An AHP Model towards an Agile Enterprise

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***Abstract*—Companies are facing different challenges in order to adapt to their environmental context. They should be aware of the changes on the social, political, ecological and economical levels. Moreover, they should act in an efficient and rapid manner by leveraging new and reconfigurable resources. Organizational agility is the firm's key dynamic capability which enables it to deal with changes and exploit them as opportunities. Firms' objective is thus to attain a higher degree of agility which can help them to perform durably. In this article, a new model based on analytical hierarchy process (AHP) method is proposed. This can help companies to raise their agility level by deploying the most suitable agility enablers which can be either general or specific when related to information technologies. They can thus develop the most appropriate strategy towards agility regarding their internal and external contexts.**

***Keywords*—Organizational agility; analytical hierarchy process; information technology; agility enablers**

I. Introduction

The international context of companies is characterized by increased competition due to globalization, free trade and low cost labor in Asian and other emerging countries.

In addition, the local environment for companies is rapidly changing as countries are adopting new laws regularly, adapting their monetary/fiscal policies and facing social challenges.

Companies should in this rapidly changing environment, adapt their strategies regularly in order to manage risks and to create a competitive advantage.

They should thus be agile regarding their current and future environmental challenges.

Organizational agility is the firm's dynamic capability which allows it to combine the features of chaos and flexibility with a minimum of order, control, and predictability [1], [2].

It is the ability of the firm to sense changes in its environment and to respond in an adequate and rapid manner [3], [4].

The aim of companies is to enhance their agility's level continuously. They should be able to detect key levers and develop thus a strategy towards agility.

In this paper, a new model based on multi criteria method (AHP) is proposed. It allows the company to define a global strategy by leveraging agility's enablers based on their weights. Then, the IT levers of agility are highlighted. The company can activate them and integrate them into its IT strategy in order to be more agile. The presented model is original as previous works have proposed methods in order to assess firm's agility without proposing a detailed strategy for improvement [5].

The structure of this work is organized as follow. Section II is dedicated to the definition of AHP method, its advantages and main applications. In Section III, the organizational agility concept is defined. Then, the adopted methodology and the AHP model are described. Section IV allows illustrating the application of the proposed model. It presents the global and IT specific methods for enhancing enterprise agility. Finally, Section V provides a brief conclusion of this article and the future research perspectives.

II. AHP

A. Definition

AHP is a multi-criteria approach for decision making based on the definition of a goal as a top priority and on a decision hierarchy from the highest to the lowest criteria in term of importance [6].

AHP starts from the judgments of decision makers to form a decomposition of problems into hierarchies. The problem complexity is represented by the number of levels in the hierarchy which combine with the decision maker's model of the problem to be solved.

Decision making process through AHP requires two phases: design and evaluation.

Design, as described earlier, is reaching a consensus about the hierarchy model.

Evaluation is based on pair wise comparison. The criterions on the same level of the hierarchy are compared with each others, and with other elements on the level above [7].

The pair wise comparison is accomplished thanks to the use of a square matrix. As in (1), the rows and columns represent the criterions which are compared and the entries of each cell of the matrix represent the weight of an element of the matrix when compared to another element.

$$A = \begin{bmatrix} a11 & \cdots & a1n \\ \vdots & \ddots & \vdots \\ an1 & \cdots & ann \end{bmatrix} = \begin{bmatrix} 1 & \cdots & w1/wn \\ \vdots & \ddots & \vdots \\ wn/w1 & \cdots & 1 \end{bmatrix} \quad (1)$$

Where, aij = wi/wj and aij represents the importance of the weight wi over wj.

The matrix A has positive entries everywhere and satisfies the reciprocal property aji = 1/aij. This kind of matrix with this property is called a reciprocal matrix.

Saaty, 1977 proposed a hierarchical decomposition in which the elements are grouped in classes of about 7 elements each, in order to limit the number of comparisons required and to minimize the number of errors that could arise. Thus, a 1-9 scale is used in order to assign weights to each criterion (Table 1). In the case of this article, a linear scale is used [8]-[10].

There are other scales for comparisons in the literature [10]- [17] (Table 2).

TABLE I. THE LINEAR SCALE FOR COMPARISONS (SAATY, 1977) [10]

Intensity of importance	**Description**
1	Equal Importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Intermediate values
Reciprocals	Values for inverse comparison

TABLE II. THE DIFFERENT SCALES FOR COMPARISONS (ISHIZAKA & LABIB, 2009) [10]

Scale Type	**Values**								
Linear (Saaty 1977) [10]	1	2	3	4	5	6	7	8	9
Power (Harker and Vargas 1987) [12]	1	4	9	16	25	36	49	64	81
Geometric (Lootsma 1989) [13]	1	2	4	8	16	32	64	128	256
Logarithmic (Ishizaka, Balkenborg et al. 2006) [14]	1	1.58	2	2.32	2.58	2.81	3	3.17	3.32
Root square (Harker and Vargas 1987) [12]	1	1.41	1.73	2	2.23	2.45	2.65	2.83	3
Asymptotical (Dodd and Donegan 1995) [15]	0	0.12	0.24	0.36	0.46	0.55	0.63	0.70	0.76
Inverse linear (Ma and Zheng 1991) [16]	1	1.13	1.29	1.5	1.8	2.25	3	4.5	9
Balanced (Salo and Hamalainen 1997) [17]	1	1.22	1.5	1.86	2.33	3	4	5.67	9

The Eigenvalue method is used in order to derive priorities among criterions/sub-criterions. Thus, priorities' vector is the principal eigenvector of the matrix. It is a vector ω of order n such that $A\omega = \lambda\omega$. For such a matrix, ω is said to be an eigenvector and λ is an eigenvalue [18].

The largest eigenvalue λmax of the comparison matrix is used to calculate the consistency index. The difference between λmax and n is an indication of the inconsistency of the judgments. The consistency index (CI) can be calculated using (2) [19].

$$CI = (\lambda max - n)/ (n-1) \quad (2)$$

Then, the consistency ratio (CR) is calculated by dividing the consistency index (CI) and the random index (RI) (3).

$$CR = \frac{CI}{RI} \quad (3)$$

Saaty, 1980 describes average RI values of randomly generated matrices of different sizes.

Moreover, he suggests that if the consistency ratio (CR) exceeds 0.1, the set of judgments may be too inconsistent to be reliable. In practice, CRs of more than 0.1 have to be sometimes accepted [20].

Finally, the global priority is obtained by multiplying the priorities values of the criterions/sub-criterions across the hierarchy.

B. Advantages and Applications

AHP is an intuitive and flexible method. It allows, in addition, checking the inconsistencies in judgments [21].

It has applications in several domains. For example, in operations management, AHP can be used for "make or buy" decisions, project risk analysis [22], supplier selection [23] and strategic solutions for alternate energy/emissions management [24].

In addition, AHP can be used in software selection based on technical and managerial considerations [25].

Wei et al., 2005 proposed an AHP-based approach to select the most suitable ERP system which allows the company to enhance its performance and competitiveness [26].

Other applications proposed by Melvin, 2012 are related to choosing among different strategies for improving safety features in motor vehicles or for evaluating the quality of research and investment proposals [27].

III. PROPOSITION OF AN AHP MODEL FOR AN AGILE ENTERPRISE

A. Organizational Agility

The history of agility began in the USA in order to help the American industry to regain the leading position which was lost during the 70s and 80s in favor of Japanese and European industries.

Organizational agility is the capacity of a company to adapt itself to the changes in its environment and to exploit it as opportunities of development and growth through fast and innovative responses [28].

Organizational agility enables firms, by sensing changes in the environment, to prioritize and choose the best solution among the possible alternatives, to reconfigure business processes and to customize real-time response [29].

There are two main distinct components of agility: 1) sensing; and 2) responding.

Sensing is related to scanning the environment through exploring and incorporating new knowledge [30].

The second component refers to responding to changing market conditions in a reactive or proactive manner [31].

These sensing and responding components should be aligned in order to maximize the impact of agility on firm's performance [32].

B. The Methodology

Fig. 1 below describes the methodology adopted for this study. First, the AHP hierarchy is defined by setting the goal, the criterions and sub-criterions.

Then, based on pair wise comparisons, the weights of each criterion and sub-criterion are calculated.

Finally, a threshold is fixed which and allows selecting the general agility's levers and the specific IT levers of agility.

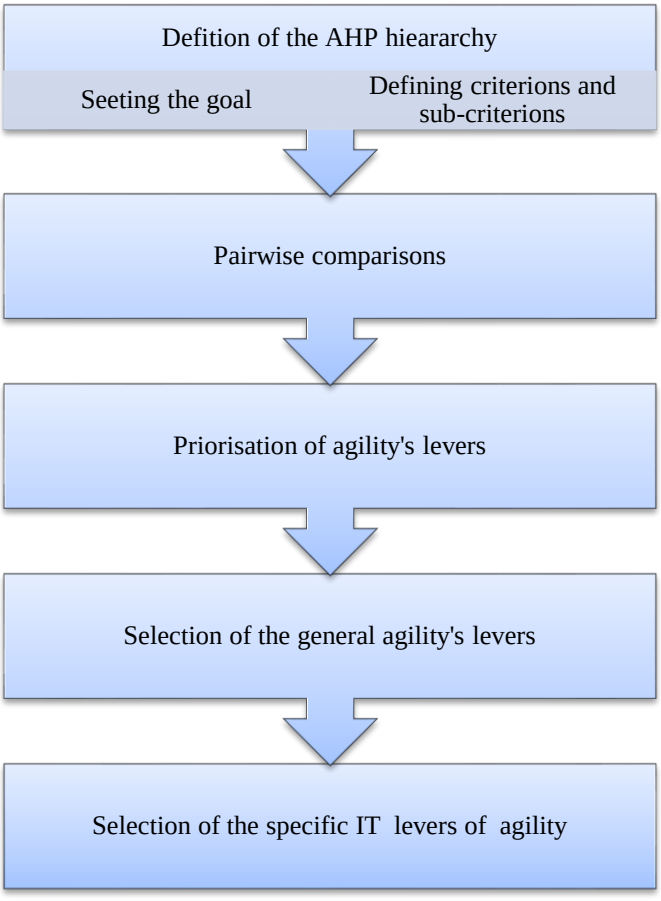

Fig. 1. The adopted methodology.

C. AHP Model proposition

The proposed model has three levels (Table 3):

- The goal is to achieve the firm's agility.
- The criterions and sub-criterions include the main agility enablers. They belong to six groups: IT, human resources, process, knowledge management, organizational structure and innovation [33].

TABLE III. THE PROPOSED HIERARCHY

Level (0) Goal	**Level (1) Criterion**	**Level (2) Sub-criterion**
Agile enterprise	IT	IT resources
		IT skills
		IT acceptance
		IT innovation
		Knowledge management systems
	Human resources	Mindset
		Behavior
		Planning
		Training
		Evaluation
		Motivation
	Process	Flexible process
		Efficient decision making
	Knowledge management	Capitalizing knowledge
		Balance in managing knowledge and change
		Learning organization
	Organizational structure	Adaptable structure
		Independent/multidisciplinary business units
		Self-organization
	Innovation	Introduction of new products
		Entering new markets

IV. ILLUSTRATION : PRACTICAL APPLICATION OF THE MODEL FOR THE DEFINITION OF A GLOBAL AND IT STRATEGY TOWARDS AGILITY

The purpose of the proposed model is to allow companies to prioritize the most relevant attributes enabling them to be more agile.

The global approach is based on the by classification of the sub-criterions related to six enablers groups: IT, HR, process, knowledge management, organizational structure and innovation. Then, a specific approach related to IT is proposed.

The data is used below for illustration purposes of the proposed model.

The PriEST software, which is an open-source priority estimation tool developed by Sajid Siraj is adopted [34].

A. Pairwise Comparisons

First, a first pair wise comparison of the six criterions of level (1) is made.

Fig. 2 below presents a graph view of this pair wise comparison using the PriEsT tool (CR=2,5%<0,1).

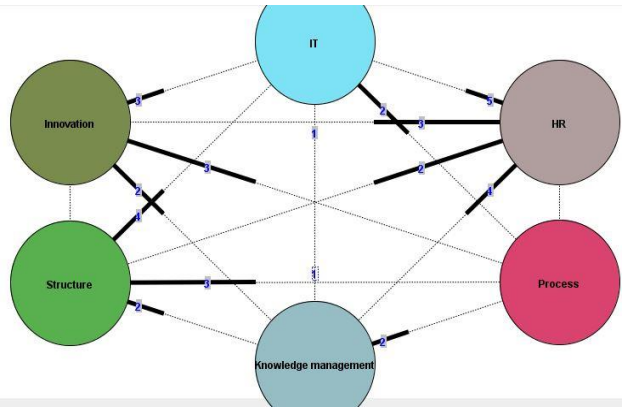

Fig. 2. Graph view of pair wise comparison between the six criterions.

