Assessment of companies practices concerning the evaluation of R&D investment project

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Abstract

This study introduces an on-going research project aimed at analyzing the impact of R&D projects both from the public and private points of view. From the public perspective the social impacts and objectives of these projects, frequently supported by National or European R&D programmes, should be underlined and properly considered in the evaluation process. On the other hand, the private perspective emphasizes mainly financial and strategic returns for the companies involved in research projects. This paper addresses part of the research conducted so far, focusing in particular on the private perspective, namely on the identification of the more appropriate methods for the evaluation of research and development (R&D) investments projects by companies.

Several studies indicate that the use of traditional financial methods is not the most appropriate for evaluating R&D projects (see, for example, Chan, 2001, Proctor and Canada, 1992, and Mensah and Miranti, 1989). The use of these methods consists, basically, on discounting the expected future cash flows and the adoption of several methods for measuring its financial viability (e.g. NPV, IRR). This implies that the costs and benefits associated with the investment are easily and objectively quantified. Nevertheless this is not always possible for all types of investments, particularly in the Advanced Manufacturing Technology (AMT), in Information and Communication Technologies (ICT), or in projects of R&D. For these type of investments, the estimation of financial flows and the assessment of their risks tend to be different from general tangible investments. This is particularly important in the calculation of benefits, which can be of three types: strategic, quantifiable and intangible. For example, the intangible benefits are difficult to quantify but may have a significant impact on return on investment (Adler, 2000).

Moreover, has been witnessing an increasing trend for companies to include non-financial dimensions/variables (e.g. strategy, flexibility and quality) of the problem in their decision-making process on investment projects. Indeed, these non-financial aspects are particularly important in the new industrial environment in which companies today operate, where new technological developments tend to occur more rapidly than the development of methods for the evaluation of investment projects (Brownell and Merchant, 1990).

One of the objectives of this paper is to present an up-to-date state-of-the-art regarding the non-financial techniques that have been proposed to evaluate investment projects in research and development (R&D). Indeed, the evaluation of such projects, although often conducted purely in the perspective of business profitability, cannot be reduced to a simple analysis of discounted cash flows, since these projects often provide strategic gains that could hardly be translated into quantifiable monetary benefits in the short term. Moreover, there are also other factors that are difficult to measure/quantify, such as: political issues, environmental impacts, knowledge, intuition, or experience.

As a result, this study discusses several non-financial criteria to be considered in the evaluation of R&D projects, which have been proposed in the literature related to products manufacturing, environmental, employment, users of the results of R&D, competitiveness of technology, relevance of technology, economic benefit, social benefit, quality of technical plan, availability of resource, technical risk, development risk, commercial risk, and return of investment.

A second objective is to conduct an inquiry to a sample of metallurgical companies in northern Portugal and southern Galicia in order to assess which practices have been used to evaluate R&D investments. In fact, this would allow us to gain an insight concerning both the financial and non-financial criteria used and if they use software support, as well as the importance of certain non-financial criteria in the evaluation of projects. Moreover we are trying to see if they currently use any of the multi-criteria methods.

The ultimate goal of this research would be to propose an integrated methodology that can be applied to the evaluation of R&D projects, based on financial and non-financial methods using multi-criteria techniques. The purpose of multi-criteria models is to break a complex problem into simpler parts. That allows the decision-maker to structure a problem with many criteria in a visual way, through the construction of a hierarchical model that basically contains three levels: aim or objective, criteria and alternatives. Once the model is built, two by two comparisons are made between these elements (criteria-subcriteria and alternatives) and numerical values are given to the preferences assigned by individuals, therefore obtaining a summary value by aggregating this partial judgements (Rodríguez, 2008).

Keywords: R&D projects, financial criteria, non-financial criteria, multi-criteria methods, evaluation.

Introduction

In this study it is argued that in the evaluation of R&D investment projects, the use of traditional financial methods only is not the most appropriate procedure. In fact, companies are moving in turbulent environments that directly affect them and there is an enormous competition among companies. Therefore, these need more suitable methods to assess the value of R&D investments.

The present paper aims at contributing to the literature by proposing a hierarchy model to evaluate R&D projects (based on multi-criteria decision approach) and describing the questionnaire constructed to collect the necessary data.

The paper is structured as follows. In the first section, a literature review on financial and non-financial methods used to evaluate investment projects is presented. The second section describes the research methodology adopted, emphasizing the structure of the questionnaire and the process of data collection. In the third section, there is a brief discussion of the multi-criteria decision models that would be necessary to aggregate financial and no-financial indicators. Finally, the last section presents the conclusions and the opportunities for further work.

Literature review

Financial criteria

Over the years companies have generally based the assessment of their projects on financial criteria in order to achieve the best economic performance. This is why the academic community has proposed several methods that can help to improve capital investment decisions of companies. These investment evaluation criteria are indicators that help to determine whether a project should be or not undertaken, allowing important decisions of the project to be optimized, such as location, technology, optimal time to invest in or abandon a particular project.

Financial convenience to undertake an investment project can be analyzed in principle, according to their economic performance or expected profitability, that is, if the net cash flows generated during their lifetime (revenues minus costs and expenses) outweigh the initial investment.

The translation of the economic realities to algebraic equations is always a delicate approach, and it is odd that a mathematical formulation, as thorough and deep as it may be, may reflect the complexity and the highly uncertain nature of the problems of the economy world.

Below a brief summary of the main financial methods is given, distinguishing between those that do not take into account the time value of money from those which do. The first group includes the payback period (PBP) and the accounting average rate of return (ARR).

The payback period (PBP) calculates the number of years needed to recover the initial investment. Its interest lies only in the recovery time of this invested amount, hence its decision criterion is based on choosing the project that recovers the initial investment in a shorter period of time (Fernández, 2007). Therefore, this method rewards liquidity over profitability. Thus, the money invested will soon be recovered and one will have a lower risk investment (Mascareñas, 2008). In times of high volatility the use of this method is a way to increase the security of investments since the time it would take to recover the investment would be known (Garcia 2007). In addition this method is easily understood and very simple to be implemented. However, as this method is only interested in the time period in which the initial investment is recovered, it disregards the cash flows generated after the recovery period. Another drawback of this method is the fact that it does not consider the time value of money. This problem can be easily overcome using discounted cash flows (Vela, 2005). Finally, this method tends to accept more projects with a shorter live over more profitable projects but with a longer period of time to recover the initial investment (García 2007).

The accounting average rate of return (ARR) method, relates the average annual cash flow and the initial investment showing an average rate of return of the project (Fernández, 2007). This is an easy method to understand and to apply as the values used are the ones directly obtainable from accounting data, and it is also easy to obtain a term of comparison (García, 2007, Fernández, 2007).

However this method presents some problems: First, it ignores the time value of money. Secondly, it is based on accounting profits and not on the project cash flows. Furthermore, it is necessary to set a standard reference for assessing a project (Fernández, 2007)

In the second group of methods (discounting cash flow methods) one can distinguish between the net present value (NPV), the internal rate of return (IRR) and the profitability index (PI). The NPV consists of discounting all the expected future cash flows of an investment project, using a discount rate which is the opportunity cost of the capital employed in the investment project. After discounting all the future cash flows the value of the initial investment is subtracted, hence the name of Net Present Value (Mascareñas, 2008). This method by discounting the expected future values of cash flows, eliminates the disadvantages of the two former methods in relation to the time value of money, but its calculation requires time, the understanding of this concept and also a discount rate for calculations (García, 2007)

The discount rate applicable is the cost of capital or minimum acceptable rate of return, which includes the loss of purchasing power of money, the risk-free interest rate and the risk premium (Baca, 1996). The cash flows should consider all payments and receipts for a certain project over its lifetime.

The NPV has some drawbacks. It is unable to properly assess investment projects that are flexible with time, i.e. that incorporate real options (growth, abandonment, postponement, learning, etc.), which implies that the value obtained through the simple discounted cash flows underestimate the true value of the project. Another drawback is that in the computation of the NPV it is implicitly assumed that the cash flows, which are generated over its lifetime, will have to be reinvested until its term at a rate identical to their opportunity cost of capital (Mascareñas, 2008).

Usually, as the investor does not know the reinvestment rate he will have no choice but to calculate the NPV, but knowing that at the time of the reinvestment of cash flows the interest rates could be above or below the initial cost of capital used, which could lead to a different result from the one calculated at the time of elaborating the investment project. Moreover, this method implies to determine the discount rate previously (Rocabert, 2007).

There is a variant of the NPV method: the profitability index, which consists of dividing the present value of cash flows by the initial disbursement of the investment (Mascareñas, 2008). This method is applied in situations where there are capital restrictions. At first, those investments whose rate of return exceeds the unit would be undertaken, since this fact would indicate that the amount recovered from the investment, taking into account the effect of time on the value of capital, is higher than the one paid. The main limitation of this method is that it does not yield a period return but throughout the time horizon of investment, which complicates their understanding.

The internal rate of return (IRR) represents the discount rate for which the NPV of the project is zero. Implicitly it assumes that cash flows are reinvested at the same IRR until the end of their life in the same project or other projects with the same performance (García Dumrauf, 2003). Besides the capital growth is expressed in relative terms, and the growth rate of capital is determined per period (Rocabert, 2007).

This is a widely used criterion for project evaluation because it can be compared to the opportunity cost of capital. However, when using the IRR the following problems can be highlighted. Firstly, the problem of multiple IRR, when there are positive cash flows mixed with negative ones. Secondly, in the case of mutually exclusive projects, NPV and IRR can lead to different conclusions about what project should be accepted. Finally, in calculating the IRR it is implicit the assumption that the cash flows being generated by the project during its economic life are reinvested at the IRR. However, this seems to be an unrealistic hypothesis, especially when high values are obtained for the IRR.

It is noteworthy that there is a variant of the IRR called IRRM. This method of valuation takes into account that the reinvestment of cash flows generated by the project will have to be at the opportunity cost of capital, and therefore it always provides a unique positive rate of return which is very useful for the completion of the projects (Chang, 1999).

Several authors, (e.g. Peumans, 1974, Weston and Brigham, 1984, Brealey and Myers, 1998 and Belli, 1996) argue about the difficulty of applying the criterion of the IRR due to the lack of good properties of this indicator of desirability of a project. Thus, Gronchi (1986) states that the internal rate of return can be used in decision-making procedures only if it is unique. Given these difficulties, one can opt to dispense the IRR and use the NPV, which is Oehmke's main conclusion (2000) and Castelo's starting point (2001): If the researcher is very sure of the appropriate discount rate to use, then there is no problem: either the NPV is positive in that type or not. For Ross (1995), the IRR is not a good decision criterion at all, because it does not lead to the same decision as the NPV. The problem might also be simply ignored examining only the case of the unique IRR.

Non-financial criteria

During recent decades, the globalization of financial markets, the intensifying competition among companies, financial institutions and organizations, as well as the rapid economic and social development, and technological changes have led to growing uncertainty and instability in the financial situation and business environments (Zopounidis and Doumpos 2002). Simultaneously, in order to achieve higher profits and to maximise the value of the company, managers seek a differentiation with the rest of their competitors, which implies, in some cases, to invest in R&D projects.

Steuer and Na (2003) argue that a modern enterprise is a complex organization in which different interests interact one another, each one with its own idea on the maximization of wealth, subject to concerns about risk, liquidity, corporate social responsibility, environmental protection, welfare of employees, and so on.

That is why it may be desirable to apply a multiple objective approach to many decision-making criteria. That is why the decisions should be made taking into account not only economic aspects, given that not all factors that change with an intervention are quantitatively expressed in a traditional or monetary way. The political consequences, their environmental impact, some after-effects to the project, the achievement of strategic objectives, the contribution to decentralization, the investment risk, the term return, among others, are factors difficult to quantify and can have a major impact on projects. From the design to the completion of a project throughout the process, factors such as perception, intuition, experience and others, are of vital importance, therefore, the human-qualitative factor cannot be excluded.

According to Henig and Katz (1996), the evaluation of R&D projects is difficult using only the traditional financial methods. In fact, for these type of projects the NPV is nearly impossible to calculate, given that the firm is dealing with new technologies, the project is exclusive to the firm and all relevant information concerning the value of the project is the exclusive property of the firm.

Some authors (e.g. Henig and Katz, 1996, Linton *et al.*, 2000, Krupka *et al.*, 2005, Fernández *et al.*, 2008, and Huang *et al.*, 2006) have identified and gathered several criteria to be considered at the time of evaluating investment projects. In the following paragraphs a brief description of these studies is presented.

For example, Linton *et al.* (2000), when analysing the adoption of Advanced Technologies, considers a variety of quantitative and qualitative measures, namely: the required investment, the anticipated cash flow for the next four years, the stage of the product life cycle, and the stage of the intellectual property lifecycle.

Henig and Katz (1996) propose a set of criteria focused on product such as the following:

- Size of existing market: this criterion is determined from market research.
- Competition: It would have to analyze the likelihood that competition could develop similar products.
- Competitive advantage: It should also analyze the capacity of a new product to compete with existing ones.
- Patentability: It is important to know the likelihood of a product or technological innovation can be patented as they would provide future revenues for the company.
- Development capacity: The extent to which the company has the technology to develop the product.
- Production: The total production cost of the finished product.
- Development costs: The cost that leads to the fact of developing a project in a given year.
- Time of Completion: When the product is put on the market.
- Toxicity: We must also take into account whether the product is toxic to mammals, plants or other beneficial organisms.

Krupka *et al.* (2005) analyze the environmental criteria when evaluating projects. Creating a decision-making process for the environmental system is complicated, since it is difficult to define the environmental benefits of a project. The objectives, for example, would be to minimize the emission of harmful substances, and the increase in the value of the effects achieved by the unit of invested costs. In a purely environmental investment, the summary of impacts in a single economic measure is often quite problematic.

The importance of the environmental investment is in vigorous growth, both in technology application or as an integrated system with a preventive approach to investment. Eco-efficiency expresses the efficiency with which ecological resources are used to meet the economic goals established. The minimum cost, the maximum amount of cash or a combination of both, are the criteria for absolute evaluation (to apply or reject) or for a selection of a definite number of variants.

As highlighted by Krupka *et al.* (2005), there are many methods used to assess the effectiveness and efficiency of investment. Each one is a guide for further analysis and decision-making, however none of the recommended methods can serve as a general application. The contribution focuses on eco-efficiency as an integration of economy and ecology. Thus, the eco-efficiency is a connection that can be controlled through two generic indicators: ecological and its reverse intensity, the eco-productivity. Some costs and benefits are intangible, with regard to environmental concerns. The valuation of environmental benefits (the stability of ecosystems, visibility, the value of nature, etc.) taking into account the investment on environment is a problem. The reason is the impossibility of comparing the assessment of individual consequences (Krupka *et al.*, 2005).

In a study undertaken by Fernández et al. (2008), it was concluded that the following criteria were used by some companies when evaluating R & D projects. These criteria are classified into the following groups: Employment, users of the results of R & D and environment.

- Employment: Job Creation / Transformation / Removal in implementing the outcome of a project. Job quality (improvements in working conditions: physical, psychological, etc. Level of employee training. Collaboration between businesses, universities, etc.

- Users of the results of R&D: Improvement in meeting economic / social needs of end users due to unmet needs. Contribution to solving / creating social problems (relocation, discrimination, disabilities, etc). Company social responsibility (CSR). Knowledge dissemination through patents.
- Environment: Effects on the functioning of markets: structure, corporate behaviour, strategy, impact on suppliers, competition, creation of new businesses, outsourcing.

Huang *et al.* (2006) show a detailed study of the results obtained which describes the criteria taken into account by the Industrial Technology Development Program in Taiwan, as well as the relative weights of each of them to be used in a multi-criteria analysis. The criteria considered were the following:

- Competitiveness of technology: Proprietary technology, Key of technology, Innovation of technology, Advancement of technology.
- Relevance of technology: Technological extendibility, Technological connections, Generics of technology.
- Economic benefit: Technology spillover effects, The potential size of market, Improvement on research capability.
- Social benefit: Improvements on QESIS, Coincidence with S&T policy, Benefits for human life, The contributions to the state of Knowledge.
- Quality of technical plan: Content of technical plan, Capability of research team, Reasonableness for research period, Reasonableness for research cost, Environmental and safety consideration.
- Availability of resource: Technical resource availability, Technical support, Equipment support.
- Technical risk: Opportunity of technical success, Evidence of scientific feasibility, Specification of technology.
- Development risk: Risk for development cost, Risk for time cost, Timing for project.
- Commercial risk: Opportunity of market success, Opportunity of project result implementation.

As one can conclude, there are many criteria that should be taken into account when evaluating R&D projects. In fact, each company or each business sector will have different decision criteria and different adoptions for each criterion. Therefore, each company must conduct an in-depth analysis before the evaluation of projects in order to determine the weight to attribute to each criterion. For these, firms can rely on a group of experts group depending on the future path the firm wants to follow. In the study that is being conducted, we are trying to analyze the criteria used by metallurgical companies in the North of Portugal and in the South of Galicia as well as possible adoptions for each one of them. To help in the decision making process it is of major importance the use of multi-criteria techniques, which allow to convert qualitative information in quantitative data.

Research Methodology

Questionnaire structure

Surveys are based on data collected through various methods such as personal surveys, telephone, postal, or via internet. In the present study, an electronic questionnaire was used. Then, in order to improve the response rate, a series of telephonic contacts were initiated. An electronic mail was sent to the selected companies with a link that redirect them to the survey. In this process, it is very important both the selection of respondents and the survey design. In fact, if the survey has an appropriate sample size and a correct structure, the findings obtained can be generalised (Afonso, 2008).

The survey method is often used because it is time and cost-efficient. In fact, surveys are efficient because they allow a large quantity of data to be obtained at a lower cost (Afonso, 2008). There is a low cost of design, publishing and distribution. Additionally, electronic surveys allow eliminating geographic barriers (Mahía, 2002). Therefore, surveys can be done at any time, without time constraints and the speed with which answers can be received. The data collected can, therefore, be handled much easer.

However, the interpretation of survey data presents some limitations. Firstly, the answers are the opinion of an individual and may not fully reflect the company's position (Ryan and Ryan, 2002). Secondly, survey participants may not be representative of the defined population of firms and survey questions may be misunderstood by some participants (Graham and Harvey, 2001). Finally, in the case of online surveys, there is evidence that the response rates tends to be very low, perhaps due to the amount of spam being received via mail (Mahía, 2002).

The questionnaire used in this research project was designed to gather information on techniques and software used in the evaluation of R&D projects of metallurgical companies in the North of Portugal and in the South of Galicia, and also the criteria used in the evaluation projects trying to discover the relative importance of each one of them. At the end of the questionnaire there was a space for comments, allowing respondents to give his opinion about the survey, and also if they have any point about the survey or comment on something that was not questioned on it. Finally, there is also a space for respondents to add his/her email address to receive a report with the main results of the survey respondents for those who want it. Most questions were measured using a five-point Likert scale. Likert scales are particularly useful for measuring the technique or level of use of the criteria. The following subsections present each question's group in more detail.

Table 1 – Questionnaire structure

Group	Window	Variables
Group 1	General information about the firm	Enterprise sector, position in the company, age, incomes, exports, number of employees, research and development projects
Group 2	Research and development projects	Budget, years
Group 3	Financial criteria	PBP, ARR, NPV, IRR, software
Group 4	Non-financial criteria	Jobs, social, technology, environmental, risk, economic and strategic
Group 5	Multicriteria methods	Methods, software

As it's shown in the Table 1, the survey has five groups of questions. Some of them have only one answer, others are of open response, and others are presented by using simple statements. The first group concerns the general company information and the position of the respondent in the company. The second group of questions is seeking to differentiate between companies that perform R&D from those that do not. The third group intends to know which are the financial criteria used by companies and the support software used. The fourth group tries to indicate the importance that some non-financial indicators have to companies. The fifth group shows Multi-criteria techniques in order to know which one are used by the companies and the support software used. The questionnaire is detailed below.

Group 1: General information about the firm

a) Sector to which the firm belongs:
b) Responder position in the firm:
c) Number of years the firm has been in business:
d) Annual sales:
e) Exports (% of annual sales):
f) Number of employees:
g) Has your company invested in R&D projects, or is involved in R&D projects?

The answers to these questions are obtained from a range of possible answers. If the answer to question g) is no, the respondent skips directly to the Group 3. These questions seek to know the current status of the company, so at analysis time of the data obtained to differentiate between the different companies the techniques used and the criteria scale according to their characteristics.

Group 2: Research and development projects

a) Percentage of revenues invested in R&D activities.
b) How many years has been your company invested in R&D projects?

The answers to these questions are obtained from a range of possible answers. These questions seek to determine the degree of engagement of firms in R&D activities.

Group 3: Financial criteria

a) Indicate the frequency with which your company uses the following financial methods to evaluate R&D projects.
b) If your company uses another financial criterion indicate which it is.
c) Does your company use software to support any of these methods?
d) If yes, which is it?

The answer to the question a) is measured based on five-point Likert scale, between: "Never" and "Always". This question seeks to know which of the financial criteria are used by companies surveyed. While the answers to questions b) and d) they are open questions, the answer to question c) it's a choice between "yes" and "no" values. Also it is explored what support software is used by companies surveyed. Source: Garcia (2007).

Group 4: Non-financial criteria.

Indicate the frequency with which your company uses the following no-financial methods to evaluate R&D projects or in your opinion the relevance that it has in the:

JOBS:

a. Fewer workers.
b. Improvement in the quality of work.
c. Improvement in the level of training for the job.
d. Maintenance / Consolidation Employment.

Source: Fernández et al. (2008).

SOCIAL:

e. Reconciliation of work and family.
f. Corporate social responsibility.
g. Search unmet social needs or improvements in quality of life.
h. Social recognition.

Source: Fernández et al. (2008), Huang et al. (2006).

TECHNOLOGY:

i. Advancement of existing technology.
j. Property rights on patents
k. Improved production processes.
l. Market size for which it is.

Source: Huang et al. (2006) and Henig and Katz (1996).

ENVIRONMENTAL:

m. Pollution reduction.
n. Government Assistance.
o. Social impact.
p. Reduction of energy use.

Source: Krupka et al (2005), Henig and Katz (1996).

RISK:

q. Time to recovery of the money invested.
r. Total money invested in the project.
s. Time until the project is finished.
t. Risk on the viability.

Source: Huang et al (2006).

ECONOMICAL AND STRATEGIC:

u. Improving competitiveness.
v. Development of partnerships with companies, universities.
w. Pursuit of differentiation with other companies.
x. Patents exploitation.

Source: Fernández et al (2008).

The answers of these questions are measured based on five-point Likert scale between: "Not important" and "Very important". These questions seek to know what criteria is the most important by companies or the most used. These information is very important when conducting a multi-criteria analysis.

Group 5: Multi-criteria methods

a) Indicate the frequency with which your company uses the following multi-criteria methods to evaluate R&D projects.
b) If your company uses another multi-criteria method say which one is it.
c) Does your company use software to support any of these methods?
d) If yes, which is it?

The answer to the question a) is measured based on five-point Likert scale between: "Never" and "Always". This question seeks to know what multi-criteria methods are used by companies. While the answers to questions b) and d) are open questions, the answer to question b) is a choice between "yes" and "no" values. These questions seek to know the support software for these methods which is used by the companies.

Collecting the data

Before beginning collecting the data of the survey, it is necessary to design its structure, as well as to choose the addressees of the survey. First of all, we looked up the metallurgical companies in the Vigo area in a database from Vigo University. In the first selection, a total of 259 companies were chosen of the following sectors: research and development, metallurgy, manufacture of metal products, automotive and naval.

Then a second selection was carried out. For this, companies with an income under 1,000,000 € and less than 20 employees were eliminated. From this selection, a total of 119 companies were obtained. It is worth showing that this first stage is about obtaining some first results that subsequently will be extrapolated to the highest number of companies from Galicia and North of Portugal. Once the final database of the companies was obtained, we proceeded to the research of emails and telephone numbers through the World Wide Web (WWW).

According to Afonso (2008), the use of electronic questionnaires through the Web has a series of important advantages: the low cost, the speed with which answers are received and the possibility of using the data collected as a straight input for statistical software packages.

In the electronic questionnaire developed, questions were grouped in different windows. This procedure allows respondents to have a higher focus on each particular issue, as they are not distracted by other questions. Moreover, the use of several screens reduces the perceived length of the questionnaire. The use of a multi-window questionnaire is useful to ensure the validation of the answers in the data collection process. Additionally, the answer to a particular question can change the order or the evolution of the questions. This happens with the question of window 1 “Has your company invested in R&D projects?” If they answered “NO”, they would jump to window 3, otherwise they would continue with window 2.

The collection of data has begun in June 2009. A brief email has been sent to all the companies to explain concisely the purpose of the project and its relevance with a link to the questionnaire. A series of reminders were sent during the last weeks. Finally, to obtain a higher response rate, a number of telephonic contacts will be established.

