Evaluation of the Value Creation in an Innovative Product Using Fuzzy Linguistic Computing

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***Abstract* - Innovation is a vital tool for growth, enhancing value creation and is also a competitive advantage. The aim of this research is to propose a methodology to evaluate the potential for value creation in innovation of a new product, relatively to intangible and tangible assets. For intangible assets the proposed methodology combines a multiple criteria decision-making method with an adaptation of Tai and Chen (2009) model using 2-tuple fuzzy linguistic approach. This methodology was applied to the EToll product developed by the Portuguese company Brisa Innovation and Technology. It was concluded that the benefits that most contributed to value creation are the development and entrepreneurship of national companies and a better cooperation with suppliers and partners. The EToll also allowed a significant reduction in operating costs in the company. The originality of this study is based in the challenge for business managers to assess the real impact of new products based not only on financial reports, but also in terms of intangible assets and also, how to consider the more appropriate qualitative dimensions to evaluate the performance of intangible assets resulting from innovation.**

***Keywords* -** *Innovation, Value Added, Intangible Benefits, Stakeholders, Multiple Criteria Analysis, Linguistic Variables, 2-Tuple fuzzy.*

1. Introduction

In a competition-based economy era, innovation has become a vital tool for growth, as it enhances value creation, becoming a competitive advantage (Damanpour and Wischnevsky, 2006). Also, the process of developing new products is more and more an open innovation system where suppliers, research partners and customers are gaining more and more highlight. Therefore, during a new product development project it becomes necessary to assess the real impact of innovation not only for shareholders, but also for all the stakeholders that take part in the project (Pérez-Luño, Cambra, 2013).

This study has several contributions to the literature. The first concerns the novelty of investigating the return on investment from an innovative product that is often not only tangible but also intangible. In fact it is a challenge for business managers to assess the real impact of new products based not only on financial reports, but also in terms of intangible assets. The second is to consider the more appropriate qualitative dimensions to evaluate the performance of intangible assets resulting from innovation. Commonly, intangible assets' evaluation methods cannot appropriately evaluate the qualitative factors and expert judgment in the evaluation process of intangible benefits.

The aim of this research is to propose a methodology to evaluate the potential for value creation in innovation of a new product, taking into account not only the financial return on investment, as usually happens, but also the intangible benefits to shareholders and company stakeholders.

Thus, to evaluate the intangible benefits we propose the application of a multiple criteria methodology combined with an evaluation model for intangible assets based on 2-tuple fuzzy linguistic variables. Finally, the tangible benefits resulting from the development of a new product are measured through the net present value, as well as the additional evaluation indicators of the investment projects.

The article is organized as follows: Section 2 introduces the concept and measurement of value creation of intangible benefits resulting from the

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innovation of a new product. Section 3 makes a brief summary of the evaluation of intangible assets models. Section 4 presents the adopted methodology for this research. Section 5 proposes the model for measuring intangible benefits. Section 6 shows the method based on 2-tuple fuzzy linguistic information through a case study of an innovation of the new product "EToll" - toll payment system. Finally, section 7 presents the concluding remarks.

2. Innovation and Value Creation

The developments of new products are crucial for companies when innovations are recognized as key processes of competitiveness in markets (Quintana-Garcia and Benevides-Velasco, 2004).

Nowadays, the markets look for high quality and products' performance in development cycles more and more short, at a lower cost (Maffin, 2001).

For a good performance of a new product, it is important to have an efficient and effective management of the product development process. However, what seems to be missing in this process is the consistency in the development system, including an effective process of assessing the potential for value creation of the new product. Particularly companies are interested in measuring the profitability of an innovation in terms not only tangible but also intangible (Choi, Poon and Davis, 2008).

However, the development of innovative products depends on the net of customers, suppliers and partners of the company that contribute to the generation of new ideas and concepts. More and more, companies are applying an open innovation to their new projects, accepting that new ideas can come from inside or outside the company (Chesbrough *et* al., 2006; Dornberger and Suvelza, 2012).

Brooking (1996), Sveiby (1998), Stewart (2002), Lev (2001), Martín de Castro and López Sáez (2008) and Vidrascu (2013) among others, try to classify the intangible assets. A great majority of the authors who study intangible assets classify them in three or four categories. For instance, Sveiby (2002) proposed that intangible assets should include employee competence, internal structure, and external structure. Stewart (2002) identified also three categories such as human capital, structure capital and customer capital.

However, for Brooking (1996), the intangibles have four classes:

- human assets, are linked with to the benefits that individuals can provide to organizations through their experience, creativity, knowledge and capacity to solve problems, among others;
- Assets market are related to the market, with the main brand, customers, customer loyalty, the recurring business, ongoing operations and distribution channels;
- intellectual property assets are connected with know-how, trade secrets, copyrights, patents and designs;
- Assets infrastructure are technologies, methodologies and processes as information systems, management methods, customers' databases.

According to Kayo (2002) intangible assets can also be divided into four categories:

- human assets, such as knowledge, talent, skills and experience of employees, management, and training;
- innovation assets, such as research and development, patents, technological know-how;
- structural assets, such as processes, information systems and databases;
- relationship assets, such as brands, trademarks, copyrights, contracts with customers and suppliers.

Mahroum and Al-Saleh (2013) concluded that there is a positive relationship between the activities of research and development and companies' market value, what is in accordance with other studies that showed the same results.

