A Model based on Fuzzy Analytic Hierarchy Process for Risk Analysis in Customs Supply chain: A case study

Lamia Hammadi [1,2], Eduardo Souza De Cursi [1], Abdellah Ait Ouahman [2], Aomar Ibourk [3]

[1] LOFIMS Laboratory, National Institute of Applied Sciences INSA, Rouen, France

[2] OSCARS Laboratory, National School of Applied Sciences,Marrakech, Morocco

[3] GRES Laboratory, Faculty of Juridical, Economic and Social Sciences, Marrakech, Morocco

Abstract: Risks such as smuggling of drugs, weapons or commercial fraud highlighted the vulnerability of the Customs supply chain. In fact, the economic, political and social impacts of those risks are highly detrimental to the countries, businesses and the public. Effective Risk analysis in the Customs context could not only fulfill the safety requirements but also provide a competitive advantage in the commercial world. Nevertheless, making optimal decisions in this regard is not always as simple as it sounds, given, the qualitative nature of, and the uncertainty associated with, the parameters involved in the decision-making process. The main objective in this study is to propose an analytical approach to assess risks under a fuzzy environment. A fuzzy Analytic Hierarchy Process (FAHP) model, which combines Fuzzy logic with AHP is constructed to evaluate various aspects of risks in customs supply chain. As an input, it defines uncertainties in the system and it quantifies the risk using the relative weight as a risk indicator. As an output, FAHP model provides a list of most critical risks as well as some target mitigation actions. A case study of Moroccan customs is presented, and a numerical analysis is included in this paper to prove the effectiveness and demonstrate how the proposed model it works. The model is a general form that can be tailored and applied in different contexts come from customs world.

Keywords: Customs Supply Chain, Fuzzy Analytic Hierarchy Process (FAHP), Risk, Risk analysis, Moroccan customs.

INTRODUCTION

Customs Supply Chain is widely classified as a complex system, due to not only the large number of actors (customs, businesses, companies categorized, freight forwarders, individuals,...), but also their complex structural links, and the interactions between these actors. In fact, this system is subject to various types of Risks. For this reason, risk management in the Customs Supply Chain context is becoming a crucial issue to ensure the sustainability, safety and performance.

Risk management based approach as systematic identification and implementation of all measures necessary to limit exposure to customs risk, determines which persons, goods, and means of transport should be examined and to what extent. Therefore, it is clear that just any safety policy, implementation of risk management principles, consists of an effective risk analysis. Accordingly, it is important to use an integrated risk assessment approach toeffectively analyze of the risk faced in customs context, thus enabling decision makers to understand the capabilities and resources that need to be deployed to successfully implement risk management in the Customs Supply Chain. Making such approach is not always as simple as it sounds, due to not only there are many qualitative factors concerned with the Risk assessment decision making process, but also the large number of partners involved in Customs Supply Chain. In the literature, analytic hierarchy process (AHP) is a widely employed methodology to handle this kind of process. Nevertheless, typical AHP is unable to deal with uncertainty (Wang, Chan, Yee and Diaz-Raineya, 2012).Uncertainty is a particular issue in risk assessment within customs context since, in this field, the decision criteria are generally subjective judgment and individual preferences. In order to consider these issues, we introducea decision model combining AHP and fuzzy logic (FEAHP), which is used to incorporate uncertain parameters into the proposed model. AHP and FEAHP techniques are usedto synthesize the opinions of decision-makers and to identify the weight of each risk.

The remaining sections of this paper are organized as follows: the next one presents the customs supply chain as a context for Risk assessment and discusses the concept and identifies the major risks. The right after section contains the discussion about the different decision criteria and attributes considered when prioritizing risks in Moroccan Customs. The next section discusses the FEAHP proposed. Second to last section discusses the complete implementation of the FEAHP approach and presents a numerical example. Finally,the conclusions close thispaper.

Customs supply chain

The customs logistics specialists considered the customs supply chain with wide interest. Nevertheless, its practical useis often imprinted by ambiguity. Consequently, it is necessary to spot clearly its conceptual, structural and functional sides.

Definition of Customs Supply Chain

Customs supply chain incorporates all aspects of moving cargo from the exporter through the transport process, the logistics operations and customs crossing to the final importer. The customs crossing refers to declaration processing, custom clearance, data analysis, risk assessment, document checking, scanning, physical inspection, etc. The customs supply chain is no longer contained within countries borders, but encompasses all nations, whether they are exporters, importers or manufacturers(Tang, 2006).

Customs Supply Chain Actors

Any organization taking part in the routing of flows from the starting point to its destination in the best conditions is called link or actor in the supply chain (Hugos and Michael, 2003). During the research internship carried at the Casablanca port, we determined the actors and their roles in the Customs Supply Chain and the major actors are divided into the main building blocks of our system, whose results are summarized in Tab.1.

Tableau 1 - Role of actors in the Customs Supply Chain (case of Morocco).

Basic blocks	Actors	Role in the supply chain
Customs operators	Importers	Importers, in international trade, bring in (goods, merchandise, commodities, etc...) from a foreign country into a domestic country (Morocco) for use, sale, processing, re-export, or services.
	Exporters	In International Trade, "Exporter" refers to selling goods and services produced in the home country to other markets
Transport process	Air/rail/sea carriers	Carriers transport cargo via air, rail, or sea
	Border highway carriers	Highway carriers transport cargo for scheduled and unscheduled operations via road across the Algerian or Mauritanian borders.
Customs crossing	Customs officer	Officers clear goods through customs. The responsibilities of a customs agent include documentary control, the preparation of the registration form and deposit, the determination of duties and taxes to pay, and arranging for delivery to the importer.
	Freight forwarder	Is a person or company that organizes shipments for individuals or corporations to get goods from the manufacturer or producer to a market, customer or final point of distribution. A forwarder does not move the goods but acts as an expert in supply chain management.
Logistic process	Freight consolidators/ Transportation intermediaries and Nonvessel-operating common carriers	- A freight consolidator is a firm that accepts partial container shipments from individual shippers and combines the shipments into a single container for delivery to the carrier. - A transportation intermediary facilitates transactions by bringing buyers and sellers together. - A nonvessel-operating common carrier is a company that buys shipping space through a special arrangement with an ocean carrier and resells the space to individual shippers.
	Port authorities Terminal operators	- A port authority (in Morocco: National Ports Agency, ANP) is an entity of state or local government that owns, operates, or otherwise provides wharf, dock, and other marine terminal investments at ports. - Terminal operator (in Morocco: Marsa Maroc) responsibilities include the overseeing and unloading of cargo from ship to dock, checking the actual cargo against the ship's manifest (list of goods), checking documents authorizing a truck to pick up cargo, overseeing the loading and unloading of railroad cars, and so forth.

