A Vendor Rating model resulting from AHP and the linear model

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Abstract: - A survey about the different kinds of available vendor rating models has been carried out. After a comparative analysis, we selected the solution involving AHP together with the linear method. AHP has been particularly used to determine the weight of the different contributions involved in the definition of supplier rating. This solution has been enforced in a case study concerning a cosmetic company. At the moment, the project is at its start-up stage.

Key-Words: - Vendor Rating, AHP, linear model.

1 Introduction
The choice of available sources, made by the firms, to fulfill the goods and/or services’ internal demand, is led by a variables’ analysis which influences the total cost of the transaction [1], more precisely:
  o Resources’ specificity exchange-object;
  o Intrinsic uncertainty of the supplier-costumer relationship arising from the impossibility to forecast a priori all the future events;
  o Relationship’s frequency along the period.

These 3 elements determine a greater /smaller complexity of the customer-supplier’s relation which, on its turn, can leads to:
  o Expediency
  o Limited balance (all the necessary information and/or the necessary capacities of elaboration to execute optimizing guideline aren’t always available to suppliers and enterprises).

Firstly, the landmark to express a judgment is represented by the suggested price. After a time, however, we realized that this only variable has a low weight and we need to consider others ones, which just like the previous, have an influence on the products. The judgment about the supplier is a synthesis of:
  o Cost
  o Quality
  o Service
  o Innovation

The beginning of the judgment’s creation process about the supplier must start a managerial virtuosity of the fleet suppliers aiming to:
  • Decrease the vendor’s number to which serve and realize long-time relation. In this way the supplies’ volume increases for each person achieving a price decrease.

  • Optimize and improve the selection through a performance’s ranking in order to know, when necessary, who ask for and what kind of results expect for.

In the field of the suppliers’ evaluation process, owing to the need of analyze the different offer’s size, it’s more and more spread the use of multi-criteria models to understand to which partner assign a specific job-order.

2 Literature review
In the literature there are several methods for the suppliers’ assessment. Afterwards we propose a summary and a comparison’s chart.

2.1 Weights based linear model
This methodology is the most common in the business practice. The model provides a synthetic assessment on suppliers’ performances, combining several indexes, previously defined and weighted [2].

The synthetic assessment is given by the following formula:

\[ \text{Vendor Rating}_{\text{supplie}} = \sum_{i=1}^{n} \text{index}_i \times w_i \]  

where:
  index$_i$: index $i$ related performance
  \( w_i \): weight assigned to the index $i$
  \( n \): number of indexes observed

The simple version provides, therefore, weights to the different indicators in according to the importance assigned to them. Subsequently the performances indexes are multiplied by the respective weights and a synthetic assessment is obtained determining the sum of such values. As an example we can consider the following table 1.


The formula (1) can be broken down into four parts, concerning the performance evaluation of quality, price, innovation and technology. The reasoning is similar to that concerning the performance evaluation of quality, price, innovation and technology. The formula can be broken down into four parts, the resulting formula overall assessment of the considered supplier taking into account the weight assigned to them. The resulting formula will be:

\[ \text{Vendor Rating}_{\text{Supplier}} = \text{QVR} \times w_{\text{QVR}} + \text{PVR} \times w_{\text{PVR}} + \text{IVR} \times w_{\text{IVR}} + \text{SVR} \times w_{\text{SVR}} \]

Once calculated, the four indicators will determine the overall assessment of the considered supplier taking into account the weight assigned to them. The resulting formula will be:

\[ \text{Vendor Rating} = \text{QVR} \times w_{\text{QVR}} + \text{PVR} \times w_{\text{PVR}} + \text{IVR} \times w_{\text{IVR}} + \text{SVR} \times w_{\text{SVR}} \]

However, this model, among its intrinsic features, is characterized by compensation of the performances. This indicates that a good performance on one criterion may be balanced by a low one on another. To work on this issue, we can proceed alternatively:

- Excluding suppliers that fall below the predetermined threshold of acceptance
- Normalizing performances. Normalization is a tool able to homogenize indexes that are expressed in different units of measure/terms (quantitative, qualitative, relative, absolute values and so on. In this way we can express all the parameters in a scale of values from 0 to 100.

