NEW PRODUCT PROJECTS EVALUATION AND SELECTION MODELS:
A QUALITATIVE APPROACH

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Abstract

Nowadays product innovation has become essential for success and competitiveness. So, numerous theories, techniques and models have been developed to help making right decisions when valuating and selecting alternative product projects. Nevertheless, empirical research prove that a lot of these proposals aren’t but “elegant” establishments, far away from any practical use. New tendencies also point up towards a major use of synthesis and qualitative reasoning based models.

In this paper a new model is proposed, FS (Fuzzy Scoring), based on a fuzzy treatment of qualitative information what provides the possibility of including shades and particular value judgements about projects.
1. Introduction: Product innovation and projects evaluation and selection models

Evolution of markets determines that innovation processes become nowadays “basic” elements of entrepreneurial strategy to achieve long-term success and competitiveness in all kind of organizations. At this point new products become “imperative” or “essential”.

Nevertheless, product innovative processes result not as easy as could appear. Three different functional areas must work close together in a relationship not ever free of misunderstandings: Marketing, research and development (R&D), and production. Each “team” member brings crucial skills and knowledge to the “party”; marketing’s major job is to bring the “voice of the market” (Dolan, 1993).

Once inside this process, there is an agreement within authors when considering the existence of several phases or steps. This agreement turns into disagreement when precising the number and contents of every phase, but there is again an agreement about the presence of some kind of stage related to the evaluation and selection between alternative projects (Vázquez, 1995). Moreover, importance attributed to this concrete stage increases if the great relationship between decisions taken at this point and final success of adopted projects is considered, as said by available empirical evidence (Cooper and Kleindschmidt, 1986). So a lot of theories, techniques and models have been developed to help making right choices when taking this decisions. Nevertheless, empirical studies prove that a lot of these proposals are not but “elegant” and “correct” establishments, far away from any practical use.

2. Use of new product projects evaluation and selection models: From theory to practice

Surveys like those carried out by Booz, Allen and Hamilton (1982), and Cooper and Kleindschmidt (1986), improved by Mahajan and Wind (1992), give evidence about latest statement. Martínez (1992) explains differences between developed and used models because of high complexity level associated to mathematical basis of certain models, which separates theoretical developments from real necessities, perceiving an increasing gap between both categories, especially from the beginning of the 70’s (Souder, for example, evidenced in 1970 the practical use of 14 models from 41 described by literature).

If speaking about characteristics of used models, Allen (1970), over a 112 british firms sample, evidenced that about a third of them regularly used models with some mathematical support, alone or combined with scoring criteria. In Spain, Pérez-Carballe (1977) reported almost 40 % of medium or high sized firms applying models opted for VAN or ROI techniques, alone or linked to other criteria. Other studies confirm this perception, as done by Liberatore and Titus (1983), pointing up that used models were basically those including some financial reference, just as VAN (74 %) or ROI (68 %). These authors also reported the presence of some other hardly extended categories of models, as check lists or scoring models (47 %). Moreover, practical “non-utilization” of other model categories was also evidenced.
Over an industrial firms sample, Martínez (1988) reported the major knowledgement in Spain of quantitative models in opposition to qualitative. This fact was really significant if compared with the situation in other developed countries, showing a clearly inverse tendency. This author pointed at eventual train deficiencies in innovation management aspects when qualification of this function responsibilities is analyzed. Nevertheless, most used were also VAN, ROI and scoring models, especially in technologically advanced or high-technology firms, where managers’ formation levels and foreign capital presence are higher.

Another survey has been done in June 1998 over a sample of 500 Spanish industrial firms, resulting that main used models (Table 1) are notation indexes (51.72 % of responses, with many references to VAN), followed by scoring models (22.84 %), programming models (18.10 %), check lists (16.81 %), and portfolio analysis models (9.48 %). There were also some sporadic choices (27.59 %), referred to graphical models, pertinence or relevance trees, and “own” developed models. Differences according to the size of inquired enterprises show a major utilization of “complex” categories of models in big sized firms (like notation index, programming and portfolio analysis models), meanwhile there is a major use of more “simple” or “intuitive” categories in small sized firms (as check lists or scoring models).