Source: Authors.

Functional Analyze

Most of specialists consider customs supply chain as a complex system, due to not only the large number of components (customs, companies categorized, freight forwarders, individuals, etc.), but also their Structural links, and the interactions between these components. Indeed, to establish links between actors in the customs supply chain, we opted by the use of a Functional Diagram for positioning the system in its environment (Fig. 1).The system functions are divided in Basic Functions (BF) and Complementary Function (CF):

- **BF1**: Reduce clearance delay; Simplify customs clearance procedures; Covering the customs duties and other taxes,
- **BF2**: Achieving an appropriate balance between trade facilitation and regulatory control.
- **BF3**: Fight against fraud; Comply with customs regulations (sanitary, phytosanitary, technological, etc.);Comply with customs laws.
- **CF1**: Achieving compliance between Customs procedures and international regulations and standards
- **CF2**: Facilitate commercial exchange;

• **CF3**: AchievingCustoms supply chain safety and security;Monitor and manage the supply chain.
• **CF4**: Managing risks to ensure that the customs objectives are achieved as efficiently and effectively as possible.
• **CF5**: Control cargo by the use of risk-based selectivity.
• **CF6**: Identifying high-risk operators (the World Customs Organization WCO's SAFE Framework of standard).

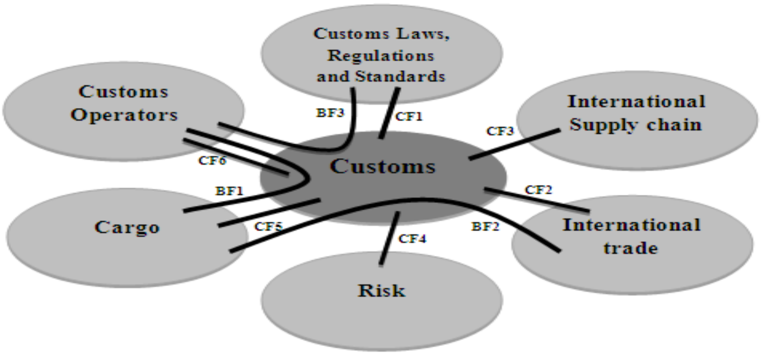

Figure 1 - Functional diagram of the customs supply chain.

Risk typology in Customs context

Whenever, we are asked to provide a consideration on risks in the customs context, there are many questions to be answered, ″What are the risks? How will they be identified, recognized and assessed? Where, When and How the risk is likely occurred? Who does it affect? and Why are there possibilities of fraud?″. Determining the answers to these questions may result complex, due to not only the relative difficulty of the actors to understand the true nature of risks, but also the large number of partners involved in customs supply chain and the economic and financial environment changing. The concept of risk in customs context refers to the possibility of events and activities occurring that may prevent the customs from achieving their objectives (Widdoson, 2004). It is a commonly held belief that risk is a strategic prevention and response to potential threats (Autry and Bobbitt, 2008). The important consideration from a risk perspective is to ensure that the potential risk has been correctly identified, assessed and treated, so as to achieve three primary objectives— secure the customs supply chain, ensure compliance with regulatory requirements and guarantee balance between the needs for trade facilitation and the level of regulatory control and intervention. Risks faced bycustoms are related to the potential for noncompliance with customs laws, regulatory requirements and international standards such as restricted and prohibited goods, rules of origin, duty exemption regimes, security and safety regulation, sanitary, environmental and technical standards, intellectual property, transnational crime, commercial fraud, and illicit traffics, as well as the organizational risks. Customs supply chain, like any other supply chain, needs to manage its risks. This requires the systematic implementation of Risk management principles to limit exposure to those risks in a way to achieve a high level of both performance and safety. The underlying elements of such a strategy are identifying, analyzing, evaluating and treating risks.

Three main risk areas are defined in the documents on selectivity controls in customs operations adopted by the Moroccan Customs Administration. They are customs frauds, threats on social safety and security and organizational risks. Customs frauds, as evading payment of tariffs and other duties, are treated through: declaring and accepting improper customs value; declaring and accepting misclassification; declaring and accepting improper origin of goods; discharging of import for processing; discharging of outward processing; illicit removal of goods from customs supervision; and undeclared import goods for customs clearance, are one of the most important and highly recognized risks in Customs management strategies worldwide. Threats on social safety and security in terms of public health, environment and consumers, including proper implementation of measures related to import and export of goods to and from Morocco, as a risk area is regarded to: smuggling of weapons; smuggling of drugs and precursors; money laundering and terrorist financing; smuggling endangered animal and plant species; smuggling of nuclear and radioactive material; smuggling of high technology and weapons; illicit trade in dual-use goods; smuggling of cultural heritage; trafficking in counterfeit / pirated goods; ecological crime, and human traffics. And organizational threats are the events and activities occurring that may prevent Moroccan customs from achieving its objectives , as a risk area is regarded to : lack of staff competence, integrity, ineffective procedures, lack of coordination with other agencies, limited human and material resources, and IT failure. Determined risk areas, along with the information from different sources (IT system for processing declaration; internal detailed records from different related units within Customs Administration; information from external governmental institutions; international customs cooperation), are the main basis for *identification of risks*. Based on the obtained information,each identified risk is analyzed in terms of probability of risk occurrence and consequences of the risk occurrence. The level of risk is determined as intolerable, substantial or moderate.It often assumed that , as the level of vulnerability increases, the severity of impacts increases also, this is an extremely simplistic views, as it assumes that risks in customs context have economic, political, environmental and social impacts cause serious harm to the countries, businesses and the public. Its deleterious consequences occur every day when governments cannot afford to provide vital public services because revenues are siphoned away by smugglers, criminals and corrupt officials, risks are also reckoned negatively affect industrial and commercial development due to the huge loss of turnover for some domestic companies and the transfer of economic power from the market, government and citizens to criminals which leads to the increase of crime rate (terrorism, illicit trade), The proliferation of hazardous and noxious products, which do not meet the standards of quality and consumer's health or environmental deterioration or death cases due to the drugs or counterfeit medicines consumption.

