IMPROVEMENT OF THE SUBJECTIVITY OF THE AHP METHOD IN THE TEXTILE SECTOR IN MOROCCO

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ABSTRACT
This present piece of work attempts to remedy the subjectivity problem of the AHP method, by combining it with the entropy method In Moroccan Textile Sector. The study is done in two steps; first, we make a literature review of AHP, Entropy and combined AHP entropy method. Then the weight of all appropriate key performance indicators (AKPI), are calculated by combined AHP-Entropy method to release a formula for calculating the overall performance. Finally, the findings of this work show that Moroccan suppliers consider the efficiency of the production system and price subcontractor as the priority.

Keywords: AHP, entropy, global performance formula, appropriate key performance indicators, Moroccan textile industry.

INTRODUCTION
Given the importance of reducing the subjectivity of the AHP method because it depends mainly on the judgment of the experts, and the reality of the inadequacy of the utilization of a solitary method (Yi-Peng LI, 2017), The use of the combined AHP-Entropy method, gives more efficient results, and reduce the subjectivity of the AHP method through the calculation of the subjective weight of the AHP method and the objective weight of the entropy method then the calculation of weight of combined AHP-Entropy method finally. The combination of the two methods coordinates the weaknesses of each strategy, the benefits of both, and gives better results (Ghunem et al., 2011).

We will see through this research how we can reduce the subjectivity of the AHP method for the selection of suppliers in the textile sector in Morocco.

METHODOLOGY
The following methodology was carried out to achieve the objective of this research: First the method of Hierarchy analytical process was presented with its steps. Then the entropy method is presented and its steps. Moreover the problem of the subjectivity of the AHP is explained. In addition, we explain how to reduce the subjectivity of the AHP method by combining it with entropy, while giving examples of the authors who used the same method and our contribution in this article of research in the textile sector in Morocco.

Furthermore, in case study: The weight of all Appropriate Key performance Indicators (AKPI) for all textile sector in Morocco, will be calculated by combined AHP-entropy method and the graph of (AKPI) weight’s obtained by the combined AHP-Entropy method is analyzed, shows that the best of (AKPI) weight’s. in addition The formula of (GP) overall performance is expressed by the weights of combined AHP-Entropy of the AKPI, helping that the companies to select the best supplier in textile sector in Morocco.

Finally, in the section: Discussion, through this article, we will show the effectiveness of the method for the case studied and we will discuss the strengths and weaknesses of the combined AHP-entropy method.

RESULTS
Analytical hierarchy process
In a variety of areas, companies face difficulties in making accurate decisions, Thus the AHP has been used, and still is, for this reason (Chen, 1992). The choice and comparison of criteria differs from one area to another: each company chooses the criteria according to its specialty, and the final phase of the AHP method concerns the selection of the best criteria that will be taken into account (Taylor, 2004), (Zhang, 2010). Whether the solution comes from a qualitative or quantitative problem, the AHP method is used in more than 2000 applications in scientific research (Subramanian and Ramanathan, 2012). Usually, scale used for AHP is from 1 to 9 to reflect the importance of one factor over another.
The judgment matrix $A$ which contains pair wise comparison matrix value $a_{ij}$ for all $i, j \in \{1, 2, \ldots, n\}$

\[
A = \begin{bmatrix}
a_{11} & a_{12} & \cdots & a_{1n} \\
a_{21} & a_{22} & \cdots & a_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
a_{n1} & a_{n2} & \cdots & a_{nn}
\end{bmatrix}
\]  

(1)

A. Normalize each column to get a new judgment matrix $A'$ where $\sum_{i=1}^{n} a_{ij}$ is the sum of column $j$ of judgment matrix $A$.

\[
A' = \begin{bmatrix}
a'_{11} & a'_{12} & \cdots & a'_{1n} \\
a'_{21} & a'_{22} & \cdots & a'_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
a'_{n1} & a'_{n2} & \cdots & a'_{nn}
\end{bmatrix}
\]  

(2)

B. Sum up each row of normalized judgment matrix $A'$ to get weight vector $V$

\[
\begin{align*}
v_1 &= \sum_{j=1}^{n} a_{1j} \\
v_2 &= \sum_{j=1}^{n} a_{2j} \\
\vdots \\
v_n &= \sum_{j=1}^{n} a_{nj}
\end{align*}
\]  

(3)

C. Define the final normalization weight vector.

\[
\begin{align*}
w_1 &= v_1 / \sum_{i=1}^{n} v_i \\
w_2 &= v_2 / \sum_{i=1}^{n} v_i \\
\vdots \\
w_n &= v_n / \sum_{i=1}^{n} v_i
\end{align*}
\]  

(4)

### Entropy

Entropy was first used in thermodynamics to calculate the reversibility of a system (Mon et al., 1994), then there was the appearance of the entropy of Shannon to calculate the degree of disorder of a system (Shannon, 1948). Shannon entropy’s is essential for many logistic chains and domains, as the measure of disorder in them makes it possible to know if they need a study or a change to reduce their rate of disorder, moreover the entropy of the information makes it possible to define also whether the data grant an effective information or not (Liu and Cui, 2008). In addition, the weight of the criteria by the entropy method is given by the following steps, (Li et al., 2011):

Firstly it is assumed that there is a set of $m$ feasible alternatives, $Ai$ ($i = 1, 2, \ldots, m$) and $n$ evaluation criteria $Cj$ ($j = 1, 2, \ldots, n$) in the problem.

a) The decision matrix which shows the performance of different alternatives $A(i=1,2,\ldots,m)$ and respect to various criteria $C(j=1,2,\ldots,n)$ is formed.
b) The decision matrix is normalized

Beneficial (maximization) and non-beneficial (minimization) are normalized by (eq.5 and eq.6) respectively.

\[
\begin{align*}
    r_{ij} &= \frac{X_{ij} - \min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})} & \text{for } i = 1, 2, \ldots, m \text{ and } j = 1, 2, \ldots, n \\
    r_{ij} &= \frac{\max(X_{ij}) - X_{ij}}{\max(X_{ij}) - \min(X_{ij})} & \text{for } i = 1, 2, \ldots, m \text{ and } j = 1, 2, \ldots, n
\end{align*}
\]  

(5)

(6)

c) Entropy values (e_j) are determined for each criterion:

\[
    f_{ij} = \frac{r_{ij}}{\sum_{m} r_{ij}} \quad \text{and} \quad 0 < e_j < 1 
\]  

(7)

And

\[
    e_j = -\frac{\sum_{i=1}^{m} f_{ij} \ln f_{ij}}{\ln m} \quad (8)
\]

If \( f_{ij} \) are all the same then the entropy values of each criterion is the maximum (e_j=1). If \( f_{ij} = 0 \), then \( f_{ij} \ln f_{ij} = 0 \) (Wu et al., 2011).

d) Entropy weights (W_j) are calculated:

\[
    W_j = \frac{1 - e_j}{n - \sum_{j=1}^{m} e_j} \quad \text{where} \sum_{j=1}^{n} W_j = 1
\]  

(9)

Problem of the subjectivity of the AHP method

The AHP method provides subjective data that is caused by the variation of judgment from one decision maker to another (De Felice et al., 2015). Since it contains a strong subjectivity that depends on the judgment of the experts, the AHP method requires an objective correction of the weight obtained (Su et al., 2016).

Reducing the subjectivity of the AHP method by combining it with entropy

The objective weight is calculated by the entropy method, it can also be used with other Multi Criteria Decision Making (MCDM) methods such as AHP to calculate the combined weight (Ishak et al., 2016).

The objective weight is determined by the entropy of Shannon (Zou et al., 2006). The Entropy method is an objective weighting method, which provides an objective weight. AHP is a subjective weighting method thus providing a subjective weight. The combination of the two methods is thus to achieve a certain unity between objectivity and subjectivity, to remedy the problem of subjectivity, and to make the weight obtained more reasonable and dependable (Chuansheng et al., 2012). To remedy the problem of the subjectivity of the AHP method, different researches combined the AHP methods with the entropy method are represented in this table:

<table>
<thead>
<tr>
<th>Author</th>
<th>Research</th>
<th>Concept-case study</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Hamidi et al., 2015)</td>
<td>Hamidi et al. use the combined AHP-Entropy method to evaluate the weight of important criteria that affect the selection of the best brands in Iran's beverage industries (Hamidi et al., 2015)</td>
<td>Beverage industries in Iran</td>
</tr>
<tr>
<td>(Luo et al., 2009)</td>
<td>To protect land in China against the expansion of industrialization and urbanization, Luo et al. use the combined AHP-Entropy method to assess a more objective weight of indicators that have an effect on intensive land use in districts, counties and other provinces of China (Luo et al., 2009)</td>
<td>Districts, counties province sector in China</td>
</tr>
<tr>
<td>(Chuansheng et al., 2012)</td>
<td>Chuansheng et al. use the combined AHP-entropy method to calculate the weight of criteria impacting the measure of the safety level of smart grids in four regions of China (Chuansheng et al., 2012)</td>
<td>Electricity sector in China</td>
</tr>
<tr>
<td>(Li and Zhang, 2017)</td>
<td>Li and Zhang use combined AHP-Entropy method to calculate the criterion that have the great impact on road traffic capacity, especially with the presence of traffic congestion problem caused mainly to the development of cities in China (Li and Zhang, 2017)</td>
<td>Road traffic in China</td>
</tr>
</tbody>
</table>

From what precedes, we propose the use of the combined AHP-Entropy method in the Moroccan context, for the improvement of the decision support for the
objective choice of the suppliers of the Moroccan textile sector, where this method is never used.

Combined AHP-Entropy weights

After calculating weight by AHP method and then entropy is applied to derive a set of objective criteria weights. The final set of criteria weights is determined from both objective and subjective weights (Feng & Chen, 1992) as follows:

$$W = \frac{\sum_{i,j=1}^{m} W_i W_j}{m} \text{ and } i, j = 1, 2, \ldots, m$$ (10)

Case study

In his research (Hlyal et al., 2015) developed a model for Performance measurement system by using Performance Measurement Questionnaire (PMQ), AKPI and AHP method to obtain a global formula. This following table shows, identification of AKPI for each KSF (key success factors) of Moroccan textile suppliers:

Table-3. Identification of AKPI for each KSF of Moroccan textile suppliers (Hlyal et al., 2015).

<table>
<thead>
<tr>
<th>KSF</th>
<th>AKPI</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>Price subcontractor (Pr)</td>
<td>Price of all or part of the subcontracted product</td>
</tr>
<tr>
<td>Quality</td>
<td>Rate of non compliance (Rc)</td>
<td>Number of non-compliant section divided by the total quantity delivered over a period</td>
</tr>
<tr>
<td>Logistics efficiency</td>
<td>Cycle time (Ct)</td>
<td>Delivery Date-date of order</td>
</tr>
<tr>
<td>Production</td>
<td>Production capacity (Pc)</td>
<td>Production capacity over a period representative</td>
</tr>
<tr>
<td>Social climate</td>
<td>Turn over (To)</td>
<td>((Number of recruited+ number of departures)/2)/actual</td>
</tr>
<tr>
<td>Versatility</td>
<td>Versatility (Vr)</td>
<td>Number of versatile employee / staff</td>
</tr>
</tbody>
</table>

The calcul of weights using AHP-method

The pair wise comparison matrix is in this Table:

Table-4. The pair wise comparison matrix (Hlyal et al., 2015).

<table>
<thead>
<tr>
<th></th>
<th>Pr</th>
<th>Rc</th>
<th>Ct</th>
<th>Pc</th>
<th>To</th>
<th>Vr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pr</td>
<td>1</td>
<td>1/4</td>
<td>5/7</td>
<td>1</td>
<td>1/9</td>
<td>2</td>
</tr>
<tr>
<td>Rc</td>
<td>1/4</td>
<td>1</td>
<td>1/4</td>
<td>6/7</td>
<td>3/4</td>
<td>1/2</td>
</tr>
<tr>
<td>Ct</td>
<td>5/7</td>
<td>1/4</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Pc</td>
<td>1/1</td>
<td>1/4</td>
<td>1/6</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>To</td>
<td>1/9</td>
<td>1/7</td>
<td>1/3</td>
<td>5/1</td>
<td>1</td>
<td>1/2</td>
</tr>
<tr>
<td>Vr</td>
<td>1/2</td>
<td>2</td>
<td>1/3</td>
<td>1/4</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

using the equation (2) we obtain the following matrix:

Table-5. Pair wise comparison matrix is normalized by AHP method (Hlyal et al., 2015).