Table 1
Used new product projects evaluation and selection models

<table>
<thead>
<tr>
<th>Category of model</th>
<th>Small sized firms a (154) c</th>
<th>Big sized firms a (78) c</th>
<th>Total (232) c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notation index models</td>
<td>46.10 % (71)</td>
<td>62.82 % (49)</td>
<td>51.72 % (120)</td>
</tr>
<tr>
<td>Scoring or grid models</td>
<td>24.67 % (38)</td>
<td>19.23 % (15)</td>
<td>22.84 % (53)</td>
</tr>
<tr>
<td>Programming models</td>
<td>12.99 % (20)</td>
<td>28.20 % (22)</td>
<td>18.10 % (42)</td>
</tr>
<tr>
<td>Check lists</td>
<td>22.08 % (34)</td>
<td>6.41 % (5)</td>
<td>16.81 % (39)</td>
</tr>
<tr>
<td>Portfolio analysis models</td>
<td>1.30 % (2)</td>
<td>25.64 % (20)</td>
<td>9.48 % (22)</td>
</tr>
<tr>
<td>Others</td>
<td>29.22 % (45)</td>
<td>24.36 % (19)</td>
<td>27.59 % (64)</td>
</tr>
</tbody>
</table>

a Small sized firms range from 1 to 99 employees, and big sized ones have 100 or more employees on staff.

b In brackets is the number of each kind of inquired enterprises (500) that use new product projects evaluation and selection models (multiple response).

Even when satisfaction levels with used models were fairly high, many experts asked for “wider” models (with more selection criteria) and more easily understandable. Possibility of “qualitative” supported models was immediately considered, mainly because of the important advantages achieved when including shades and particular value judgements about projects in respect to “good”, “bad” or similar adjective terms (Kaufmann and Gil-Aluja, 1992), and then increasing number of potential users of models without specific mathematical formation.

1 A similar survey, but over a sample of 252 industrial firms from Castilla y León (a concrete Spanish region), was previously done (from June 1994 to February 1995) to determine the factors or criteria used in the scoring step of the synthesis model “MP”, obtaining similar results (Vázquez, Bello and Placer, 1998).
3. A fuzzy logic based scoring model for new product projects evaluation and selection

Usually, in a quantitative situation the information required is expressed as numerical values. Sometimes, however, when working in qualitative areas characterised by vague or imprecise knowledge, the information can’t be set out in a precise numerical way. Thus, it will be a more realistic approach to use linguistic information, provided that variables involved in the problem lend themselves to expression in this manner (Zadeh, 1975). This way of looking at things can be applied to a wide range of problems, e.g. information retrieval (Bordogna and Passi, 1993), clinical diagnosis (Degani and Bortolan, 1988), education (Law, 1996), personnel selection (López, Mendaña and Rodríguez, 1996), or decision making (Yager, 1995; Herrera, Herrera-Viedma and Verdegay, 1995; etc.), and new product projects evaluation and selection don’t suppose an exception.

In our case, we have a list of possible new product projects to valuate, represented as vector \( X = \{X_1, X_2, \ldots, X_m\} \). So we are going to introduce the mathematical representation of the linguistic evaluation-selection problem, proposing a methodology by means of fuzzy logic.

According to the philosophy of a scoring model, we must begin establishing precise factors or criteria to consider when valuating projects. This is a work properly to be done in every activity sector (according to the specifications of products and markets), or even inside every innovative organization. Nevertheless, we can generically speak about presence of “product” and “enterprise” factors or criteria (following Dwyer and Mellor, 1991).

