” the importance of indicator  $i'$ , then necessarily, indicator  $i'$  is “1/p-times” the importance of indicator  $i$ , where the diagonal  $a_{ii} = 1$  and reciprocal property  $a_{ii'} = \left(\frac{1}{a_{i'i}}\right)$  such as  $i, i' = 1, \dots, n$ .

Weight of indicators  $i$  ( $w_{ij}$ ) is given by the formula:

$$w_{ij} = \frac{\sum_{i'} a_{ii'}}{\sum_k a_{ki'}} \quad n: \text{number of indicators} \quad (04)$$

One disadvantage of AHP method outlined in literature [19] is the problem of intransitivity preferences. Indeed, pair wise comparison may lead to the non-transitivity that cannot be removed as part of AHP method.

However, perfect consistency rarely occurs in practice. In AHP method the pair wise comparisons in a judgment matrix are considered to be adequately consistent if the corresponding consistency ratio (CR) is less than 10% [15]: CR should not exceed the value of 0.05 if  $A_j$  is (3 x 3), 0.08 if the matrix is (4 x 4) and 0.1 if the matrix is greater than or equal to (5 x 5) [20].

CR coefficient is calculated as follows: first a consistency index (CI) needs to be estimated. This is done by adding the columns in the judgment matrix and multiply the resulting vector by the vector of priorities (i.e., the approximated eigenvector) obtained earlier. This yields an approximation of the maximum eigenvalue, denoted by  $\lambda_{max}$ . Then, CI value is calculated by using the formula:

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (05)$$

Next, CR is obtained by dividing CI by random consistency index (RI) as given in table 7.

**Table 7:** RI values for different values of n[21]

<b>n</b>	1	2	3	4	5	6	7	8	9	10
<b>RI</b>	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

<b>n</b>	11	12	13	14	15	16	17	18	19	20
<b>RI</b>	1.51	1.54	1.56	1.57	1.59	1.60	1.61	1.62	1.63	1.63

Otherwise matrix A should be evaluated:

$$CR = CI/RI \quad (06)$$

- **Step 4:** calculate the sub-indices  $I_{sjt}$

$I_{sjt}$  : the sub-index of the performance of dimension j of sustainable development, at time t, which is calculated by equation below:

$$I_{sjt} = \sum_i w_{ij} \times I_{Nijt}^+ + \sum_i w_{ij} \times I_{Nijt}^- \text{ with } \sum_i w_{ij} = 1, w_{ij} \geq 0 \text{ and } 0 \leq I_{sjt} \leq 1 \text{ (07)}$$

- If  $0 \leq I_{sjt} < 0.5$  : the performance of dimension j of sustainable development of supply chain is low in period t;
- If  $I_{sjt} = 0.5$  : the performance of dimension j of sustainable development of supply chain is average in period t;
- If  $0.5 < I_{sjt} \leq 1$  : the performance of dimension j of sustainable development of supply chain is good in period t;

- **Step 5:** weighting of sub-indices  $I_{sjt}$  using AHP method (same principle as in step 3).

- **Step 6:** calculate the index of global performance of the supply chain  $I_{gt}$  :

$I_{gt}$  : the index of global performance of supply chain at time t which is calculated by the equation below:

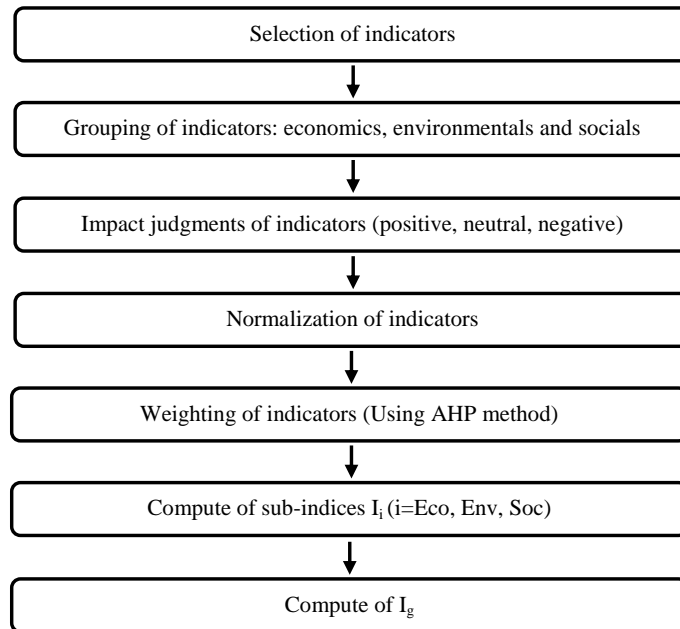
$$I_{gt} = \sum_{j=1}^{j=3} W_j \times I_{sjt}; \quad \sum_j W_j = 1; W_j \geq 0 \text{ (08)}$$