Moreover, it is significant the influence of the innovations in the customer loyalty, in the less vulnerability to competitive marketing actions and in the possible opportunities for extension of the product line. As a consequence the company has higher and more consistent operating results in the medium-term (Dobni, 2008).

3. Evaluation Models of Intangible Assets

The importance of intangible assets in business valuation is so significant that many authors have developed models for evaluating intangible assets. In fact, these models had its great development in the nineties decade. Some authors employ accounting ratios or traditional models of companies' assessment, which use corporate financial reports. However, these procedures do not reflect the real value of intangibles.

Qualitative evaluation methods of intangible assets are proposed to tackle the existing problems of traditional financial reports' methods (Smith, 2003). It became essential to consider multiple dimensions or factors, which were evaluated by experts in the evaluation process of intangibles (Sohn and Ju, 2013).

These models are rich in structural terms. The comparison between these models is made in terms of the calculation process and the identification of the starting and arrival points, since each model uses a different process.

For other authors the measurement indicators are based on a questionnaire elaborated with the company's stakeholders. However, in the models based on scorecards as the Skandia Navigator (Edvinsson, 1997) or the Intangible Assets Monitor (Sveiby, 1997) it is not easy to visualize the elements of intangible assets. Besides, they do not provide a systematic process to build the evaluation model.

Thus, the inclusion of the experts' subjective judgments on value creation is an essential process in order to consider all the important components of the problem.

4. Methodology

The methodology that we follow, respects the perceptions of shareholders and stakeholders of a company, namely company employees, customers, partners and suppliers, among others. In other words, the proposed methodology must take into account several aspects evaluated by the stakeholders and capture the value of intangible benefits of the new product.

Therefore, to properly assess the value created in the innovation of a new product, we suggest the multiple criteria decision-making (MCDM) methodology. This procedure should include:

- Problem structuring;
- Model structuring;
- Evaluation process.

Problem structuring contains the problem context and the actors identification involved. Then, model structuring is composed by the definition of an hierarchical structure of intangible benefits of the new product, grouped into classes with their respective criteria. Also, for each criterion are defined measurement indicators. Finally, evaluation process is the construction and implementation of a research instrument through which the context actors will make subjective value judgments on each of the evaluation items and assign weights according to its importance. Besides, to each indicator is given a rating that reflects the performance of the product with respect to each criterion.

Then, the rating of the performance of the evaluating criteria and of the benefits are calculated using an adaptation of the algorithm to measure the intellectual capital developed by Tai and Chen (2009), which uses a dual fuzzy linguistic approach.

At the end, the value created by the new product considering each of the intangible benefits of the product is obtained.

Definition 1. A positive triangular fuzzy number $\tilde{T}$ can be defined as $\tilde{T}=(l, m, u)$, where $l \leq m \leq u$ and $l>0$. The function $\mu_{\tilde{T}}(x)$ is defined as:

$$\mu_{\tilde{T}}(x)=\begin{cases} \frac{x-l}{m-l}, & l<x<m \\ \frac{u-x}{u-m}, & m<x<u \\ 0, & otherwise \end{cases} \quad (1)$$

Definition 2. The value β [0,1], will be obtained after aggregating the result of the evaluation using the linguistic variable set *S*. Then, the symbolic translation process is applied to translate β into a 2-tuple linguistic variable. The translation function (Δ) can be represented as:

$$\Delta : [0,1] \rightarrow S \times [\tfrac{-1}{2g}, \tfrac{1}{2g})$$

$$\Delta(\beta) = (s_i, \propto) \text{ with } \begin{cases} s_i & i = round\ (\beta \cdot g) \\ \alpha = \beta - \frac{i}{g} & \alpha \in \left[\frac{-1}{2g}, \frac{1}{2g}\right) \end{cases} \quad (2)$$

Where $\beta \in [0,1]$

Definition 3. When $x = \{(s_1, \alpha_1), \dots, (s_n, \alpha_n)\}$ is a 2-tuple *fuzzy* linguistic set, its arithmetic average $\overline{X}$ is computed as follows:

$$\bar{X} = \Delta\left(\frac{1}{n}\sum_{i=1}^{n}\Delta^{-1}(s_i, \alpha_i)\right) = \Delta\left(\frac{1}{n}\sum_{i=1}^{n}\beta_i\right) = (s_m, \alpha_m) \quad (3)$$

In the process of the information aggregation, both symbolic translation functions Δ and Δ-1 are applied to ensure that the dual fuzzy linguistic variable can have two tuples with no loss of information (Herrera-Viedma et al., 2004).

Definition 4. When $x = \{(s_1, \alpha_1), \dots, (s_n, \alpha_n)\}$ is a 2-tuple fuzzy linguistic set, and $W = \{w_1, \dots, w_n\}$ is the set of weights of each x_i, its *2*-tuple fuzzy linguistic weighting average $\overline{X}^w$ is:

$$\overline{X^w} = \left(\frac{\sum_{i=1}^{n}\Delta^{-1}(s_i,\alpha_i)\cdot W_i}{\sum_{i=1}^{n}W_i}\right) = \Delta\left(\frac{\sum_{i=1}^{n}\beta_i \cdot W_i}{\sum_{i=1}^{n}W_i}\right) = (s^w, \alpha^w) \quad (4)$$

5. Proposal for a New Model to Measure Intangible Assets

The proposed model is an adaptation of the evaluation model of intellectual capital based on computing with linguistic variables from Tai and Chen (2009). However, in this study we intend measuring the level of intangible benefits for companies, when a new product is developed (Fig. 1).