3.1. Product factors

First group of factors to valuate projects are related to specific characteristics or properties of possible new products, making them more or less attractive to customers. These “product” factors will be \( P = \{P_1, P_2, \ldots, P_n\} \). Their importance level has to be determined, what can be done with vector \( \tilde{P} \) by using a linguistic approach, and so the \( \tilde{P}_j \) elements could be included in the nine term label set \( \tilde{W} = \{\text{Essential, Very High, High, Fairly High, Medium, Fairly Low, Low, Very Low, Unnecessary}\} \). Figure 1 shows graphical appearance of this scale.

According to this representation, triangular fuzzy numbers can be associated to every label\(^2\). In Table 2 the nine labels and associated fuzzy numbers can be seen.

Figure 1
Nine term set with triangular fuzzy numbers

\(^2\) Alternatives can be considered both in number or linguistic expressions of labels. Nevertheless, we think nine possibilities are enough to describe the importance level that a person (“expert”) gives to a concrete factor as, in case we use a scale with more chances, choosing a concrete possibility could result more difficult. Moreover, an “odd” scale has the additional advantage of having a precise and “useful” central or medium term.

\(^3\) Obviously, other semantic of the functions can be considered.
There are different ways to concrete “product” factors and their importance levels. Perhaps the easiest procedure consists on going to the aid of some empirical survey over an experts’ sample, and then use obtained results\(^4\). By this procedure (or alternatives), matrix \(\tilde{V_P}\) can be obtained with valuations given to “product” factors by everyone of \(Z\) inquired experts.

However, model user (innovative organization) can give more or less credibility to different experts’ valuations and opinions because of those experts’ knowledge, experience, decision capacity, etc. So, these opinions can be balanced, for instance, by using the linguistic labels from \(\tilde{W}\) set. Consequently –and supposed again the number of \(Z\) inquired experts- a vector \(\tilde{W_E}\) would contain weights attributed to everyone of experts’ opinions or valuations.

\[
\tilde{V_P} = \begin{cases} 
V_P_{11} & V_P_{12} & K & V_P_{1Z} \\
V_P_{21} & V_P_{22} & K & V_P_{2Z} \\
M & M & K & M \\
V_P_{n1} & V_P_{n2} & K & V_P_{nZ}
\end{cases} \quad \forall \tilde{V}_{Pjk} \in \tilde{W} \\
\tilde{W_E} = \begin{cases} 
W_E_1 \\
W_E_2 \\
W_E_Z
\end{cases} \quad \forall \tilde{W}_{Ek} \in \tilde{W}
\]

\(^4\) These experts could be personnel members of the organization that is valuating the new product alternative projects, workers of several organizations operating in the same activity sector, etc. In fact, every user of this scoring model might develop its own way to stablish both “product” and “enterprise” factors.
If a final valuation about importance levels of “product” factors is desired, we have to find some way of joining experts’ valuations and corresponding weights. So matrices $V\tilde{P}$ and $W\tilde{E}$ can be multiplied through the semantic representation of proposed linguistic labels or, what’s the same, associated triangular fuzzy numbers. The result obtained when multiplying two triangular fuzzy numbers is not a triangular fuzzy number; nevertheless –due to practical and operational reasons- this result can be easily approximated to a triangular fuzzy number (Dubois and Prade, 1980) and thus, in spite of a minimum deviation in the result, a reasonable amount of quickness is gained when doing the required calculations. Based in all formerly said, we obtain a final valuation about importance levels of “product” factors, $\tilde{I} \tilde{P}$, as follows:

$$\tilde{I} \tilde{P} = V\tilde{P} \cdot W\tilde{E} = \begin{bmatrix} \sum_{k=1}^{Z} V\tilde{P}_{1k} \cdot W\tilde{E}_{K} \\
\sum_{k=1}^{Z} V\tilde{P}_{2k} \cdot W\tilde{E}_{K} \\
\sum_{k=1}^{Z} V\tilde{P}_{n1k} \cdot W\tilde{E}_{K} \end{bmatrix} = \begin{bmatrix} \tilde{I} \tilde{P}_{1} \\
\tilde{I} \tilde{P}_{2} \\
\tilde{I} \tilde{P}_{n} \end{bmatrix} \quad i\tilde{P}_{j} \in \tilde{W} \quad [1]$$