The ability to make a choice that does not reflect the real difference of the values between the alternatives must be limited to the minimum. Decisions can be misled if a Supplier, has good performances considering a set of criterion on which a Supplier, is weak, while this one has good performances considering another set, on which the first supplier is weak. In this case the buyer will have to rely on his skills and previous experiences to figure out how to place the job order. Thus, the results obtained from the assessment should not justify the choices made. Instead, they must support the daily activities of analysis with the aim of understanding the supplier's potential.

2.2 Analytic Hierarchy Process

The Analytic Hierarchy Process is a methodology developed by Saaty T.L. that is well suited to the problem of selecting a supplier. AHP can be used both to determine the weights of attributes used for assessment and to determine the rankings of potential suppliers.

3 Problem Formulation

3.1 The model

An evaluation model has been thought in order to select a new sleeve supplier, to carry out a correct analysis and a related comprehension of its ability in satisfying company's needs. Therefore, such a tool is a guide to improve the supplying process aiming at synthetizing evaluations about several analysis dimensions. In the suggested work we chose to adopt the weight-based linear model (Vendor Rating) mainly for its easy use and adaptability to every purchasing situation. Analytic Hierarchy Process has been chosen to determine weights because it seemed to be the best structured model. Thanks to the weight firmness system, it makes us decide whether obtained values respect correctly the opinions about the relationships among variables.

Then, model formulation is:

\[ \text{Overall Evaluation}_{t,T} = \text{GE}_T \times w_{\text{GE}} + \sum_{t=1}^{T} \left( \text{PET}_t \times w_{\text{PET}} \times w_{\text{job,n}} \right) \]

with:

- \text{GE}_T: General Evaluation at time T
- \text{PET}_t: Punctual Evaluation for each job at time t
- \text{w}_{\text{GE}} and \text{w}_{\text{PET}}: assigned weights at GE and PE, defined and related to time T
- \text{w}_{\text{job,n}}: Weight related to n job value at time t

where \( t = 1, 2, 3, \ldots T \), moments when evaluation gets updated due to a job given by supplier, T is the fixed time (month,
quarter, semester) which represents the analysis temporal unit of measurement.

The overall evaluation is defined depending on the performance recorded by the several suppliers. The general evaluation can be updated at the end of the fixed period of time (month, quarter and so on), but the punctual evaluation works in a different way because:

- during that reference period, a supplier can manage several jobs and it usually manages more than one. It means that the punctual evaluation must include a synthetic evaluation about performances.
- synthetic evaluation should depend on the importance of the job. In the worst case, if the output quality level is “poor”, a low profile job could affect the company outcome less than a high profile one.

That’s why the punctual evaluation regards also the economic aspect and the job value $n$ is:

$$w_{job\_value_n} = \frac{\sum job\_value_n}{w_{job\_value_n}}$$

So, all in all, the evaluation tool can be considered:

- complete about the variables needed for the evaluation
- dynamic due to:
  - continuous updates after every job
  - the possibility of modifying variable weights according to what is considered the most critical aspect at a specific moment.

In such a situation characterized by a systemic crisis, for sure we will pay more attention to financial variables. On the other hand, in more stable situations it is possible to recognize greater weights for service and quality standards.

After choosing the model we:

- defined 1st and 2nd level standards
- quantified variable relative importance

Analysis dimensions have been defined both for overall and punctual evaluations.

For secondary evaluation, the following 1st level standards have been defined instead:

<table>
<thead>
<tr>
<th>VARIABLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
</tr>
<tr>
<td>Quality</td>
</tr>
<tr>
<td>Service</td>
</tr>
<tr>
<td>Timing</td>
</tr>
</tbody>
</table>

Service means supplier’s performance according to its availability and feedback time at every purchase request. Timing means the average time needed for delivering the ordered lot.

### 3.2.1 Determining weights

About variables’ weights, we referred to the Analytic Hierarchy Process, whose main steps are:

- decomposition of the complex problem into a hierarchy,
- formulation of comparative evaluations at the same hierarchical level,
- synthesis of priorities or obtained weights.

Creating a dominance hierarchy about standards needed for evaluating alternatives has been necessary to carry out a hierarchical analysis.