<table>
<thead>
<tr>
<th></th>
<th>Pr</th>
<th>Rc</th>
<th>Ct</th>
<th>Pc</th>
<th>To</th>
<th>Vr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pr</td>
<td>0.45</td>
<td>0.35</td>
<td>0.67</td>
<td>0.43</td>
<td>0.33</td>
<td>0.18</td>
</tr>
<tr>
<td>Rc</td>
<td>0.11</td>
<td>0.09</td>
<td>0.03</td>
<td>0.36</td>
<td>0.26</td>
<td>0.05</td>
</tr>
<tr>
<td>Ct</td>
<td>0.09</td>
<td>0.35</td>
<td>0.13</td>
<td>0.12</td>
<td>0.11</td>
<td>0.27</td>
</tr>
<tr>
<td>Pc</td>
<td>0.06</td>
<td>0.01</td>
<td>0.07</td>
<td>0.06</td>
<td>0.19</td>
<td>0.36</td>
</tr>
<tr>
<td>To</td>
<td>0.05</td>
<td>0.01</td>
<td>0.04</td>
<td>0.01</td>
<td>0.04</td>
<td>0.05</td>
</tr>
<tr>
<td>Vr</td>
<td>0.23</td>
<td>0.18</td>
<td>0.04</td>
<td>0.02</td>
<td>0.07</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Using the equations (3) and (4) we get the weights of AKPI by the AHP method:

Table-6. Weight of AKPI by AHP method (Hlyal et al., 2015).

<table>
<thead>
<tr>
<th></th>
<th>Pr</th>
<th>Rc</th>
<th>Ct</th>
<th>Pc</th>
<th>To</th>
<th>Vr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pr</td>
<td></td>
<td>0.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rc</td>
<td>0.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ct</td>
<td>0.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pc</td>
<td>0.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To</td>
<td>0.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vr</td>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Weight calculation by the entropy method

Using equation (5), we calculate the highest values of: Production capacity: Pc, and Versatility: Vr, because they are beneficial AKPI. Moreover we use equation (6) to the smaller values of Price subcontractor: Pr, Rate of non compliance: Rc, Cycle time: Ct, Turn Over: To, because they are non-beneficial AKPI (Işık and Adali, 2017).

Then Table-7 shows the normalization of the matrix given in Table-4, by using equation (5) and (6).
Table-7. Pair wise comparison matrix is normalized by equation (5) and (6).

<table>
<thead>
<tr>
<th></th>
<th>Pr</th>
<th>Rc</th>
<th>Ct</th>
<th>Pc</th>
<th>To</th>
<th>Vr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pr</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0,4285</td>
</tr>
<tr>
<td>Rc</td>
<td>0,8437</td>
<td>0,7777</td>
<td>1</td>
<td>0,8529</td>
<td>0,25</td>
<td>0</td>
</tr>
<tr>
<td>Ct</td>
<td>0,8999</td>
<td>0</td>
<td>0,8421</td>
<td>0,2647</td>
<td>0,75</td>
<td>0,7142</td>
</tr>
<tr>
<td>Pc</td>
<td>0,9643</td>
<td>0,9938</td>
<td>0,9473</td>
<td>0,1176</td>
<td>0,5</td>
<td>1</td>
</tr>
<tr>
<td>To</td>
<td>1</td>
<td>1</td>
<td>0,9824</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Vr</td>
<td>0,5624</td>
<td>0,5185</td>
<td>0,9824</td>
<td>0,0073</td>
<td>0,875</td>
<td>0,1428</td>
</tr>
</tbody>
</table>

\[ \sum_{i=1}^{m} r_{ij} = 4,2703 \]

By using equation (7) we obtain:

Table-8. Calcul of \( F_{ij} \).

<table>
<thead>
<tr>
<th></th>
<th>Pr</th>
<th>Rc</th>
<th>Ct</th>
<th>Pc</th>
<th>To</th>
<th>Vr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pr</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0,4459</td>
<td>0</td>
<td>0,1874</td>
</tr>
<tr>
<td>Rc</td>
<td>0,1975</td>
<td>0,2363</td>
<td>0,2103</td>
<td>0,3803</td>
<td>0,0740</td>
<td>0</td>
</tr>
<tr>
<td>Ct</td>
<td>0,2107</td>
<td>0</td>
<td>0,1771</td>
<td>0,1180</td>
<td>0,2222</td>
<td>0,3124</td>
</tr>
<tr>
<td>Pc</td>
<td>0,2258</td>
<td>0,3020</td>
<td>0,1992</td>
<td>0,0524</td>
<td>0,1481</td>
<td>0,4375</td>
</tr>
<tr>
<td>To</td>
<td>0,2341</td>
<td>0,3039</td>
<td>0,2066</td>
<td>0</td>
<td>0,2962</td>
<td>0</td>
</tr>
<tr>
<td>Vr</td>
<td>0,1317</td>
<td>0,1575</td>
<td>0,2066</td>
<td>0,003</td>
<td>0,2592</td>
<td>0,0624</td>
</tr>
</tbody>
</table>

By using equation (8) we obtain:

Table-9. Calcul of Entropy.