In conclusion, the Customs risks affect negatively a country's economic growth, grind down its social development programs and erode investor confidence.

Connecting risks to Customs Supply Chain CSC structure

In order to obtain a consistent specification for the decision making of a supply chain subject to risks, the identified risks must be put in relation with the CSC structure introduced in section 1 and 2. To this end, for each risk, we identify the CSC elements which are impacted by the occurrence of said risk. We observe that two main types of effects exist, which can be modeled as follows:

1) **Risk that may affect actors'operations:** in this case, the risks affect the role of actors in the CSC.
2) **Risk that may destroy actors or links:** a risk that prevent the actor to complete its role.

The risk classification presented in Tab. 2 provides a view of the CSC risks based on the occurrence location in the CSC structure.

Tableau 2 - Risk classification into Customs Supply Chain structure.

Type	Nature	Risks
Risks impacting actors' operations	Social safety and Security	Illicit traffic, counterfeit, dangerous products or not corresponding to the requiredtechnical, standards products not corresponding to the required sanitary standards, toxic waste, substances impoverishing the ozone layer, polluting products
	Fiscal risks	Commercial fraud and Money laundering
Risks destroying actors and links	Organizational risks	Lack of staff competence,integrity, ineffective procedures, lack of coordination with other agencies, limited human and material resources, and it failure

Integrated risk assessment model using FEAHP based-approach

Supply chain risk management is a field of growing importance and aims at developing approaches to the identification, assessment, analysis and treatment of areas of vulnerability and risk in supply chains (Neiger et al, 2009). Current supply chain risk management techniques in customs context focus on risks related to the potential for non-compliance with customs laws, regulatory requirements and international standards such as licensing requirement, valuation provision, rules of origin, duty exemption regimes, trade restriction, security and safety regulation, illicit traffic, as well as the organizational risks. By way of contrast, this paper focuses on establishing a risk indicator measuring the risks in customs supply chain context. In this section, an integrated customs supply chain risk assessment model is presented using analytical hierarchy process and fuzzy set theory. It aims to effectively analyze, identify and assess the risks facing in different stages of customs supply chain.

Hierarchical structure

This phase involves formulating an appropriate hierarchy of AHP model, consisting of the goal, strategic areas, sub-factors and results. The following steps have been considered to establish the hierarchy:

1) Identify the overal objectives;
2) Define the Risk areas and identify risks that prevent the system to ashieve its goals;
3) Structure the hierarchy ;
4) Devide the major risks into Risk areas.

The goal of our problem is to prioritize Risks in Customs Supply Chain to implement an appropriate action plan so as to prevent or respond the frequency of risks.This goal is placed on the first level of the hierarchy as illustrated in Fig.2. Five strategic risk areas are identified to achieve this goal, which form the second level of hierarchy. The third level of hierarchy consists of twenty eight risks of five strategic risk areas. The strategic areas and their sub factors used in these two levels of AHP hierarchy can be assessed using the basic AHP approach of pair wise comparison of elements in each level with respect to every parent element located one level above (Rajesh and Singh, 2013). The lowest or the fourth level of hierarchy consists of the result (i.e.effective risk assessment in customs supply chain context).So the important consideration from the AHP model in customs context is that the hierarchical structure can be viewed as the combination of the main objective of the system and the risks that prevent this system from achieving these objectives.

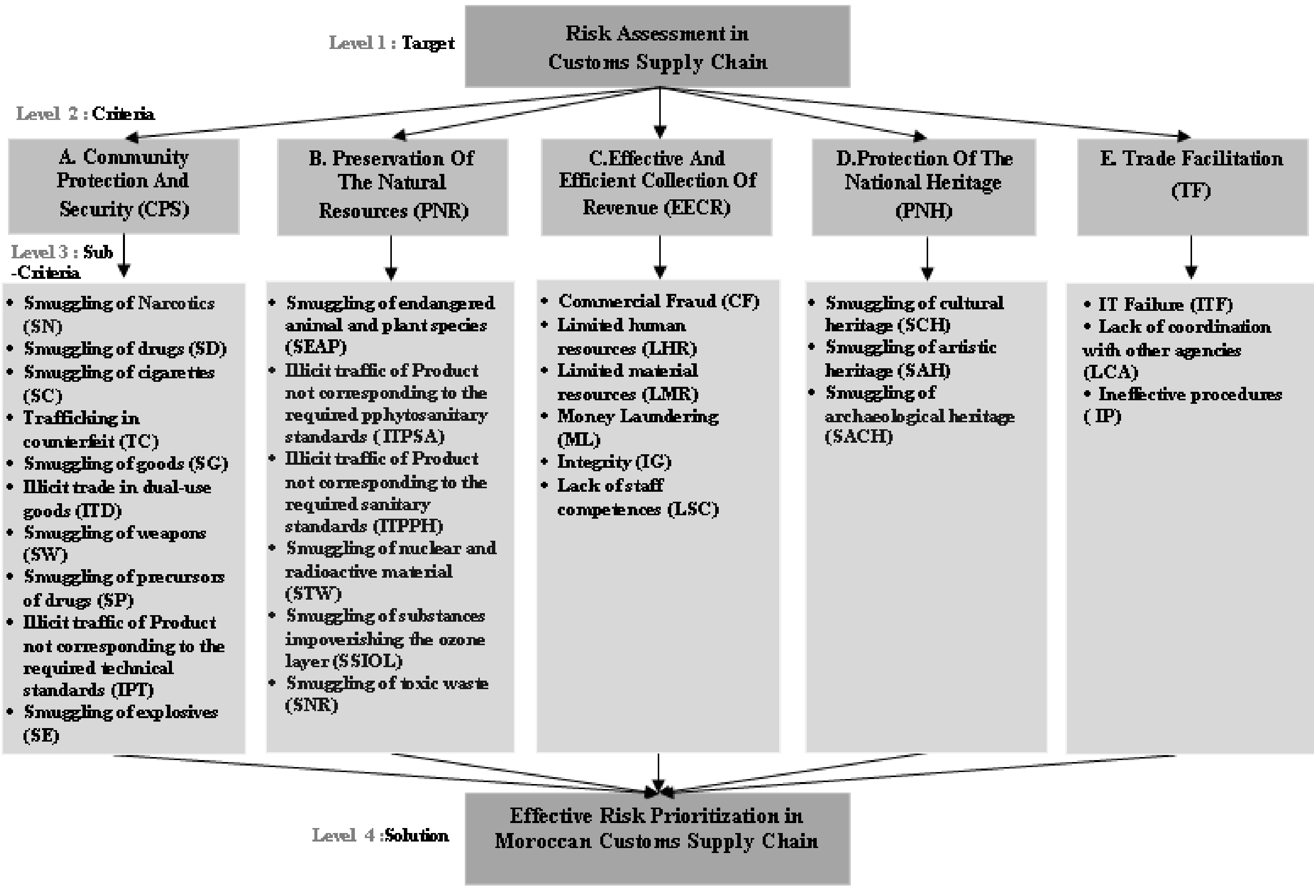

Figure 2 - Hierarchical structure of integrated risk assessment model for Moroccan customs supply chain.