When valuating new product projects it’s possible to choose between narrow or wide ranged scales. Moore and Baker (1969) postulated that a minimum range of seven choices is precised to achieve results with scoring models positively correlated to those obtained by means of any other more complex procedure (to be precise, they concluded that these kind of scoring models provide a considerably easier way to valuate new product projects, obtaining consistent results with more complex models at 90% of chances). Other evidences suggest a wide range of choices when using scoring models, but in most cases nine options is the widest range the human brain can effectively consider based in subjective opinions (Martínez, 1986).

In our case, this latest argument justifies convenience of using scales or sets with nine linguistic labels, as formerly done. So, evaluated projects can fit better or worse criteria, and we can obtain a linguistic valuation of this fitness, expressed by a number of $z$ experts thanks to a new nine term label set $\tilde{V}$, differing from previously used $\tilde{W}$ in its word expressions but similar in semantic fuzzy numbers representing linguistic labels. This new set could be $\tilde{V} = \{Very\ Best,\ Very\ Good,\ Good,\ Fairly\ Good,\ Indifferent,\ Fairly\ Bad,\ Bad,\ Very\ Bad,\ Very\ Worst\}$.

So, a matrix $\tilde{N} \tilde{P}^{j}$ is obtained for everyone of $m$ evaluated new product projects, containing the valuations by every expert in respect to every “product” factor, just as follows:

---

5 There is no reason for $z$ (inquired experts in order to valuate new product projects) and $Z$ (previously inquired experts to determine “product” valuation factors and their corresponding importance level) to coincide.
In the same sense, and supposing different credibility or importance levels for experts' valuations, these opinions could be balanced by multiplying matrices $\tilde{N}P^i$ and $W\tilde{E}^\prime$:

$$
\forall i = 1, K, m \quad \bar{p}^i = N\tilde{P}^i \cdot W\tilde{E}^\prime = \left\{ \begin{array}{c}
\sum_{k=1}^{z} N\tilde{P}^i_{1k} \cdot W\tilde{E}^\prime_k \\
\sum_{k=1}^{z} N\tilde{P}^i_{2k} \cdot W\tilde{E}^\prime_k \\
\sum_{k=1}^{z} N\tilde{P}^i_{n1k} \cdot W\tilde{E}^\prime_k \\
\end{array} \right\} = \left\{ \begin{array}{c}
\bar{p}^i_1 \\
\bar{p}^i_2 \\
\bar{p}^i_n \\
\end{array} \right\} \in \tilde{V} \quad [2]
$$

3.2. Enterprise factors

Second group of factors for valuating new product projects includes those related to specific characteristics, objectives or strategies operating at innovative organizations, mainly about their capability to develop selected projects. These “enterprise” factors will be $E = \{E_1, E_2, K, E_{n2}\}$.

As with “product” factors, once “enterprise” criteria have been established, their importance level has to be concreted by means of a vector $\tilde{I}E = \{\tilde{I}E_1, \tilde{I}E_2, K, \tilde{I}E_{n2}\}$ with a linguistic approach. So, $\tilde{I}E_i \in \tilde{W} = \{\text{Essential, Very High, High, Fairly High, Medium, Fairly Low, Low, Very Low, Unnecessary}\}$. Likewise we can go to the aid of an empirical survey and then:

$$
\tilde{V}E = \left\{ \begin{array}{c}
\tilde{V}E_{11} \\
\tilde{V}E_{21} \\
\tilde{V}E_{n1} \\
\end{array} \right\} \quad \tilde{V}E_{ik} \in \tilde{W}
$$

$$
\tilde{I}E = \tilde{V}E \cdot \tilde{W} = \left\{ \begin{array}{c}
\sum_{k=1}^{z} \tilde{V}E_{1k} \cdot \tilde{W}E_k \\
\sum_{k=1}^{z} \tilde{V}E_{2k} \cdot \tilde{W}E_k \\
\sum_{k=1}^{z} \tilde{V}E_{n2k} \cdot \tilde{W}E_k \\
\end{array} \right\} = \left\{ \begin{array}{c}
\tilde{I}E_1 \\
\tilde{I}E_2 \\
\tilde{I}E_{n2} \\
\end{array} \right\} \quad \tilde{I}E_i \in \tilde{W} \quad [3]
$$