### 3 Case study and Results

Sleeve is a plastic thermoretractable muff which allows the product labelling covering completely its surface and fitting to the contents. It allows extremely coloured and bright packagings with a lot of space for writing legends, suggestions or ingredients.

First we chose three new potential sleeve suppliers. During this stage of the project suppliers have been selected mainly according to the company location (for shortening the time needed to reach the plant guaranteeing a high quality service) and the already attended customers (in this way we could identify companies which were already supplying multinational corporations and were able to satisfy the requests promptly, providing high quality and highly innovative feedback). During this stage selected suppliers were SUPPLIER1, SUPPLIER2 and SUPPLIER3.

According to the needs come out during the meetings with managers, it has been decided to divide evaluation into two subclasses:

- on one hand, the punctual evaluation carried out for every single job;
- on the other hand, the overall evaluation carried out through a questionnaire sent to suppliers.

Since the second mentioned subclass could be twisted because suppliers could answer the questionnaire according to their own advantages, the weight given to the first subclass will be greater.

We made some hypotheses about relationships among attributes, according to the scale of values proposed by the theory (Tab.2). In particular, we set the following weights to the two subclasses (overall evaluation and punctual evaluation), using that scale of values and the values assigned to the comparisons.

<table>
<thead>
<tr>
<th>Assessment or choice</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely favourite</td>
<td>9</td>
</tr>
</tbody>
</table>
Between strongly favourite and extremely favourite 8
Strongly favourite 7
Between favourite and strongly favourite 6
Favourite 5
Between moderately favourite and favourite 4
Moderately favourite 3
Between neutral and moderately favourite 2
Neutral 1

Table 2 - Scale of values

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Overall evaluation</th>
<th>Punctual evaluation</th>
<th>Averages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>0.25</td>
<td>0.25</td>
<td>25%</td>
</tr>
<tr>
<td>Punctual</td>
<td>0.75</td>
<td>0.75</td>
<td>75%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>4</td>
<td>1.33</td>
<td>100%</td>
</tr>
</tbody>
</table>

Consistency = Comparisons matrix * estimated solutions vector

\[
\begin{pmatrix} 1 & 0.33 \\ 3 & 1 \end{pmatrix} \times \begin{pmatrix} 0.25 \\ 0.75 \end{pmatrix} = \begin{pmatrix} 0.5 \\ 1.5 \end{pmatrix} \]

\[
\text{total} = \frac{0.5}{0.25} + \frac{1.5}{0.75} = 4
\]

\[
\lambda_{\text{max}} = 2
\]

C1 = 0
C2 = 0

Figure 2 - Weights determined for the subclasses

The weights of the I level variables were built in the same way to define the general evaluation

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Certification</th>
<th>Financial</th>
<th>Supplying</th>
<th>Production</th>
<th>Logistics</th>
<th>After Sales Service</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOTAL</strong></td>
<td>11.50</td>
<td>15.06</td>
<td>4.83</td>
<td>6.33</td>
<td>2.83</td>
<td>9.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Certification</th>
<th>Financial</th>
<th>Supplying</th>
<th>Production</th>
<th>Logistics</th>
<th>After Sales Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certification</td>
<td>0.087</td>
<td>0.13</td>
<td>0.104</td>
<td>0.08</td>
<td>0.09</td>
<td>0.06</td>
</tr>
<tr>
<td>Financial</td>
<td>0.043</td>
<td>0.07</td>
<td>0.068</td>
<td>0.05</td>
<td>0.09</td>
<td>0.06</td>
</tr>
<tr>
<td>Supplying</td>
<td>0.174</td>
<td>0.20</td>
<td>0.207</td>
<td>0.32</td>
<td>0.18</td>
<td>0.22</td>
</tr>
<tr>
<td>Production</td>
<td>0.174</td>
<td>0.20</td>
<td>0.104</td>
<td>0.16</td>
<td>0.18</td>
<td>0.22</td>
</tr>
<tr>
<td>Logistics</td>
<td>0.348</td>
<td>0.27</td>
<td>0.414</td>
<td>0.32</td>
<td>0.35</td>
<td>0.33</td>
</tr>
<tr>
<td>A S Service</td>
<td>0.174</td>
<td>0.13</td>
<td>0.104</td>
<td>0.08</td>
<td>0.12</td>
<td>0.11</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Mean</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certification</td>
<td>0.09</td>
<td>9%</td>
</tr>
<tr>
<td>Financial</td>
<td>0.06</td>
<td>6%</td>
</tr>
<tr>
<td>Supplying</td>
<td>0.22</td>
<td>22%</td>
</tr>
<tr>
<td>Production</td>
<td>0.17</td>
<td>17%</td>
</tr>
<tr>
<td>Logistics</td>
<td>0.34</td>
<td>34%</td>
</tr>
<tr>
<td>A S Service</td>
<td>0.12</td>
<td>12%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>1.00</td>
<td>100%</td>
</tr>
</tbody>
</table>