$W_j$  : weight of sub-index  $I_{sjt}$  and  $0 \leq I_{gt} \leq 1$

- If  $0 \leq I_{gt} < 0.5$  : the global performance of supply chain is low in period t;
- If  $I_{gt} = 0.5$  : the global performance of supply chain is average in period t;
- If  $0.5 < I_{gt} \leq 1$  : the global performance of supply chain is good in period t;

By comparing the value of global composite index calculated with desired goal (value 1), we get the level reached ((+) or (-)) for the global performance of supply chain.

We summarize the method of calculating the composite index of global performance which is divided into several parts in the Fig. 1.



**Fig. 1:** calculation procedure of  $I_g$

**Application:**

The reliability of the proposed module has been tested in a case study. We chose an automotive supply chain installed in north of Morocco (Tangier), which its principal business activity is electrical harnesses for cars.

Achieving the leadership of its branch is therefore a core principle at the supply chain. Needed data have been obtained from General Management team.

This supply chain is constituted of:

- Three production sites (in Tangier)
- Eight suppliers (in Tangier)
- Three customer (In United Kingdom, France and United States)

To evaluate global performance of this supply chain, our proposed module was applied to the case chain and  $I_{gt}$  was delivered for 2016.

### Compute of Economic Performance:

**Table 8:** Normalized economic indicators of the case supply chain.

N°	Indicator I	Symbol	Impact	Unit	$I_t$	$I_{inf}$	$I_{sup}$	$I_N$
1	Orders reliability	$O_R$	Positive	Digit	837300	0	840000	<b>0.997</b>
2	Stocks reliability	$S_R$	Negative	Hour	260440	0	33857200	<b>0.992</b>
3	Conception reactivity	$C_R$	Positive	Digit	39500	0	40000	<b>0.988</b>
4	Procurement reactivity	$P_R$	Positive	Digit	21000	0	22000	<b>0.955</b>
5	Production reactivity	$P'_R$	Positive	Digit	840000	0	840000	<b>1.000</b>
6	Reactivity of returned products	$R_R$	Positive	Digit	2600	0	3000	<b>0.867</b>
7	Orders flexibility	$O_F$	Positive	Digit	23500	0	30000	<b>0.783</b>
8	Quality of products/services	$Q_P$	Negative	Digit	700	0	840000	<b>0.999</b>
9	Total cost of supply chain	$T_C$	Negative	MEURO	130	0	350	<b>0.629</b>

**Table 9:** weights of economic indicators of the case supply chain.

I	$O_R$	$S_R$	$C_R$	$P_R$	$P'_R$	$R_R$	$O_F$	$Q_P$	$T_C$	Weights
$O_R$	1	2	2	2	2	2	2	1	1	
$S_R$	1/2	1	1	1	1	1	1	1/2	1/2	
$C_R$	1/2	1	1	1	1	1	1/2	1/2	1/2	
$P_R$	1/2	1	1	1	1	1	1/2	1/2	1/2	
$P'_R$	1/2	1	1	1	1	1	1/2	1/2	1/2	
$R_R$	1/2	1	1	1	1	1	1/2	1/2	1/2	
$O_F$	1/2	1	2	2	2	2	1	1	1/3	
$Q_P$	1	2	2	2	2	2	1	1	0.5	
$T_C$	1	2	2	2	2	2	3	2	1	
$\Sigma$	6.000	12.000	13.000	13.000	13.000	13.000	10.000	7.500	5.333	
$O_R$	0.167	0.167	0.154	0.154	0.154	0.154	0.200	0.133	0.188	<b>0.163</b>
$S_R$	0.083	0.083	0.077	0.077	0.077	0.077	0.100	0.067	0.094	<b>0.082</b>
$C_R$	0.083	0.083	0.077	0.077	0.077	0.077	0.050	0.067	0.094	<b>0.076</b>
$P_R$	0.083	0.083	0.077	0.077	0.077	0.077	0.050	0.067	0.094	<b>0.076</b>
$P'_R$	0.083	0.083	0.077	0.077	0.077	0.077	0.050	0.067	0.094	<b>0.076</b>
$R_R$	0.083	0.083	0.077	0.077	0.077	0.077	0.050	0.067	0.094	<b>0.076</b>
$O_F$	0.083	0.083	0.154	0.154	0.154	0.154	0.100	0.133	0.062	<b>0.120</b>
$Q_P$	0.167	0.167	0.154	0.154	0.154	0.154	0.100	0.133	0.094	<b>0.142</b>
$T_C$	0.167	0.167	0.154	0.154	0.154	0.154	0.300	0.267	0.188	<b>0.189</b>