6 Just as there’s no reason for $z$ and $Z$ to coincide, there’s no reason either for $W\tilde{E}^\prime_k$ and $W\tilde{E}^\prime_K$ values to coincide. They would be the same only in case the $z$ and $Z$ considered experts were the same and so the weights assigned to their opinions both when determining “product” factors and when valuating new product projects.
After valuating each criterion a matrix $\tilde{N}_E^i$ can be obtained for each one of $m$ projects, containing valuations by $z$ different experts in respect to “enterprise” factors:

$$\forall i = 1, \ldots, m \quad \tilde{N}_E^i = \begin{pmatrix} N\tilde{E}_{11}^i & N\tilde{E}_{12}^i & K & N\tilde{E}_{1z}^i \\ N\tilde{E}_{21}^i & N\tilde{E}_{22}^i & K & N\tilde{E}_{2z}^i \\ M & M & M \\ N\tilde{E}_{n1}^i & N\tilde{E}_{n2}^i & K & N\tilde{E}_{nz}^i \end{pmatrix}, \quad \tilde{N}_E^i \in \tilde{V}$$

Supposing different credibility or importance levels in experts’ valuations, suitability between projects and factors can be seen as the result of multiplying matrices $\tilde{N}_E^i$ and $\tilde{W}_E'$:

$$\forall i = 1, \ldots, m \quad \tilde{E}^i = \tilde{N}_P^i \cdot \tilde{W}_E' = \begin{pmatrix} \sum_{k=1}^{z} N\tilde{E}_{1k}^i \cdot \tilde{W}_{E_k}' \\ \sum_{k=1}^{z} N\tilde{E}_{2k}^i \cdot \tilde{W}_{E_k}' \\ M \\ \sum_{k=1}^{z} N\tilde{E}_{n2k}^i \cdot \tilde{W}_{E_k}' \end{pmatrix}, \quad \tilde{E}^i \in \tilde{V} \quad [4]$$

Once formerly described procedures and calculations have been done, selecting new product projects becomes a problem of finding the best option in a mix by means of imprecise or fuzzy information data and considering two additional criteria or objectives: a) selected new product projects to be developed must fit to markets and customers’ demands and requirements, and b) they must also fit to the characteristics or capacities of the organization supposed to turn them into practice. Consequently, both “product” and “enterprise” criteria ( $\tilde{P}^i$ and $\tilde{E}^i$ ) must be considered when taking decisions in selection processes$^7$. At this point a conjoint valuation for every proposed project can be obtained in respect to all “product” factors by multiplying vectors $\tilde{P}^{-1}$ and $\tilde{P}^i$ and attaining a fuzzy number $V\tilde{G}P^i$, as follows$^8$:

$$\forall i = 1, \ldots, m \quad V\tilde{G}P^i = \tilde{P}^{-1} \cdot \tilde{P}^i = \begin{pmatrix} \sum_{j=1}^{n_1} \tilde{P}_{j}^{-1} \cdot \tilde{P}_j^i \end{pmatrix} \quad [5]$$

In the same way, and in respect to “enterprise” factors, a conjoint valuation $V\tilde{G}E^i$, can be obtained by multiplying vectors $\tilde{E}^{-1}$ and $\tilde{E}^i$:

$$\forall i = 1, \ldots, m \quad V\tilde{G}E^i = \tilde{E}^{-1} \cdot \tilde{E}^i = \begin{pmatrix} \sum_{j=1}^{n_2} \tilde{E}_{j}^{-1} \cdot \tilde{E}_j^i \end{pmatrix} \quad [6]$$

$^7$ In case it could be convenient or required, a linguistic label from $\tilde{W}$ set in order to determine the importance level attributed to every factors category by $Z$ inquired experts.

