The role of causal maps in intellectual capital measurement and management

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The role of causal maps in intellectual capital measurement and management

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Abstract

Purpose – The purpose of this paper is to investigate the measurement and the management of the dynamic aspects of intellectual capital through the use of causal mapping.
Design/methodology/approach – The paper details the methods utilized in a single in-depth case study of a network-based business model.
Findings – The paper illustrates how causal mapping can be used to understand how intellectual capital really works in the specific business context in which it is deployed. Moreover, exploiting the causal map as a platform for extracting a set of indicators can provide information on the length of the lag and the persistence of the effects of managerial actions. In addition, it can signal when and how to refine and update the causal map. The combination of these factors can potentially support the dynamic measurement and management of intellectual capital.
Research limitations/implications – The paper presented has two main limitations. First, the use of a single case study to provide in-depth and rich data limits the generalizability of the observations. Second, the proposed approach has not been implemented in practice. Future research opportunities include interventionist-type case studies that put the causal mapping approach into practice.
Practical implications – The paper highlights the need to build causal maps to enhance the measurement and management of intellectual capital, which is dynamic in nature. As a consequence, this tool can be useful for monitoring the intangibles of companies and networks and to better understand the contribution their intellectual capital makes to the value creation process.
Originality/value – The paper openly questions the measurement of the fluid and dynamic aspects of intellectual capital. It proposes a tool for governing these aspects and it suggests that even the existing intellectual capital measurement systems can improve their usefulness by including these dimensions. So, a shift in intellectual capital measurement is prescribed.

Keywords Measurement, Causal maps, Intellectual capital dynamism, Network-based businesses
Paper type Research paper

1. Introduction

This paper investigates possibilities for creating more dynamic modes of measurement and management of intellectual capital performance. Several authors have recently argued that intellectual capital is an intensely complex web of company-specific knowledge resources (Dumay, 2009; Dumay and Cuganesan, 2011). Because intellectual capital is a fluid and dynamic phenomenon, its complexity and ambiguity has to be analyzed in the specific company in which it is applied. Therefore, the objective of this paper is to answer the call for performative research made by Mouritsen (2006) and more recently repeated by Guthrie *et al.* (2012) and Dumay and Garanina (2013).

The implication that these authors' research puts forth is that measuring and managing intellectual capital dynamism is essential for managers in order to govern the value creation process of their companies and the networks in which they are

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encompassed. However, the intellectual capital measurement systems (ICMSs) of today have been criticized for not being fully able to explain the value creation process triggered by intangibles (Mouritsen, 2006; O'Donnell *et al.*, 2006; Dumay, 2009). Intangible resources in existing ICMSs are extracted from the context in which they work and are then measured "on hold," not "in action" (Chiucchi, 2013). Hence, the dynamic aspects of intellectual capital are not fully measured and managed. Since the state of the art in this research area is still unable to provide exhaustive answers, we need further steps aimed at understanding which types of tools are suitable in order to dominate the real nature of intellectual capital, i.e. its complex and dynamic aspects. From this perspective, causal maps can help to fill this gap.

Specifically, this paper presents the case study of a network of companies that are working to develop and utilize mobile phone location data for commercial purposes. Thus, the first aim of this paper is to represent the relationships among the intellectual capital elements activated by companies in the network through a causal map. This visualization can make the dynamic aspects of intellectual capital accessible to managers, thereby potentially enabling a more effective managerial intervention. The second aim of the paper is to explore how the causal map can be applied as a platform for extracting indicators, thus supporting the measurement and the management of intellectual capital dynamism. The paper makes a contribution to the intellectual capital measurement literature by showing how to obtain additional information on the dynamics of intellectual capital in order to improve manageability of it and, as a consequence, its contribution to value creation. As such, this paper contributes to the extant literature by providing important insight into the design of performance measurement systems in networks. Following along these lines, the paper also provides an important understanding of the distinction between the value network analysis proposed by Verna Allee (2000, 2002) and the causal mapping techniques adopted by scholars such as Marr *et al.* (2004), Fernström *et al.* (2004), Cuganesan (2005), Carlucci and Schiuma (2006, 2007), Cuganesan and Dumay (2009), Jhunjhunwala (2009).

The structure of the remainder of the paper is as follows: Section 2 offers a discussion of the evolution of the concept of intellectual capital and its measurement along with a description of the causal mapping tool and its application to intellectual capital visualization. Section 3 describes the features of the case study network, called the Gemini network, while Section 4 presents the methodology used to collect and analyze the data on which the causal map is built. Section 5 discusses the findings of the paper and Section 6 concludes the paper by presenting the main implications of the discussion for the dynamic measurement and management of intellectual capital.

2. Intellectual capital measurement and management

The concept of intellectual capital is closely related to the creation, sharing and management of knowledge within companies (Mouritsen *et al.*, 2005; Guthrie *et al.*, 2012). Especially in the early stages of research concerning intellectual capital, many definitions and associated classifications have been proposed to understand what it is and where it is located within the company (Catasús and Chaminade, 2007). Already in 1997, Edvinsson (1997) defined intellectual capital as "the possession of knowledge, applied experience, organizational technology, customer relationships and professional skills that provide [...] a competitive edge in the market." In the Danish Guideline for Intellectual Capital Statements (Mouritsen *et al.*, 2003) the concepts of intellectual capital and knowledge management are intertwined as these intrinsic aspects are given a form which can be managed (see also Mouritsen and Larsen 2005).

Here, intellectual capital is considered a phenomenon that allows the "activation" of intangible resources, i.e. the knowledge resources connected to employees, customers, technologies and processes.

There is currently a broad consensus on the classification that identifies the following three categories within intellectual capital: human capital, organizational capital and relational capital (Bjurström and Roberts, 2007; Guthrie *et al.*, 2012). However, attention has gradually shifted from the categories to the dynamic aspects and multifaceted nature of intellectual capital (Kianto, 2007), because these intellectual capital subcategories cannot be rigidly separated in a meaningful manner (Nielsen and Dane-Nielsen, 2010). According to Mouritsen (2006), it is not possible to identify a priori the features and functions of a company's intellectual capital because they depend on the original combination that is set up in the specific company context. Moreover, the relationships among the intellectual capital elements are not stable; they do not always display the same features and they may even cease to exist or change intensity, direction and nature over time. Hence, the relationships among intellectual capital elements are often fragile, ambiguous or merely potential.

During the measurement process, the different elements that give life to intellectual capital have to be identified, i.e. the intangible resources, the interactions among them and with the value creation. It is with reference to all these aspects that the measurement takes place. Indicators should be consistent with the mobilization of the resources aimed at achieving targets and financial success (Grasenick and Low, 2004) and the choice of indicators to be associated with specific elements is not easy. Therefore, there's the risk of designing indicators that only partially represent the elements that make up the complex web of intellectual capital. The need to combine financial and non-financial indicators derives from the inability of the latter to adequately represent the complex web of intangible resources. The financial measures are symptomatic: they measure only the final outcomes, not allowing for the identification of the causes that generate the results (Kaplan and Norton, 1996b). Eccles (1991), among others, argues that using non-financial measures allows us to capture the causes of the company's success. In a sense, leading indicators "drive" the performance of lagging indicators (Eccles, 1991).

The measurement of intellectual capital for internal management purposes ensures the availability of information in order to support and guide the decision-making process toward the creation of value through an efficient and effective management of intellectual capital (Sveiby, 1997). In particular, the measurement process should be mainly focussed on the relationships among the intangible assets that make up the complex system of intellectual capital, i.e. the real source of value creation. This perspective would capture the dynamic nature of the phenomenon under investigation, allowing the managers to monitor the way in which the actions carried out on intellectual capital contribute to the overall corporate performance. Thus, the measurement for internal management purposes produces knowledge on intellectual capital. It is not a mere representation of the past, but it allows for the identification of problems and risks in the present. Moreover, information attained from measures can be considered a stimulus to make changes in the future, creating goals and weighing alternative courses of action (Mouritsen, 2004; Chiucchi, 2008). This means that measurement and management are closely related terms.

Over the past 15 years, academics and practitioners have developed definitions, measures and frameworks; however, the use of static modes of intellectual capital measurement does not fit with the real essence of intellectual capital. A growing number of contributions have argued that the existing frameworks for intellectual capital measurement are not able to fully explain the value creation process triggered

by intangible resources (O'Donnell *et al.*, 2006; Dumay and Cuganesan, 2011). The relationships among intangible resources, between them and the creation of are not explicitly handled in the ICMSs, which have been proposed so far. Most of them are based on categories that have been identified as one of the main problems for intellectual capital measurement (Bjurström and Roberts, 2007; Mouritsen, 2009). In fact, categories create separations: intangible resources are mainly extracted from the context in which they are deployed and then they are measured "on hold," not "in action." In this way, categories hinder the full consideration of the dynamic aspects of intellectual capital.

2.1 Causal mapping: a tool to be used to visualize and measure intellectual capital

Intellectual capital dynamism is seen, here, from the perspective of the individual, not only in terms of skills, experiences and competences, but also in terms of values, motivations, feelings and behavior (Jankowicz, 2001). These cognitive aspects affect the relationships among individuals and, as a consequence also the intellectual capital dynamics and the value creation process. Actors inside companies have many – often varying – aspirations, values and interests, which inherently complicates their coexistence and cooperation. As such, the relevance of these facets has been recognized not only in the field of psychology, but also in the fields of management, strategy and organization (see Narayanan and Armstrong, 2005 for an exhaustive review).

Analyzing the mental models through which individuals filter information and make decisions (Weick, 1977) may prove to be a good platform for understanding the value creation process and the contribution of intellectual capital dynamism. Hence, the knowledge of the way in which intellectual capital works in a specific operational context is stored in the mind of the actors who apply it every day. Therefore, gaining access to this knowledge can potentially provide an understanding of how intellectual capital is really used. Cognitive maps have the potential to facilitate this task, by making explicit individuals' knowledge of the way in which the company generates value. This tool can be defined as "a graphic representation that provides a frame of reference and locates people in relation to their information environments" (Fiol and Huff, 1992, p. 267). In other words, cognitive maps are used to elicit the content of people's mental models.

There are different kinds of cognitive maps (Huff, 1990), but for the aim of this paper one typology appears particularly suitable, namely the causal map (Axelrod, 1976). This tool is a network of nodes and arrows, where the direction of the arrows means believed causality (Fiol and Huff, 1992; Langfield-Smith, 1992; Eden, 2004; Montibeller and Belton, 2006). It elicits the causal structure of the individuals' thought, highlighting the variables which influence the decision-making process inside companies and organizations (Hodgkinson *et al.*, 2004). Making this structure more visible means identifying the relationships among key actors, key knowledge, key objectives and key actions and thus, understanding how individuals perceive the stream of events.

In a sense, causal maps can be compared to geographical maps: following a certain "itinerary," made up of decisions and actions, can lead to a particular "destination," that is, the achievement of certain targets. This is a precondition to understanding the reasons behind actors' behaviors as well as to identifying alternative courses of actions. Causal maps are very suitable for analyzing context-dependent and dynamic phenomena (Ambrosini and Bowman, 2002), such as intellectual capital. Its elements, in fact, find their meaning according to the relationships they develop with each other and with the other variables of the specific business context in which they are used (vision, mission, strategy, management challenges). Moreover, causal maps have the

potential to clarify complex and ambiguous phenomenon. They can be considered "a way of ordering and analysing something that is 'fuzzy'" (Ambrosini and Bowman, 2002, p. 22) and they "can facilitate organizational activities by simplifying inevitably complex domains" (Huff and Jenkins, 2002, p. 14). As highlighted above, intangible resources have several opportunities to develop and relationships can change direction or intensity over time. So, the effects of managerial actions are uncertain. Causal maps can clarify which intellectual capital elements and which relationships can potentially generate non-linear events or emergent properties. Visualizing multiple explanations and identifying potential problems is very relevant for an aware management of intellectual capital.

Another tool that aims to represent the dynamics of intellectual capital is the value network analysis proposed by Verna Allee (2000, 2002). Even though value network analysis and causal mapping technique have similar goals, i.e. to answer the question "How is value created?" these methodologies are quite different. Hence, the above-mentioned question is answered in different ways. While Verna Allee's method builds on three mapping elements (Allee, 2002 and 2008):

- the participants (the nodes of the map) who are real people;
- the transactions among them, represented by the arrows that originate with one participant and end with another; and
- the deliverables, the actual "things" that move from one participant to another, can be tangible or intangible.

The causal mapping technique proposed in the paper builds on two elements:

- The value drivers, i.e. any node of the map, which is a key activity, competence, attribute, objective that is considered a critical prerequisite for the success of an organization. In other words, the value drivers are those that are perceived to be relevant by the managers concerned (Ferreira and Otley, 2009).
- The causal relationships, i.e. the arrows among the value drivers, that mean impact or influence.

The features of causal maps match the needs that have arisen in relation to the nature of intellectual capital, that is, on the one hand, to bring to the surface the way in which actors use the elements of intellectual capital and, on the other hand, to capture the dynamic dimension of intellectual capital, i.e. to understand what flows connect the IC elements together in order to allow an adequate representation of them. The visualization of these aspects allows the managers to comprehend how the intellectual capital of a company really works in its operational context as well as to realize how intangible resources are linked to value creation. Therefore, the action-oriented nature of causal mapping (Fiol and Huff, 1992) can support the visualization of intellectual capital "in action" by creating knowledge about the relationships between managerial actions on intangibles and the impact on value creation. The information content of the causal map can considerably increase if it is used as a platform to create an appropriate set of key performance indicators to measure intellectual capital. As the explicit development of a causal model is the starting point for designing the indicators (Kaplan and Norton, 2000, 2004), the causal mapping technique is more suitable than that of value network analysis for the sake of this study, in that the latter does not rely so much on causal reasoning which would potentially hinder the identification process of the indicators. Some attempts at representing intellectual capital through causal mapping techniques have been made already. These attempts are discussed in the next section.

2.2 Visualization techniques and intellectual capital measurement

In the field of management accounting, the relevance of visualization techniques (the so-called strategy maps) is well acknowledged. This is largely due to the development of multi-dimensional performance measurement systems and, in particular, of the balanced scorecard (Kaplan and Norton, 1992, 1996b). In these multi-dimensional performance measurement systems, the measurement process is closely related to the management process (Ittner and Larcker, 2003). Nevertheless, Kaplan and Norton have proposed a tool specifically aimed at measuring and affecting the company's strategy as a whole, namely strategy maps (Kaplan and Norton, 2001, 2008). Strategy maps, therefore, are not intended to measure and govern the whole intangible "legacy" of the company, but only the improvement in specific areas considered critical for strategic purposes, i.e. the intangible elements contained in the customer perspective, in the process perspective and in the learning and growth perspective. In this way, strategy maps may undervalue the relevance of other intangible elements that can potentially affect the competitive success of the company, like the relationships with other stakeholders (e.g. suppliers). Despite a growing tendency to adopt them, the use of these techniques is not so well established in the field of intellectual capital.

Instead of using this type of strategy map, the contribution of Fernström *et al.* (2004) explicitly focusses on intangible asset interactions that take place in the R&D department of a pharmaceutical company. As such, the map they propose does not concern the business strategy as a whole, but a specific value creation process within the company. The aim of Fernström *et al.*'s study is to understand the role the R&D department plays in meeting the company's objectives. Through workshops and individual interviews, the authors are able to identify the bundle of resources (human, organizational, relational, physical and monetary) at the company's disposal as well as the relationships among them. The authors stress the usefulness of their map in highlighting the efficiency and the effectiveness with which the resources are deployed as well as the deficiencies and malfunctions which can affect the value creation process within the company. As a consequence, this is a relevant tool that can be used to identify areas of improvement, potential actions and alternatives. Even if measurement is not one of the aims of the project, the authors state that the map helps to identify a set of indicators useful for measuring the company's progress in fulfilling its strategic goals. In particular, the map makes it possible to identify the relevant resources to be measured, to support the selection of indicators and to improve, as a consequence, the selectiveness of the measurement system.

Marr *et al.*'s (2004) study is similar to that of Fernström *et al.* (2004), because it contributes by producing an IC map of a specific activity in a company, here in the form of a new product development department in a manufacturing firm. The building procedure of the map is based on a series of semi-structured interviews and focus groups, which involve middle-range managers and team leaders of the process under analysis. The main aim is to take into account the direct relationships between organizational resources and strategic objectives as well as the indirect relationships between organizational resources. Different arrow sizes are used to express the strength of the relationships according to participants' perceptions. From a measurement perspective, Marr *et al.* (2004) match the map only to two indicators relating to the process performance (time to prototype a new model and the number of iterations between design and production). The improvement of these indicators is supposed to generate a positive effect on time-to-market, which is argued by management to be one of the most relevant generators of success for the company. These indicators are not

extracted from the map, but are already present in the performance measurement system of the company.

As is the case with the present paper, a dynamic approach to intellectual capital measurement, too, is the foundation of Cuganesan's (2005) map which is based on a case study of an Australian financial services company involved in the creation of software for customers. In particular, an "initial" map is built by the subjects participating in the project before the launch of the new software. This map contains the hypothesized relations among the intangible assets involved in the project and the related impacts on company performance (in terms of reduced costs, increased customer retention and improved profitability). After the software introduction, the subjects are asked to build another map. This new map does not coincide with the "initial" map, and thus, the actual relationships among intellectual capital elements and the value creation process are strikingly different from the ones identified in the first map. Moreover, the final map shows multidirectional and complex relationships, while only linear relationships were originally assumed in the "initial" map. Regarding the measurement perspective, the map is neither used to design new indicators nor to understand the effects of the launch of the new software on costs, profitability and retention.