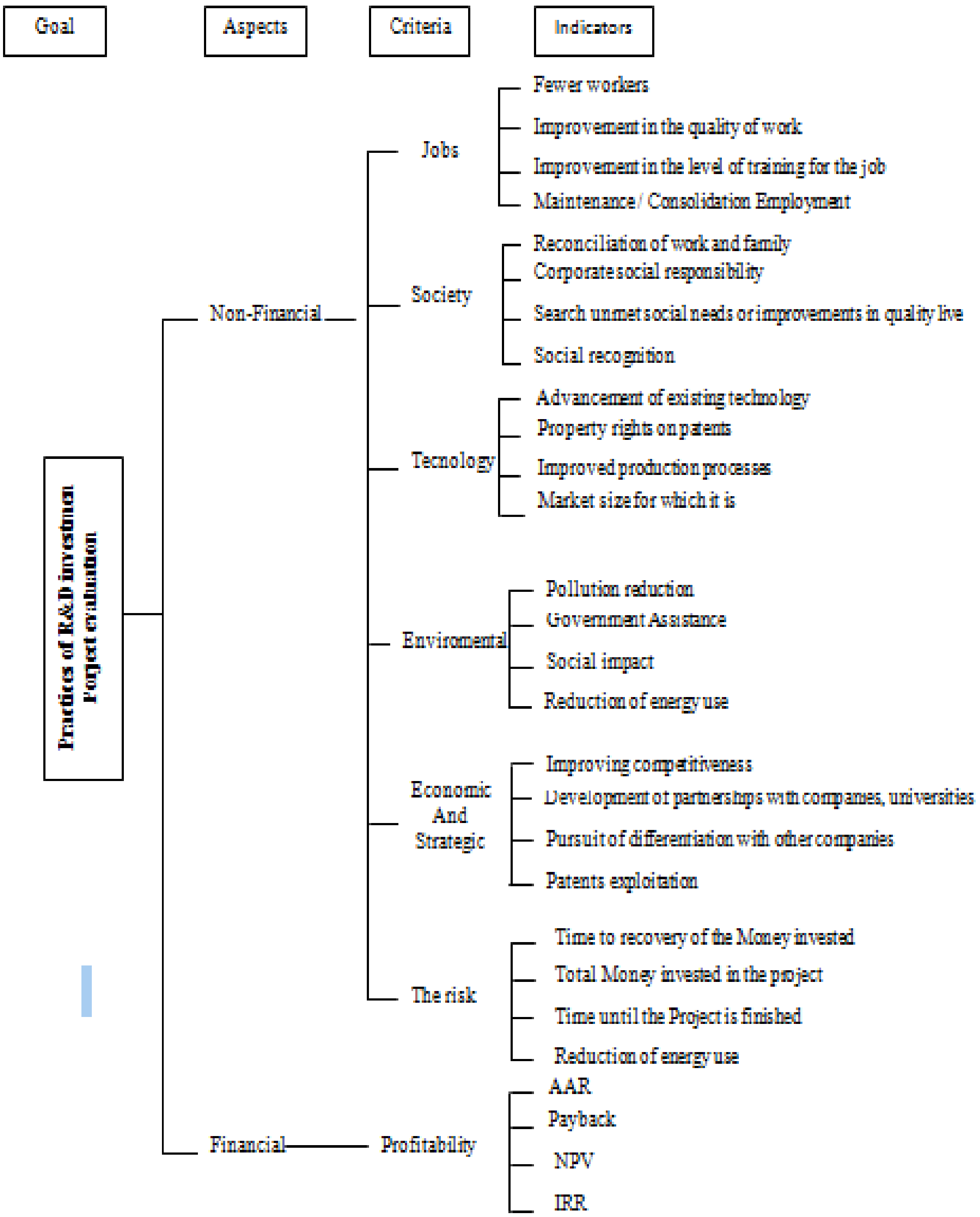
Empirical analysis

According to Berumen and Llamazares (2007), the search for the efficiency and the productivity of companies and industrial sectors is contributing to the adoption of sophisticated decision-making supporting tools, especially when there are many selection variables or criteria involved. The current environment surrounding firms is characterised by the speed and the intensity with which changes arise. This means that firms’ managers are obliged to make decisions constantly, what depends on many quantitative and/or qualitative criteria or attributes. This implies that every time it is more necessary the use of methodologies that permit to reduce or temper the risk of improvised conjectures or suppositions, in the eagerness to reach better levels of competitiveness of companies and industrial sectors.

Contreras and Pacheco (2007) emphasised that when there are many intangible variables impossible to quantify with traditional measurements (e.g. political, social and environmental aspects), which have to be measured in a common scale and taken into account when evaluating the projects, and that those variables are difficult to measure, limits the use of traditional methods for evaluating projects. The way of solving this typical problem is the use of a collection of theories, methods, models and supporting tools. It is necessary a methodology which manages to combine the different dimensions, objectives, actors and scales involved in the process, without sacrificing quality, reliability and consensus in the results. As a response to these problems we have multi-criterion methods, since one of the main characteristics of multi-criterion methodologies is the range of factors that we manage to incorporate into the process of evaluation. Its peculiarity is the way of converting the measuring and perceptions into a unique scale, in order to compare the elements and to establish priority orders, converting qualitative variables into quantitative ones.

The purpose of multi-criterion methods is to break a complex problem into simpler parts, what allows the decision-maker agent to structure a problem with many criteria in a visual way, through the construction of a hierarchical model that basically contains three levels: aim or objective, criteria and alternatives. Once the model is built, two by two comparisons are made between these elements (criteria-subcriteria and alternatives) and numerical values are given to the preferences assigned by individuals, therefore obtaining a summary value by aggregating this partial judgements (Rodríguez, 2008).

In this paper the following hierarchical model is proposed to evaluate R&D investment projects:



Figue 1- Hierarchy frame for evaluation of R&D investment projects

According to Zouponidis and Doumpos (2002), the following multi-criteria decision approaches have been used in the evaluation of investment projects: Multi-attribute utility theory (e.g. AHP); Outranking relations (e.g. ELECTRE and PROMETHEE) and preference disaggregation (e.g. UTA and UTADIS).

In the next paragraphs the main advantages and disadvantages of multi-criteria decision models are discussed based on the following authors: Pacheco and Contreras (2008), Saaty (2008), Hogarth (1991), Berumen and Llamazares (2007), Ross (2007), Fernández and Escribano (2001), Fernández (1991).

The main advantages of multi-criteria methods are the following. Firstly, it permits to simplify and find a solution to complex situations, because multi-criteria analysis permits to advance step by step towards the search for a solution. Secondly, it is an understandable method given that the bases of the criteria selection and the marking of the results are often simple, understandable and determined by the group that leads the analysis. Thirdly, it is a rational method due to the homogeneous and simultaneous study of a great number of factors. Fourthly, multi-criteria analysis permits a sound assessment of the different elements included in the analysis, which allows to rationalise the process that leads to the decisions. Finally, it is a useful negotiation tool in complex discussions.

In what concerns the main disadvantages of the multi-criteria models, one can highlight the following problems. Firstly, the need to clearly define previous conditions and the corresponding agreement of all individuals involved in the process. Secondly, the discussions about this process can be long, complex and difficult, since it is necessary to select the actions or alternatives of the study, to define the comparison criteria and to prepare the marking tables. Thirdly, in certain situations, the lack of reliable data in the needed period to establish and validate the methods can mean a problem. Fourthly, the length of time implied by the multi-criteria analyses. In fact, this is often based on long and iterant processes that may require an important and long negotiation period. Fifthly, the technical nature of the method: it is necessary to use computer tools and there are mathematical concepts involved. Finally, critics of this approach argued that it is a subjective method.

Conclusions and further work

This study tries to explain and understand the criteria used by companies in the evaluation of R&D projects. In fact, companies must bear in mind many factors when making decisions regarding R&D projects. Therefore, the use of both financial methods and non-financial ones would be recommended. We explain the use of a questionnaire with the aim of knowing the criteria used by the companies of the metallurgical sector from the North of Portugal and the South of Galicia, as well as to identify the software used by companies as a means of supporting the decisions. We, also, proposed a hierarchy frame for evaluation of R&D investment projects. In this hierarchy frame, we stressed the importance of non-financial criteria such as the one related to: the impact on jobs, social aspects, technological, environmental, the risk of investment, and economical and strategic. This study is still being carried out since the data collection process resulted in a very difficult task. On the other hand, multi-criterion methods were presented as a solution to the problem of analysing several factors at the same time in the assessment of R&D projects.

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