$^8$ It must be remarked that the result of multiplying two triangular fuzzy numbers is not, by definition, a triangular fuzzy number, but it can only be approximated to a new triangular fuzzy number. As a result of this, there is no linguistic label associated to different fuzzy numbers $V\tilde{G}P^i$, $V\tilde{G}E^i$ and $V\tilde{G}^i$. 
Finally, a definitive "global" valuation or mark can be established for every project, being a fuzzy number, resulting from sum of "product" and "enterprise" conjoint valuations:

$$\forall i = 1, K, m \quad V\tilde{G}^i = V\tilde{G}P^i + V\tilde{G}E^i$$  \[7\]

So, "global" valuations of new products (\(X = \{X_1, X_2, K, X_m\}\)) can be expressed by vector

$$V\tilde{G} = \{V\tilde{G}^1, V\tilde{G}^2, K, V\tilde{G}^m\}$$

whose elements are fuzzy numbers. According to this, after a fuzzy evaluation of suitability or not of every project, a fuzzy number obtained as "global" mark is used as indicator of the goodness or convenience of each project.

In case any reason make precise choosing only one or a few potentially convenient projects to be developed, it will be precise to set up a hierarchy among them. At this point, main selection criterion could be major to minor "global" mark values by comparing directly associated fuzzy numbers. Nevertheless, a better proposal could be using fuzzy distance (Kaufmann and Gil-Aluja, 1987) from the origin (singleton 0), which is defined as follows:

$$d(\tilde{A}, \tilde{B}) = \int_{\alpha=0}^{1} \left( |A_{\alpha}^1 - B_{\alpha}^1| + |A_{\alpha}^2 - B_{\alpha}^2| \right) d\alpha$$ \[8\]

where \([A_{\alpha}^1, A_{\alpha}^2]\) is the confidence interval of \(\tilde{A}\) at the signification level \(\alpha\). Thus the advantage of comparing only one single value associated to each project is achieved (what is an easier procedure than comparing the three values defining a triangular fuzzy number).

4. An example of determining valuation factors and importance levels

In spite of valuation criteria must be properly determined indoors each innovative organization, in this section we provide a generic example. In this proposal both "product" and "enterprise" factors and respective importance levels were determined by means of an empirical survey carried out over a sample of 500 Spanish industrial enterprises\(^9\). Practical result has been called FS (Fuzzy Scoring).

When carrying out this survey 500 experts from innovative firms were asked about possible "product" and "enterprise" factors they would take into account when valuating alternative new product projects, and so about the importance levels they would attribute to these factors or, what’s the same, which linguistic label would be assigned to them from set \(\tilde{W} = \{\text{Essential, Very High, High, Fairly High, Medium, Fairly Low, Low, Very Low, Unnecessary}\}\). As a remarkable fact, there was a great coincidence in most expressed opinions, since only at punctual (even exceptional) cases factors differing from "standard" ones were alluded. Moreover, it was also remarkable the "receptiveness" that most of

\(^9\) See section 2 of this paper.
inquired experts show towards the idea of expressing their opinions by means of qualitative terms or linguistic, non-quantitative labels (in contrast with what occurred when doing similar studies and experts were asked to express their opinions translating them into quantitative or numerical scales).

Resultant “product” factors can be seen in Table 3, and so corresponding importance levels attributed by experts\(^\text{10}\). As can easily be seen, a total amount of twelve “product” factors were considered, being subdivided into six categories with two factors each.

In the same way, “enterprise” factors and corresponding importance levels are shown in Table 4. As with “product” factors, the twelve considered “enterprise” factors are grouped in six different categories with two criteria each. So, both types of criteria are equally balanced (same number in every category and both categories weight in the same way).

\(^{10}\) As proposal of this survey was providing an example of determining factors and importance levels, inquired experts’ opinions were all assigned an “indifferent” or “medium” weight \((W_{E_k} = \{Medium\} \quad \forall K = 1, K \leq 0.500)\).
Table 3
“Product” factors to valuate and select new product projects and associated linguistic importance labels

<table>
<thead>
<tr>
<th>Category</th>
<th>Factor or criterion</th>
<th>Importance level (linguistic label)</th>
<th>Associated quantitative punctuation&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Linguistic label fulfilment&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Product newness</td>
<td>Innovation degree</td>
<td>Fairly High</td>
<td>0.73575</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>Idea development degree</td>
<td>Fairly High</td>
<td>0.73575</td>
<td>0.70</td>
</tr>
<tr>
<td>B. Available</td>
<td>Technological knowledge</td>
<td>High</td>
<td>0.86525</td>
<td>0.54</td>
</tr>
<tr>
<td>technological basis</td>
<td>Future development lines</td>
<td>High</td>
<td>0.86525</td>
<td>0.54</td>
</tr>
<tr>
<td>C. Potential market</td>
<td>Market range</td>
<td>Very High</td>
<td>0.88075</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>Growth tendency</td>
<td>High</td>
<td>0.79125</td>
<td>0.84</td>
</tr>
<tr>
<td>D. Market accessibility</td>
<td>Legal barriers</td>
<td>High</td>
<td>0.79850</td>
<td>0.81</td>
</tr>
<tr>
<td></td>
<td>Presence of monopolies</td>
<td>High</td>
<td>0.79850</td>
<td>0.81</td>
</tr>
<tr>
<td>E. Product protection</td>
<td>Legal protection</td>
<td>Fairly High</td>
<td>0.73400</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>Other kind of methods</td>
<td>Medium</td>
<td>0.60100</td>
<td>0.80</td>
</tr>
<tr>
<td>F. Competence</td>
<td>Competence level</td>
<td>High</td>
<td>0.77525</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>Imitation risk</td>
<td>High</td>
<td>0.77525</td>
<td>0.90</td>
</tr>
</tbody>
</table>

<sup>a</sup> This associated quantitative punctuation is obtained by assigning a single numerical (and non fuzzy) value to every linguistic label (e.g. Essential=9, Very High=8, ..., Unnecessary=1) and balancing experts’ judgements through a weight mean (that in this concrete case turns into an arithmetic mean) in a punctuation scale ranging 0 to 1. This value reveals irrelevant when operating with fuzzy numbers, but it’s included in Table as an illustrative or referential element.