<table>
<thead>
<tr>
<th>( e_{j} )</th>
<th>Pr</th>
<th>Rc</th>
<th>Ct</th>
<th>Pc</th>
<th>To</th>
<th>Vr</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,8881</td>
<td>0,7566</td>
<td>0,8971</td>
<td>0,6434</td>
<td>0,8483</td>
<td>0,6764</td>
<td></td>
</tr>
</tbody>
</table>

By using equation (9) we obtain:

Table-10. Weight of AKPI by Entropy method.

<table>
<thead>
<tr>
<th>Weight by Entropy</th>
<th>Weight by AHP</th>
<th>Weight by combined AHP-Entropy method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pr 0,0867</td>
<td>0,4</td>
<td>0,2445</td>
</tr>
<tr>
<td>Rc 0,1886</td>
<td>0,15</td>
<td>0,1994</td>
</tr>
<tr>
<td>Ct 0,0797</td>
<td>0,18</td>
<td>0,1011</td>
</tr>
<tr>
<td>Pc 0,2764</td>
<td>0,13</td>
<td>0,2532</td>
</tr>
<tr>
<td>To 0,1175</td>
<td>0,03</td>
<td>0,0248</td>
</tr>
<tr>
<td>Vr 0,2508</td>
<td>0,1</td>
<td>0,1767</td>
</tr>
</tbody>
</table>

By using equation (10) we obtain:

Table-11. Weight of AKPI by combined AHP-Entropy method.
Weights analysis obtained by the combined AHP-Entropy method

![Weight of AKPI by Combined AHP-Entropy method](image)

**Figure-1.** Graph shows the weights of AKPI by combined AHP-entropy.

The figure shows that Pc: Production capacity has the first rank, then Price subcontractor, has the second rank, also, Rc: Rate of non-compliance has the third rank. Ct: cycle time, To: Turn over and Vr: Versatility has the little impact in performance measurement. That shows that: Production, cost and Quality are the prior Key Factor of Success which should be take in consideration in Moroccan textile sector industry.

**Global performance**

The global performance (GP) is expressed in the formula below (Chen, 2008).

\[
GP = 100 \times \left( P_{AKPI} \times \sum_{i=1}^{6} r_i \right)
\]  

(11)

The formula for overall performance by combined AHP-Entropy method of Moroccan textile suppliers is calculated as follows:

\[
GP=100\times(0, 24P_{Pr}+0, 19P_{Re}+0, 10P_{Ct}+0, 25P_{Pc}+0,02P_{To}+0, 17P_{Vr})
\]  

(12)

**DISCUSSIONS**

Combined AHP-entropy decreases the subjectivity of the AHP method by combining the subjective weights of AKPI via the AHP method, and the objective weights of AKPI via the entropy method. It allows for more effective results: that shows that production and cost are the prior key success in textile Sector in Morocco. Furthermore, the final weight of AKP’s via combined AHP-entropy allows us to calculate the formula for overall performance of Moroccan textile suppliers. It helps all companies working in textile sector in Morocco to select the best supplier.

However, the combined AHP-Entropy method does not reflect reality. Although the results obtained have shown that production is the priority, this does not reflect the aspect of proximity to the customer.

**CONCLUSIONS**

Our research is based on the application of the combined method AHP-Entropy in the textile sector in Morocco. The subjectivity of the AHP method has been reduced by its combination with the entropy method. In Case study, we first calculated the subjective weights of the AKPI via the AHP method, and the objective weights of the AKPI by the entropy method, then we calculated the final weights by Combined AHP-Entropy method.

Then we have obtained the predominant KPI which is the production capacity that emanates from the key factor of success: production. This will help companies to focus as much as possible on this key success factor, and improve it better.

Moreover, research has also facilitated the obtaining of the global overall formula, which is very important for textile companies in Morocco, which will enable them to select the best supplier among others.

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