In fact, there is a lack of knowledge of how to measure these benefits. In this situation the linguistic

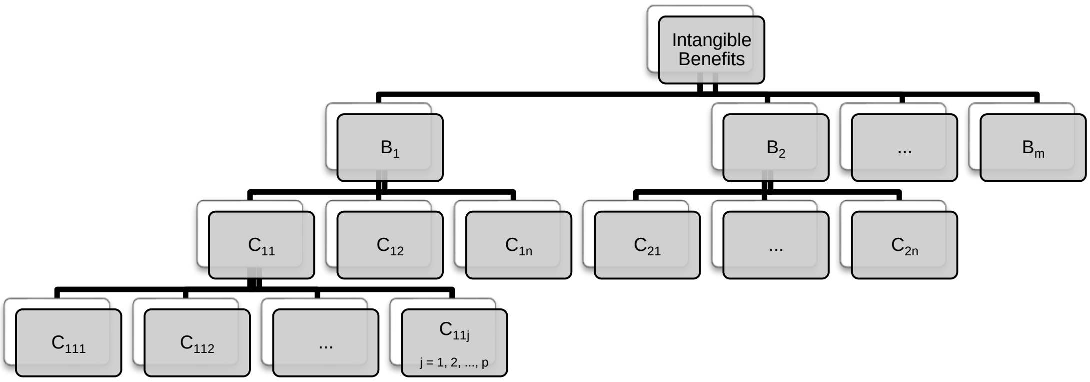

Figure 1 - Evaluation framework of intangible benefits.

variables are suitable to evaluate the level of intangible benefits by managers.

It is assumed that there are *m* intangible benefits resulting from the new product B_l ($l = 1, 2, ..., m$) and *n* C_{li} criteria ($i = 1, 2, ..., n$) with respect to each benefit. Each criterion contains several indicators of measurement. The steps of the proposed method are as follows:

Step 1. During the questionnaire, each expert uses the linguistic importance variables (shown in Table 1) to represent the weight of each intangible benefit for the study, the weight of each criterion with respect to each benefit and the weight of each item with respect to each criterion. Also, linguistic rating variables (shown in Table 2) are used to evaluate the performance of items with respect to each criterion.

Table 1. Importance of linguistic variables

Linguistic label	Linguistic term	Triangular fuzzy number
s_{w4}	Very important (VI)	(0.75, 1.00, 1.00)
s_{w3}	Important (I)	(0.50, 0.75, 1.00)
s_{w2}	Fair (F)	(0.25, 0.50, 0.75)
s_{w1}	Unimportant (U)	(0.00, 0.25, 0.50)
s_{w0}	Very unimportant (VU)	(0.00, 0.00, 0.25)

Table 2. Rating of linguistic variables

Linguistic label	Linguistic term	Triangular fuzzy number
s_4	Very good (VG)	(0.75, 1.00, 1.00)
s_3	Good (G)	(0.50, 0.75, 1.00)
s_2	Fair (F)	(0.25, 0.50, 0.75)
s_1	Poor (P)	(0.00, 0.25, 0.50)
s_0	Very poor (VP)	(0.00, 0.00, 0.25)

Step 2. Combining the values of the fuzzy evaluation of the *K* experts, we obtain:

- The performance rating $\bar{X}_{lij}$ of the item j, with respect to the criterion C_{li} and the benefit B_l, after the evaluation of all the experts:

$$\bar{X}_{lij} = \Delta\left(\frac{1}{K}\sum_{k=1}^{K}\Delta^{-1}\left(s_{lijk}, \propto_{lijk}\right)\right)$$

$$\bar{X}_{lij} = \Delta\left(\frac{1}{K}\sum_{k=1}^{K}\beta_{lijk}\right) = \left(s_{lij}, \propto_{lij}\right) \quad (5)$$

Where s_{lijk} is the fuzzy rating of item *j*.

- The weight $\overline{W}_{lij}$ of the item *j*, with respect to the criterion C_{li} and the benefit B_l, after the evaluation of all the experts:

$$\overline{W}_{lij} = \Delta\left(\frac{1}{K}\sum_{k=1}^{K}\Delta^{-1}\left(s_{wlijk}, \propto_{wlijk}\right)\right)$$

$$\overline{W}_{lij} = \Delta\left(\frac{1}{K}\sum_{k=1}^{K}\beta_{wlijk}\right)=\left(s_{wlij}, \propto_{wlij}\right) \quad (6)$$

Where s_{wlijk} is the fuzzy importance of item *j*.

- The weight $\overline{W}_{li}$ of criterion C_{li} with respect to benefit B_l, after the evaluation of all the experts:

$$\overline{W}_{li} = \Delta\left(\frac{1}{K}\sum_{k=1}^{K}\Delta^{-1}\left(s_{wlik}, \propto_{wlik}\right)\right)$$

$$\overline{W}_{li} = \Delta\left(\frac{1}{K}\sum_{k=1}^{K}\beta_{wlik}\right) = \left(s_{wli}, \propto_{wli}\right) \quad (7)$$

Where s_{wlik} is the fuzzy importance of criterion C_{li}.