B. Prioritization of Agility's Levers

Then, a pair wise comparison between sub-criterions of level (2) is performed (CR=7,7%<0,1).

This allows calculating the priorities (column on the right) among agility's levers using the BPMSG AHP Online System which apply the eigenvector method [35] (Fig. 3).

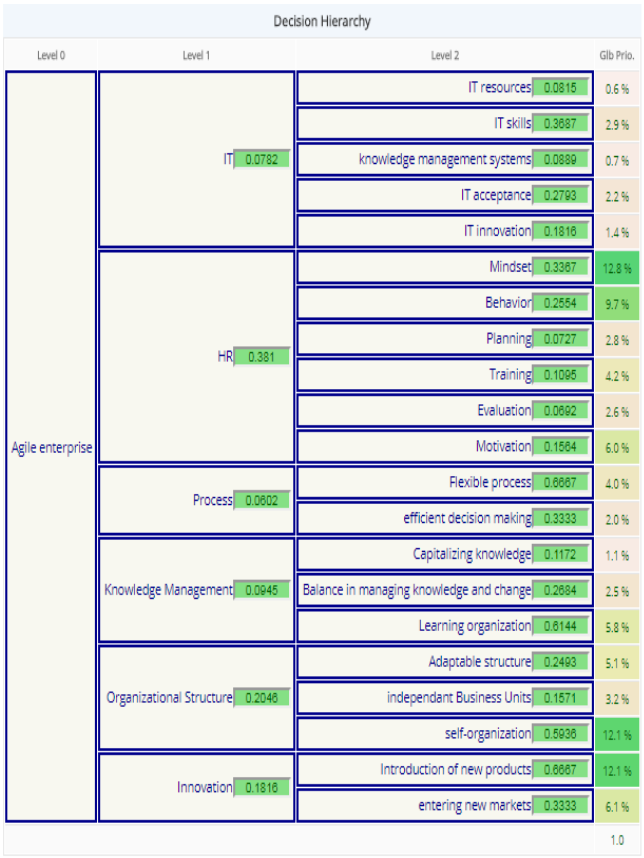

Fig. 3. Prioritization of agility's levers.

C. Global Approach towards Agility

In order to select the most influencing levers on which the company should focus, a threshold is calculated as (4):

$$\text{Threshold} = 1/NB(\text{agility's levers}) \quad (4)$$

As presented in Table 4 below, the agility's levers with a priority which is higher or equal to the previous threshold are selected.

In this example, Threshold = 1/19 = 0,047619.

TABLE IV. SELECTION OF THE MOST INFLUENCING AGILITY ENABLERS

Agility's enablers	Priority	Selected agility's enabler
IT resources	0,006368	No
IT skills	0,028816	No
knowledge management systems	0,006946	No
IT acceptance	0,021835	No
IT innovation	0,014198	No
Mindset	***0,128275***	***Yes***
Behavior	***0,097312***	***Yes***
Planning	0,027706	No
Training	0,041726	No
Evaluation	0,026379	No
Motivation	*0,059589*	*Yes*
Flexible process	0,040139	No
efficient decision making	0,020069	No
Capitalizing knowledge	0,011075	No
Balance in managing knowledge and change	0,025359	No
Learning organization	***0,05805***	***Yes***
Adaptable structure	***0,051008***	***Yes***
Independent Business Units	0,032131	No
self-organization	***0,121451***	***Yes***
Introduction of new products	***0,121045***	***Yes***
entering new markets	***0,060522***	***Yes***

In conclusion, in order to enhance its agility, the focus should be in this example on employee's mindset, their behavior, their motivation, on having an adaptable/ learning and self-organized structure, and on innovation (introduction of new products, entering new markets).

D. The IT Specific Approach towards Agility

In the rest of this article, the agility's levers related to information technology (IT) are highlighted.

A third level is then added to the AHP model (Table 5 below).

TABLE V. THE EXTENDED HIERARCHY RELATED TO IT LEVERS OF AGILITY

Level (0) Goal	Level (1) Criterion	Level (2) Sub-criterion	Level (3) Sub-criterion
Agile enterprise	IT	IT resources	IT architecture(SOA)
			Cloud computing
			Interoperability
		IT skills	Mastering IT resources
			Use of HRIS
		IT acceptance	Perceived ease of use of IT
			Usefulness of IT
		IT innovation	3D printing
			Robotics
			RFID
			IoT
			Mobile
		Knowledge management systems	Use of groupware and workflow Tools
			Use of Intranet/extranet
			Use of DMS
			Use of CMS
			Decision support systems
			Big data analytics
			Manage knowledge using AI

Then, a pair wise comparison allows prioritizing the IT levers of agility based on their weights (the column on the right in Fig. 4 below) (CR=6,6%<0,1).

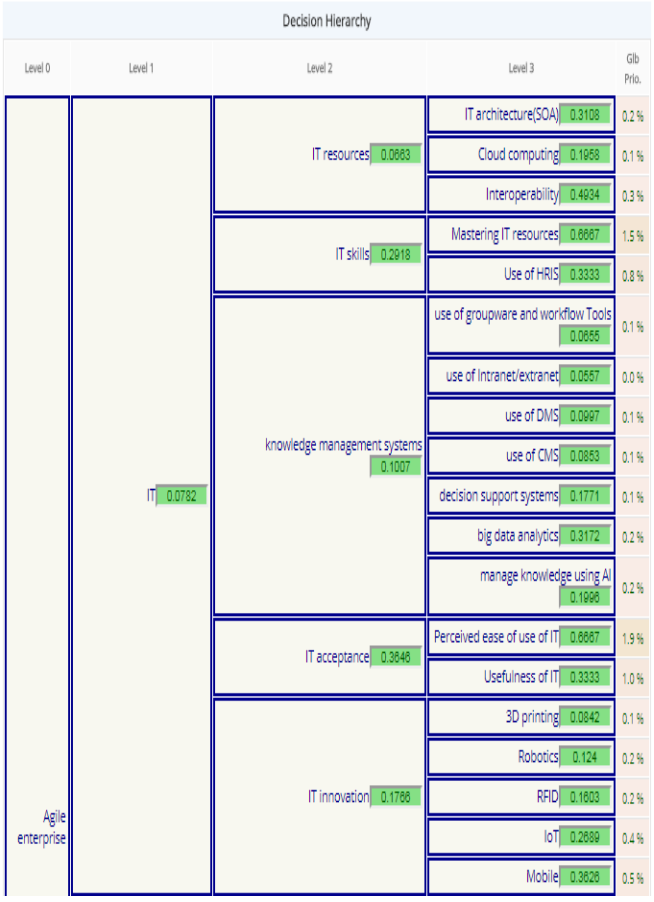

Fig. 4. Prioritization of IT levers of agility.

An IT threshold is calculated as the mean of the IT agility levers priorities (5).

In this example,

IT Threshold =∑ IT levers of agility priorities/19 (5)

IT Threshold = 0,004113

Then, the most influencing IT levers of agility are selected (Table 6 below).

TABLE VI. SELECTION OF THE MOST INFLUENCING IT LEVERS OF AGILITY

IT levers of agility	Priority	Selected IT levers of agility
IT architecture(SOA)	0,00161	No
Cloud computing	0,001014	No
Interoperability	0,002556	No
Mastering IT resources	***0,015204***	***Yes***
Use of HRIS	***0,007602***	***Yes***
use of groupware and workflow Tools	0,000515	No
use of Intranet/extranet	0,000438	No
use of DMS	0,000785	No
use of CMS	0,000671	No
decision support systems	0,001394	No
Big data analytics	0,002496	No
Manage knowledge using AI	0,001571	No
Perceived ease of use of IT	***0,019001***	***Yes***
Usefulness of IT	***0,0095***	***Yes***
3D printing	0,001162	No
Robotics	0,001712	No
RFID	0,002213	No
IoT	0,003712	No
Mobile	***0,005006***	***Yes***

In this example, company should focus on using mobile, on IT acceptance (Usefulness and perceived ease of use of IT), and developing IT skills (mastering IT resources and using HRIS) among employees.

V. CONCLUSION AND FUTURE PERSPECTIVES

The current article has allowed the proposition of a new model based on the AHP method. It may help companies to enhance their agility's level by selecting the most appropriate enablers regarding their context.

It can be improved and adapted to the company's internal and external environment. Thus, criterions and sub-criterions may be added or removed according to the company's resources or activity sector.

Future research will focus on the application of the model in a real case through an action research methodology aggregating the pair wise comparisons across company's experts by using an appropriate survey.

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