Essence of AHP, Fuzzy Extended AHP

AHP has become one of the most widely used methods for multiple criteria decision-making. It can solve unstructured problems in different areas of human needs and interests, such as economic, social and management sciences (Lee, 2009). The procedures of AHP to solve a complex problem involve five essential steps (Zahedi, 1986; Cheng, 1999; Lee et al, 2006) as depicted below :

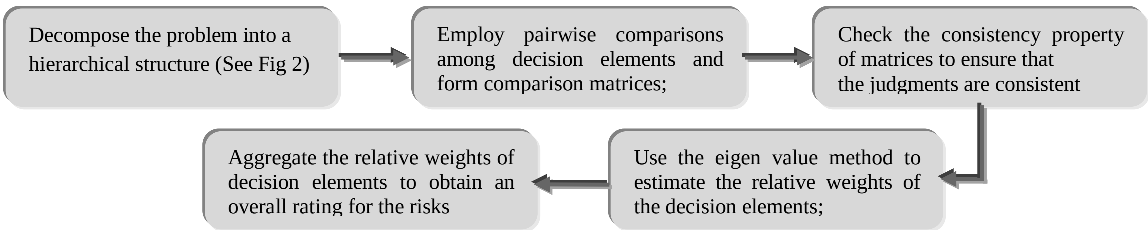

Figure 3 - Steps of risk assessment model.

AHP employs exact numbers such as 1–9 to score. However, much decision-making involves some uncertainty. Typical AHP does not take into account the uncertainty associated with the mapping of one's perception to a number (Huang, Chu and Chiang, 2006). Nevertheless, uncertainty is a particular issue in risk assessment within customs context since the different decision criteria in this field are subjective judgment and individual preferences. In view of this, fuzzy set theory is applied to quantify the risk of individual variables identified in each attribute to give decision-makers a measure of the vulnerability within the supply chain. Moreover, uncertainty problems can not be expressed simply using the concept of probability or crisp values. Since (Zadeh, 1965) introduced fuzzy set theory, it has been frequently used to solve problems of uncertain nature. The fuzzy set theory resembles human reasoning in its use of approximate information and uncertainty to support decision-making processes. It provides the opportunity to mathematically represent uncertainty and vagueness. The fuzzy approach is adopted here as a means of transforming a qualitative risk evaluation into fuzzy values and consequently into quantitative assessment outcomes for the supply chain oriented risk assessment model. The FEAHP is the fuzzy extension of AHP to efficiently handle the fuzziness of the data involved in the risk assessment in CSC. It is easier to understand and it can effectively handle both qualitative and quantitative data in this multi-attribute decision making problems (Chan and Kumar, 2007). In this approach, Triangular Fuzzy Number (TFN) is employed to characterize the fuzzy values of quantitative data and linguistic terms used in the preferences of one criterion over another so as to calculate the pairwise comparison. Based on this approach, the weight vectors are decided and normalized, thus the normalized weight vectors will be determined. As a result, based on the different weights of criteria and attributes the final priority weights of the risks facing in customs supply chain are decided. The highest priority would be given to the risk with highest weight. The main goal of risk analysis using fuzzy extended AHP-based approach is to quantify systematically and quantitatively Risks by using an indicator. Such indicator is difficult to implement, since, in many cases, constraints in data quality, time, expertise and resources prevent from effective definition or quantification.

Triangular fuzzy number and Fuzzy set

A fuzzy set (Demirel and Kahraman, 2008) is characterized by a membership function, which assigns to each object a grade of membership ranging between 0 and 1. In this set the general terms such as “large”, “medium”, and “small” each will be used to capture a range of numerical values. A fuzzy number is a special fuzzy set, such that $M = \{(x, \mu (x), x \in \mathrm{R}\}$,where the value of x lies on the real line R_1, i.e. $-\infty<x<+\infty$ and$\mu_M(x)$ is a continuous mapping from R_1 to the close interval [0,1].If $\boldsymbol{n_1}$, $\boldsymbol{n_2}$ and $\boldsymbol{n_3}$, respectively, denote the smallest possible value, the most promising value and the largest possible value that describe a fuzzy event then the Triangular Fuzzy Numbers (TFNs) can be denoted as a triplet $(n1,\ n2,\ n3)$ where, $\boldsymbol{n_1} \leq \boldsymbol{n_2} \leq \boldsymbol{n_3}$. When$\boldsymbol{n_1 = n_2 = n_3}$, it is a non-fuzzy number by convention. The membership function can be defined:

$$\mu_N(x) = \begin{cases} \frac{x-n_1}{n_2-n_1}, & x \in [n_1, n_2] \\ \frac{n_3-x}{n_3-n_2}, & x \in [n_2, n_3] \\ 0 & otherwise \end{cases} \tag{1}$$

Fuzzy numbers are intuitively easy to use in expressing the decision-maker’s qualitative assessments. A fuzzy number can be given by its corresponding left and right representation of each degree of membership:

$$N = \left(N^{l(y)}, N^{r(y)}\right) = (n_1 + (n_2 - n_1)y, n_3 + (n_3 - n_2)y) \tag{2}$$

Where **l(y)**and **r(y)** denote the left- and right-hand side representation of a fuzzy number, respectively. The algebraicoperations with fuzzy numbers used in this paper can be foundin (Chang, 1996).TFNs $\boldsymbol{N_1, N_3, N_5, N_7}$and $\boldsymbol{N_9}$are used to represent the pairwise comparison of decision variables from "Equal" to "Absolutely preferred", and TFNs $\boldsymbol{N_2, N_4, N_6}$and $\boldsymbol{N_8}$represent the middle preference values between them. The membership functions of the TFNs, $N_i = (n_{i1}, n_{i2}, n_{i3})$, where $i = 1,2, \dots ,9$ and $n_{i1}, n_{i2}, n_{i3}$are the lower, middle and upper values of the fuzzy number N_i respectively. Higher the value of $(n_{i3} - n_{i1})$or $(n_{i1} - n_{i3})$signifies the greater fuzziness of the judgment.

