Measuring intellectual capital in a firm belonging to a strategic alliance

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Abstract

Purpose – The purpose of this paper is to propose a method to measure intellectual capital (IC) in firms involved in strategic alliances, an area that has received scant attention in the literature, as existing research is focused mainly on organizational level mainly and increasingly on macro-level unit such as regions or nations. There are very few works at the meso-level (i.e. alliances, clusters), and the paper aims to fill this void, by providing researchers and practitioners with a tool capable of combining measurement and management aims, developed at organizational level with the active participation of the researchers.

Design/methodology/approach – The method of analysis is based on a model formalized through a fuzzy expert system (FES). The FES are able to merge the capabilities of an expert system to simulate the decision-making process with the vagueness typical of human reasoning, maintaining the ability to still have a numeric value as a response. Its construction requires the participation of experts, whose knowledge of the problem is accumulated in the form of blocks of rules. These features make it possible to formalize the decision-making process related to the IC valuation, handling qualitative and quantitative variables, and exploring the cognitive mechanisms underlying this process.

Findings – The outcome of the application is a system designed to measure the intangible performance deriving from participation in a strategic alliance using FES. This study contributes to the broadening of the research community's understanding regarding the alternative measurement of IC created within strategic alliances.

Research limitations/implications – To the best of the authors' knowledge, IC literature lacks methods expressly designed to measure the incremental value of IC originating from collaboration among firms. From a measurement perspective, the results may be regarded as valuable proof that IC performance within strategic alliances can be measured quantitatively.

Practical implications – On the management side, the possibility of retracing the determinants of different IC intermediate indicators composing the final IC index allows strategic alliances managers to use this information for decision-making purposes.

Originality/value – To the best of the authors' knowledge this is the first study applying FES to measure IC in a firm belonging to a strategic alliance. In the authors' opinion, fuzzy logic methodology, recently applied in empirical work designed to evaluate IC, represents a reliable methodology because of the "fuzzy" nature of IC.

Some of the ideas of this paper have been presented at the 9th International Conference IFKAD, 11-13 June, Matera 2014. The author thanks all participants of the meetings for their helpful insights. They also thanks two anonymous reviewers and the editor of this Journal for their helpful comments on previous drafts of the paper. Though this work is the fruit of joint reflection and collaboration, for academic reasons the Sections 1 and 2 are to be attributed to Stefania Veltri, the Sections 3 and 5 are to be attributed to Andrea Venturelli and the Sections 4 and 6 are to be attributed to Giovanni Mastroleo.

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1. Introduction

Intellectual capital (IC) research has mainly focused on individual companies, and, to a lesser extent, on macro-level units such as regions or nations (Bontis, 2004). The research at meso-level (i.e. regional clusters, strategic alliances, etc.), appears to be scant, with few IC works focused on it (Oliver and Porta, 2006), and papers concentrating mainly on the theoretical aspect of relationships between IC and strategic alliances (Pöyhönen and Smedlund, 2004).

This research gap presents an opportunity to scholars and constitutes the purpose of this study. In detail, the main aim of the study is to propose a method to measure IC in firms involved in strategic alliances, which can be used to deal with the complexity of the IC theme in a network of firms.

This study focuses on non-equity alliances, specifically on an Italian network agreement, Progetto Impresa Business (PIB) involving seven manufacturing firms located in the Lecco province, in the northern region of Lombardy.

IC is investigated from the perspective of the single firm embedded in the network agreement (Gretzinger and Royer, 2014), the "3C Catene srl", with the aim to measure how much of the IC produced by the PIB network is attributable to the individual company "3C Catene srl".

This approach allows an answer to a limitation of a previous research conducted on this issue by one of the authors of the paper, as the study succeeded in proving that the network contributed to the growth of IC, but failed to measure the contribution of the single firm belonging to the network to the overall value creation (Caputo *et al.*, 2014).

In the paper, a fuzzy expert system (FES) approach has been chosen as its features allow the formalization of the decision-making process related to the IC valuation handling qualitative and quantitative variables and exploring the cognitive mechanisms underlying this process (Zadeh, 1965; Magni *et al.*, 2002, 2006).

The paper contributes threefold to the literature: first, it address the strong call for IC research at organizational level, a bottom-up, performative and critical research typical of IC third stage research (Guthrie *et al.*, 2012; Dumay and Garanina, 2013; Mouritsen, 2006); second, employing a fuzzy logic methodology, scarcely used in IC research (Bozbura *et al.*, 2007; Zandi and Tavana, 2010; Veltri *et al.*, 2014), it combines the intuition and experience of experts (management view) with the formal rigour of a logic system (measurement view); third, it sheds light of one of the main relevant new strategic themes of the alliance literature, that is, the knowledge dimension of networks and its links with competitive success (Baum *et al.*, 2000; Dyer and Nobeoka, 2000; Gupta and Govindarajan, 2000).

The originality of the paper resides in it being focused on a model expressly designed to measure the incremental value of IC originating from a collaboration among firms. To the best of our knowledge, this is the first research exploring the possibility of using an FES system to deal with the complexity of creating and developing IC in networks.

2. Literature review

Strategic alliances among organizations have grown dramatically during the past two decades (Arend and Amid, 2005) and are supposed to grow in the near future (Elmuti and Kathawala, 2001). A vast literature on strategic alliances and networks has thus

emerged in fields such as economics, management, sociology, and organization theory (Kim and Vonortas, 2014), with much of the research focused on the implications of strategic alliances and networks on the performance of firms engaging in such a relationship (Gulati *et al.*, 2000; Kale *et al.*, 2002; Lee, 2007; Chan *et al.*, 1997; Lin *et al.*, 2009; Lee *et al.*, 2001; Lavie *et al.*, 2012)[1].

This research is embedded into a stream of literature that links value creation in networks to underlying resources (Hervas-Oliver and Albors-Garrigos, 2007; Tallman *et al.*, 2004; Gretzinger and Royer, 2014). We thus take a resource-based view (RBV) perspective (Wernerfelt, 1984; Barney, 1991), or, better, its evolved version IC-based view (ICBV).

From an RBV perspective, networks can hold a variety of advantages for their members in the form of access to valuable shared and non-shared resources (Das and Teng, 2000; Lavie, 2006). Applying the RBV to networks, the necessary bundle of resources and capabilities are thus internal to the network but external to any single firm (Marafioti *et al.*, 2013).

Subsequent studies of the knowledge-based view focused on the intangible content and cognitive character of inter-firm relationships (Foss, 1996; Grant, 1996; Conner and Prahalad, 1996; Teece *et al.*, 1997; Curado and Bontis, 2006), which assign a predominant role in explaining firm performance variations to their possibility when belonging to a network of accessing knowledge potentially usable to generate advantages for the single firm and the whole aggregate (Grant and Baden-Fuller, 2004; Dyer and Singh, 1998; Inkpen, 1996; Della Corte and Sciarelli, 2011). Several studies adopt a knowledge-based view approach in studying network of firms, such as Kale *et al.* (2000), Inkpen and Tsang (2005), Collins and Hitt (2006), Welbourne and Pardo-del-Val (2009), Liu *et al.* (2010), and Gretzinger and Royer (2014).

The ICBV is the ultimate evolution of the RBV, claiming that firm ICV is one specific aspect of the more general RBV, in that it more narrowly considers three resources that have been theoretically linked to a firm's competitive advantage (Reed *et al.*, 2007; Martín-de-Castro *et al.*, 2011). Specifically, ICBV deals solely with knowledge that is created by and stored in a firm's three capital components; i.e., in its people (human capital), social relationships (relational capital), and information technology systems and processes (organizational capital) (Edvinsson and Malone, 1997).

Several studies adopt an ICBV approach in studying the network of firms, such as Das *et al.* (2003), Schiuma *et al.* (2005), Oliver and Porta (2006), Allee (2008); Solitander and Tidström (2010), Peng (2011), Joia and Malheiros (2009), and Chang *et al.* (2008).

Herein it is argued that the embedded instability and uncertainty associated with alliances make strong demands on IC. Since IC is an organizationally embedded competency that is valuable in managing uncertain situations, it can be sustained that IC should have a positive influence on the management of alliances (Chang *et al.*, 2008). In other words, firms with better IC should achieve greater gains from inter-firm collaboration.

Following an IC perspective, there is a need to clarify which conceptualization of IC is acceptable and, above all, how to posit the measurement problems of IC (Bititci *et al.*, 2012). The definition of IC as the dynamic, firm- and context-specific systems of intangible-knowledge-based resources and activities, as the basis of a firm's competitive advantage (Meritum Project, 2002; Veltri, 2011) answers the first issue. As regards the second, it should be underlined that methods for IC measurement can be classified in four basic categories (Sveiby, 2010): market capitalization; return on asset; direct IC; and scorecard. The first three models focus on the financial side of measurement and the

monetary value of intangible assets, whereas scorecard approaches look for quantitative and qualitative indicators usable to measure intangible resources and activities and aim at showing the role of IC in a firm's value creation (Chiucchi, 2004; Veltri, 2007). They may or may not produce a composite index (Tan *et al.*, 2008).

In the paper, the starting point is the scorecard approach, as a management perspective is adopted, with the aim of providing managers with unambiguous information that could support strategic decisions regarding organizational IC. In detail the advanced scorecard methods are referred to, which adopt the evolved notion of IC as a dynamic system on intangible resources based on knowledge[2]. These models focus their attention on the interactions between the IC items, at the basis of the organization's value creation, and on intangible activities which are essential in the production and development of intangible resources. The assumption behind these models is that the measurement of IC is necessary for the management of knowledge and their main aim is to identify the paths of an organization's value creation based on knowledge (Veltri *et al.*, 2014). A method returning an IC composite index is also sought, as an index can improve the visualization of the value-creating processes of the company, so facilitating the management of these processes (Bontis, 2001; Cricelli *et al.*, 2014).

The IC-index concept was suggested by the first generation of IC thinkers (Roos *et al.*, 1997; Edvinsson and Malone, 1997), and since then the logic of an IC-index has been supported and implemented by other scholars and practitioners (Grimaldi *et al.*, 2013). Specifically, the Intellectual Capital Index, proposed in 1997 by Edvinsson and Malone, is a synthetic measure given by the product of the potential future development of IC (C) and the efficiency in using IC (i), while the IC-index proposed by Roos *et al.* (1997) is a numeric ratio given by the weighted sum of selected IC indicators.

Among other subsequent IC-indices proposed in the literature, we can quote Low's (2000) "Value Creation Index", which identifies and measures the nine most critical intangible categories of performance that determine corporate value creation and synthesize their values through specific weights according to their relative impact; Chen *et al.*'s (2004) IC Index, based on evaluating the indices and the trend of IC instead of calculating its economic value through questionnaire-based qualitative indices, synthesized through weights according to the management's perception of their importance; Kannan and Aulbur's (2004) IC index, which is the result of a three-step IC measurement model (identification and awareness, systems and output measures, and outcome measures of tangible financial returns) and Jacobsen *et al.*'s (2005) IC Rating™ approach, a sort of a management consulting approach to measure IC. As regards the issue to measure IC within a network, only Oliver and Porta (2006) addressed the matter discussing the Intellectual Capital Cluster Index®, a weighted sum of measures and assessments of IC. The system identifies six ICCI blocks (auxiliary industry, firm strategy, linkages, performance, human resources, institutions and technological infrastructure), the first four weighted 15 per cent, the second two weighted 20 per cent, then the score assigned for each block is divided into the numbers of indicators included in each block. The system proposed allows the description, mapping, measuring and valuing of IC in clusters and the systematic control of its evolution; nevertheless, a more comprehensive practical application is needed to validate the model (Tan *et al.*, 2008).

To date, most indices have proven difficult to extend universally and, to the best of our knowledge, none of the solutions proposed in the literature have considered the performances of the IC components, the interdependencies among them as well as their

strategic contribution to the value-creation process. Some solutions were put forward to overcome these limitations by taking into consideration the managers' perceptions. The AMIC (assessment and management IC) Index, for instance, based on structured interviews to firms' managers, allows both the interdependencies among the IC elements, considered as entities grouped into value drivers which jointly act to produce value, and the managers' perception about their strategic importance in the value-creation process to be considered (Grimaldi *et al.*, 2013; Cricelli *et al.*, 2014). On the other hand, Kale (2009) and Veltri *et al.* (2014) IC index proposals, respectively in architectural/engineering/construction firms and in universities, discussed a model that uses the fuzzy set theory, with the aim to adequately handle imprecision, vagueness, and uncertainty that prevail in the IC measurement process. No study used an FES model to measure IC in networks adopting a single firm perspective.

Building on these recent studies (Kale, 2009; Veltri *et al.*, 2014; Cricelli *et al.*, 2014), we propose a system aimed to measure the IC produced by a firm belonging to a network using an FES model and taking into consideration the managers' perceptions of IC. On the basis of semi-structured interviews with the managers of the selected firm belonging to the PIB Italian network, data were obtained that, filtered by the knowledge of the experts' focus groups, became the input of an ad hoc FES model addressed to give a "numeric" measurement of an organization IC, while still taking into consideration the fuzzy nature of IC (O'Donnell, 2006), and its firm- and context-specific nature. This FES model is intended to consider the performance of IC components, their interdependencies and their contribution to the firm value creation process (Cricelli *et al.*, 2014; De Santis and Giuliani, 2013), and to deal with the dynamic nature of IC (Kianto, 2007) and with the potential value of IC: all relevant features that should be taken into consideration by researchers who deal with the IC measurement issue.

3. Research framework and methodology

This section aims to illustrate the research framework and methodology employed to address the research aim. In this study, the contribution in terms of IC of a single firm belonging to a network is investigated within a sample of non-equity strategic alliances. We have chosen non-equity, contractual strategic alliances as they are likely to involve greater risks and uncertainty than joint ventures. This in turn make them more interesting from an IC perspective, as IC and experience are expected to be more important when the transactions involve greater risks and uncertainty, so the influence of IC and experience is expected to be stronger in non-equity alliances than in joint ventures.

Adopting a firm-level perspective (Gretzinger and Royer, 2014), it was chosen to focus on a firm belonging to an Italian network agreement, the 3C Catene srl, belonging to the PIB network, localized in the province of Lecco, in the northern Lombardy region of Italy. There are several reasons for such a focus on an Italian network agreement, disciplined by Law 33/2009. First, Italian networks are governed by a flexible legislation in which network agreements can be supply chains, dyadic relations, etc., so they are a good proxy for analysing the complex theme of strategic partnerships; second, network agreements are a form of strategic alliance largely used for intangible purposes (Caputo *et al.*, 2014). Moreover, a domestic network was selected, i.e. a network in the Italian context owing to its being a context in which cooperation between companies is particularly relevant, as the economy is mainly driven by SMEs

(Marafioti *et al.*, 2013, Ricciards, 2011). In particular, the choice of PIB network was not random, in the sense that the strategic objective stated in the network contract (drawn up on 26 September 2011) is to increase innovative capacity and competitiveness in the companies' markets through the creation of highly innovative products and services. The seven companies in the PIB network operate in the manufacturing sector and are also joint holders of a product patent; the form of integration in the network is of a horizontal nature.

The main aim of the paper is to build an ad hoc FES model addressed to measure the IC contribution of the 3C Catene srl to the PIB network. To build it, the data needed was collected as inputs through the qualitative tool of the semi-structured interview to the general managers of the selected firm, then the data was interpreted by researchers in the light of the interpretivist approach[3]. On the basis of the qualitative data, the researchers acted as experts (content expert) and, together with an expert of the FES models (methodology expert), worked on developing the ad hoc FES quantitative model.

Therefore the paper follows both qualitative methodology (case study and semi-structured interviews) and quantitative methodology (FES model) in a complementary manner. The case study methodology was chosen as the most appropriate for the analysis of the way firm belonging to the network produce. Such a methodology is consistent with this goal as a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident, which is our case (Yin, 2003). Moreover, the case study approach is consistent with the aim to measure IC, which is firm and context specific (Mouritsen, 2006), and it is also coherent with the third wave performative IC research, according to which, to produce outcomes useful to advance IC knowledge, IC research should focus on IC management practices and ad hoc, focused models (Dumay and Garanina, 2013). There were several reasons behind the choice to focus on a single case study: first, a single case enhances the in-depth nature of the analysis because it allows the researchers to get a richer and deeper understanding of the phenomenon and the context in which it takes place (Montemari and Chiucchi, 2013); second, the choice responds to a specific circumstance and contingency, like the organization selected for the case study belonging to a network agreement, and we aim to study IC within a network agreement; third, the deliberate focusing on a single organization aims to investigate IC from the perspective of a single firm embedded in a network (Gretzinger and Royer, 2014).

Qualitative data have been collected using the tool of the semi-structured interview. The interview is one of the main types of qualitative data collection methods. Interviews are useful because they are very efficient in obtaining data in a very short space of time, even though they bear the risk that interviewers could expect interviewees to use researchers' perspectives and words (Ely *et al.*, 1991). There are a variety of interview methods, including the standardized (structured), the unstandardized (informal) and the semi-standardized (semi-structured) interview (Berg, 2001). The latter is the method employed for this research, because of its high degree of flexibility and because it offers the opportunity to address themes that come to light during the interviews, allowing the enhancement of the understanding of the motivations that drove the interviewee's actions as well as his/her interpretation of the situation (Qu and Dumay, 2011).

So far, some in-depth semi-structured interviews have been planned and, following Welman and Kruger (2001), an interview guide was prepared by the authors, which

consists in a list of topics and aspects of these topics that the interviewer should raise during the course of the interview. The interviews took place in a face to face setting and based on a semi-structured questionnaire with the focus on the role of IC for the firm belonging to the PIB network agreement. Then a closed questionnaire was prepared and made available on web resources (Crotty, 1998).

Each interview lasted on average 1.5 hours and was conducted in a semi-structured form by both authors together, who shared the list of topics to be investigated; top management people were interviewed twice, in order to better focus on some of the insights they offered. Interviews were recorded and type-scripted, and in case of misunderstandings a further and shorter interview was scheduled in order to clarify or detail some of the aspects of the previous interview. Once type-scripted, interviews were submitted to interviewees in order to check for potential inconsistencies or mistakes. The authors analysed the data separately in a first step, before comparing and discussing them. Consensual validity was reached through this procedure. Another manner to ensure internal validity of data and findings was the use of complementary data sources such as newspaper articles, information about the network agreement and network actors from the internet in general as well as from the homepage of the selected network agreement cluster, with the aim to obtain a rich set of data deep analysis of the case study and support interviewees' statements, so pursuing a data triangulation (Yin, 2012).

4. The ad hoc FES

FESs are expert systems which rely on fuzzy logic. Fuzzy logic is a cognitive framework that adequately replicates the natural way human beings cognize the world and think about problems and situations. In other words, fuzzy logic overcomes Boolean logic (true or false) and enables researchers to formalize qualitative (linguistic) and vague concepts such as "low", "medium", "high", "good", "excellent" and so on (Magni *et al.*, 2006). An expert system is a tool designed to replicate the way of reasoning of one or more experts, which consists in a knowledge base and an inferential engine. An FES model is thus an information system using fuzzy data, fuzzy rules and fuzzy inference usable to merge the capabilities of an expert system to simulate the decision-making process with the vagueness typical of human reasoning, which is present in fuzzy logic (Magni *et al.*, 2002, 2006). Behaviours and decisions are encoded in blocks of rules, and processed through a fuzzy logic inference engine[4].

The FES model has been used to obtain a number of advantages: first of all, the use of a model improves the description of the benefits of belonging to a network and increases the ease of understanding and implementation of the problem, but it also has the capacity for having a numeric value as a response, although not all data are quantitative; the model allows a large number of inputs to be managed, and through the use of intermediate variables it increases clarity simplifying the design of the entire system. Moreover, FES is an extremely flexible model, as it is possible to introduce several value drivers and change the rules connecting drivers and intermediate variables at any time and is a transparent model, as the experts involved put their experience and knowledge into the building of the FES and their choices are transparent, visible and manifest at any given step.

Its construction requires the participation of experts, whose knowledge of the problem is accumulated in the form of blocks of rules. These features meet the needs of the proposed methodology: to formalize and automate the decision-making process relating to the valuation of IC, handling qualitative and quantitative variables,

exploring the cognitive mechanisms underlying this process, reducing the distortions often found in the real decision-making context.

The implementation of the system was divided into the following phases:

(1) focus group with experts to define the inputs, conditions for the aggregation of intermediate variables and output;

(2) layout of the model (modular decision tree);

(3) definition of linguistic attribute (fuzzy value) for each variable, range of variables and blocks of fuzzy rules;

(4) trial processing and optimization; and

(5) analysis of the final output.

The design of an FES is the first and most important step of the study. With the help of a panel of experts, a modular system was selected, consisting of several fuzzy modules linked together. The main structure of the model is based on the aggregation of the three main components of IC: human capital (HC), structural capital (SC) and relational capital (RC) (Figure 1).

Starting from the right (going from branches to trunk), the final output "ICinNetAgr" is determined by the tree main factors HC, SC and RC, which are determined by other intermediate variables, which in turn are determined by other variables and so on until, proceeding backward, a set of initial independent variables (the inputs) is reached[5]. From a mathematical point of view, the connection between the set of the n input variables and the output can be represented by a function f of n independent variables x_i, $i = 1, 2, \ldots, n$, affecting the dependent variable y (intermediate variable), so that $y = f(x_1, x_2, \ldots x_n)$.

All the knowledge needed to design and build the system components (variables and elements for their evaluation, blocks of rules and weights for aggregation) is "pulled" by the experts using various techniques of investigation. For the purposes of this paper a Focus Group with partially structured discussions has been used. In detail, an NGT (Nominal Group Technique) approach was employed as meeting procedure. NGT uses a group of experts who hold discussions chaired by a moderator (Duggan and Thachenkary, 2004; Dunham, 2006), with the aim to reduce to a minimum distortions due to personal interaction during the discussion[6].

The FES model relies heavily on the knowledge and competence of the focus experts' group. Although this methodology involves a high level of subjectivity and is therefore subject to measurement error, it is worth remembering that it addresses some of the inherent limitations of the inferential statistical methods which are based on the direct observation of phenomena (Krueger and Casey, 2009; Morgan, 1993; Bertin, 2005) such as the need to produce information quickly, to create a shared set of terms and concepts for the different parties involved in a communication process and to involve all these parties in the evaluation process.

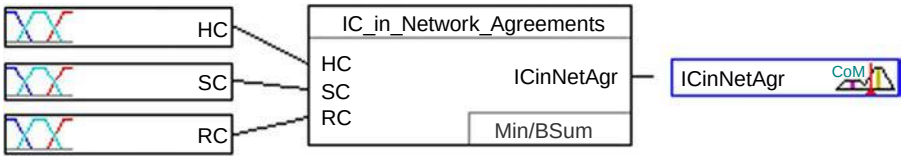

Figure 1.
Main structure of the FES model

As with all methodologies, also the focus experts' group one has its weaknesses, including factors such as individual stereotypes, which lead to the creation of a cognitive filter in the analysis (even by experts) of social phenomena; the relational dynamics, of psychological and social nature, which affect communication between the different social protagonists; the selection processes and the representativeness of the group of experts referred to; the definition of the level of reliability of the analyses carried out. Anyway, we decided to employ the focus experts' group methodology because of its usefulness in researches, such as this one, whose success is strictly determined by the way in which the inputs are fuzzified and the blocks of fuzzy rules are constructed; only researchers who have an in-depth knowledge of a particular phenomenon could assign reliable values and construct reliable rule blocks.

To overcome any possible measurement errors, several corrective measures were applied to counterbalance the use of the experts' focus group. Top management people were interviewed twice, in order to better focus on some of the insights they offered. Interviews were recorded and type-scripted, and in case of misunderstandings a further and shorter interview was scheduled in order to clarify or detail some of the aspects of the previous interview. Once type-scripted, interviews were submitted to interviewees in order to check for potential inconsistencies or mistakes. We also collected internal documents in order to support interviewees' statements and to better detail the analysis. Moreover, the inter-rater reliability was assessed, meaning that data were independently coded and the coding compared for agreements (Armstrong *et al.*, 1997). We also foresaw the rule to follow in the case of disagreement (one main referent chosen in the group) and finally, our model was corroborated by testing its reliability against a series of simulations[7].

Each value assumed by an input must be translated into a fuzzy number. This occurs in the input variables. For example, the variable "M_ExpOnTC" (Marketing expenditures/total costs), which is one of the input variables of the RC area, is made up of three sets (low, medium, high) that evaluate the degree of membership (between 0 and 1) of the terms low, medium and high, of the percentage indicated on the abscissa. To this value (2 per cent) a membership value of 0.75 is attributed to the term medium and a membership value of 0.25 to the term high. This means that a value of 2 per cent is taken more into consideration by experts: high rather than medium (Figure 2).

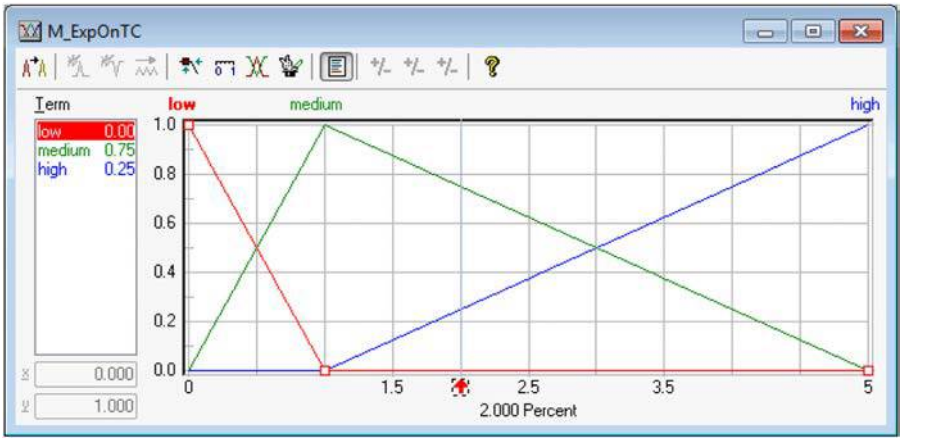

Figure 2.
The input variable: "M_ExpOnTC"

All the variables that are not initial drivers are called intermediate variables. They are not, from the beginning, directly measurable, but provide an indication of the intermediate evaluation under the modularity of the FES. Each subsystem has its own specific development required both for the structure and for the compilation of the blocks of rules. In a Rule Block you assess the levels of the input variables to provide an assessment of the intermediate variable, which is the output of the block. For example, in the block of the intermediate variable "Contract", in the RC area, two inputs are valued according to the rules given in Table I to obtain an assessment of the variable Contract (Figure 3 and Table I).

The figures and tables below show the structure and the variables that make up the subcategories. In detail, Figure 4 illustrates the structure of the HC subcategory.

The HC System is based on the evaluation of two large areas: the level of knowledge, understood both as level of education and as ability to perform well on their own work, and human resources, evaluated through the profile and the staff satisfaction and through an index of the productivity of managers. The system is constructed by aggregating 23 inputs through 16 blocks of rules (Table II), to get 15 intermediate variables (Table III), and final evaluation (the HC output).

The evaluation of the RC is made by combining the assessment of Market and Network areas with the input "SupStability" (stability of suppliers). This input was initially the result of the aggregation of other variables; after further discussion with the experts, it was considered sufficient to assess the number of years of relationship with key suppliers and simplify the model. The input is evaluated at equal weight with the other two intermediate variables (Figure 5).

The System is constructed by aggregating 21 input (Table IV) through 14 blocks of rules, to get 13 intermediate variables and the RC output (Table V).

The output of the SC System is essentially an assessment of the Research area. The evaluation of the RC is made by combining the assessment of Market and Network areas with the input "SupStability" (stability of suppliers). Except for the input

	IF			THEN
No.	ContrDuration	AllianceType	DoS	Contract
1	low	low	1.00	low
2	low	medium	1.00	low
3	low	high	1.00	medium_low
4	medium	low	1.00	low
5	medium	medium	1.00	medium_low
6	medium	high	1.00	mediurn_high
7	high	low	1.00	medium_low
8	high	medium	1.00	medium_high
9	high	high	1.00	high

Table I.
Rule block for the intermediate variable "contract"

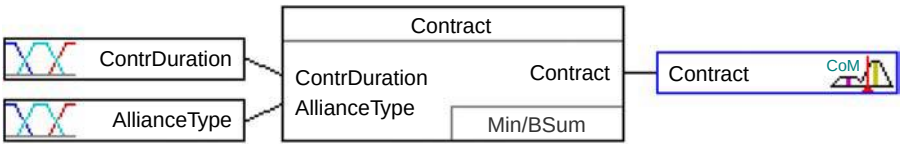

Figure 3.
Block of the intermediate variable "Contract"

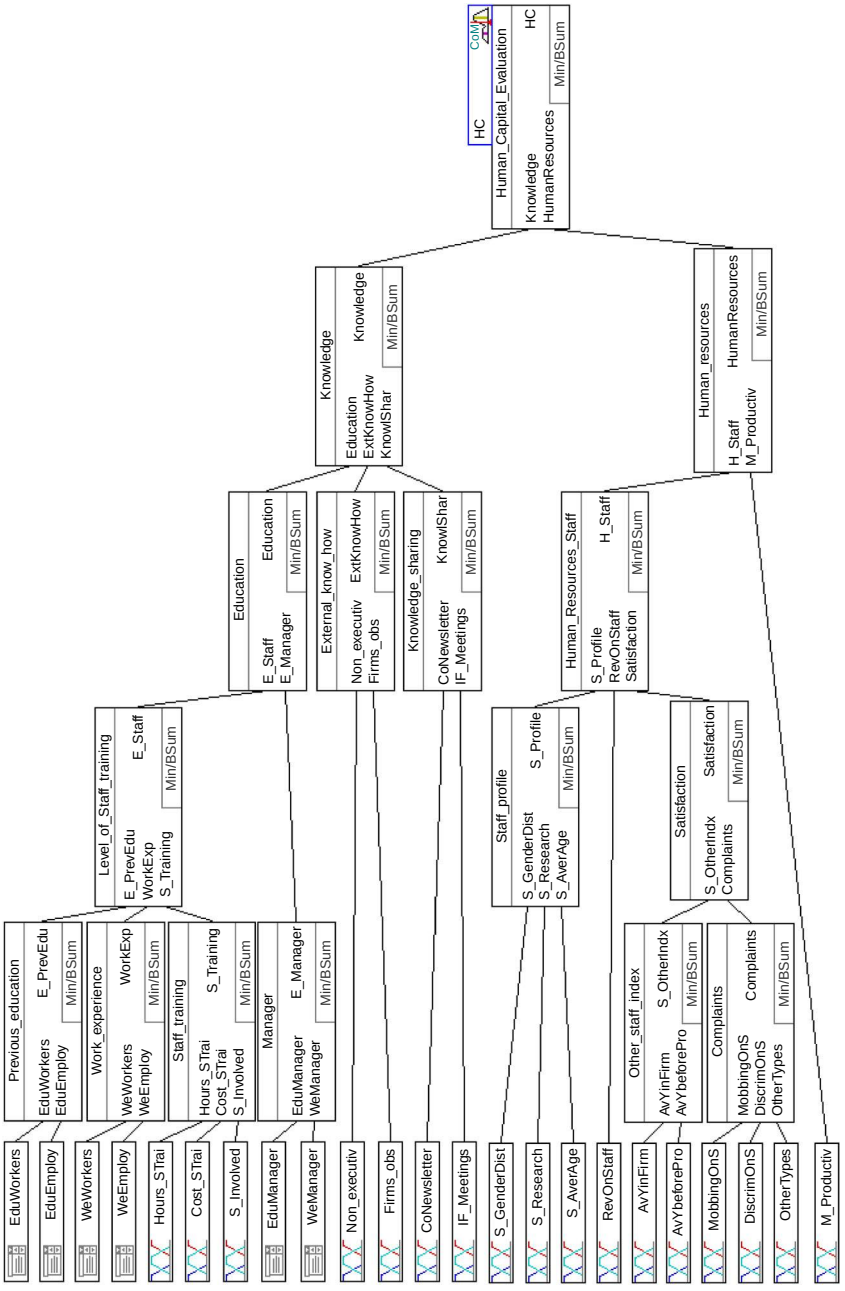

Figure 4.
Structure of human capital subcategory

Label	Input
AvYbeforePro	Average years before professional growth
AvYinFirm	Average years in the firm
CoNewsletter	Company newsletter
Cost_STrai	Cost of staff training
DiscrimOnS	Discrimination complaints / tot staff
EduEmploy	Level of education of the employees
EduManager	M_Previous education
EduWorkers	Level of education of the workers
Firms_obs	Firms of other business sectors
Hours_STrai	Hours of staff training
IF_Meetings	Inter-functional meetings
M_Productiv	Productivity: revenue/manager
MobbingOnS	Mobbing complaints/tot staff
Non_executiv	Non-executives
OtherTypes	Other types
RevOnStaff	Revenue/staff
S_AverAge	Average age of staff
S_GenderDist	Staff gender distribution
S_Involved	% of staff involved
S_Research	% research staff
WeEmploy	Work experience of employees
WeManager	Work experience in the business sector
WeWorkers	Work experience of workers

Table II. List of abbreviations: input of HC system

Label	Intermediate variable
Complaints	Complaints
E_Manager	Manager – level of training of managers
E_PrevEdu	E_Previous education
E_Staff	Level of staff training
Education	Education
ExtKnowHow	External know-how
H_Staff	Staff
HumanResources	Human resources
Knowledge	Knowledge
KnowlShar	Knowledge sharing
S_OtherIndx	Other staff index
S_Profile	Staff profile
S_Training	Staff training
Satisfaction	Satisfaction
WorkExp	Work experience

Table III. List of abbreviations: intermediate variables of HC system

"Patents", all the inputs of this system are indices that are constructed by combining information provided by the questionnaire with values that can be derived from the financial statements, and needed to have a measure of the commitment and achievements in the field of innovation (Figure 6).

The evaluation of SC System is obtained by comparing the result of the substructure Research, composed of 11 inputs (Table VI), with the input "InvITonTI", which compares the amount of investment in IT to the total of investments.

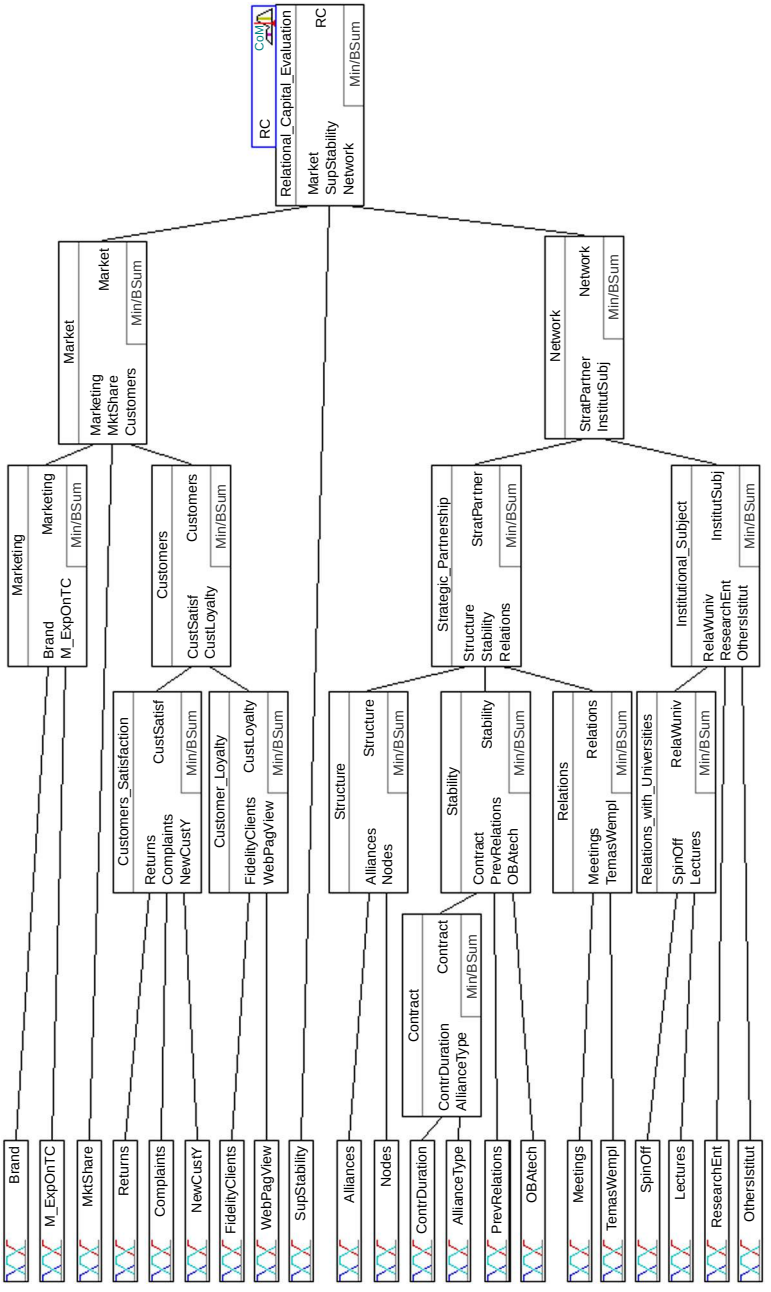

Figure 5.
Structure of relational capital subcategory

Label	Input
Alliances	N° of alliances
AllianceType	Alliance Type
Brand	Brand
Complaints	Total Complaints / total revenues
ContrDuration	Contract duration
FidelityClients	% Fidelity clients
Lectures	Lectures at scientific conference
M_ExpOnTC	Marketing expenditures/total costs
Meetings	Meetings between managers of nodes
MktShare	Market share
NewCustY	% new customers for year
Nodes	N° of nodes
OBAtech	Use of OBA techniques
OthersIstitut	Relations with other istitutional subjects
PrevRelations	Previous relations
ResearchEnt	Relations with research entities
Returns	Total returns/total revenues
SpinOff	Spin off in Universities
SupStability	Supplier stability
TemasWempl	Temas with employees of different firms
WebPagView	Web page views

Table IV. List of abbreviation: input of RC system

Label	Intermediate variable
Contract	Contract
CustLoyalty	Customer loyalty
Customers	Customers
CustSatisf	Customers satisfaction
InstitutSubj	Institutional subjects
Market	Market
Marketing	Marketing
Network	Network
Relations	Relations
RelaWuniv	Relations with universities
Stability	Stability
StratPartner	Strategic partnerships
Structure	Structure

Table V. List of abbreviation: intermediate variables of RC system

The aggregation is done through eight blocks of rules and seven intermediate variables (Table VII).

The next section analyses the result of our FES model.

5. Results and discussion

The output from the system created makes it possible to classify the values for the contribution of IC in the individual companies to the network, but not to assign absolute data values, just relative values, in terms of IC produced by the firm belonging to the PIB network, in the specific case by the "3C Catene srl".

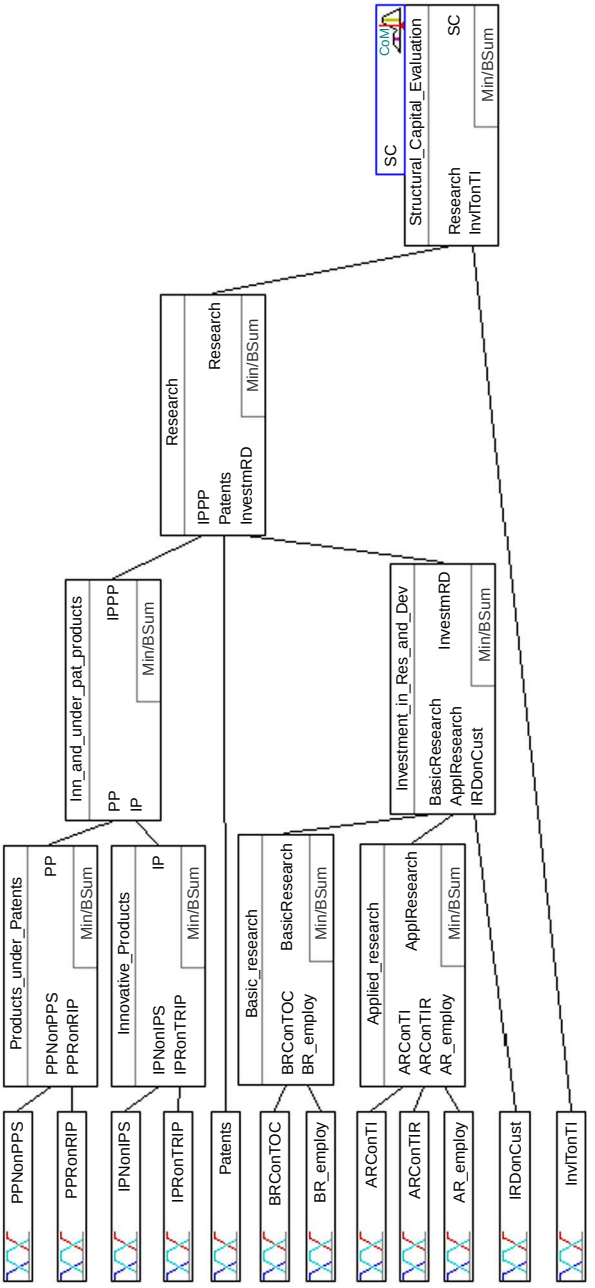

Figure 6.
Structure of structural capital subcategory

Label	Input
AR_employ	% employees in applied research
ARConTI	Cost of applied research/total investment
ARConTIR	Cost of applied research/total investment in research
BR_employ	% employees in basic research
BRConTOC	Cost of basic research/total operating costst
InvITonTI	Investments in IT/total investments
IPNonIPS	IPN number of innovative products sold/IPS innovative products sold
IPRonTRIP	IPR patented products revenue/TRIP total revenues invoiced products
IRDonCust	Investment in R&D/N° of customers
Patents	Patents
PPNonPPS	PPN number of patented products sold /PPS patented products sold
PPRonRIP	PPR patented products revenue/RIP revenues invoiced products

Table VI. List of abbreviation: input of SC system

Label	Intermediate variable
ApplResearch	Applied research
BasicResearch	Basic research
InvestmRD	Investments in R&D
IP	Innovative products
IPPP	Innovative products and products under patents
PP	Products under patents
Research	Research

Table VII. List of abbreviation: intermediate variables of SC system

The final results produced by the system are displayed in Table VIII.

The main result, measuring the contribution made to IC formation in the PIB network by the firm that is the subject of this study, 3C Catene s.r.l., is the figure of 52.68 out of 100 given in the last column. This is an extremely positive result for the company although quantifying the real contribution made will not be possible until the relevant data has also been collected from the other firms in the network, at which point comparisons of the respective IC contributions may be made.

The final figure is the result of the aggregation of the values for the HC (70.31), RC (76.13) and SC (0.11) systems.

The HC variable derives from the aggregation of the two intermediate variables: "Knowledge" and "Human Resource". Examination of the values ascribable to these variables reveals the following (Table IX).

As far as the variable "Human Resource" is concerned, it is worth noting, for example, the high level of employee satisfaction due, predominantly, to the absence of mobbing and discrimination. As regards the variable "Knowledge", on the other hand, a certain discrepancy can be seen between the level of education and training of the staff (which is high) and the level of know-how developed by the company in its relations with other companies (which is almost non-existent); the latter variable, moreover, is also affected by the value for the sharing of know-how (calculated by aggregating the adequate level of internal circulars with the low number of meetings between company representatives).

The RC variable derives from the aggregation of the two intermediate variables "Market" and "Network". Examination of the values ascribable to these variables reveals the following (Table X).

Table VIII.
Final results

1° level int. Var.	1° level int. Var.	HC System	Input	1° level int. Var.	1° level int. Var.	RC System	Input	1° level int. Var.	SC System	Output
Human Resources	Knowledge	*HC_02*	SupStability	Market	Network	*RC_02*	InvITonTI	Research	*SC_02*	ICinNetAgr
1.00	0.28	*70.31*	Very high	0.68	0.45	*76.13*	Very low	0.14	*0.11*	52.68

As regards the variable "Market", while there is only scant investment in marketing, the level of attention devoted to customers (ascertained from the high customer loyalty figures, the fact that almost no goods are returned, the enormous number of new customers acquired, and the number of visits to the company web site) is high. On the other hand, as far as the "Network" variable is concerned, the research team assigned an average value, obtained by aggregating the more than satisfactory rating for strategic partnerships (an evaluation of the stability of network relations, and of the number of meetings between company management and network management) with the less than satisfactory rating for institutional relations (an evaluation of the number of relationships with universities and with university spin-offs, and of collaborations with scientific journals).

Finally, the SC variable derives from the aggregation of the variable "Research" and an input variable "InvITonTI". Examination of the values ascribable to these variables reveals the following (Table XI).

As regards "Research", it is of particular note that while the possession of a patent merits an adequate rating, the level of impact of innovative/patented products on total sales and the level of investment in basic and applied research are wholly inadequate. Finally, investment in Information Technology is scant.

In particular, as regards HC, the relevant contribution in terms of the specific experience of the staff is worth noting.

As regards RC, it is worth noting the significant contribution of the stable relationship with suppliers and of the high market share.

2° level int. Var.		1° level int. Var.	HC System
Education	80,644	Knowledge 27,604	*HC 70,312*
ExtKnowHow	0,000		
KnowlShar	20,000		
H_Staff	80,000	Human Resources 100,00	
M_Productiv	375,530.667		

Table IX. The human capital output

2° level int. Var.			1° level int. Var.	RC System
Marketing	3,332	Market 68,332	*RC 76,134*	
Customers	100,000			
StratP artner	56,666	Network 44,642		
InstitutSubj	43,750			

Table X. The relational capital output

2° level int. Var.		1° level int. Var.		SC System
IPPP	0.000	Research 14,286	*SC 0.106*	
Patents	1			
InvestmRD	0.000			
		InvITonTI 0.042605		

Table XI. The structural capital output

In contrast with these positive results is the poor result in terms of SC, which is essentially due to the very low-level contribution made by intermediate variables connected with research. This is understandable, in the sense that the company intends to increase its research and development activities through the PIB network, the objective of which – as mentioned above – is concerned with product innovation.

6. Conclusions

This paper proposes an alternative IC evaluation model using an FES approach, usable to combine the intuition and the experience of experts, who supply the system with the knowledge base, with the formal rigour of a logic system.

The FES model created and implemented for the "3C Catene srl", a firm belonging to the Italian PIB network, processes a number of convenient input variables which first affect the three main IC subcategories (HC, RC and SC) and, via combination of the latter, produce an output in the interval [0,100].

The main findings of the paper have implications for both theoretical and empirical community. Theoretically, this study contributes to broadening the research community's understanding regarding the alternative measurement of IC created within strategic alliances and the results obtained for the selected firm may be regarded as valuable proof that IC performance within strategic alliances can be measured quantitatively.

On the management side, the possibility of retracing the determinants of the different IC intermediate indicators composing the final IC index offered by this model allows managers to use this information for their decision-making purposes. In fact, the framework that enables the calculation of the IC index considers the manager's concept of IC, the elements that constitute and influence IC production and the IC value-creation process itself. Moreover, the model proposed is intuitive and comprehensible, flexible (it can be changed by the evaluator), usable to handle a large number of quantitative and qualitative variables: as the system is modular, going from branches to trunk, it allows a high number of value drivers to be handled.

The main limitation of the research is related to the difficulty to quantify the real contribution made by the selected firm to the network production of IC, being this possible only when the relevant data have been collected from the other firms in the network.

Further empirical investigations are therefore planned to follow to all the other companies in the PIB network, but, generally speaking, the pilot model applied to the PIB Italian network is a good reference for other similar situations, as it is flexible enough for individual adaptations and adjustments. Once it is validated, it will be possible to apply the model, with a minimum of modifications, to other, vertically integrated types of network.

Notes

1. A strategic alliance can be defined as an alliance in which independent organizations share the benefits of partnership and participate continuously in one or more key strategic areas such as product design, production, marketing, distribution, technology (Arend and Amid, 2005; Gulati, 1998). Alliances can take many forms, ranging from simple agreements with no equity ties to more formal arrangements involving equity ownership and shared managerial control over joint activities (Chan *et al.*, 1997; Gulati *et al.*, 2000; Elmuti and Kathawala, 2001).
2. Scorecard methods evolved from pioneering IC measurement and management models (Edvinsson and Malone, 1997; Sveiby, 1997) to advanced ones (Meritum Project, 2002; Danish

Ministry of Technology and Innovation, 2003). For an analysis, see Chiucchi (2004), Veltri (2007), Bronzetti and Veltri (2013).

3. In other words, in the light of interpretivism, sociological phenomena cannot simply be observed but must also be interpreted by the researcher. This means that there is not one absolute reality, but rather different possibilities are generated by the perspective adopted to interpret the facts (Ryan *et al.*, 2002).
4. An example of if-then implication is the following: if market forecasts are favourable AND the quality of the products is very high AND the intensity of rivalry is low, THEN prospective profits are high. In this example an FES has to specify to what degree the market forecasts are favourable, to what degree the quality of the products is very high and to what degree the intensity of rivalry is low. If the system receives this information, the system will infer, using its inferential engine, the sentence "prospective profits are high" (Magni *et al.*, 2006).
5. The inputs have been identified by the researchers based on the findings of the interviews with the general managers of the "3C Catene srl" and their expertise on the IC components in terms of human, relational and structural capital. For reasons of brevity, a detailed description for each (input and intermediate) variable is not given, but it is available upon request as is the questionnaire used, the rating assigned to the IC components and the rule blocks.
6. The NGT model in a first phase does not rely on oral communication, instead individuals communicate in a written form, to enable individuals to overcome possible obstacles to the expression of their opinion (for shyness, reverential fear of important experts or unwillingness to offer views conflicting with those of any superiors present). Subsequent phases involve presentation and discussion of proposals; each idea is discussed by all the members of the group, then classified by each member using an ordinal scale. Finally, mathematical calculations – for example, the average of all the individual assessments – are made on the basis of the scores given.
7. We tested the reliability of our FES model through a series of simulations, varying the value of one or more value drivers simultaneously while leaving the others fixed. For reasons of space, the simulations are not described in the text, but they are available on request.

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