**Table 10:** Economic performance of the case supply chain

N°	Indicator I	Symbol	$I_N$	$w_{i-eco}$	$I_{N \times w_{i-eco}}$
1	Orders reliability	$O_R$	0.997	0.163	0.163
2	Stocksreliability	$S_R$	0.992	0.082	0.081
3	Conceptionreactivity	$C_R$	0.988	0.076	0.075
4	Procurement reactivity	$P_R$	0.955	0.076	0.073
5	Productionreactivity	$P'_R$	1.000	0.076	0.076
6	Reactivity of returned products	$R_R$	0.867	0.076	0.066
7	Orders flexibility	$O_F$	0.783	0.120	0.094

8	Qualité of products/services	Q <sub>P</sub>	0.999	0.142	0.142
9	Total cost of supply chain	T <sub>C</sub>	0.629	0.189	0.119
<b>I<sub>Eco</sub></b>					<b>0.888</b>

**Compute of Environmental Performance:****Table 11:** Normalized environmental indicators of the case supply chain

N°	Indicator I	Symbol	Impact	Unit	I <sub>t</sub>	I <sub>inf</sub>	I <sub>Sup</sub>	I <sub>N</sub>
1	Environmental budget	E <sub>B</sub>	Positive	M€	0.5	0	350	<b>0.001</b>
2	Environmental certifications	E <sub>C</sub>	Positive	Digit	33	0	45	<b>0.733</b>
3	Energy consumed	E' <sub>C</sub>	Negative	Joule (J)	120000	0	130000	<b>0.077</b>
4	Water consumed	W <sub>C</sub>	Negative	m <sup>3</sup>	1800	0	2200	<b>0.182</b>
5	Raw materials consumed	RM <sub>C</sub>	Negative	kg	163000	0	170000	<b>0.041</b>
6	Liquid pollutants	L <sub>P</sub>	Negative	m <sup>3</sup>	2700	0	3000	<b>0.100</b>
7	Solid pollutants	S <sub>P</sub>	Negative	kg	72000	0	80000	<b>0.100</b>
8	Greenhouse gas	G <sub>G</sub>	Negative	kg	5300	0	7000	<b>0.243</b>
9	Noise pollution	N <sub>P</sub>	Negative	dB	5900	0	6500	<b>0.092</b>

**Table 12:** Weights of environmental indicators of the case supply chain.

I	EB	EC	E'C	WC	RMC	LP	SP	GG	NP	Weights
<b>EB</b>	1	1	1	1	1	1	1	1/2	1/2	
<b>EC</b>	1	1	1/3	1/3	1/3	1/4	1/4	1/4	1/4	
<b>E'C</b>	1	3	1	1	1	1	1	1/2	1	
<b>WC</b>	1	3	1	1	1	1	1	1/2	1	
<b>RMC</b>	1	3	1	1	1	1	1	1/2	1	
<b>LP</b>	1	4	1	1	1	1	1	1/2	1	
<b>SP</b>	1	4	1	1	1	1	1	1/2	1	
<b>GG</b>	2	4	2	2	2	2	2	1	2	
<b>NP</b>	2	4	1	1	1	1	1	1/2	1	
<b>Σ</b>	11.000	27.000	9.333	9.333	9.333	9.250	9.250	4.750	8.750	
<b>EB</b>	0.091	0.037	0.107	0.107	0.107	0.108	0.108	0.105	0.057	<b>0.092</b>
<b>EC</b>	0.091	0.037	0.036	0.036	0.036	0.027	0.027	0.053	0.029	<b>0.041</b>
<b>E'C</b>	0.091	0.111	0.107	0.107	0.107	0.108	0.108	0.105	0.114	<b>0.107</b>
<b>WC</b>	0.091	0.111	0.107	0.107	0.107	0.108	0.108	0.105	0.114	<b>0.107</b>
<b>RMC</b>	0.091	0.111	0.107	0.107	0.107	0.108	0.108	0.105	0.114	<b>0.107</b>
<b>LP</b>	0.091	0.148	0.107	0.107	0.107	0.108	0.108	0.105	0.114	<b>0.111</b>
<b>SP</b>	0.091	0.148	0.107	0.107	0.107	0.108	0.108	0.105	0.114	<b>0.111</b>
<b>GG</b>	0.182	0.148	0.214	0.214	0.214	0.216	0.216	0.211	0.229	<b>0.205</b>
<b>NP</b>	0.182	0.148	0.107	0.107	0.107	0.108	0.108	0.105	0.114	<b>0.121</b>