Priority weights evaluation at different level of hierarchy

If the object set is denoted by $P = \{p1,\ p2, \ldots,\ pn\}$ and the objective set is denoted by $Q=\{q1,\ q2, \ldots,\ qm\}$,then according to the concept of extent analysis (Chan and Kumar, 2007) each object is taken and extent analysis for each objective $O_i$is performed, respectively. Therefore the m extent analysis values for each object are obtained with the following signs:$\boldsymbol{N_{oi}^1, N_{oi}^2, \dots, N_{oi}^m,\ \ where\ i = 1, 2, \dots, n}$,where all the $N_{oi}^j (j = 1,2,3, \dots, m)$are TFNs. The value of fuzzy synthetic extent with respect to the ith object is defined as

$$\mathbf{S_i} = \sum_{j=1}^{m} \mathbf{N_{oi}^j} \times \left[\sum_{i=1}^{n}\sum_{j=1}^{m} \mathbf{N_{oi}^j}\right]^{-1} \tag{3}$$

The value of $\sum_{j=1}^{m} \boldsymbol{N_{oi}^i}$ can be found by performing the fuzzy addition operation of m extent analysis values from a particular matrix such that

$$\sum_{j=1}^{m} N_{oi}^j = \left(\sum_{j=1}^{m} n_{1j}, \sum_{j=1}^{m} n_{2j}, \sum_{j=1}^{m} n_{3j}\right) \tag{4}$$

And the value of $[\ \sum_{i=1}^{n}\sum_{j=1}^{m} \boldsymbol{N_{oi}^j}]$ can be obtained by performing the fuzzy addition operation of $N_{oi}^j\ (j = 1,2, \ldots, m)$ such that

$$\sum_{i=1}^{n}\sum_{j=1}^{m} N_{oi}^j = \left(\sum_{i=1}^{m} n_{1j}, \sum_{i=1}^{m} n_{2j}, \sum_{i=1}^{m} n_{3j}\right) \tag{5}$$

And $[\sum_{i=1}^{n}\sum_{j=1}^{m} \boldsymbol{N_{oi}^j}]^{-1}$can be calculated by the inverseof Eq. (5) as follows:

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} N_{oi}^j\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} n_{3i}}, \frac{1}{\sum_{i=1}^{n} n_{2i}}, \frac{1}{\sum_{i=1}^{n} n_{1i}}\right) \tag{6}$$

The degree of possibility of $N_1 = (n_{11}, n_{12}, n_{13}) \geq\ \ N_2 = (n_{21}, n_{22}, n_{23})$is defined as

$$V(N_1 \geq N_2) = Sup_{x \geq y}\left[min\left(\mu_{N_1}(x), \mu_{N_2}(y)\right)\right] \quad (7)$$

When a pair (x, y) exists such that $x \geq y$ and $\mu_{N1}(x) = \mu_{N2}(y) = 1$, then we have $V(N_1 \geq N_2) = 1$.Since $N_1$and N_2 are convex fuzzy numbers so,

$$V(N_1 \geq N_2) = 1 \quad \text{if} \; n_{11} \geq n_{21} \text{and} \; V(N_2 \geq N_1) = hgt(N_1 \cap N_2) = \mu_{N_1}(d) \quad (8)$$

Where $d$is the ordinate of the highest intersection point D between μ_{N1}andμ_{N2}. when $N_1 = (n_{11}, n_{12}, n_{13})$and $N_2 = (n_{21}, n_{22}, n_{23})$then ordinate of D is computed by

$$V(N_2 \geq N_1) = hgt(N_1 \cap N_2) = \frac{n_{11} - n_{23}}{(n_{22} - n_{23}) - (n_{12} - n_{11})}. \quad (9)$$

For the comparison of N_1 and N_2, both the values of $V(N_1 \geq N_2)$and $V(N_2 \leq N_1)$are required.The degree possibility for a convex fuzzy number to be greater than k convex fuzzy numbers $N_I(i = 1,2, \dots, k)$can be defined by

$$V(N \geq N_1, N_2, \dots, N_k) = V[(N \geq N_1) and (N \geq N_2) and \dots and \; (N \geq N_k)]$$
$$= min\, V(N \geq N_i)\;, i = 1, 2, \dots, k \quad (10)$$

$$if \;\; m(P_i) = min\, V\,(S_i \geq S_k), \quad (11)$$

For $k = 1, 2, \dots, n$; $k \neq i$. then the weight vector is given by

$$W_p = \left(m(P_1), m(P_2), \dots, m(P_n)\right)^T \quad (12)$$

Where P_i $(i = 1, 2, \dots, n)$ are n elements.After normalizing Wp, we get the normalized weight vectors

$$\mathbf{W} = \left(w(P_1), w(P_2), \dots, w(P_n)\right)^T \quad (13)$$

Where W is a non-fuzzy number and this gives the priority weights of one alternative over other.

Analysis of criteria weights with AHP

To assess risk in customs context, it is essential to hierarchize the criteria used, i.e., how important one criterion or sub-criterion is when compared to another one. Using a typical AHP method, it means that the pair wise comparisons are established using a nine-point scale that converts human preferences into available alternatives such as equally, moderately, strongly, very strongly or extremely preferred. For example, if two elements are assumed equally important, the comparison will have a scale of 1. If one element is moderately more important than the other, the analysis will have a scale of 3. Subsequently, scales 5, 7 and 9 are used to describe strongly more important, very strongly more important and extremely more important, respectively. The corresponding reciprocals 1, 1/2, 1/3,..., 1/9 are used for the reverse comparison. The pair-wise comparisons of the attributes at each level in the hierarchy are arranged into a reciprocal matrix (Saaty, 1980). In general, the comparison matrices are defined as $\boldsymbol{A} = (\boldsymbol{a_{ij}})$, where A = reciprocal matrix with the elements $\boldsymbol{a_{ij} = 1/a_{ji}}$. The relative weights of the elements at each level with respect to a given element are computed as the components of the normalized eigenvector associated with the largest eigen-value of the comparison matrix A. Table 3 shows the estimated weight for risk areas using AHP matrix

Tableau 3- Pair-wise comparisons of Risk areas.