Consistency = Comparisons matrix * estimated solutions vector

\[
\begin{pmatrix} 1 & 0.50 & 0.50 & 0.50 & 0.50 & 0.09 & 0.55 \\ 0.50 & 1 & 0.33 & 0.33 & 0.25 & 0.50 & 0.06 & 0.38 \\ 2 & 3.03 & 1 & 2 & 0.50 & 2 & 0.22 & 1.34 \\ 2 & 3.03 & 0.50 & 1 & 0.50 & 2 & 0.17 & 1.06 \\ 4 & 4 & 2 & 2 & 1 & 3 & 0.34 & 2.09 \\ 2 & 2 & 0.50 & 0.33 & 1 & 0.12 & 0.73 & \end{pmatrix}
\]

\[
\text{total} = \frac{0.55}{0.09} + \frac{0.38}{0.06} + \frac{1.34}{0.22} + \frac{1.06}{0.17} + \frac{2.09}{0.34} = 36.84
\]

\[
\lambda_{\text{max}} = 6.14
\]

C1 = 0.03
C2 = 0.02

Figure 3 - Assessment of the weights of the I level variables; overall evaluation

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Price</th>
<th>Quality</th>
<th>Service</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOTAL</strong></td>
<td>3.75</td>
<td>2.33</td>
<td>14</td>
<td>5.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Certification</th>
<th>Financial</th>
<th>Supplying</th>
<th>Production</th>
<th>Logistics</th>
<th>After Sales Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certification</td>
<td>1</td>
<td>2</td>
<td>0.5</td>
<td>0.5</td>
<td>0.25</td>
<td>0.5</td>
</tr>
<tr>
<td>Financial</td>
<td>0.5</td>
<td>1</td>
<td>0.33</td>
<td>0.33</td>
<td>0.25</td>
<td>0.5</td>
</tr>
<tr>
<td>Supplying</td>
<td>2</td>
<td>3.03</td>
<td>1</td>
<td>2</td>
<td>0.5</td>
<td>2</td>
</tr>
<tr>
<td>Production</td>
<td>2</td>
<td>3.03</td>
<td>0.5</td>
<td>1</td>
<td>0.5</td>
<td>2</td>
</tr>
<tr>
<td>Logistics</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>A S Service</td>
<td>2</td>
<td>2</td>
<td>0.5</td>
<td>0.5</td>
<td>0.33</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comparisons matrix</th>
<th>Price</th>
<th>Quality</th>
<th>Service</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOTAL</strong></td>
<td>3.75</td>
<td>2.33</td>
<td>14</td>
<td>5.2</td>
</tr>
</tbody>
</table>
Assessed the weights of different variables, the model was applied to the three previously selected sleeve providers (SUPPLIER1, SUPPLIER2 SUPPLIER3) to determine the best performing supplier. As mentioned previously, the upgrade of the overall evaluation can be done at the end of fixed period T, in our case was carried out at the end of two months recording the following results:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>III Level</th>
<th>Weight</th>
<th>Judgements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logistics</td>
<td>C6</td>
<td>Is there a toll free to call in for after-sales service?</td>
<td>25%</td>
</tr>
<tr>
<td>Logistics</td>
<td>C6</td>
<td>Would you be able to provide after-sales service?</td>
<td>75%</td>
</tr>
</tbody>
</table>

Figure 51 - Assessment of the weights of the II level variables; overall evaluation

Given the values of consistency ratio obtained in according to assessments, we can say that the model is congruent with every level of analysis e from the theoretical point of view is correct and properly developed. The AHP allowed the buyers to focus on solving many small problems and then summarize the partial solution overall, rather than face simultaneously all aspects of the problem. Furthermore, the comparison between the same buyers, in the definition of comparison tables, allowed to mitigate the subjectivity of the evaluations made on the various criteria considered.
The two job orders could be considered equivalent in terms of importance but there is a slight difference in the quantity ordered. For this reason, agree with buyers, it was decided to assign different weights to the two orders, respectively 55% and 45% (in this case was used the AHP technique for determining those).