- The weight $\overline{W}_{l}$ of the benefit B_l, after the evaluation of all the experts:

$$\overline{W}_{l} = \Delta\left(\frac{1}{K}\sum_{k=1}^{K}\Delta^{-1}\left(s_{wlk}, \propto_{wlk}\right)\right)$$

$$\overline{W}_{l} = \Delta\left(\frac{1}{K}\sum_{k=1}^{K}\beta_{wlk}\right) = \left(s_{wl}, \propto_{wl}\right) \quad (8)$$

Where s_{wlk} is the fuzzy importance of benefit B_l.

Step 3. Applying equation (3) it is possible to obtain the fuzzy rating of criterion $C_{li}\overline{(X_{li}.}$)

$$\bar{X}_{li} = \Delta\frac{\left(\sum_{j=1}^{l_i}\beta_{lij}\cdot\beta_{wlij}\right)}{\sum_{j=1}^{l_i}\beta_{wlij}} = \left(s_{li}^{w}, \alpha_{li}^{w}\right) \quad (9)$$

with $\beta_{lij} = \Delta^{-1}\left(r_{lij}, \propto_{lij}\right)$ e $\beta_{wlij} = \Delta^{-1}\left(w_{lij}, \propto_{wlij}\right)$

Step 4. Applying equation (4) it is possible to obtain the fuzzy rating of benefit $B_l\overline{(X_l}$.

$$\bar{X}_{l} = \Delta\frac{\left(\sum_{j=1}^{l_i}\beta_{li}\cdot\beta_{wli}\right)}{\sum_{j=1}^{l_i}\beta_{wli}} = \left(s_{l}^{w}, \alpha_{l}^{w}\right) \quad (10)$$

with $\beta_{li} = \Delta^{-1}(r_{li}, \propto_{li})$ e $\beta_{wli} = \Delta^{-1}(w_{li}, \propto_{wli})$

Step 5. Computing the overall performance level, the linguistic term S_T can be applied to represent the performance level of the new product in terms of value creation in an innovation.

$$P = \Delta\frac{\left(\sum_{j=1}^{l}\beta_{l}\cdot\beta_{wl}\right)}{\sum_{j=1}^{l}\beta_{wl}} = (s_T, \alpha_T) \quad (11)$$

with $\beta_l = \Delta^{-1}(r_l, \propto_l)$ e $\beta_{wl} = \Delta^{-1}(w_l, \propto_{wl})$.

6. Empirical Results and Overall Evaluation

The proposed methodology was applied to evaluate the potential of value creation in the innovation of the EToll - toll payment system, which was developed by the Portuguese company Brisa Innovation and Technology. This company belongs to the highway toll Group Brisa Auto-estradas de Portugal S.A..

6.1 Problem structuring

EToll is a toll machine introduced in 2010 in the tolling system of Brisa Auto-estradas. The toll operator was replaced by the equipment EToll, which continues to provide the same payment means of the traditional manual lanes. This demonstrates the intangible value of EToll.

The actors of the problem context are shareholders and employees of Group Brisa, product users, suppliers, and partners involved in the product's implementation project.

6.2 Model Structuring

Firstly, intangible benefits are based on opinions of two employees who were involved in the project implementation. The chosen categories were the market benefits, the research and development (RD) benefits and the human capital benefits.

Secondly, from the list of benefits considered relevant to the problem, we establish the relationships between the various aspects that constitute the form of a tree structure, with the objective to identify the criteria that could contribute to value creation of each class of benefits. Throughout the design phase, the tree of points of opinions was improved with the involvement of the evaluators and the analyst. The final tree of benefits and criteria was composed by 12 benefits and 17 criteria (Fig. 2, Fig. 3, and Fig. 4).

Thirdly, in order that the resulting assessment criteria of value creation in innovation are measurable, it is necessary to have metrics that indicate the product performance in relation to these criteria. Thus, we need to design the measuring instrument, and we applied the following methodology:

It was drawn up a list with indicators and 6 experts answered objectively whether the indicators of each class of benefits would be relevant to assessing the potential for value creation in innovation through one of three possible answers: "Yes" if the respondent considers the indicator relevant for the study. "No" if the respondent considers it not relevant and "Maybe" if the respondent has doubts about the indicator.

After evaluating the comments of the experts, a new list of metrics was drawn up. This list was composed solely by metrics which had not received any rejection. Finally, the result was sent to the 6 experts requesting the final confirmation/ disconfirmation on the selected indicators.

So, the final list of metrics that comprise the pre-survey instrument was sent to internal and external groups. The first questions are related with the market benefits; the second with the research and development (R&D) benefits and the latter with human capital.

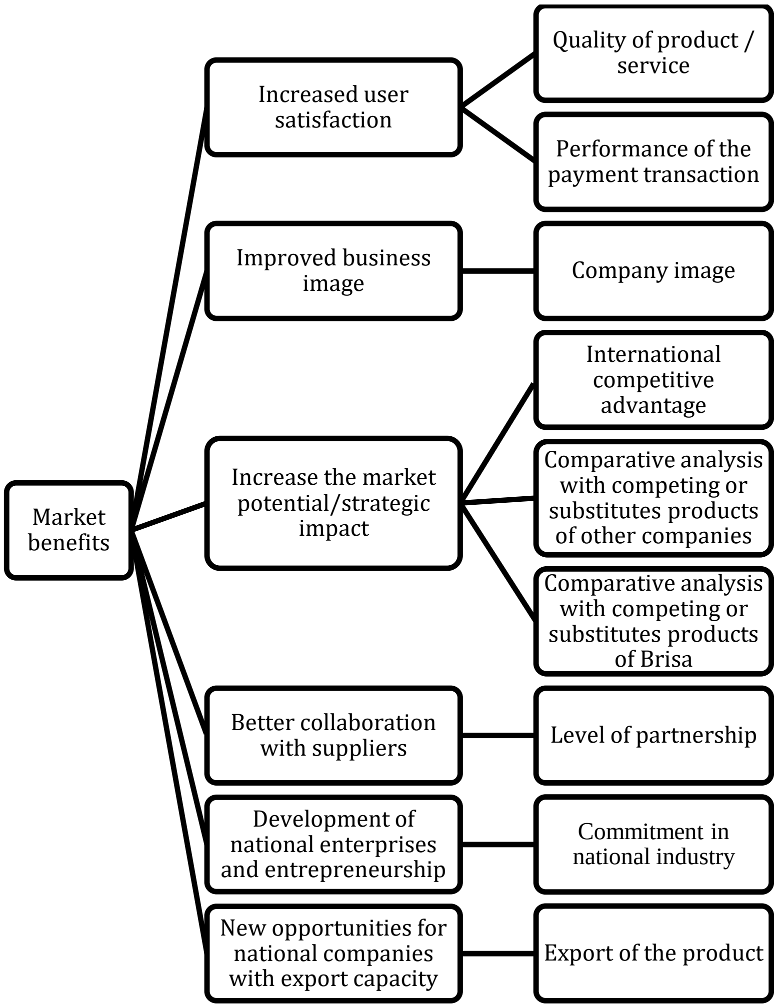

Figure 2 - Tree of market benefits and its criteria.

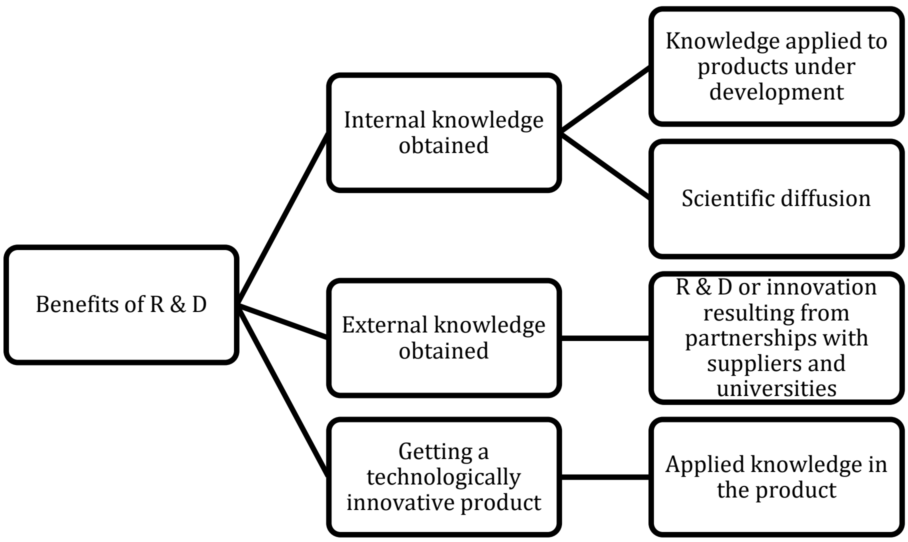

Figure 3 - Tree of R&D benefits and its criteria.

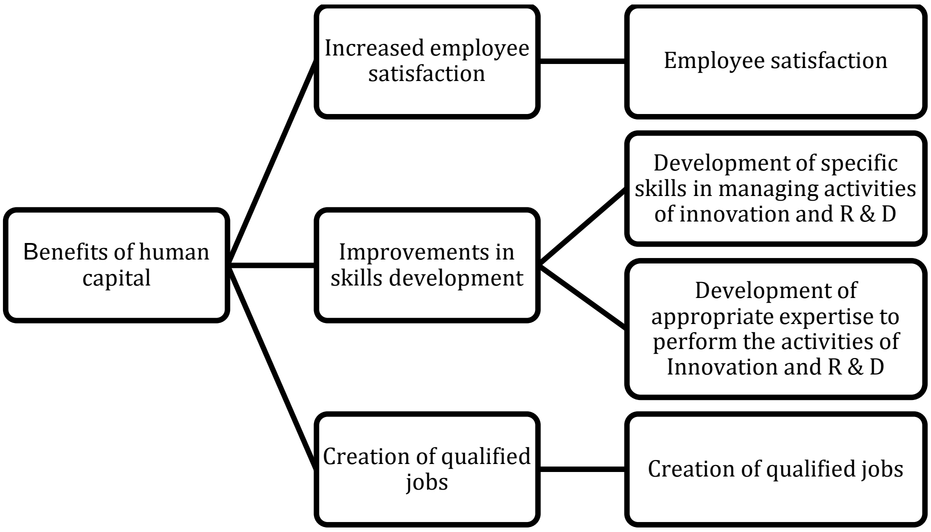

Figure 4 - Tree of human capital benefits and its criteria.

Four experts belonging to Brisa Company validated the pre-survey. The validation allowed changing 4 questions. Subsequently, we redesigned the pre-survey that was tested by 10 people randomly chosen in the internal and external groups that belong to the sample. The suggestions were considered in the design of the final survey, which was sent to the sample.

6.3 Evaluation Process

In the final phase of a multiple criteria method, the evaluation of the items that were defined in the model structuring is made through the interaction among the company's stakeholders. Therefore, internal groups (direction, commercial department, technical department, research and development department) and external groups (partners, suppliers and users of the product) of participants were defined. The application of the research method was made through the implementation of an electronic survey, which was sent to 200 participants. We adapted the algorithm used by Tai and Chen (2009), applying the dual fuzzy linguistic approach to measure the value of intangible benefits of the EToll product, through the respondents' answers.

According to the methodology suggested in section 4 and the proposal for a new model to measure intangible assets in section 5, the computing process for the evaluation of the EToll intangible benefits is presented in the following steps.

This process can be performed with the responses of all participants or one group of participants. In the examples mentioned below data is from all participants. We received 180 valid responses to the survey out of 188 responses in total.

Step 1. Evaluators use linguistic variables (Tables 1 and 2) to determine, through the survey instrument, the following items:

- The performance rating of Etoll, with respect to each indicator for each criterion;
- The weight of each indicator, with respect to each criterion for each benefit;
- The weight of each criterion, with respect to each benefit;
- The weight of each benefit for value creation in innovation.

Step 2. The 2-tuple fuzzy linguistic aggregation method was applied to compute fuzzy evaluation (Eq. 5) and the weighting value (Eq. 6) of each indicator with respect to each criterion. For instance, the fuzzy evaluation and weight of the indicator "Index of user satisfaction" with respect to the criterion "Quality of the good/service" is connected to the benefit "Increasing user satisfaction" are computed as:

$$\bar{W}_{111} = \Delta\left(\frac{1}{180}(0.75 + 0.75 + 0.5 + 1 + 1 + 0.5 + 1 + 0.5 + 0.5 + 0.25 + 0.5 + 0.5 + 0.75 + 0.75 + 0.5 + 0.75 + 0.75 + \cdots + 0.75)\right)$$

$$\bar{W}_{111} = \Delta\,(0.67) = (s_3, -0.08)$$

$$\bar{W}_{111} = \Delta\left(\frac{1}{180}(1 + 0.75 + 0.75 + 1 + 1 + 0.75 + 1 + 1 + 1 + 1 + 0.75 + 0.75 + 0.75 + 0.5 + 0.5 + 1 + 1 + \cdots + 0.5)\right)$$

$$\bar{W}_{111} = \Delta(0.82) = (s_3, 0.07)$$

The results for all indicators can be seen in Table 1A, Appendix A

The calculation of the 2-tuple fuzzy linguistic to obtain the weighting value of each criterion is based on Eq. 7. For instance, the weighting value of criterion “Quality of good/service” with respect to the benefit “Increasing user satisfaction” is computed as follows:

$$\bar{W}_{11} = \Delta\left(\frac{1}{180}(1 + 0.75 + 0.75 + 1 + 1 + 0.75 + 1 + 1 + 1 + 1 + 0.75 + 0.75 + 0.75 + 0.5 + 0.5 + 1 + 1 + \cdots + 0.5)\right)$$

$$\bar{W}_{11} = \Delta\ (0.83) = (s_3, 0.08)$$

The results for all criterions can be seen in Table 2A, Appendix A

The calculation of the 2-tuple fuzzy linguistic weighting value of each benefit is given by Eq. 8. For instance, the weighting value of benefit “Increasing customer satisfaction” is computed as follows:

$$\bar{W}_{l} = \Delta\left(\frac{1}{180}(1 + 1 + 0.75 + 0.5 + 0.75 + 0.5 + 0.75 + 1 + 0.75 + 0.75 + 1 + 0.75 + 0.75 + 0.5 + 0.75 + 0.75 + 1 + \cdots + 0.5)\right)$$

$$\bar{W}_{l} = \Delta\ (0,76) = (s_3, 0.01)$$

The results for all benefit can be seen in Table 3A, Appendix A

Step 3. The 2-tuple fuzzy linguistic weighted average method was applied to compute fuzzy rating value (Eq. 9). For instance, the fuzzy rating value of criterion “Quality of the good/service” is based on computing results presented in Table 1A, Appendix A.

$$\bar{X}_{11} = \Delta\left(\frac{0.67 \times 0.82 + 0.51 \times 0.79 + 0.63 \times 0.82 + 0.63 \times 0.71 + 0.63 \times 0.83 + 0.55 \times 0.79}{0.82 + 0.79 + 0.82 + 0.71 + 0.83 + 0.79}\right)$$

$$\bar{X}_{11} = \Delta(0.60) = (s_2, 0.10)$$

The results to the rating for all criteria can be seen in Table 2A, Appendix A)

Step 4. The same procedure was applied to obtain the fuzzy rating of performance of each benefit (Eq. 10). For instance, the fuzzy rating value of benefit “Increasing user satisfaction” is based on computing results presented in Table 2A, Appendix A computed as $\bar{X}_{l} = \Delta\left(\frac{0.60\times0.83+0.64\times0.90}{0.83+0.90}\right) = \Delta(0.62) = (s_2, 0.12)$.

The results to the rating for all benefits can be seen in Table 3A, Appendix A

Step 5. According to the fuzzy rating and weighting value of each benefit, the overall performance level of the value creation in innovation P is given by Eq. 11 and based on Table 3A, Appendix A.

$$P = \Delta\left(\frac{0.62\times0.76+0.64\times0.79+0.57\times0.85+0.74\times0.61+0.82\times0.82+0.54\times0.82+0.7\times0.88+0.63\times0.85+0.62\times0.75+0.62\times0.82+0.58\times0.86+0.57\times0.86}{0.76+0.79+0.85+0.61+0.82+0.82+0.88+0.85+0.75+0.82+0.86+0.86}\right)$$

$$P = \Delta(0.63) = (s_3, -0.12)$$

Therefore, the value creation in the innovation of the EToll corresponds to a rating of "Good", according to the set of linguistic terms S. However, it is very close to "Fair" – if the final rating was equal to $\Delta(0.62) = (s_2, 0.12)$.

This research aims at perceiving which are the intangible benefits, which contributed to the value creation in innovation. According to the value judgments of the Brisa stakeholders, ratings of performance for each intangible benefit were obtained, as shown in Table 3.

Table 3. Global rating of performance of Etoll in terms of intangible benefits

Intangible benefits	Rating of performance of EToll	Linguistic term
Development and entrepreneurship of national companies	0.82 = (s_3, 0.07)	Good
Better cooperation with suppliers	0.74 = (s_3, -0.01)	Good
Technologically innovative product	0.70 = (s_3, -0.05)	Good
Better image of the company	0.64 = (s_3, -0.08)	Good
Internal knowledge acquired	0.63 = (s_3, -0.12)	Good
Increasing user satisfaction	0.62 = (s_2, 0.12)	Fair
Increasing employee satisfaction	0.62 = (s_2, 0.12)	Fair
External knowledge acquired	0.62 = (s_2, 0.12)	Fair
Improvements in skills' development	0.58 = (s_2, 0.08)	Fair
Increase of the market potential / strategic impact	0.57 = (s_2, 0.07)	Fair
Creation of qualified employment	0.57 = (s_2, 0.07)	Fair
New opportunities for national companies with exporting capacity	0.54 = (s_2, 0.04)	Fair

6.4 Tangible Assets

To assess the potential for value creation in innovation of a new product, we must take into consideration not only the intangible assets but also the tangible.

The economic evaluation was focused on the impact and variations of perceived costs in the income statement of the company Brisa Auto-estradas de Portugal, S.A. in 2010. In this year, 249 ETolls were installed in 84 toll plazas in Brisa's network. The time horizon considered was five years, starting with the implementation of the equipment in July 2010 (year 0) and finishes in July 2015 (year 5).

According to the Annual Report the investment of the project implementation and installation of EToll resulted in 11.9 million euros. RD costs were considered as sunk costs, for purposes of the cash flows.

The implementation costs were costs of machine manufacturing, external consultancy, logistics, software development and implementation team. To estimate the cost of installing the machines, two scenarios were considered:

- In the optimistic scenario, the EToll machine is integrated in an existing toll booth;
- In the worst scenario it will be constructed a new line of tolling. It is assumed that in 70% of the cases, the tollbooths already exist and in 30% of the cases, new lines will be built.

The road construction and equipment installation costs totaled about 8.7 million euros. The residual value in year 5 was considered as 10% of the investment.

Operating costs of the EToll project consist primarily of maintenance, training, layoff and depreciation costs. It was considered that 2% of the initial investment was spent in maintenance per year and in the training costs during the installation period in year zero. We consider the equipment depreciation has a rate of 20% per year.

The major cost savings of this project were the toll employees dismissed in 2010. From 2011 until 2015, the company made high savings with the revenue. The annual values range from 6.2 million euros in 2011 to 7.2 million euros estimated in 2015. In 2010, the company managed to save 1.4 million euros. This reduction in operating costs allowed the company to be innovative when it comes to efficiency and value creation for its shareholders.

In order to obtain the net present value (NPV) of the EToll implementation project, we consider the weighted average cost of capital 4.45%. The NPV was € 8.982.362, which is positive, so the project has created value and is generating more money than the best alternative application of resources for the same risk.

The internal rate of return (IRR) is 21.9%. It is higher than the discount rate used in the calculation of the NPV (4.45%), which far exceeds the acceptance criteria of a project.

Regarding the discounted payback of the project, we obtained a relatively short payback of 3 years and 3 months. This criterion becomes important due to the economic instability that Portugal has been going through since 2010.

7. Conclusions

In this research, the methodology combined a method of multiple criteria decision support for defining the intangible benefits (respective criteria and indicators) and from the adaptation of the model for evaluating intellectual capital from Tai and Chen (2009).

Linguistic variables were applied to express the level of qualitative evaluation items, criteria and benefits of experts' subjective judgment. It was concluded that the benefits which most contributed to value creation in innovation of the EToll were "Development and entrepreneurship of national companies", "better cooperation with suppliers" and "technologically innovative product". However the evaluating weights of innovation process is different considering the distinctive stages of the process, even within the same company Wang et. al (2014).

The EToll project is an example to other national companies with technological scope. The production and implementation of the new product EToll will be done by Portuguese companies what will improve national economy, with a high multiplicative factor, since many companies are involved in this project, such as manufacturing, software, equipment installation and also consulting companies.

Considering the scale of operations, there is also a potential for new external partnerships and technical services. Furthermore, Brisa has to seize the strategic advantage of being the only company in Portugal that has a machine that allows the integration of several payments forms. There were also created new control of route processes, such as remote assistance, charging and collection of cash.

The reduction in operating costs allowed the company to be innovative when it comes to efficiency and create value for its shareholders. The NPV of the project was approximately € 9.0 million and the payback period of 3 years and 3 months.

In synthesis, the EToll generates high positive cash flows, according to the prevision calculations of the project, what allows the Brisa Auto-estradas de Portugal S.A. sparing annually an average of 6.9 million euros, since 2011.

We conclude that the methodology used to evaluate the potential of value creation in the innovation of a new product is a good contribution to management science, since the evaluation model of the intangibles assets used in this research, allowed the company understand which intangibles assets more contributed to the value creation in the innovation of EToll.

Additionally, this paper aid to lead for further studies such as the subjective evaluation of technology transfer and optimal solution patents. It can also be applied in the evaluation and selection of other innovation processes.

Limitations of the study

One of the major problems was the lack of adherence to participation in the research instrument of the employees and the difficulty in obtaining financial data of the company with respect to EToll implementation and installation costs as well as information relating to operating expenses or savings. For the analysis of NPV some data had to be estimated from the available data.

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Appendix A. List of the computing results

Table 1A. Rating of the EToll performance per indicator and the respective indicator weight

# Indicator	Indicator Name	Rating	Importance
111	Index of user satisfaction about the product	0.67	0.82
112	Customer retention rate	0.51	0.79
113	Good performance compared to the quality goal	0.63	0.82
114	Number of uses of remote assistance per year	0.63	0.71
115	Number of errors or equipment failures per month	0.63	0.83
116	Investment in user support	0.55	0.79
121	Percentage of transactions per year	0.62	0.71
122	Service performance compared to the quality goal	0.69	0.83
123	Average response time of transaction payment	0.65	0.88
124	Average response time of remote assistance	0.62	0.89
211	Rate associations of the product name to the company	0.61	0.76
212	Number of citations in the media that relate the product to the brand	0.54	0.74
213	Index of company's innovation	0.76	0.76
311	Number of international competitors	0.59	0.62
312	Number of competing products or substitutes of international companies	0.58	0.68
313	Characteristics of competing products or substitutes for international companies	0.56	0.74
321	Characteristics of competing products or substitutes	0.59	0.68
322	Duration of competitive differential	0.69	0.66
331	Utilization rate of the new equipment in relation to other payment methods	0.48	0.74
411	Relationship with partners	0.73	0.75
412	Number of years with major partners	0.75	0.72
511	Percentage of national companies involved in the project	0.82	0.87
611	Number of identified business opportunities for national companies with export capacity	0.55	0.81
612	Number of national companies with export capacity potentially interested in the product	0.52	0.76
711	Percentage of R&D applied	0.70	0.77
811	Percentage of R&D applied to products under development	0.73	0.76
821	Number of presentations at scientific conferences per year	0.57	0.65
822	Number of scientific publications per year	0.45	0.61
911	Number of established technology partnerships with suppliers	0.66	0.75
912	Number of implemented ideas resulting from partnerships with universities	0.58	0.71
1011	Motivation Index	0.63	0.75
1012	Index of empowerment	0.63	0.74
1013	Satisfaction index	0.62	0.74
1111	Investment in management training on Innovation and R&D	0.58	0.78
1121	Investment in technical training on Innovation and R&D.	0.58	0.78
1211	Number of jobs created	0.57	0.75

Table 2A. Rating of the EToll performance per criterion and the respective criterion weight

# Criterion	Criterion Name	Rating	Importance
11	Quality of product / service	0.60	0.83
12	Performance of the payment transaction	0.64	0.90
21	Company Image	0.64	0.76
31	International competitive advantage	0.58	0.81
32	Comparison with competing products or substitutes of national companies	0.64	0.79
33	Comparison with competing products or substitutes of Brisa company	0.48	0.79
41	Partnership level	0.74	0.75
51	Commitment to national industry	0.82	0.87
61	Opportunity to export the product to national companies	0.54	0.81
71	Knowledge applied to the product	0.7	0.77
81	Knowledge applied to products under development	0.73	0.81
82	Science communication	0.51	0.68
91	R&D or innovation resulting from partnerships with suppliers and universities	0.62	0.75
101	Employee satisfaction	0.62	0.74
111	Development of specific skills in managing innovation activities and R & D	0.58	0.74
112	Development of technical expertise adequate to the activities of Innovation and R&D	0.58	0.76
121	Creation of qualified jobs	0.57	0.86

Table 3A. Rating of the EToll performance per benefit and the respective benefit weight

# Benefit	Benefit Name	Rating	Importance
1	Increased user satisfaction	0.62	0.76
2	Improved company image	0.64	0.79
3	Increase the potential market / strategic impact	0.57	0.85
4	Improved collaboration with suppliers	0.74	0.61
5	Development of national enterprises and entrepreneurship	0.82	0.82
6	New opportunities for national companies with export capacity	0.54	0.82
7	Getting a technologically innovative product	0.7	0.88
8	Gain insider knowledge	0.63	0.85
9	Gain external knowledge	0.62	0.75
10	Increased employee satisfaction	0.62	0.82
11	Improvements in skills development	0.58	0.86
12	Creation of qualified jobs	0.57	0.86