Criteria	TF	PNH	EECR	PNR	CPS	Weights	
TF	1	1/3	1/5	1/7	1/9	**0,033**	**Consistency Index: CI**
PNH	3	1	1/2	1/6	1/8	**0,064**	CI= 0,0952
EECR	5	2	1	1/4	1/7	**0,103**	**Consistency Ratio: CR**
PNR	7	6	4	1	1/7	**0,230**	
CPS	9	8	7	7	1	**0,570**	CR= 0,085.

Evaluation of aggregative risk

The application is carried out at the Moroccan Customs, searching the best Risk assessment for the most critical risks faced in its supply chain and that prevent the system from achieving its goals. The main objectives of the Moroccan Customs are related to revenue collection, ensuring community protection and security, preservation of the national heritage, protection of the natural resources and ensuring compliance with the laws and regulations administered by Customs in a way that guarantees facilitation of trade (WCO, 2003). The customs want to take into account all the "risk areas" which may affect the supply chain. A decision-making group is formed which consists of the experts and senior officials from Moroccan customs administration who had been tasked with implementing the risk management in Moroccan customs. Detailed discussion on every criterion and attribute have been conductedand based on primary discussion, five critical Risk areas have been identified. The discussion has been further prolonged to decide the twenty eight attributes or risks. After constructing the hierarchy of integrated risk assessment model, the next step consists on calculating the different priority weights of each Risk area and Risk using FAHP approach. Below, the fuzzy assessment method for evaluating the priority weights of the different level of the hierarchy is presented. The fuzzy evaluation matrix of the Risk areas is constructed by the pairwise comparison of the different criterion relevant to the overall objective using triangular fuzzy numbers, which is shown in Tab.4 (Zahedi,1986; Chan and Kumar, 2007).

Tableau 4 - The Fuzzy Evaluation Matrix of Risk areas with Respect to the Goal.

Criteria	CPS	PNR	EECR	PNH	TF	W_G
CPS	(1,1,1)	(13/2,7,15/2)	(13/2,7,15/2)	(15/2,8,17/2)	(17/2,9,19/2)	**0,24**
PNR	(2/15,1/7,2/13)	(1,1,1)	(7/2,4,9/2)	(11/2,6,13/2)	(13/2,7,15/2)	**0,22**
EECR	(2/15,1/7,2/13)	(2/9,1/4,2/7)	(1,1,1)	(3/2,2,5/2)	(9/2,5,11/2)	**0,21**
PNH	(2/17,1/8,2/15)	(2/13,1/6,2/11)	(2/5,1/2,2/3)	(1,1,1)	(5/2,3,7/2)	**0,16**
TF	(2/19,1/9,2/17)	(2/15,1/7,2/13)	(2/11,1/5,2/9)	(2/7,1/3,2/5)	(1,1,1)	**0,16**

The different Risks are compared under each Risk area separately by following the same procedure as presented above. The comparison of the importance of one risk with respect to another is obtained from structured discussions with a panel of experts and the use of a questionnaire survey.The Fuzzy AHP weightings were computed using Excel. Tables 5-9 present the fuzzy evaluation matrices of Risks and the weight vector of each Risk in the FEAHP model. At the same time, the consistency ratio of each judgment was calculated and checked to ensure that it is inferior to 0,1.

Tableau 5 - The Fuzzy Evaluation Matrix of Risk area : Natural resources.

Criteria	SEAP	ITPSA	ITPPH	STW	SSIOL	SNR	W_D
SEAP	(1,1,1)	(5/2,3,7/2)	(9/2,5,11/2)	(11/2,6,13/2)	(13/2,7,15/2)	(13/2,7,15/2)	**0,34**
ITPSA	(2/7,1/3,2/5)	(1,1,1)	(1/2,1,3/2)	(5/2,3,7/2)	(5/2,3,7/2)	(9/2,5,11/2)	**0,18**
ITPPH	(2/11,1/5,2/9)	(2/3,1,2)	(1,1,1)	(3/2,2,5/2)	(5/2,3,7/2)	(9/2,5,11/2)	**0,19**
STW	(2/13,1/6,2/11)	(2/7,1/3,2/5)	(2/5,1/2,2/3)	(1,1,1)	(3/2,2,5/2)	(5/2,3,7/2)	**0,04**
SSIOL	(2/15,1/7,2/13)	(2/7,1/3,2/5)	(2/7,1/3,2/5)	(2/5,1/2,2/3)	(1,1,1)	(3/2,2,5/2)	**0,07**
SNR	(2/15,1/7,2/13)	(2/11,1/5,2/9)	(2/11,1/5,2/9)	(2/7,1/3,2/5)	(2/5,1/2,2/3)	(1,1,1)	**0,17**

Tableau 6 - The Fuzzy Evaluation Matrix of Risk area : Collection of revenues

Criteria	CF	ML	LHR	LMR	IG	LSC	W_C
CF	(1,1,1)	(3/2,2,5/2)	(9/2,5,11/2)	(13/2,7,15/2)	(15/2,8,17/2)	(17/2,9,19/2)	**0,49**
ML	(2/5,1/2,2/3)	(1,1,1)	(7/2,4,9/2)	(9/2,5,11/2)	(9/2,5,11/2)	(13/2,7,15/2)	**0,04**
LHR	(2/11,1/5,2/9)	(2/9,1/4,2/7)	(1,1,1)	(3/2,2,5/2)	(5/2,3,7/2)	(7/2,4,9/2)	**0,38**
LMR	(2/15,1/7,2/13)	(2/11,1/5,2/9)	(2/5,1/2,2/3)	(1,1,1)	(3/2,2,5/2)	(5/2,3,7/2)	**0,10**
IG	(2/17,1/8,2/15)	(2/11,1/5,2/9)	(2/7,1/3,2/5)	(2/5,1/2,2/3)	(1,1,1)	(3/2,2,5/2)	**0,00**
LSC	(2/19,1/9,2/17)	(2/15,1/7,2/13)	(2/9,1/4,2/7)	(2/7,1/3,2/5)	(2/5,1/2,2/3)	(1,1,1)	**0,00**

Tableau 7 - The Fuzzy Evaluation Matrix of Risk area : Community protection and Security.