Therefore, we recorded the performance of three suppliers for both PR in terms of price, quality, service and delivery times, obtaining the results summarized in Tables 3, 4, 5, 6, 7 and 8.

All providers were compared on two different PR in the two months under review, in detail:
- provision of 480,000 sleeves PRODUCT_A
- provision of 300,000 sleeves PRODUCT_B
After defining categories for both macro evaluation criteria, weights and performance of suppliers, we used the model previously defined, to determine the best supplier, calculating the (9):

$$\text{overall evaluation}_t = (V_{G_t} \cdot p_{V_G}) + \sum_{s \in 4} (V_P \cdot p_{V_P} \cdot p_{job\_value})$$

where:

$$V_{G_t} = (V_{G_{finant}} \cdot p_{finant}) + (V_{G_{finant2}} \cdot p_{finant2}) + (V_{G_{supp}} \cdot p_{sup}) + (V_{G_{prod}} \cdot p_{prod}) + (V_{G_{log}} \cdot p_{log}) + (V_{G_{serv}} \cdot p_{serv})$$

$$V_P = (V_{P_{qual}} \cdot p_{qual}) + (V_{P_{price}} \cdot p_{price}) + (V_{P_{serv}} \cdot p_{serv})$$

$$p_{V_G}$$ and $$p_{V_P}$$ : weights assigned to the two categories.

By using linear weighting algorithm, it implicitly accepts the logic of evaluation fully compensatory, meaning that a good performance on one criterion can offset a poor on another, which in many cases is not desirable. Sometimes because some variables are so important in the global assessment to exclude any type of compensation (not totally logical compensation) or may be accepted only a degree of compensation (partially compensatory logic) [5]. In this case it was decided to exclude suppliers who have not attained a certain threshold of acceptability in performance, set the value of 4 (insufficient).

A further problem was to assign numerical values to performance (especially those related to qualitative variables). Again, the problem has been resolved appropriately trying to relate the numerical scales used, so as to limit and standardize the subjective opinions of different buyers in relation to the same factor.

The observed results are given in Table 9:

<table>
<thead>
<tr>
<th>Supplier</th>
<th>OE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUPPLIER1</td>
<td>9.4</td>
</tr>
<tr>
<td>SUPPLIER2</td>
<td>8.4</td>
</tr>
<tr>
<td>SUPPLIER3</td>
<td>7.3</td>
</tr>
</tbody>
</table>

The analysis allowed to identify the best provider in SUPPLIER1, having:
- best price
- best service (high availability and quick response)
- good product quality
- timing

In addition the supplier is compliant with the constraint for annual turnover. In fact, the purchasing department has to verify regularly about the dependency of a supplier, which should avoid to be a part (> 30%) too important of the turnover of the supplier.

5 Conclusion

Finally, we proceeded to codify the new detected supplier with the previous model and we introduced it in a short list. In this way, for every PR (Purchase Requisition) given by the marketing function related to the films, we can put at least three supplier in competition and in 2010 we can obtain savings near to 30% considering the average price paid for the sleeve in 2009. This is possible because SUPPLIER1 requested an appreciably lower price than the actually used supplier, providing the same product quality. The firm will be able to quantify the benefits achieved only in the future. Surely, at this moment, we can say that the supervising model will help the firm and its supplier. The evaluation won't be only a tool useful to measure the performances and to eliminate the supplier that don't respect certain thresholds. On the contrary, this will be a constructive activity that will stress limits and capabilities and will make possible a comparison between the adverse parties, understanding the reasons linked to the results. Moreover, in a long term using this method will lead to the building of an informative database which can strengthen a decision comparing the performances related to the alternatives that we want to assess. Finally, the continuous score update (after every job) and the chance to change the criterion weights give a dynamism in evaluating suppliers, avoiding to choose in a continuous way always the same suppliers.

References: