Designing an AHP methodology to prioritize critical elements for product innovation: an intellectual capital perspective

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Abstract

Intellectual capital has for the past decades been evidenced as an important source of competitive advantages and differentiation at the firm level. At the same time, innovation has become a critical factor for companies to ensure their sustainability and even their survival in a globalized business landscape. Having in mind these two crucial concepts for business success, this study intends to build on the relationships between intellectual capital and product innovation at the firm level. Specifically, we will design and test a model based on the Analytic Hierarchy Process, whose aim is to allow the prioritization of intellectual capital elements according to their relative importance for product innovation performance at the firm level. The main goal of this research is to build a diagnosis and action tool that helps business managers incorporate an intellectual capital perspective into their product innovation initiatives. This framework will help managers to better understand which intellectual capital elements are more critical to their product innovation efforts, and thereby systematize actions and clarify resource allocation priorities to improve their product innovation capabilities. In order to validate the practicability of this proposal, the methodology was empirically applied to a Portuguese innovative company.

Keywords: intellectual capital, product innovation, Analytic Hierarchy Process, Portugal, AHP, SMEs

1 INTRODUCTION

Competitiveness is nowadays a key concern for nearly every firm, maybe more than ever. The business landscape has for the past years become more and more demanding, with a widespread economic and financial crisis adding to an already challenging environment, shaped by complex structural trends such as globalization, technological evolution, accelerated product cycles and rapid changes in consumers' needs and expectations (Daneels, 2002).

Against this backdrop, two critical factors for the competitiveness of firms assume particular relevance: intellectual capital (IC) and innovation.

In fact, as the "resource-based view of the firm" stream of research began to highlight (Barney, 1991; Wernerfelt, 1984), resources and competencies of intangible characteristics, as opposed to the traditional "land, labour and financial capital", have gradually emerged as critical success factors to corporations. Intangible assets comply particularly well with the assumption that only valuable, rare, inimitable and non-substitutable resources are potential sources of sustainable competitive advantages (Barney, 1991; Itami, 1987). It is now abundantly clear that intangible assets are driving value creation in today's global economy (Dumay and Garanina, 2013; OECD, 2012). The recognition that strategic knowledge assets are at the foundation of company competitiveness needs to be taken into account, both as a critical element in strategy formulation and as an instrumental lever to achieve strategic outcomes (Lerro et al., 2014).

At the same time, innovation has become one of the most crucial drivers of long term development (Leiponen, 2005; Lederman, 2010). At the firm level, innovation is a key aspect for business success in the current competitive arena, representing one of the best ways for reaching competitive advantages (Delgado-Verde et al., 2011).

As we will argue in our literature review section, several studies have linked intangible assets, and IC in particular, to the firms' ability to innovate. It thus seems especially relevant for managers to be able to analyse and manage this relationship, so that actions can be taken and strategies corrected in order to develop and improve the firm's innovation capabilities. The main goal of this article is thus to try to address this need. Specifically, we will design and test a model to allow the prioritization of IC elements according to their relative importance to product innovation success at the firm level.

The structure of the paper is as follows: the following section proposes a brief review of the literature regarding IC, product innovation, the relationships between those concepts, and the benefits of measuring IC. The next section presents our proposed methodology to prioritize critical IC indicators for product innovation, using the Analytic Hierarchy Process (AHP). We will then describe the application of the model within a small and medium enterprise (SME). Finally, some insights and conclusions will be extracted and discussed.

2 LITERATURE REVIEW

2.1 Intellectual Capital

Research on IC gained steam in the mid-nineties as a natural corollary of the resource and knowledge-based views of the firm. The aim was to understand the implications of those theories for the daily management of corporations, through the analysis of the intangible assets' contribution to an organization (Roos et al., 2001). As stated by Petty and Guthrie (2000), the IC perspective surfaced as a means to better understand what constitutes the value of the business and to manage more successfully those elements that effectively generate value.

Descriptions of IC abound in the literature, although there isn't yet a clear, internationally accepted single definition. For the purpose of this study, we will thus define IC as "the stocks or funds of knowledge, intangible assets, and ultimately intangible resources and capabilities, which allow for the development of basic business processes of organizations, enabling the achievement of competitive advantages" (Martín-de-Castro et al., 2011, p. 650). IC is thus a multidimensional concept. It is nowadays generally accepted that the main components of IC can be structured into three dimensions: human capital, structural capital and relational capital (Guthrie et al., 2012).

Human capital represents those intangible resources that are linked to the individual and generate value to the company. Human capital includes such diverse elements as individual values and attitudes, aptitudes, and know-how (Subramaniam and Youndt, 2005). According to Marr (2008), the principal sub-components of an organization's human capital are its workforce's skill sets, depth of expertise, and breadth of experience. Human resources can be thought of as the living and thinking part of intellectual capital resources. Some examples of human capital elements include skills and competencies of employees, their know-how in certain fields that are important to the success of the enterprise, and their aptitudes and attitudes.

Structural capital is the knowledge that the company has managed to internalize and that remains in the organisation, either in its structure, its processes or its culture, even when the employees leave. Martín-de-Castro et al. (2011) subdivide structural capital into technological and organizational capital. The first one refers to the development of the activities and functions of the technical system of the organization, responsible for obtaining

products and services; the second one can be seen as the combination of explicit and implicit, formal and informal knowledge which structure and develop the organizational activity of the firm. This includes culture, structure and organizational learning. Bueno & Salmador (2000) refer to structural capital as the systematized and explicit knowledge that has been internalized by the organisation, such as its values, culture, routines, protocols, procedures, systems, technological breakthroughs and intellectual property. In other words, it refers to the organisation's intelligence, which, unlike human capital, belongs in fact to the company.

The relational capital concept is based on the consciousness that companies are actively and permanently connected to multiple external entities. All valuable relationships of this kind, with customers, suppliers and other relevant stakeholders, represent relational capital (Roos et al. 2001). Marr (2008) argues that although formalised external relationships tended to be predominant in the past, today informal external relations have a more important impact on how firms are managed. Brand image, corporate reputation, and product/service reputation, which reflect the relationships between organizations and their (current and potential) customers, also fall into this category. Bueno & Salmador (2000) state that relational capital represents the firm's "competitive and social intelligence", while Martin-de-Castro (2011) adds that relational capital provides a useful external guide for the firm to improve and develop new knowledge.

According to some authors (for example Dumay, 2014; Guthrie et al., 2012), IC research is nowadays going through a new, emerging stage, characterised by growing calls for a more practice-based IC research, supported on a critical and more interventionist analysis of IC practices in action.

2.2 Product Innovation

Innovation is in the core of economic change, and its role as the main driver of long term development is today widely acknowledged (Leiponen, 2005). Both at the macro and at the micro level, policies focused on employment creation and social welfare have been aiming at strengthening the innovative ability of enterprises and regions to enhance their competitiveness (Bullinger et al., 2004). At the firm level, innovation is nowadays considered to be inevitable. To succeed in today's complex economic environment, or even to remain viable, corporations must respond with innovation (Govindarajan and Trimble, 2005).

In the Oslo Manual (OECD, 2005), innovation is defined as the implementation of a new or significantly improved product (good or service) or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations. Different types of innovations are also distinguished: product innovations, process innovations, marketing innovations and organisational innovations. Among these distinct types of innovations, product innovation stands out as an element of particular importance to any business. Companies must develop new products, at least on occasion, to maintain or gain competitive advantages, and their ability to create new products has been linked to performance and even long-term survival (De Jong and Vermeulen, 2006; Linzalone, 2008). This study will therefore focus on product innovation, defined in the Oslo Manual (OECD, 2005) as the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses.

The way firms approach product innovation, and particularly the process of new product development (NPD), has evolved significantly in the last decades. From a mechanistic and linear approach that focused on R&D projects ("technology push"), whose success depended essentially on the efficient allocation of resources to technological research activities, product innovation is now seen as an integrated, multidisciplinary process, often chaotic and unpredictable, incorporating knowledge which is sometimes tacit, and very sustained in intangible elements such as creativity, culture for innovation, interaction and knowledge sharing competences, etc. (Cooper et al., 2004). The characteristics of innovative processes have also become more complex due to some important trends: the increasing specialization in the production of knowledge, the increasing complexity of physical products and the technology they use, and the need to accommodate new technological opportunities with market needs and organizational practices. In this context, two central features of product innovation have been emphasized: first, that the innovative process includes the coordination and integration of increasingly specialized knowledge; second, that this process requires continuous learning, in conditions of great uncertainty (Bullinger et al., 2004; Castellacci et al., 2005).

The increasing strategic importance of new products for companies and the awareness of the high percentage of failures in their introduction led to the gradual development of formally structured NPD processes. These are typically defined as a sequence of steps or activities that a company develops in order to conceive, design, test and market a new product. The literature offers many different proposals and representations of these steps. One significant example is the "stage-gate" model from Cooper et al. (2002), an effective conceptual and operational map for moving a new product project from idea to launch.

2.3 Relationships between IC and product innovation

Lerro et al. (2014) argue that the resource-based view of the firm helped establish a very clear link between intangible assets and innovation. Within this body of work, knowledge has emerged as a strategically significant resource for the firm and has been asserted to play a significant role in the innovation process, as well as in supporting organizational innovation capacity.

The relationship between intangible assets and innovation has been analysed in several empirical studies, generally concluding that intangible assets are positively and significantly associated with the firms' innovative capabilities. For example, Cañibano et al. (2002) found that innovative, technology-intensive companies are typically those where intangible assets assume a more critical role. Del Canto and Gonzalez (1999) argue that intangible resources have a decisive impact on the "absorption" ability of firms, that is, on their ability to recognize and exploit opportunities abroad (an external perspective), and also on their "transformation" ability, meaning the aptitude to continuously redefine their product portfolios based on the opportunities created within the company (an internal perspective). The European Commission (2006) contends that there are strong links and contingencies between research and development, innovation, human capital and relational capital. Other studies state that firm-level knowledge is associated with a higher degree of innovation (Thornhill, 2006; Bueno et al., 2010), and that knowledge assets can play a critical role in the different phases of the NPD process (Linzalone, 2008).

The specific analysis of the relationship between IC and product innovation is scarcer. However, some recent studies have shown that the distinct components of IC (human capital, structural capital and relational capital), either individually or combined, show a significant positive relationship with the outcomes of product innovation efforts at the firm level (Chen et al., 2006; Costa et al., 2014; Delgado-Verde, 2011; Dorrego et al., 2013; Fernandez-Jardón et al., 2014; Hsu and Fang, 2009; Santos Rodrigues et al., 2010; Subramanian, 2012; Subramaniam and Youndt, 2005; Wu et al., 2008).

Regarding the influence of human capital on product innovation, Costa et al. (2011) found various indications that some employees' characteristics positively contribute to the firm's ability to innovate, and therefore to its product innovation success. Building on an extensive literature review, they structured those characteristics into three human capital elements: competencies, representing the formal education, professional experience and specific competencies of managers and employees; values and attitudes, associated to the orientation towards cooperation and knowledge sharing, risk assumption and creativity, and also to the degree of commitment to the firm's values and strategy; and capabilities, representing employees' learning and team work abilities and their leadership skills, as well as their understanding of the internal product innovation process.

In what concerns the relationship between structural capital and product innovation, Fernandez-Jardón et al. (2014) argue that the existence of some organisational intangible and tangible elements, comprising "the intelligence of a firm", can enhance creativity and the propensity to innovate, and simultaneously turn innovation initiatives more focused and effective. The authors divide those elements into four structural capital categories: corporate culture towards innovation, associated to an organisational structure which permanently encourages and feels comfortable with concepts such as new ideas, autonomy, entrepreneurship, change, risk-taking and failure; top management role, related to top management commitment towards product innovation success; strategy and innovation, representing the level of interaction between the firm's strategic goals and the definition of priority areas for product innovation focus; and, finally, new product development management, comprising the existence of a formal, well organised new product development process.

Dorrego et al. (2013) analysed the impact of relational capital on product innovation performance at innovative SMEs. The authors state that relational capital, representing the set of channels, contacts and initiatives that build bridges between the firm and its external environment, can be a critical source of new knowledge that feeds the firm's innovative capabilities. They divide those initiatives into two basic relational capital elements: the existence of vertical and horizontal relationships with the exterior of the firm (including customers, suppliers, partners, competitors and other stakeholders), and the internal management of relationship processes.

2.4 Measuring intellectual capital

According to Marr (2004), organizations measure IC for different reasons: to formulate and assess strategy; to influence people's behaviour; and to externally validate performance, which includes reporting and benchmarking. The European Commission (2006) argues that as the future potential of an enterprise lies not within its financial capital but in its IC, measuring the enterprise's IC will enable it to manage its intangible resources better and increase its staff's confidence and motivation. An IC framework will function as an internal navigation tool to help develop and allocate resources – create strategy, prioritise challenges, monitor the development of results and thus facilitate decision-making. Chiucchi (2008) also notes that the implementation of an IC measurement system positively affects managerial competences since the analysis of company drivers and cause and effect relationships not only increases the understanding of the business but it also improves the quality of the company management, making it more rational and professional. Lerro et al. (2014) add that the

assessment and management of knowledge assets support the governance of an organization, not only by improving strategy planning, but most importantly by affecting organizational behaviour.

According to Sveiby (2010), the most interesting reason for measuring intangibles is the learning motive.

The increasing awareness of the benefits of measuring and managing IC is reflected in the growing number of its measurement frameworks (Marr, 2004). In fact, Sveiby (2010) identifies over 40 models or frameworks that cover both the financial and non-financial measures of IC. However, none of those models actually tries to assess the drivers of intangible value creation within a product innovation context. Hence, just as Yu and Humphreys (2013) state that measuring IC constitutes a learning process and an experience that enhances a firm's future earnings potential, we argue that measuring and managing IC within a product innovation context can enhance the firm's ability to successfully launch new products and services, and thus become more competitive and profitable. Yet, most companies do not identify core IC indicators in many areas that directly influence business value, and those that do frequently use them in an inefficient manner (Kim and Kumar, 2009). The remaining of this article tries to address this issue, by offering some clues regarding the possibilities of modelling and prioritizing IC indicators within a product innovation context.

3 A METHODOLOGY TO PRIORITIZE CRITICAL IC ELEMENTS

Having argued that product innovation is a key source of competitiveness and that IC can decisively influence its success, it is only natural for us to stress that these two concepts and their relationships cannot be ignored by business managers. They should be analysed and managed carefully.

3.1 The AHP method

The Analytic Hierarchy Process (AHP) analysis, proposed by Saaty (2008), is a pair-wise comparison methodology that results in breaking down a complex problem and then combining the solutions. It has been broadly acknowledged that the AHP analysis is one of the best methodologies to prioritize various indicators. Furthermore, the AHP approach needs only a small number of respondents with experience and knowledge (Kim and Kumar, 2009).

The AHP methodology complies particularly well with the stated goal of this research. In fact, when trying to put forth a methodological proposal to manage IC elements in a product innovation context, we must keep in mind that besides listing and classifying a company's intellectual elements, it is equally important to hierarchize them, that is, to identify those which have more potential impact on the organization's strategic goal. Moreover, the proactive participation of managers in this process is of paramount importance: their experience and acquaintance with the context is critical in the suggestion of the most relevant intangible elements and measurement indicators. Management perceptions are thus very important to the preliminary selection and subsequent evaluation of those intangible assets (Grimaldi and Cricelli, 2009). It is also especially relevant to be able to identify the specific areas of the organization that demand particular attention, and which IC elements need to be subject to a more careful and urgent analysis As we will see next, the approach we are proposing addresses these demands quite thoroughly.

The basic principle of the AHP method lies in analysing several alternatives from different criteria. Thus, a hierarchy is built where at the top is the problem to be taken into consideration. The next layer consists in the criteria or strategies to be considered; and the last layer resides in several alternative activities or actions (for each of the criteria from the second level).

Based on comparative judgments, a positive matrix of choices is derived from these criteria. A ranking structure is achieved afterwards as a vector of priorities, based on the theory of eigenvectors. The same procedure is applied for the alternatives considered with respect to every criterion. Then, weights beard by the criteria are applied to the considered alternatives and lastly, the corresponding totals for each alternative are calculated. Within the very abstract and fuzzy framework of IC, the step by step approach provided by AHP, breaking down the problem into smaller parts that can be more easily handled, represents an important advantage.

The first level of our proposed hierarchical structure encompasses the organization's goal (in our specific case, maximizing product innovation performance through the identification and management of critical IC elements). Second level variables are the basic IC components (human capital, structural capital and relational capital), as vital drivers of product innovation performance; the particular intangible elements that refer to each second level component are grouped in third level variables, which are those IC elements considered to be more critical to product innovation success. At the last level, the specific indicators for each IC element are established. Although the main goal of this research is not to develop a standardized IC model, but to propose a methodology to prioritize critical IC elements as perceived by each company, we will materialize our hierarchical structure with concrete IC elements and indicators, as a way to better explain and exemplify this proposal. For that purpose, we will resort to the exact same structure and indicators suggested by the aforementioned work of Costa et al. (2011), Dorrego et al. (2013) and Fernandez-Jardón et al. (2014) when

studying the influence of intellectual capital elements on product innovation. Table 1 presents our suggested hierarchical structure.

Table 1 The AHP model hierarchy: critical IC elements for product innovation

1st Level: organization's goal
Maximizing product innovation performance through the identification and management of critical IC elements

2nd Level: IC components	3rd Level: critical IC elements	4th level: specific indicators
Human Capital	Competencies	*Top managers and technical staff possess high education levels and specialized training *Top managers and technical staff possess professional experience in different activities *Top managers and technical staff possess (among them) an heterogeneous academic education *Employees possess specific competencies that are adequate to the firm's product innovation goals
	Values and attitudes	*Employees cooperate and share knowledge *Employees take risks, are enterprising and creative *Employees show interest and participate on idea generation activities *Employees are committed to the firm's strategy
	Capabilities	*Employees participate on training initiatives related to innovation and successfully apply the knowledge they acquire *Employees often develop team work *Leaders strive to communicate the role of innovation on the firm's strategy *Employees know and understand the firm's new product development process
Structural Capital	Corporate culture towards innovation	*There is a new product ideas scheme in place, and employees are encouraged to participate (for instance through economic incentives) *Entrepreneurs and innovative project leaders are encouraged and rewarded, with no punishment for failures *Employees have autonomy and resources to develop their creativity through informal and parallel projects
	Top management role	*Innovation metrics represent an explicit and important part of top management's performance evaluation *Top management is strongly committed to the product innovation process *Top management provides clear support, autonomy and authority to the people involved in product innovation projects
	Strategy and innovation	*The role of innovation in achieving the firm's strategic goals is clearly defined *There is a plan to identify/acquire the skills that are necessary to achieve product innovation goals *The areas of strategic focus on which to concentrate the product innovation efforts are clearly identified
	NPD management	*The characteristics of project teams are a very important feature of the product innovation process *There is a system to manage new product development projects *There is a well organised new product development process
Relational Capital	Vertical and horizontal relationships	*There are vertical relationships (with customers and suppliers) with the specific goal of strengthening our product innovation capabilities *There are horizontal relationships (with partners and competitors) with the specific goal of strengthening our product innovation capabilities *There are relationships with other institutions (government agencies, external experts, public and private R&D centres, shareholders, etc.) with the specific goal of strengthening our product innovation capabilities
	Management of relationship processes	*The company makes a specific effort to identify and establish relationships with customers or users who are more receptive to innovative products (lead users) *The company actively manages formalized relationship processes with clients *The company actively manages formalized relationship processes with suppliers *The company actively manages formalized relationship processes with competitors *The company actively manages formalized relationship processes with institutions, shareholders and investors

Source: Own elaboration based on Costa et al. (2011), Dorrego et al. (2013) and Fernandez-Jardón et al. (2014).

The next step is to compare the relative importance of all variables. For that purpose a questionnaire must be built, pairing components, elements and indicators, questioning which of each pair is more important with regards to the objective, and how much more important. In order to help the respondent to assess the pair-wise comparisons, Saaty created a nine point intensity scale of importance between two elements (Saaty, 2008).

Although this approach has generated some criticisms, the latest research defends against them by presenting persuasive theoretical works (Kim and Kumar, 2009). According to Saaty (2008), there are numerous examples validating the use of the 1–9 scale.

The suggested numbers to express degree of preference between two elements are shown in Table 2.

Table 2 The fundamental scale for pair-wise comparisons (Saaty, 2008)

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favour one activity over another
5	Strong importance	Experience and judgment strongly favour one activity over another
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2,4,6,8	For compromise between the above values	Sometimes one needs to interpolate a compromise judgment numerically because there is no good word to describe it

The questionnaire is then built and presented to respondents. Next is an example of the pair-wise questionnaire for level 2 IC components, level 3 elements for human capital and level 4 indicators for the human capital element "Competencies" (as depicted on Table 1):

Level 2 – IC Components:

	How important is "**Human Capital**" when compared to "**Strutural Capital**"?																
Q1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is "**Human Capital**" when compared to "**Relational Capital**"?																
Q2	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is "**Strutural Capital**" when compared to "**Relational Capital**"?																
Q3	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Level 3 - Human capital elements:

	How important are "**Competencies**" when compared to "**Values and attitudes**"?																
Q1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important are "**Competencies**" when compared to "**Capabilities**"?																
Q2	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important are "**Values and attitudes**" when compared to "**Capabilities**"?																
Q3	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Level 4 - Indicators for the human capital element "Competencies":

	How important are "**Education levels & specialized training**" when compared to "**Professional experience**"?																
Q1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important are "**Education levels & specialized training**" when compared to "**Heterogeneous academic education**"?																
Q2	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important are "**Education levels & specialized training**" when compared to "**Specific competencies for product innovation**"?																
Q3	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is "**Professional experience**" when compared to "**Heterogeneous academic education**"?																
Q4	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is "**Professional experience**" when compared to "**Specific competencies for product innovation**"?																
Q5	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is "**Heterogeneous academic education**" when compared to "**Specific competencies for product innovation**"?																
Q6	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

The next step, the calculation of relative weights based on the answers to the questionnaire, can be conducted using Microsoft Excel. As previous research suggested (Saaty, 2008), three steps are employed. They are:

(a) Using questionnaire results to insert the data in Excel, building binary comparison matrices for each level of the hierarchical structure;

(b) Calculating relative weights:

(b.1) Sum of each column of the matrix;

(b.2) Dividing each element of the matrix by the sum of the corresponding column, obtaining a new standardized matrix;

(b.3) Calculating the average of each line of the standardized matrix (sum and divide by n variables considered), obtaining the column vector "w" (relative weight). The sum of the vector must equal 1;

(c) Verifying matrix consistency:

(c.1) Multiplying the sum of each column of the original matrix (step b.1) by vector "w" (step b.3), obtaining a new vector (consistency measure);

(c.2) If the matrix is consistent, the vector calculated in step c.1 will have values ideally equal to 1.

3.2 Testing the AHP methodology: empirical results

Once the conceptual structure of this methodology was completed, an empirical test of its functionality was in order. More than any kind of frequency count or statistical generalization, our aim was to make sure that the intended users of this tool (business managers) would understand its purpose and *modus operandi*, and to get feedback on those issues as well as on the overall usefulness of the methodology. Considering these goals, an "action research" approach seemed the most adequate way to fully apprehend how the framework would work in practice. This methodological choice seeks to bring together action and reflection, theory and practice. The researcher acts in concert with the host organisation, observes process and outcome, and analyses findings in view of the relevant literature. Hence, this methodology not only reflects upon the observations of the researcher, but also on the actual development of the interventions. The main benefit for researchers is the ability to develop insights into the implementation of new management innovations in organisations; for practitioners the benefit is to gain the assistance and knowledge of academics in the implementation process (Demartini and Paoloni, 2013).

This methodological choice also addresses recent calls for an emerging "third stage" of IC research, characterised by critically studying IC in practice, in search for the managerial implications of how to use IC in managing a company. According to this perspective, "for IC research to remain relevant, researchers need to concentrate on research based on managing IC at the operating level of case/field study/interviews rather than taking a top-down approach to research." (Dumay, 2014, p. 16).

Hence, in this section the implementation of our proposed model is demonstrated on a real firm, a Portuguese innovative SME, as part of a larger case-study. The firm is located in northern Portugal and operates in the chemical industry. Creating innovative products is one of its core strategic aims. It has around 100 employees and an annual turnover estimated at €72 million, thus complying with the European Commission Recommendation 2003/361/EC from May 6th 2003 in what concerns its SME status. It operates both in the domestic and international market, with the latter corresponding to 85% of its sales. The research was conducted with the firm's CEO, as suggested by the Oslo Manual (OECD, 2005), since he represents the key informant that better knows the subject of the research and who is most available to communicate it to the researcher. From the preliminary interview and presentation of our questionnaire it became apparent that the CEO generally understood the concept of IC, recognizing its importance to the company's product innovation strategy.

However, the company had never conducted any kind of structured initiative in order to systematise or measure in any way the intangible resources that could impact product innovation. This study was therefore labelled as very pertinent, as the respondent recognized the relevance of building a model that in an intuitive way depicts the relative importance of each IC element to the firm's innovation strategy.

Due to time constraints, and also because the CEO generally agreed with the elements and indicators that were included, it was decided that the hierarchical structure depicted on Table 1 would be utilized without any changes. The resulting pair-wise comparison questionnaire was thus prepared, as explained on section 3.1, and fully filled in the course of a few personal interviews. The corresponding results were subsequently introduced and handled in Microsoft Excel. The exact steps described on section 3.1 were followed in order to build the binary comparison matrices, the standardized matrices and finally to obtain the intellectual elements' relative weights and the resulting hierarchy. Recapping those steps, we started by building the binary comparison matrices for each level of the hierarchical structure, based on the questionnaire results; then a new standardized matrix was built from each original matrix, through dividing each cell by the sum of its corresponding column, so that relative weights were calculated; next, the average of each line of the standardized matrix was calculated, obtaining the column vector "w" (relative weight).

Some examples of this procedure will be depicted next, including level 2 IC components, level 3 elements for human capital and level 4 indicators for the human capital element "Competencies":

Level 2 – IC Components:

Original matrix:

	HC	SC	RC
HC	1	4	1
SC	0,25	1	0,33
RC	1	3	1
Sum:	2,250	8,000	2,333

HC – Human Capital
SC – Structural Capital
RC – Relational Capital

Standardized matrix:

	HC	SC	RC
HC	0,444	0,500	0,429
SC	0,111	0,125	0,143
RC	0,444	0,375	0,429
Sum:	1,000	1,000	1,000

w	CM
0,458	1,030
0,126	1,011
0,416	0,971
1,000	

(w=relative weight; CM=consistency measure)

Level 3 - Human capital elements:

Original matrix:

	Comp	V&A	Cap
Comp	1	0,25	0,25
V&A	4	1	1
Cap	4	1	1
Sum:	9,000	2,250	2,250

Comp – Competencies
V&A – Values and Attitudes
Cap – Capabilities

Standardized matrix:

	Comp	V&A	Cap
Comp	0,111	0,111	0,111
V&A	0,444	0,444	0,444
Cap	0,444	0,444	0,444
Sum:	1,000	1,000	1,000

w	CM
0,111	1,000
0,444	1,000
0,444	1,000
1,000	

(w=relative weight; CM=consistency measure)

Level 4 - Indicators for human capital element "Competencies":

Original matrix:

	ELST	PE	HAE	SC
ELST	1	3	4	1
PE	0,33	1	1	0,33
HAE	0,25	1	1	0,33
SC	1	3	3	1
Sum:	2,583	8,000	9,000	2,667

ELST – Education levels and specialized training

PE – Professional experience

HAE – Heterogeneous academic education

SC – Specific competencies for product innovation

Standardized matrix:

	ELST	PE	HAE	SC
ELST	0,387	0,375	0,444	0,375
PE	0,129	0,125	0,111	0,125
HAE	0,097	0,125	0,111	0,125
SC	0,387	0,375	0,333	0,375
Sum:	1,000	1,000	1,000	1,000

w	CM
0,395	1,021
0,123	0,980
0,114	1,030
0,368	0,980
1,000	

(w=relative weight; CM=consistency measure)

After applying the same process to all levels, we were able to illustrate the final results using our original hierarchical structure, as shown in Figure 1:

Figure 1 - An application of the AHP model hierarchy

Level 1 - Strategic Goal:

Maximizing product innovation performance through the identification and management of critical IC elements

Level 2 - IC Components:

Human Capital 45,8%

Relational Capital 41,6%

Structural Capital 12,6%

Level 3 - IC Elements:

Capabilities 44,4%

Values and attitudes 44,4%

Competencies 11,1%

Vertical and horizontal relationships 50%

Management of relationship processes 50%

Corporate culture towards innovation 39%

Strategy and innovation 30,4%

Top management role 18,5%

NPD management 12,2%

Level 4 - IC Indicators:

Training initiatives & successful application 47,2%

Interest and participation on idea generation activities 41,1%

Education levels & specialized training 39,5%

Vertical relationships 65,5%

Formalized relationship processes with suppliers 27%

Autonomy & resources to develop parallel projects 65,5%

Identification of areas of strategic focus 57,4%

Clear support & autonomy to product innovation projects 65,5%

There is a well organised NPD process 57,9%

Knowledge & understanding of the NPD process 25,7%

Cooperation & knowledge sharing 35,7%

Specific competencies for Product Innovation 36,8%

Horizontal relationships 18,7%

Identify and establish relationships with lead users 26,4%

Entrepreneurs & project leaders encouraged & rewarded 23,1%

Role of innovation in strategic goals clearly defined 28,6%

Innovation metrics part of performance evaluation 23,1%

There is a system to manage NPD projects 23,4%

Leaders communicate the role of innovation on strategy 20,1%

Take risks, are enterprising and creative 13,6%

Professional experience 12,3%

Relationships with other institutions 15,8%

Formalized relationship processes with clients 25,5%

New product ideas scheme in place 10,4%

Identification of necessary skills to innovation goals 14%

Strongly committed to the product innovation process 10,4%

Characteristics of project teams 18,7%

Team work 7%

Commitment to the firm's strategy 9,6%

Heterogeneous academic education 11,4%

Formalized relationship processes with competitors 13%

Formalized relationship processes with o/ stakeholders 8%

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This map depicts the hierarchization of all critical IC components, elements and particular indicators in what concerns their importance to product innovation success, as per the perception of the firm's CEO. We can see for example that human capital is considered to be the most important IC component, as opposed to structural capital which ranked as the least important; the elements 'capabilities' and 'values and attitudes' assume equal importance within the human capital component; the most valued specific human capital items are 'training initiatives and their successful application', 'interest and participation on idea generation activities' and 'education levels and specialized training'. Regarding relational capital, considered the second most important IC component, the elements 'Vertical and horizontal relationships' and 'Management of relationship processes' were deemed as equally important, while 'Vertical relationships' stands out as the most valued relational capital specific item. Finally, 'Corporate culture towards innovation' was ranked as the most critical structural capital element, particularly in what concerns the existence of 'Autonomy and resources to develop parallel projects'.

Building on Kim and Kumar's (2009) proposal, by considering the relative weight of each element within the IC components and recalculating the relative importance of each indicator accordingly, we can put together a second map oriented to the practical envisage of the prioritized elements from an operational perspective, thus avoiding indiscriminately weighing very distinct intangible elements, or unintentionally neglecting important ones. Figure 2 shows which areas should be subject to a more careful and urgent attention (core focus areas), helping the firm to visualize more intuitively the specific IC elements where it should focus its resources and efforts, in order to improve its product innovation performance.

Figure 2 Focus areas for IC development towards product innovation success
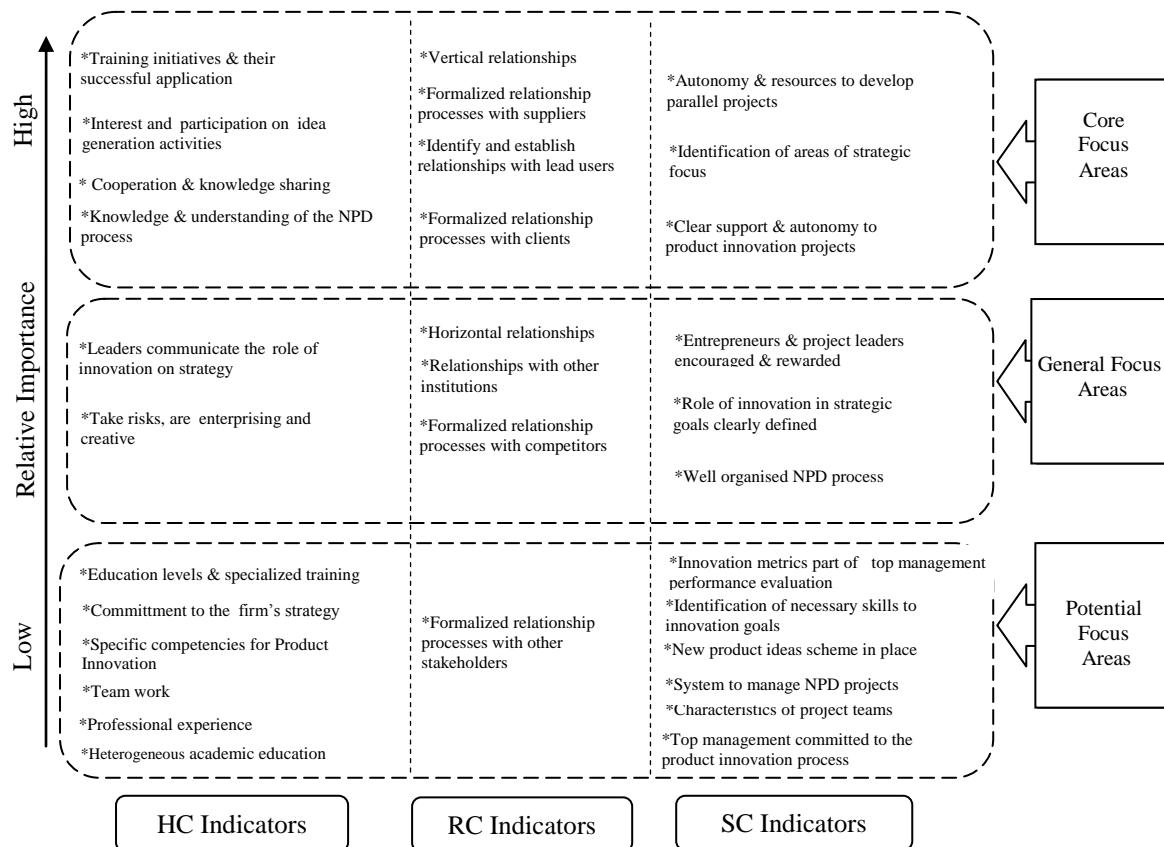
The empirical testing of the proposed AHP methodology was thus, in our opinion, very successful, fully meeting the goals that were initially set. Not only the company acknowledged its interest and understood its variables and *modus operandi* without major difficulties, but also the handling of the responses allowed for the construction of a preference hierarchy and the identification of focus areas, which was recognized as meaningful and useful for the company's product innovation strategy. Ultimately, the company agreed that prioritizing intangible elements and identifying critical improvement areas can be key to efficiently mobilize IC management for product innovation.

4 CONCLUSIONS

In today's competitive environment, product innovation should be regarded as a priority by any business. However, firms in general and SMEs in particular are confronted with two paradoxical issues when it comes to innovation: intensify innovation efforts to develop new products, and in doing so, become more vulnerable by engaging in projects characterized by very high levels of risk. Indeed, product innovation projects are very risky in nature since, generally, they take more time than expected, cost more material resources than those planned, and do not always produce the anticipated benefits with respect to performance. SMEs are particularly vulnerable to this dilemma: on the one hand, they usually have a smaller financial capacity and less market power than larger companies, and as such are even more dependent on innovative dynamics (EC, 2006; Vaona and Pianta, 2008); on the other hand, the typical scarcity of resources at their disposal dramatically reduces their margin of error (Rhaiem, 2012). This reality, in our opinion, strongly reinforces the importance of IC management to enhance product innovation performance at SMEs. In fact, even if their individual ability to have an impact on their industry is small, the strategic decisions regarding their orientation towards a higher level of intensity in IC elements is under their control, and that can be an important catalyst for product innovation success. Moreover, as most SMEs cannot assume the financial risk of conducting a large portfolio of new product projects (European Commission, 2006), the importance of identifying and prioritizing those factors that are most critical to the success of each innovation initiative becomes even more apparent. At a time when there is growing evidence of IC's relevance for product innovation performance, this dilemma strongly reinforces the importance of IC management as a means to increase the odds of product innovation success at SMEs.

Additionally, although the basic relationship between knowledge-based factors, innovation dynamics and companies' performance is on the whole convincing, many issues remain to be understood in what concerns intangible resources exploitation and deployment to improve companies' innovation dynamics and organizational performance (Lerro et al., 2014). There is still too little evidence of "IC in action" and its actual benefits in what concerns product innovation management. Conducting research based on critically analysing IC management practices in action seems to be the right response to this knowledge gap.

Against this backdrop, this research aimed to address these issues by designing and testing a diagnosis and action tool to help business managers incorporate an intellectual capital perspective into their product innovation efforts.

We understand our proposal as a relevant contribution for both the literature and practice of IC and product innovation, as it stresses the importance of identifying and prioritizing those intangible elements that are decisive to the success of product innovation initiatives at SMEs. In fact, the proposed AHP methodology represents a particularly effective way of conducting this process, ultimately allowing managers to concentrate on the most critical intangible factors that drive product innovation within their firm.

We hope this proposal can contribute to help managers successfully turn IC identification and prioritization into effective innovation management. As stated by Lerro et al. (2014), the full potential of IC in what concerns its impact on innovation dynamics is realized when knowledge resources are efficiently identified through easy-to-use models and frameworks.

Also, as this study was conducted within a Portuguese context, we feel compelled to add a few remarks regarding our view of the potential usefulness of this type of framework within the Portuguese business environment. Bloom et al. (2014) developed a project called the "World Management Survey", which sought to address the issue of whether management practices were an important factor in understanding the heterogeneity of firm productivity. Many of the management practices under evaluation at that research can easily be associated, either directly or indirectly, with the use of our proposed framework (process improvements, human capital management, etc.). Their general conclusion was that management does indeed appear to be important in accounting for the large differences in cross-country total factor productivity, as well as within-country differences. When analysing differences between countries, they show that "average management scores" for Portugal are well below those of other countries like the US, Japan, the UK, Germany or France. Actually, for some southern European countries such as Portugal, management accounts for half of the total factor productivity gap with the US, whereas for other nations like Japan or Sweden that fraction is only one tenth. Considering that 99.9% of all Portuguese companies are SME, and 95.9% are micro companies under 10 employees (INE, 2014), it is fair to assume that this problem has its roots on SME managers (in fact, the aforementioned research empirically demonstrates that there is a positive correlation between management quality and firm size). Portuguese SME managers (as well as many worldwide SME managers in comparable circumstances) should therefore take this data into serious consideration and try to close this gap, by developing and adopting new, more innovative and modern management practices. We hope our proposal can contribute to address this challenge, by suggesting an original and effective way of deploying intangible resources to enhance product innovation performance.

Finally, we cannot forget that accepting the importance of IC and embracing it as a management priority is the final result of a learning process within the firm, that involves talking about IC, understanding its

contribution to the value creation process, thinking about how and when it impacts corporate phenomena - that is, "the pragmatic dimension" of IC (Giuliani and Marasca, 2011). The implementation of this methodology can also contribute to this learning path, as it will inevitably trigger a brainstorming process regarding IC inside the firm, ultimately helping it to develop a better understanding of how distinct IC elements impact its product innovation efforts.

The authors acknowledge that this paper has a few limitations, offering possibilities for future research. In fact, although this tool is conceptually applicable to any firm, the effectiveness of the methodology was tested in only one SME. In order to generalize the findings, future research should test the model validity on other types of organizations, ideally in different industries and even countries.

We should also once again stress that our main goal was not to develop a standardized IC model, but to propose a methodology that can help managers systematize and prioritize critical IC elements that are suitable for their particular reality. In fact, although we admit that presenting standardized indicators "ex-ante" could help many organizations to better understand the importance of IC management within their product innovation strategy, IC is ultimately firm-specific and closely tied to the organization. Therefore, our proposed IC variables must be understood as a starting base, which can (and should) be subject to adaptations depending on the reality of each firm.

REFERENCES

Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, 17(4), 99-120.

Bloom, N., Lemos, R., Sadun, R., Scur, D. and Van Reenen, J. (2014). The New Empirical Economics of Management, *Journal of the European Economic Association*, 12(4), 835- 1126.

Bontis, N. (1999). Managing Organizational Knowledge by Diagnosing Intellectual Capital: Framing and Advancing the State of the Field. *International Journal of Technology Management*, 18(5-6-7-8), 433–462.

Bueno, E. and Salmador, Mª P. (2000) *Perspectivas sobre Dirección del Conocimiento y Capital Intelectual.* Madrid: Instituto Universitario Euroforum Escorial, Octubre.

Bueno, E., Aragon, J. A., Salmador, Mª. P. and Garcia, V. (2010). Tangible Slack versus Intangible Resources: the Influence of Technology Slack and Tacit Knowledge on the Capability of Organizational Learning to Generate Innovation and Performance. *International Journal of Technology Management*, 49(4), 314-337.

Bullinger, H.-J., Auernhammer, K. and Gomeringer, A. (2004). Managing innovation networks in the knowledge-driven economy. *International Journal of Production Research*, 42(17), 3337-3353.

Cañibano, L., Sanchez, P., García-Ayuso, M. and Chaminade, C. (2002). *Guidelines for Managing and Reporting on Intangibles (Intellectual Capital Report),* MERITUM Project, [pdf] Retrieved May 19, 2014 from http://www.uam.es/personal_pdi/economicas/palomas /DIRECTRICES%20MERITUM%20-%20INGLES.pdf

Castellacci, F., Grodal, S., Mendonca, S. and Wibe, M. (2005). Advances and Challenges in Innovation Studies. *Journal of Economic Issues*, 33(1), 91-121.

Chen, Y., Lin, M. and Chang, C. (2006). The Influence of Intellectual Capital on New Product Development Performance – The Manufacturing Companies of Taiwan as an Example. *Total Quality Management,* 17(10), December 2006, 1323-1339.

Chiucchi, M.S. (2008). Exploring the benefits of measuring intellectual capital. The Aimag case study. *Human Systems Management* 27(3), 217-30.

Cooper, R., Edgett, S. and Kleinschmidt, E. (2002). Optimizing the Stage-Gate Process; What Best-practice Companies Do. *Research Technology Management* 45(5), 21-27

Cooper, R., Edgett, S. and Kleinschmidt, E. (2004). Benchmarking Best NPD Practices – I. *Research Technology Management*, 47(1), 31-43.

Costa, R. V., Figueroa, P. and Fernández-Jardón, C. (2011). "An Empirical Analysis of the Influence of Human Capital on Product Innovation Performance", *International Journal of Engineering and Industrial Management*, 3/2011, 127-149.

Costa, R. V., Fernández-Jardón, C., Figueroa Dorrego, P. (2014). Critical elements for product innovation at Portuguese innovative SMEs: an intellectual capital perspective. *Knowledge Management Research and Practice*, 12(3), 322-338.

Daneels, E. (2002). The Dynamics of Product Innovation and Firm Competences. *Strategic Management Journal,* 23(12), 1095–1121.

De Jong, J. and Vermeulen, P. (2006). Determinants of Product Innovation in Small Firms - A Comparison Across Industries. *Small Business Journal,* 24(6), 587-609.

Del Canto, J. and González, I. (1999). A Resource-based Analysis of the Factors Determining a Firm's R&D Activities. *Research Policy,* 28(1999), 891-905.

Delgado-Verde, M. (2011). The Role of IC Assets on the Radicalness of Innovation. *UAM-Accenture Working Papers*, Autonomous University of Madrid, Faculty of Economics

Delgado-Verde, M., Martín-de Castro, G., Navas-López, J.E. (2011). Organizational Knowledge Assets and Innovation Capability: Evidence from Spanish Manufacturing Firms. *Journal of Intellectual Capital*, 12(1), 5-19.

Demartini, P. and Paoloni, P. (2013). Implementing an intellectual capital framework in practice. *Journal of Intellectual Capital*, 14(1), 69–83.

Dorrego, P. F., Costa, R. V. and Fernández-Jardón, C. (2013). Product Innovation and Relational Capital: Evidence from Portugal. *The Electronic Journal of Knowledge Management*, 11(4), 295-308.

Dumay, J. (2014).15 years of the Journal of Intellectual Capital and counting. *Journal of Intellectual Capital*, 15(1), 2-37.

Dumay J., Garanina, T. (2013) Intellectual Capital Research: a Critical Examination of the Third Stage. *Journal of Intellectual Capital*, 14(1), 10-25.

EC - European Commission (2006). RICARDIS: *Reporting Intellectual Capital to Augment Research, Development and Innovation in SMEs*, Luxembourg.

Fernández-Jardón, C., Costa, R. V. and Dorrego, P. F. (2014). The Impact of Structural Capital on Product Innovation Performance: an Empirical Analysis. *International Journal of Knowledge-Based Development*, 5(1), 63-79.

Giuliani, M., Marasca, S., (2011). Construction and valuation of intellectual capital: a case study. *Journal of Intellectual Capital*, 12(3), 377 – 391.

Govindarajan, V. and Trimble, C. (2005). Organizational DNA for Strategic Innovation. *California Management Review*, 47(3), 47-76.

Grimaldi, M. and Cricelli, L. (2009). Intangible asset contribution to company performance: the "hierarchical assessment index". *VINE - The Journal of Information and Knowledge Management Systems,* 39(1), 40-54.

Guthrie, J., Ricceri, F. and Dumay, J. (2012). Reflections and projections: a decade of intellectual capital accounting research. *British Accounting Review*, 44(2), 68-82.

INE – Instituto Nacional de Estatística (2014). *Empresas em Portugal 2012*. Lisboa: Instituto Nacional de Estatística.

Itami H, Roehl T (1987). *Mobilizing Invisible Assets*. Cambridge, MA: Harvard University Press.

Kim, D., and Kumar, V. (2009). A framework for prioritization of intellectual capital indicators in R&D. *Journal of Intellectual Capital,* 10(2), 277 – 293.

Lederman, D. (2010). An International Multilevel Analysis of Product Innovation. *Journal of International Business Studies,* 41(4), 606-619.

Leiponen, A. (2005). Skills and Innovation. *International Journal of Industrial Organization,* 23(2005), 303-323.

Lerro, A., Linzalone, R. and Schiuma, G. (2014). Managing intellectual capital dimensions for organizational value creation, *Journal of Intellectual Capital*, 15(3), 350 – 361.

Linzalone, R. (2008). Leveraging Knowledge Assets to Improve New Product Development Performance. *Measuring Business Excellence,* 12(2), 38-50.

Marr, B. (2004). Measuring and Benchmarking Intellectual Capital, *Benchmarking: An International Journal,* 11(6), 559 – 570.

Marr B. (2008). *Impacting Future Value: How to Manage your Intellectual Capital*. Canada: the Society of Management Accountants of Canada, the American Institute of Certified Public Accountants and the Chartered Institute of Management Accountants.

Martín-de-Castro, G., Delgado-Verde, M., López-Saez, P. and Navas-López, J.E. (2011). Towards 'an intellectual capital-based view of the firm': origins and nature. *Journal of Business Ethics,* 98(4), 649-662.

OECD - Organisation for Economic Co-Operation and Development (2005). *Guidelines for Collecting and Interpreting Innovation Data, Oslo Manual (3rd. Edition)*. Paris: OECD.

OECD - Organisation for Economic Co-Operation and Development (2012). Corporate Reporting on Intangible Assets: A Progress Report, *OECD Corporate Governance Committee Meeting*, 18-20 April 2012, [pdf] Retrieved June 23, 2014 from http://www.oecd.org/daf/ca/Intangible%20Assets.pdf.

Petty, R. and Guthrie, J. (2000). Intellectual Capital Literature Review: Measurement, Reporting and Management. *Journal of Intellectual Capital,* 1(2), 155–76.

Rhaiem, M. (2012). Innovate or Perish: Success Factors and Sources of Failure. *Journal of International Business and Economics,* 12(3), 102-121.

Roos, G., Bainbridge, A. and Jacobsen, K. (2001) Intellectual Capital Analysis as a Strategic Tool. *Strategy and Leadership,* 29(4), 21-26.

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International Journal of Services Sciences,* 1(1), 83-98.

Santos Rodrigues, H., Figueroa Dorrego, P. and Fernández-Jardón, C.M. (2010). The Influence of Human Capital on the Innovativeness of Firms. *International Business and Economics Research Journal,* 9(9), 53-63.

Sveiby, K. E. (2010). *Methods for Measuring Intangible Assets*, [pdf] Retrieved July 10, 2014 from: www.sveiby.com/ articles/intangibleMethods.htm.

Subramaniam, M. and Youndt, M. (2005). The Influence of Intellectual Capital on the Types of Innovative Capabilities. *Academy of Management Journal,* 48(3), 450-463.

Subramanian, A. (2012). A Longitudinal Study of the Influence of Intellectual Human Capital on Firm Exploratory Innovation. *IEEE Transactions on Engineering Management,* 59(4), 540-550.

Thornhill, S. (2006). Knowledge, Innovation and Firm Performance in High - and Low – Technology Regimes. *Journal of Business Venturing,* 21(2006), 687-703.

Vaona, A. and Pianta, M. (2008). Firm Size and Innovation in European Manufacturing, *Small Business Economics,* 30(3), 283–299.

Yu, A., Humphreys, P. (2013). From measuring to learning? – Probing the evolutionary path of IC research and practice. *Journal of Intellectual Capital,* 14(1), 26-47.

Wernerfelt, B. (1984). A Resource-based view of the firm. *Strategic Management Journal,* 5(2), 171-180.

Wu, W., Chang, M. and Chen, C. (2008). Promoting Innovation Through the Accumulation of Intellectual Capital, Social Capital, and Entrepreneurial Orientation. *R&D Management,* 38(3), 265-277.

APPENDIX I

Pair-wise Questionnaire

Please read the following questions carefully and enter your answer in the appropriate place, considering the scale shown below. If the first attribute is more important in relation to the second, enter your answer in one of the boxes to the left of the option "1", depending on your preference. Whenever the second attribute is more important than the first, choose your response from the boxes placed to the right of option "1".

Saaty's scale for pair-wise comparisons

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one activity over another
5	Strong importance	Experience and judgment strongly favor one activity over another
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	For compromise between the above values	Sometimes one needs to interpolate a compromise judgment numerically because there is no good word to describe it

Level 2 – IC Components:

	How important is "**Human Capital**" when compared to "**Strutural Capital**"?																
Q1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is "**Human Capital**" when compared to "**Relational Capital**"?																
Q2	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is "**Strutural Capital**" when compared to "**Relational Capital**"?																
Q3	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Level 3 - Human capital elements:

	How important are "**Competencies**" when compared to "**Values and attitudes**"?																
Q4	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important are "**Competencies**" when compared to "**Capabilities**"?																
Q5	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important are "**Values and attitudes**" when compared to "**Capabilities**"?																
Q6	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Level 4 - Indicators for the human capital element "Competencies":

	How important are "**Education levels & specialized training**" when compared to "**Professional experience**"?																
Q7	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important are "**Education levels & specialized training**" when compared to "**Heterogeneous academic education**"?																
Q8	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important are "**Education levels & specialized training**" when compared to "**Specific competencies for product innovation**"?																
Q9	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is "**Professional experience**" when compared to "**Heterogeneous academic education**"?																
Q10	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is "**Professional experience**" when compared to "**Specific competencies for product innovation**"?																
Q11	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is "**Heterogeneous academic education**" when compared to "**Specific competencies for product innovation**"?																
Q12	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Level 4 - Indicators for the human capital element "Values and attitudes":

	How important is "**Employees cooperate and share knowledge**" when compared to "**Employees take risks, are enterprising and creative**"?																
Q13	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important is "**Employees cooperate and share knowledge**" when compared to "**Employees show interest and participate on idea generation activities**"?																		
Q14	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important is "**Employees cooperate and share knowledge**" when compared to "**Employees are committed to the firm's strategy**"?																		
Q15	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important is "**Employees take risks, are enterprising and creative**" when compared to "**Employees show interest and participate on idea generation activities**"?																		
Q16	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important is "**Employees take risks, are enterprising and creative**" when compared to "**Employees are committed to the firm's strategy**"?																		
Q17	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important is "**Employees show interest and participate on idea generation activities**" when compared to "**Employees are committed to the firm's strategy**"?																		
Q18	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Level 4 - Indicators for the human capital element "Capabilities":

How important is "**Employees participate on training initiatives related to innovation**" when compared to "**Employees often develop team work**"?																		
Q19	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important is "**Employees participate on training initiatives related to innovation**" when compared to "**Leaders strive to communicate the role of innovation on the firm's strategy**"?																		
Q20	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important is "**Employees participate on training initiatives related to innovation**" when compared to "**Employees know and understand the firm's NPD process**"?																		
Q21	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important is "**Employees often develop team work**" when compared to "**Leaders strive to communicate the role of innovation on the firm's strategy**"?																		
Q22	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important is "**Employees often develop team work**" when compared to "**Employees know and understand the firm's NPD process**"?																		
Q23	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important is "**Leaders strive to communicate the role of innovation on the firm's strategy**" when compared to "**Employees know and understand the firm's NPD process**"?																		
Q24	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Level 3 - Structural capital elements:

How important is "**Corporate culture towards innovation**" when compared to "**Top management role**"?																		
Q25	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important is "**Corporate culture towards innovation**" when compared to "**Strategy and innovation**"?																		
Q26	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important is "**Corporate culture towards innovation**" when compared to "**NPD management**"?																		
Q27	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is **"Top management role"** when compared to **"Strategy and innovation"**?																
Q28	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is **"Top management role"** when compared to **"NPD management"**?																
Q29	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is **"Strategy and innovation"** when compared to **"NPD management"**?																
Q30	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Level 4 - Indicators for the structural capital element "Corporate culture towards innovation":

	How important is "**There is a new product ideas scheme in place**" when compared to "**Entrepreneurs and innovative project leaders are encouraged and rewarded**"?																
Q31	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is "**There is a new product ideas scheme in place**" when compared to "**Employees have autonomy and resources to develop their creativity**"?																
Q32	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is "**Entrepreneurs and innovative project leaders are encouraged and rewarded**" when compared to "**Employees have autonomy and resources to develop their creativity**"?																
Q33	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Level 4 - Indicators for the structural capital element "Top management role":

	How important is "**Innovation metrics represent an explicit and important part of top management's performance evaluation**" when compared to "**Top management is strongly committed to the product innovation process**"?																
Q34	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is "**Innovation metrics represent an explicit and important part of top management's performance evaluation**" when compared to "**Top management provides clear support, autonomy and authority to the people involved in product innovation projects**"?																
Q35	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is "**Top management is strongly committed to the product innovation process**" when compared to "**Top management provides clear support, autonomy and authority to the people involved in product innovation projects**"?																
Q36	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Level 4 - Indicators for the structural capital element "Strategy and innovation":

	How important is "**The role of innovation in achieving the firm's strategic goals is clearly defined**" when compared to "**There is a plan to identify/acquire the skills that are necessary to achieve product innovation goals**"?																
Q37	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is "**The role of innovation in achieving the firm's strategic goals is clearly defined**" when compared to "**The areas of strategic focus on which to concentrate the product innovation efforts are clearly identified**"?																
Q38	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important is "**There is a plan to identify/acquire the skills that are necessary to achieve product innovation goals**" when compared to "**The areas of strategic focus on which to concentrate the product innovation efforts are clearly identified**"?																		
Q39	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Level 4 - Indicators for the structural capital element "NPD management":

How important is "**The characteristics of project teams are a very important feature of the product innovation process**" when compared to "**There is a system to manage new product development projects**"?																		
Q40	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important is "**The characteristics of project teams are a very important feature of the product innovation process**" when compared to "**There is a well organised new product development process**"?																		
Q41	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important is "**There is a system to manage new product development projects**" when compared to "**There is a well organised new product development process**"?																		
Q42	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Level 3 - Relational capital elements:

How important is "**Vertical and horizontal relationships**" when compared to "**Management of relationship processes**"?																		
Q43	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Level 4 - Indicators for the relational capital element "Vertical and horizontal relationships":

How important are **"Vertical relationships (with customers and suppliers)"** when compared to **"Horizontal relationships (with partners and competitors)"**?																		
Q44	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important are **"Vertical relationships (with customers and suppliers)"** when compared to **"Relationships with other institutions (government agencies, external experts, public and private R&D centres, shareholders, etc.)"**?																		
Q45	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important are **"Horizontal relationships (with partners and competitors)"** when compared to **"Relationships with other institutions (government agencies, external experts, public and private R&D centres, shareholders, etc.)"**?																		
Q46	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Level 4 - Indicators for the relational capital element "Management of relationship processes":

How important is **"The company makes a specific effort to identify and establish relationships with lead users"** when compared to **"The company actively manages formalized relationship processes with clients"**?																		
Q47	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important is **"The company makes a specific effort to identify and establish relationships with lead users"** when compared to **"The company actively manages formalized relationship processes with suppliers"**?																		
Q48	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

How important is **"The company makes a specific effort to identify and establish relationships with lead users"** when compared to **"The company actively manages formalized relationship processes with competitors"**?																		
Q49	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is **"The company makes a specific effort to identify and establish relationships with lead users"** when compared to **"The company actively manages formalized relationship processes with institutions, shareholders and investors"**?																
Q50	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is **"The company actively manages formalized relationship processes with clients"** when compared to **"The company actively manages formalized relationship processes with suppliers"**?																
Q51	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is **"The company actively manages formalized relationship processes with clients"** when compared to **"The company actively manages formalized relationship processes with competitors"**?																
Q52	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is **"The company actively manages formalized relationship processes with clients"** when compared to **"The company actively manages formalized relationship processes with institutions, shareholders and investors"**?																
Q53	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is **"The company actively manages formalized relationship processes with suppliers"** when compared to **"The company actively manages formalized relationship processes with competitors"**?																
Q54	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is **"The company actively manages formalized relationship processes with suppliers"** when compared to **"The company actively manages formalized relationship processes with institutions, shareholders and investors"**?																
Q55	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

	How important is **"The company actively manages formalized relationship processes with competitors"** when compared to **"The company actively manages formalized relationship processes with institutions, shareholders and investors"**?																
Q56	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9