Criteria	SN	SD	SC	TC	SG	SW	SP	IPT	ITD	SE
SN	(1,1,1)	(1/2,1,3/2)	(1/2,1,3/2)	(1/2,1,3/2)	(1/2,1,3/2)	(9/2,5,11/2)	(13/2,7,15/2)	(13/2,7,15/2)	(13/2,7,15/2)	(13/2,7,15/2)
SD	(2/3,1,2)	(1,1,1)	(1/2,1,3/2)	(1/2,1,3/2)	(1/2,1,3/2)	(9/2,5,11/2)	(13/2,7,15/2)	(13/2,7,15/2)	(13/2,7,15/2)	(13/2,7,15/2)
SC	(2/3,1,2)	(2/3,1,2)	(1,1,1)	(1/2,1,3/2)	(1/2,1,3/2)	(9/2,5,11/2)	(13/2,7,15/2)	(13/2,7,15/2)	(13/2,7,15/2)	(13/2,7,15/2)
TC	(2/3,1,2)	(2/3,1,2)	(2/3,1,2)	(1,1,1)	(1/2,1,3/2)	(9/2,5,11/2)	(13/2,7,15/2)	(13/2,7,15/2)	(13/2,7,15/2)	(13/2,7,15/2)
SG	(2/3,1,2)	(2/3,1,2)	(2/3,1,2)	(2/3,1,2)	(1,1,1)	(9/2,5,11/2)	(13/2,7,15/2)	(13/2,7,15/2)	(13/2,7,15/2)	(13/2,7,15/2)
SW	(2/11,1/5,2/9)	(2/11,1/5,2/9)	(2/11,1/5,2/9)	(2/11,1/5,2/9)	(2/11,1/5,2/9)	(1,1,1)	(3/2,2,5/2)	(7/2,4,9/2)	(9/2,5,11/2)	(9/2,5,11/2)
SP	(2/15,1/7,2/13)	(2/15,1/7,2/13)	(2/15,1/7,2/13)	(2/15,1/7,2/13)	(2/15,1/7,2/13)	(2/5,1/2,2/3)	(1,1,1)	(5/2,3,7/2)	(5/2,3,7/2)	(7/2,4,9/2)
IPT	(2/15,1/7,2/13)	(2/15,1/7,2/13)	(2/15,1/7,2/13)	(2/15,1/7,2/13)	(2/15,1/7,2/13)	(2/9,1/4,2/7)	(2/7,1/3,2/5)	(1,1,1)	(3/2,2,5/2)	(5/2,3,7/2)
ITD	(2/15,1/7,2/13)	(2/15,1/7,2/13)	(2/15,1/7,2/13)	(2/15,1/7,2/13)	(2/15,1/7,2/13)	(2/11,1/5,2/9)	(2/7,1/3,2/5)	(2/5,1/2,2/3)	(1,1,1)	(3/2,2,5/2)
SE	(2/15,1/7,2/13)	(2/15,1/7,2/13)	(2/15,1/7,2/13)	(2/15,1/7,2/13)	(2/15,1/7,2/13)	(2/11,1/5,2/9)	(2/9,1/4,2/7)	(2/7,1/3,2/5)	(2/5,1/2,2/3)	(1,1,1)

The weight vector from Table 6 is calculated as $\mathbf{W_A} = (\mathbf{0.16\ ,0.16,0.16,0.16,0.16,0.08,0.05,0.04,0.00,0.00})^T$

Tableau 8 - The Fuzzy Evaluation Matrix of Risk area : National Heritage.

Criteria	SCH	SAH	SACH	W_D
SCH	(1,1,1)	(1/2,1,3/2)	(5/2,3,7/2)	**0,58**
SAH	(2/3,1,2)	(1,1,1)	(3/2,2,5/2)	**0,42**
SACH	(2/7,1/3,2/5)	(2/5,1/2,2/3)	(1,1,1)	**0,00**

Tableau 9- The Fuzzy Evaluation Matrix of Risk area : Trade Facilitation.

Criteria	LCA	IP	ITF	W_E
LCA	(1,1,1)	(5/2,3,7/2)	(13/2,7,15/2)	**0,20**
IP	(2/7,1/3,2/5)	(1,1,1)	(9/2,5,11/2)	**0,11**
ITF	(2/15,1/7,2/13)	(2/11,1/5,2/9)	(1,1,1)	**0,69**

The Risk of each Risk area is assessed by considering its severity and frequency. These basic risk factors are expressed qualitatively and TFNs are used to define the qualitative scales before the estimated indices at the higher levels. The Risk weight or Risk index is evaluated through the Fuzzy method discussed in section 4. It provides a numerical value representing the risk level.

The result for the selected Risk scenario gives an effective Risk Prioritization in Moroccan Customs Supply Chain. According to the final score depicted in the Fig. 4 , the community protection and security is the most critical risk areas because it has a highest priority weight, and Smuggling of Narcotics, Smuggling of cigarettes, Smuggling of drugs, Trafficking in counterfeit /pirated goods, Smuggling of goods, Smuggling of weapons, Smuggling of precursors of drugs, Illicit traffic of Product not corresponding to the required technical standards, Illicit trade in dual-use goods and Smuggling of explosives are the most critical risks within Moroccan Customs Supply Chain which required a specific treatment. Such treatment is impacted by many different issues, including: internal capability; internal capacity; risk rating/level/ nature return of treatment, and financial, human and material resources allocated to addressing risk. And preservation of the natural resources and effective and efficient collection of revenue are the next recommended risk areas to give more importance in order to secure Moroccan Customs Supply Chain. All other risks under protection of the national heritage and trade facilitation must be dealt with by **scrutiny**, in order to keep precious time and efforts for potentially higher risks.

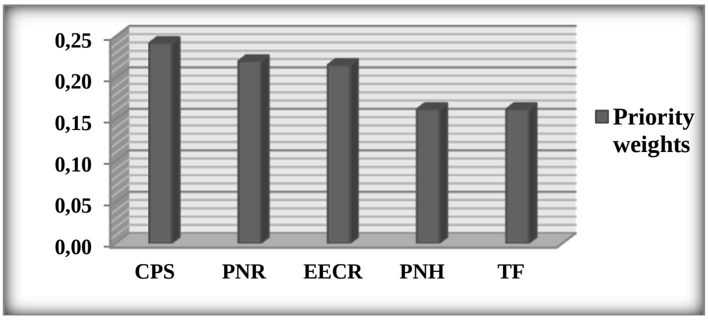

Figure 4 - Final priority weights of each Risk areas.

One main purpose of this research is to establish the Risk assessment model for prioritizing risks in Customs Supply chain. Such a quantified risk indicator will be useful to compare the risk level between the various stages of supply chain under different approach of Risk management and deriveclassification of Risks. A higher risk indicator corresponds to a more critical risk in the customs context, which requires a specific treatment and control process. Through the numerical analysis presented, the effectiveness of the proposed model is established. The development of such an assessment model assists in the determination of procedures and main points where efforts and resources have to be concentrated. It helps to answer questions such as, where future compliance resources should be directed ? which goods and means of transport should be examined? to what extend?. In addition, it furnishes a way to ensure that the relevant risk has been effectively quantified, to avoid the uncertainties or the introduction of extraneous variables into the decision making process.

CONCLUSION

In this paper a Risk analysis model is developed enabling a structured assessment and an effective prioritization of Risks in the Moroccan Customs Supply chain. A hierarchical structure model was developed addressing diverse Risk scenarios associated in different stages of Customs Supply Chain. The quantitative scales were expressed by TFNs to capture the vagueness in the linguistic subjectivity of risk parameters. Fuzzy Extended AHP is used to quantify the Risk indicator. Numerical analysis was discussed to demonstrate how the proposed model works. The relative weight of each risk gives an indicator to measuring the risk in customs context and helps to identify key critical risks that highlight the vulnerability of Moroccan customs supply chain. The Results could be used to support the decision-making process especially in the implementation of measures necessary to treat this vulnerability.

The FEAHP methodology presented here would be applied for analyzing, specification, and evaluation of risks in CSC as well as for solving uncertainty and qualitative aspect of criteria. By means of the modeling capabilities and formulating hierarchy, it would potentially play a significant role in Risk assessment and analysis. The FEAHP model discussed in this paper is proved to be simple, less time taking and having less computational expense as compared to other existing decision making systems to assess risk. The use of FEAHP model does not involve cumbersome mathematical operation, and it is tractable enough to capture the vagueness of uncertainty and vulnerability within the customs supply chain, as well as to provide the efficiency and flexibility to tap the subjectivity and preferences of decision makers. Despite the benefits of the proposed model for prioritizing risks in customs context, there are some limitations and weaknesses of the model. the criteria used to assess risk can be extended to add more criteria like the degree of risk-control, since the level of risk is a function of the criticality and the level of mastery. In addition, users have to make subjective decisions when conducting pair-wise comparisons to obtain weights for Risk areas and Risks. Infact, the functionality of the model is highly dependent on the knowledge, expertise and communication skills of assessors. The assessment results are most comparable when the same assessment team performs all the assessments. Finally, our future research consist of the development of a model of risks in the customs supply chain. This proposal will serve as a basis for developing a solution for decision support in customs supply chain.

ACKNOWLEDGEMENT

The Moroccan Customs Administration and SCAC «Service de Cooperation et d'Action Culturelle», France, support this work.

REFERENCES

Autry, C.W, Bobbitt, L. M., 2008, "Supply chain security orientation: conceptual development and a proposed framework", The International Journal of Logistics Management, Vol. 19 Iss: 1, pp.42 – 64.

Chan, F.T.S., kumar, N., 2007, "Global supplier development considering risk factors using fuzzy extended AHP-based approach", Omega The International Journal of Management Science, Vol.35, No.4, pp. 417-431.

Chang, D.Y., 1996, "Applications of the extent analysis method on fuzzy AHP", European Journal of Operational Research, Vol .95, pp. 49–55.

Cheng, C. H.,1999, "Evaluating weapon systems using ranking fuzzy numbers", Fuzzy Sets and Systems, Vol. 107, pp. 25–35.

Demirel, T., Demirel, N., Kahraman, C., 2008, "Fuzzy analytic hierarchy process and its application", Springer Science and Business Media, LLC, pp. 53-83.

Huang. C., Chu. P., Chiang. Y., 2006, "A Fuzzy AHP application in government-sponsored R&D project selection", Omega The International Journal of Management Science, pp.1041.

Hugos, M., 2003,"Essentials of supply chain Management",s.l. John Wiley & Sons Inc, Hoboken, New Jersey, pp. 23.

Lee, A. H. I., Kang, H. Y., & Wang, W. P. (2006). Analysis of priority mix planning for semiconductor fabrication under uncertainty. International Journal of Advanced Manufacturing Technology, Vol :28. P : 351–361.

Lee, H.I., 2009, "A Fuzzy suppliers selection model with the consideration of of benefits, opportunities, costs and risks", Expert Systems with Applications, Vol. 36, pp. 2879-2993.

Neiger, D., Botaru, K., Churilov, L., 2009, "Supply chain risk identification with value-focused process engineering". Journal of Operations Management, Vol.27, No. 2, pp.154–168.

Report of World Customs Organization WCO, 2003, "Risk Management in Customs Context", Vol .1, pp. 3-54.

Saaty, T.L., 1980, "The Analytic Hierarchy Process", Mc Graw-Hill, New York.

Singh, R.K., 2013,"Prioritizing the factors for coordinated supply chain using analytic hierarchy process (AHP)", Measuring Business Excellence, Vol. 17, Iss 1, pp. 80 – 97.

Tang, C.S.,2006, "Perspectives in supply chain risk management", International Journal of Production Economics, Vol. 2, pp . 451- 488.

Wang, C., Yee, D.R.,2012, "A two-stage fuzzy-AHP model for risk assessment of implementing green initiatives in the fashion supply chain", International Journal of Production Economics, Vol .35(2), pp .595– 606.

Widdoson, D.,2004,"Managing Risk in the Customs Context", Luc De Wolf & Jose B Sokol (eds) Customs Modernization Handbook, World Bank, Washington DC, pp.91-99.

Zahedi, F.,1986, "The AHP: a survey of the method and its applications", Interfaces, Vol. 16, pp. 96-108.

Zadeh, LA., 1965, "Fuzzy sets", Information and Control, Vol.8, pp. 338–53

RESPONSIBILITY NOTICE

The authors are the only responsible for the material included in this paper.