**Table 13:** Environmental performance of the case supply chain

N°	Indicator I	Symbol	I <sub>N</sub>	w <sub>i-env</sub>	I <sub>Nx</sub> w <sub>i-env</sub>
1	Environmental budget	E <sub>B</sub>	0.001	0.092	0.000
2	Environmental certifications	E <sub>C</sub>	0.733	0.041	0.030
3	Energy consumed	E' <sub>C</sub>	0.077	0.107	0.008
4	Water consumed	W <sub>C</sub>	0.182	0.107	0.019
5	Raw materials consumed	RM <sub>C</sub>	0.041	0.107	0.004
6	Liquid pollutants	L <sub>P</sub>	0.100	0.111	0.011
7	Solid pollutants	S <sub>P</sub>	0.100	0.111	0.011
8	Greenhouse gas	G <sub>G</sub>	0.243	0.205	0.050
9	Noise pollution	N <sub>P</sub>	0.092	0.121	0.011
<b>I<sub>Env</sub></b>					<b>0.145</b>

**Compute of Social Performance:**

**Table 14:** Normalized social indicators of the case supply chain

N°	Indicator I	Symbol	Impact	Unit	I <sub>t</sub>	I <sub>inf</sub>	I <sub>sup</sub>	I <sub>N</sub>
1	Staff number who are submitted to case of no respect of free competition	N <sub>FC</sub>	Negative	Digit	230	0	29000	<b>0.992</b>
2	Staff number who are submitted to case of injustice caused by hierarchical power	N <sub>HP</sub>	Negative	Digit	850	0	29000	<b>0.971</b>
3	Staff number who are submitted to case of discrimination	N <sub>D</sub>	Negative	Digit	104	0	29000	<b>0.996</b>
4	Staff number representatives	N <sub>R</sub>	Positive	Digit	580	0	580	<b>1.000</b>
5	Staff number who has a forced labor	N <sub>FL</sub>	Negative	Digit	0	0	29000	<b>1.000</b>
6	Staff number who are children	N <sub>Ch</sub>	Negative	Digit	0	0	2900	<b>1.000</b>
7	Staff number participated in professional elections	N <sub>PE</sub>	Positive	Digit	23000	0	29000	<b>0.793</b>
8	Staff number who are submitted to case of violations of privacy	N <sub>VP</sub>	Negative	Digit	87	0	29000	<b>0.997</b>
9	Ratio of lowest wage / cost of local life	R <sub>LW/LL</sub>	Positive	%	0.7	0	1	<b>0.700</b>
10	level of salary retention in case of illness	N <sub>RI</sub>	Positive	%	0.8	0	1	<b>0.800</b>
11	Number of services offered to staff	N <sub>S</sub>	Positive	Digit	8	0	20	<b>0.400</b>
12	Staff number who are victims of occupational accidents	N <sub>OA</sub>	Negative	Digit	176	0	29000	<b>0.994</b>
13	Staff number who are victims of diseases caused by work	N <sub>D</sub>	Negative	Digit	650	0	29000	<b>0.978</b>
14	Number of jobs created	N <sub>J</sub>	Positive	Digit	29000	0	50000	<b>0.580</b>
15	Staff number with CID	N <sub>CID</sub>	Positive	Digit	26300	0	29000	<b>0.907</b>
16	Staff number with CDD	N <sub>CDD</sub>	Negative	Digit	2700	0	29000	<b>0.907</b>
17	Number of CDD transformed to CID	N <sub>DI</sub>	Positive	Digit	500	0	2700	<b>0.185</b>
18	Number of layoffs	N <sub>L</sub>	Negative	Digit	54	0	29000	<b>0.998</b>
19	Budget destined to promote social activities	B <sub>SA</sub>	Positive	M€	0.2	0	350	<b>0.001</b>
20	Number of products / services subject of claims following a non-compliance issue	N <sub>N-C</sub>	Negative	Digit	700	0	840000	<b>0.999</b>