<sup>b</sup> The linguistic label fulfilment (or associated fuzzy number fulfilment) of each factor results from an integration of corresponding associated quantitative punctuation into the used nine term set distribution (see Figure 1). It would measure for each factor in a range from 0 to 1 the coincidence or consistence level between its associated fuzzy number (linguistic label) and its associated quantitative punctuation, allowing comparisons among these two alternative methodologies.
<table>
<thead>
<tr>
<th>Category</th>
<th>Factor or criterion</th>
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<th>Associated quantitative punctuation&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Linguistic label fulfilment&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Product / enterprise</td>
<td>- Enterprise activities</td>
<td>Fairly High</td>
<td>0.68350</td>
<td>0.84</td>
</tr>
<tr>
<td>enterprise suitability</td>
<td>suitability</td>
<td>Fairly High</td>
<td>0.68350</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>- Enterprise strategy</td>
<td>suitability</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>suitability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Project supports</td>
<td>- Presence of project</td>
<td>High</td>
<td>0.81875</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td>champions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Presence of project</td>
<td>High</td>
<td>0.81875</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td>sponsors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Product normative</td>
<td>- Legal dispositions</td>
<td>Fairly High</td>
<td>0.72200</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td>- Ecol. and cultural factors</td>
<td>Fairly High</td>
<td>0.72200</td>
<td>0.74</td>
</tr>
<tr>
<td>D. Productive equipment</td>
<td>- Equipment goods</td>
<td>High</td>
<td>0.80250</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>- Financial resources</td>
<td>High</td>
<td>0.80950</td>
<td>0.76</td>
</tr>
<tr>
<td>E. Human resources</td>
<td>- Non-qualified labour</td>
<td>High</td>
<td>0.80250</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>force</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Qualified labour force</td>
<td>High</td>
<td>0.86525</td>
<td>0.54</td>
</tr>
<tr>
<td>F. Material resources</td>
<td>- Raw materials</td>
<td>High</td>
<td>0.80250</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>availability</td>
<td>Medium</td>
<td>0.55475</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td>- Supplies availability</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> This associated quantitative punctuation is obtained by assigning a single numerical (and non fuzzy) value to every linguistic label (e.g. *Essential*=9, *Very High*=8, ..., *Unnecessary*=1) and balancing experts’ judgements through a weight mean (that in this concrete case turns into an arithmetic mean) in a punctuation scale ranging 0 to 1. This value reveals irrelevant when operating with fuzzy numbers, but it’s included in Table as an illustrative or referential element.

<sup>b</sup> The linguistic label fulfilment (or associated fuzzy number fulfilment) of each factor results from an integration of corresponding associated quantitative punctuation into the used nine term set distribution (see Figure 1). It would measure for each factor in a range from 0 to 1 the coincidence or consistence level between its associated fuzzy number (linguistic label) and its associated quantitative punctuation, allowing comparisons among these two alternative methodologies.

5. FS development possibilities: Future research guidelines
FS model provides a helpful tool for experts from innovative organizations in order to valuate and select new product projects for R&D processes. Main contribution consists on a better understanding and modelization of reality, and so an easier way to interpret obtained results, all by means of linguistic terms and fuzzy logic (moreover when FS is supported at the moment with a software application specifically designed). Nevertheless, there are several desirable paths of development to improve the model utility and its results:

- A possible first research guideline consists in considering the possibility of making a concrete and further detailed analysis and treatment of projects financial viability (by now, this first version only includes this mention when scoring corresponding “enterprise” factor). This guideline would contribute by giving experts an additional and complementary selection criterion for hierarchizing and selecting between those new product projects that, e.g., would have obtained a minimum “global” mark at previous scoring phase.

  In order to carry out this financial analysis, costs and incomes would have to be forecasted to valuate projects in a $h$ time periods horizon. Fuzzy numbers can also be used to achieve this objective, but in this case trapezoidal fuzzy numbers would be more suitable than triangular ones to be assigned to corresponding situations of variables. Acting according to this procedure, we would dispose of fuzzy data in terms of forecasted unit sales of each potential new product, medium sales prices per unit, fixed costs, variable costs and share taxes, all for every time period.

- As a consequence of productive processes are not independent at most cases, a second research guideline would be referred to introduce possible positive or negative relationships between products (actually included in the product portfolio of the organization) and potential new products (resulting from developed projects) that might be considered in terms of incomes, fixed costs, variable costs, etc. (mainly because of their complementary or substitutive character, etc.). This would introduce a new element of reality when selecting not only new product projects but project portfolios to be developed.

- Finally, as third research guideline, the problem to solve could be even more approximated to reality by including the assumption of some principles and postulates from Games Theory, and so including references to possible strategies to be put in practice by competitors, possible legal, political or socioeconomical sceneries, etc., that could all affect viability and results of valuated new product projects if developed.

  All these exposed guidelines would be translated in solving a square multicriteria problem of finding optimums. With this proposal, and according to the results from previous experiences (López, Mendaña and Rodríguez, 1996), the use of genetic algorithms would be in charge of searching and finding these wished optimums (best new product projects or best new product project portfolios) as required and, by this way, improving the goodness of final solutions.

6. References