**Table 15:** Weights of social indicators of the case supply chain

I	N <sub>F</sub> c	N <sub>H</sub> P	N <sub>D</sub>	N <sub>R</sub>	N <sub>F</sub> L	N <sub>C</sub> h	N <sub>P</sub> E	N <sub>V</sub> P	R <sub>L</sub> w/L L	N <sub>RI</sub>	N <sub>S</sub>	N <sub>O</sub> A	N <sub>D</sub>	N <sub>J</sub>	N <sub>C</sub> ID	N <sub>C</sub> DD	N <sub>D</sub> I	N <sub>L</sub>	B <sub>S</sub> A	N <sub>N</sub> -c	Wei ghts
N <sub>F</sub> c	1	1	1/3	1	1/2	1/2	1	1/2	1/2	1/2	1/2	1/4	1/4	1/2	1	1	1	1/3	1	1	
N <sub>H</sub> P	1	1	1/3	1	1/2	1/2	1	1/2	1/2	1/2	1/4	1/4	1/4	1/2	1	1	1	1/3	1	1	
N <sub>D</sub>	3	3	1	2	1	1	2	1	1	1	1	1	1	2	2	2	2	1	2	2	
N <sub>R</sub>	1	1	1/2	1	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	
N <sub>F</sub> L	2	2	1	2	1	1	2	1	1	1	2	1	1	2	2	2	2	1	2	2	
N <sub>C</sub> h	2	2	1	2	1	1	2	1	1	1	2	1	1	2	2	2	2	1	2	2	
N <sub>P</sub> E	1	1	1/2	2	1/2	1/2	1	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	
N <sub>V</sub> P	2	2	1	2	1	1	2	1	1	1	1	1/2	1/2	1	1/2	1/2	1/2	1	2	2	
R <sub>L</sub> w/L L	2	2	1	2	1	1	2	1	1	2	2	1	1	1	2	2	2	2	1	2	2
N <sub>RI</sub>	2	2	1	2	1	1	2	1	1/2	1	1	1/2	1/2	1/2	1	1	1	1/3	1	1/2	
N <sub>S</sub>	2	2	1	2	1/2	1/2	2	1	1/2	1	1	1/2	1/2	1/2	1	1	1	1/3	1	1/2	

N <sub>O</sub> <sub>A</sub>	4	4	1	2	1	1	2	2	1	2	2	1	1	1	1/2	1/2	1/2	1	1/3	1/2	
N <sub>D</sub>	4	4	1	2	1	1	2	2	1	2	2	1	1	1	1/2	1/2	1/2	1	1/3	1/2	
N <sub>J</sub>	2	2	1	2	1	1	2	1	1	2	2	1	1	1	4	4	4	1	2	2	
N <sub>C</sub> <sub>DI</sub>	1	1	1/2	2	1/2	1/2	2	2	1/2	1	1	2	2	1/2	1	2	1	1/4	1	1	
N <sub>C</sub> <sub>SD</sub>	1	1	1/2	2	1/2	1/2	2	2	1/2	1	1	2	2	1/2	1/2	1	1/4	1/4	1/4	1/4	
N <sub>SI</sub>	1	1	1/2	2	1/2	1/2	2	2	1/2	1	1	2	2	1/2	1	4	1	1/3	1	1	
N <sub>L</sub>	3	3	1	2	1	1	2	1	1	3	3	1	1	1	4	4	3	1	2	2	
N <sub>S</sub> <sub>A</sub>	1	1	1/2	2	1/2	1/2	2	1/2	1/2	1	1	3	3	1/2	1	4	1	1/2	1	1	
N <sub>N-</sub> <sub>C</sub>	1	1	1/2	2	1/2	1/2	2	1/2	1/2	2	2	2	2	1/2	1	4	1	1/2	1	1	
Σ	37	37	15.166	37	15	15	35.5	22	14.5	2	27	22	22	13.75	27	37.5	25.75	13.165	23.916	23.25	
N <sub>F</sub> <sub>C</sub>	0.027	0.027	0.022	0.073	0.033	0.033	0.028	0.023	0.034	0.020	0.019	0.011	0.016	0.003	0.037	0.027	0.037	0.025	0.042	0.043	<b>0.028</b>
N <sub>H</sub> <sub>P</sub>	0.027	0.027	0.022	0.073	0.033	0.033	0.028	0.023	0.034	0.020	0.019	0.011	0.016	0.003	0.037	0.027	0.037	0.025	0.042	0.043	<b>0.028</b>
N <sub>D</sub>	0.081	0.081	0.066	0.054	0.067	0.067	0.056	0.045	0.069	0.047	0.037	0.045	0.047	0.007	0.077	0.053	0.076	0.076	0.084	0.086	<b>0.064</b>
N <sub>R</sub>	0.027	0.027	0.033	0.073	0.033	0.033	0.024	0.023	0.034	0.022	0.019	0.013	0.016	0.003	0.037	0.027	0.037	0.025	0.042	0.043	<b>0.025</b>
N <sub>F</sub> <sub>L</sub>	0.054	0.054	0.066	0.054	0.067	0.067	0.056	0.045	0.069	0.047	0.037	0.045	0.047	0.007	0.077	0.053	0.076	0.076	0.084	0.086	<b>0.063</b>
N <sub>C</sub> <sub>h</sub>	0.054	0.054	0.066	0.054	0.067	0.067	0.056	0.045	0.069	0.047	0.037	0.045	0.047	0.007	0.077	0.053	0.076	0.076	0.084	0.086	<b>0.063</b>
N <sub>P</sub> <sub>E</sub>	0.027	0.027	0.033	0.073	0.033	0.033	0.024	0.023	0.034	0.022	0.019	0.013	0.016	0.003	0.037	0.027	0.037	0.025	0.042	0.043	<b>0.027</b>
N <sub>V</sub> <sub>P</sub>	0.054	0.054	0.066	0.054	0.067	0.067	0.056	0.045	0.069	0.047	0.037	0.045	0.047	0.007	0.077	0.053	0.076	0.076	0.084	0.086	<b>0.051</b>
R <sub>L</sub> <sub>W/L</sub> <sub>L</sub>	0.054	0.054	0.066	0.054	0.067	0.067	0.056	0.045	0.069	0.047	0.037	0.045	0.047	0.007	0.077	0.053	0.076	0.076	0.084	0.086	<b>0.065</b>
N <sub>RI</sub>	0.054	0.054	0.066	0.054	0.067	0.067	0.056	0.045	0.069	0.047	0.037	0.045	0.047	0.007	0.077	0.053	0.076	0.076	0.084	0.086	<b>0.042</b>
N <sub>S</sub>	0.054	0.054	0.066	0.054	0.067	0.067	0.056	0.045	0.069	0.047	0.037	0.045	0.047	0.007	0.077	0.053	0.076	0.076	0.084	0.086	<b>0.039</b>
N <sub>O</sub> <sub>A</sub>	0.108	0.108	0.066	0.054	0.067	0.067	0.056	0.045	0.069	0.047	0.037	0.045	0.047	0.007	0.077	0.053	0.076	0.076	0.084	0.086	<b>0.058</b>
N <sub>D</sub>	0.108	0.108	0.066	0.054	0.067	0.067	0.056	0.045	0.069	0.047	0.037	0.045	0.047	0.007	0.077	0.053	0.076	0.076	0.084	0.086	<b>0.058</b>
N <sub>J</sub>	0.054	0.054	0.066	0.054	0.067	0.067	0.056	0.045	0.069	0.047	0.037	0.045	0.047	0.007	0.077	0.053	0.076	0.076	0.084	0.086	<b>0.075</b>
N <sub>CI</sub> <sub>D</sub>	0.027	0.027	0.033	0.073	0.033	0.033	0.024	0.023	0.034	0.022	0.019	0.013	0.016	0.003	0.037	0.027	0.037	0.025	0.042	0.043	<b>0.045</b>

N <sub>C</sub> DD	0.027	0.027	0.033	0.054	0.033	0.033	0.056	0.091	0.034	0.044	0.037	0.091	0.091	0.018	0.019	0.027	0.021	0.019	0.001	0.001	0.001	<b>0.038</b>
N <sub>DI</sub>	0.027	0.027	0.033	0.054	0.033	0.033	0.056	0.091	0.034	0.044	0.037	0.091	0.091	0.018	0.019	0.027	0.021	0.019	0.001	0.001	0.001	<b>0.048</b>
N <sub>L</sub>	0.081	0.081	0.066	0.054	0.067	0.067	0.056	0.045	0.069	0.012	0.011	0.045	0.045	0.073	0.014	0.010	0.011	0.076	0.084	0.088	0.006	<b>0.080</b>
B <sub>S</sub> A	0.027	0.027	0.033	0.054	0.033	0.033	0.056	0.091	0.034	0.044	0.037	0.091	0.091	0.018	0.019	0.027	0.021	0.019	0.001	0.001	0.001	<b>0.051</b>
N <sub>N-</sub> C	0.027	0.027	0.033	0.054	0.033	0.033	0.056	0.091	0.034	0.044	0.037	0.091	0.091	0.018	0.019	0.027	0.021	0.019	0.001	0.001	0.001	<b>0.050</b>

Table 16: Social performance of the case supply chain

N <sup>o</sup>	Indicator I	Symbol	I <sub>N</sub>	w <sub>i-soc</sub>	I <sub>Nx</sub> w <sub>i-soc</sub>
1	Staff number who are submitted to case of no respect of free competition	N <sub>FC</sub>	0.992	0.028	0.028
2	Staff number who are submitted to case of injustice caused by hierarchical power	N <sub>HP</sub>	0.971	0.028	0.027
3	Staff number who are submitted to case of discrimination	N <sub>D</sub>	0.996	0.064	0.064
4	Staff number representatives	N <sub>R</sub>	1.000	0.025	0.025
5	Staff number who has a forced labor	N <sub>FL</sub>	1.000	0.063	0.063
6	Staff number who are children	N <sub>Ch</sub>	1.000	0.063	0.063
7	Staff number participated in professional elections	N <sub>PE</sub>	0.793	0.027	0.021
8	Staff number who are submitted to case of violations of privacy	N <sub>VP</sub>	0.997	0.051	0.051
9	Ratio of lowest wage / cost of local life	R <sub>LW/LL</sub>	0.700	0.065	0.046
10	level of salary retention in case of illness	N <sub>RI</sub>	0.800	0.042	0.034
11	Number of services offered to staff	N <sub>S</sub>	0.400	0.039	0.016
12	Staff number who are victims of occupational accidents	N <sub>OA</sub>	0.994	0.058	0.058
13	Staff number who are victims of diseases caused by work	N <sub>D</sub>	0.978	0.058	0.057
14	Number of jobs created	N <sub>J</sub>	0.580	0.075	0.044
15	Staff number with CID	N <sub>CID</sub>	0.907	0.045	0.041
16	Staff number with CDD	N <sub>CDD</sub>	0.907	0.038	0.034
17	Number of CDD transformed to CID	N <sub>DI</sub>	0.185	0.048	0.009
18	Number of layoffs	N <sub>L</sub>	0.998	0.080	0.080
19	Budget destined to promote social activities	B <sub>SA</sub>	0.001	0.051	0.000
20	Number of products / services subject of claims following a non-compliance issue	N <sub>N-C</sub>	0.999	0.050	0.050
I <sub>Soc</sub>					<b>0.809</b>

**Compute of Global Performance:**

Equal weights (1/3) have been attributed to each sub-index to derive (I<sub>g</sub>). Certainly, other methods of weighting the sub-indices of (I<sub>g</sub>) could be applied, for example by using public opinion polls or involving expert judgment. However, which makes equal weighting a sensible option.

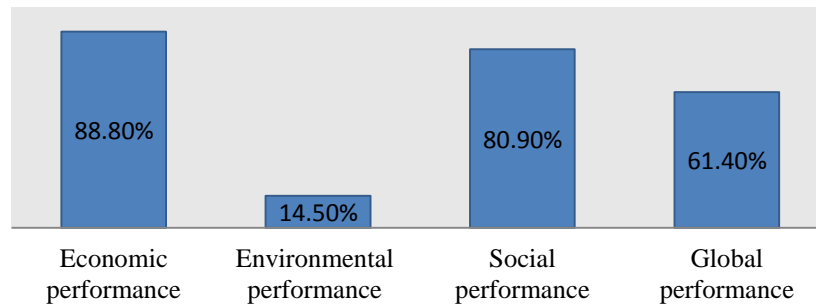
Finally, we find global composite index (I<sub>g</sub>), based on the following equation:

$$I_{gt} = \frac{I_{Eco} + I_{Env} + I_{Soc}}{3} = \frac{0.888 + 0.145 + 0.809}{3} = 0.614 \quad (09)$$

**Interpretation of Results:**

9 economic, 9 environmental and 20 social indicators were aggregated into sustainable sub-indices for a case supply chain and finally aggregated into the I<sub>g</sub>. The values of sustainable sub-indices and the I<sub>g</sub> for the case supply chain over 2016 year are graphically presented in Fig. 2.

Economic performance has a value of 88.80% shown that this supply chain fulfilled a good performance from economic point of view. This good economic performance based on the high value of positive indicators and the low values of negatives indicators. However, the economic development affects, but does not determine the  $I_g$  results. That is very important since nowadays a great emphasis have been put on the economic assessments and less on the social and environmental one. Environmental performance of the case supply chain has a value of 14.50% which is a very bad performance that is to say this supply chain has a very negative impact on the environment. As the economic performance, social performance achieved a verge good value (80.90%), thing which reflect the respect of social side by this supply chain. Taking into consideration these three performances, this supply chain achieved a good global performance (61.40%) which must be improved in the coming years especially through the improvement of environmental performance.



**Fig. 2:** Economic, environmental, social and global performance of the case supply chain over 2016.

### Discussion and Contribution of Our Module:

The purpose of ( $I_g$ ) is to give both a simplified and quantified expression for a more complex composition of several indicators. It can be used to inform decision-makers of development trends in supply chain.

However, it may also be included in a more targeted context, such as reflecting the status of supply chain regarding sustainability, providing information to critical decision processes, or possibly forming the basis for a supply chain to head in a certain direction. This evaluation module helps to highlight opportunities for improvement and where best practices might be found. It provides early warning information and tracks sustainability of supply chain. Decision-makers could easily interpret ( $I_g$ ) and its corresponding sub-indices than trying to find a trend in many separate criteria of sustainable development. If included in the annual sustainability report, we could use this module to present the progress of supply chain in terms of sustainability to various parties interested in supply chain sustainability. Also, this evaluation module if would be applied to different supply chains, it would be possible to compare and rank them in terms of sustainability.

Based on our evaluation module of global performance we can decide if we apply or not a given best practice in supply chain following its sustainable performance calculated by ( $I_{Eco}$ ,  $I_{Env}$ ,  $I_{Soc}$  and  $I_g$ ).

By this module, we provide to decision maker a tool which allows him:

- ❖ To analyze the current and potential value of activities implemented and to consider actions to strengthen this value such as the implementation of sustainable best practices. This analysis allows him to define the scope of activities and to consider several options for this end, as part of differentiation strategy by CSR.
- ❖ To analyze the profile of the global performance related to supply chain decisions during the planning phase, choose the configuration of the chain and the way to exploit it in advanced and optimized manner in order to ensure target level of global performance. This later defines the strategy or CSR policy that the decision maker wishes to implement.
- ❖ To know precisely the additional investment in terms monetary, which he must engage to achieve the level of global performance desired.
- ❖ And finally, to have quantitative performance indicator which used to control the supply chain and for the purposes of communication.



### Conclusion:-

The purpose of this paper is to show the difficulties in measuring global performance, fuzzy concept, presented by many authors as aggregation of economic, environmental and social performance of supply chain.

While sustainability information is typically treated separately, this paper tries to translate it into a form that corresponds to needs of decision-makers. This paper illustrates that it is possible to assess sustainable development in an integrated way that provides good guidance for decision-making. As the business case for sustainable practices becomes increasingly clear, sustainability reporting offers a measurable value to those whose business is to assess the current sustainability health of supply chains and influence future actions. At present, content of sustainability reports tends to appear in forms and units that are not readily convertible into unique terms. The module presented in this paper promises advance in sustainability assessment of supply chain and makes sustainability information more useful to decision-makers. Core and supplemental indicators ( $I_{Eco}$ ,  $I_{Env}$ ,  $I_{Soc}$ ) when combined into global composite index ( $I_g$ ) can be used to reflect the achievements of supply chain towards sustainability.

Even though further development is called for, it is evident that this module for sustainable development assessment has the potential to become very useful as one of the tools available. The combination of better assessment methods is likely to continue this movement towards a new generation of integrated sustainability performance reports.

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### Conflict of Interest Statement:

Authors certify that they have NO affiliations with or involvement in any organization or entity with any financial interest, or non-financial interest in the subject matter or materials discussed in this manuscript.

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