These issues are further explored in a paper by Cuganesan and Dumay (2009), whose objective is to visualize the relationships among intangible assets to managers. Compared to Cuganesan (2005), the building process of the map is analyzed in greater depth. Through a series of interviews with the managers and employees of a company in the Australian financial sector and using a software-based analysis solution, the authors extract a number of factors related to intellectual capital as well as the links among them. This leads to the development of two maps. The first one relates to the process of creating value for the company, while the second one concerns the value creation process for the customer. So, the particularity of this contribution consists in adopting a double "perspective": i.e. the perspective of the company and the perspective of the customer. In fact, the combined analysis of these two maps shows that they are linked to each other, forming, as a consequence, two sides of the same coin. Moreover, the authors identify what they denote as "abstract indicators." However, these are not indicators in the sense of key performance indicators. Rather, they are action-oriented initiatives (creating value for the customers, beating the competition, coming up with innovative products) which represent the nodes of the map.

The contributions of Carlucci and Schiuma (2006, 2007) can be considered an evolution of the study by Marr *et al.* (2004). Here too, the aim is to visualize and analyze the relationships between the knowledge assets and the company's performance in a new product development department in a manufacturing firm. The maps are built through the use of focus groups and interviews involving the company's top management and the managers of the R&D department. Carlucci and Schiuma (2006) focus on the link between knowledge management and the company's business performance. In such a context, the purpose of the map is to support the company in planning and implementing knowledge management initiatives in order to achieve the performance objectives. Carlucci and Schiuma (2007) advance this theory by applying the analytic hierarchy process (AHP) methodology to weight the knowledge assets according to their potential impact for achieving the performance objectives. This allows the company to rank its knowledge assets for the sake of intervention priorities.

However, both papers are aligned to Marr *et al.* (2004) in regards to the measurement perspective. The indicators used to identify the impact of the knowledge management initiatives (product design activity time and time to produce the prototype) are not

extracted from the map. Moreover, the potential relationships and the trends of these indicators are not explained.

In the last paper of the literature review section, Jhunjhunwala (2009) highlights the relevance of discovering the network of interrelated intangible assets for understanding the value creation process of a company. In particular, the author proposes three generic maps for the hotel industry, the software industry and the pharmaceutical industry. These models visually represent the key intangible variables as well as their interrelations, both of which would have to be managed in order to increase the overall value creation. For example, for the hotel industry, the map identifies value drivers such as the chain brand or the service quality, in terms of reception, restaurant and room service. Moreover, the author proposes to match the graphic representations to a set of indicators in order to validate the cause-effect chain. The aim of this "matching" is to ensure that each intangible asset in the map is performing as desired. However, the proposed indicators are not directly extracted from the map. Rather, they are generic intellectual capital indicators. This means that their applicability to single companies may be limited because they are not "tailored" to specific needs and features.

Although the studies analyzed above are heterogeneous in terms of features and building processes, a common denominator can be identified in their purposes. All of the maps are constructed for the sake of improving the management of tangible and intangible value drivers and tangible assets, increasing, as a consequence, the value creation related to the company as a whole or to a particular process or function. However, all of the above-mentioned contributions undervalue the extraction of a set of specific indicators from the maps. Despite the fact that they, in general, suggest the identification of performance measures, they do not fulfill this aspect sufficiently. As a consequence, the usefulness of the map is limited and some of its potentialities are left unexploited. Even when there is an attempt to match some indicators to the maps, as in the contributions of Fernström *et al.* (2004), Marr *et al.* (2004), Carlucci and Schiuma (2006, 2007) and Jhunjhunwala (2009), the effects of this action for managerial purposes are not fully utilized.

The identification of specific indicators from the causal maps would potentially allow for the measurement of both the static aspect of intellectual capital (the stock of intangible resources at a company's disposal) and the dynamic aspect of this phenomenon (the way in which tangible and intangible resources combine with each other in order to generate value), much in line with the arguments put forth in the Danish guideline for ICS (Mouritsen *et al.*, 2003; Mouritsen and Larsen, 2005). The theoretical contribution of this paper thus rests on the assumption that managers should learn to build and to refine causal maps for visualizing the company's intellectual capital. These maps should be enriched through appropriate indicators that can improve the existing measurement and management practices of intangibles. These new skills could potentially improve the decision-making process revolving around the use of the intellectual capital in its operational context, avoiding the mere attempt to find a "fit" between the company's intellectual capital and one of the existing measurement frameworks.

3. Description of the case study: the Gemini network

The Gemini network is a network-based business model composed of four companies located in the Northern Jutland region of Denmark. The Gemini network has been a part of the International Centre for Innovation (ICI) project, a five-year research project aiming at developing ten new network-based business models and working on improving the globalization potential of them. This particular network is concerned

with the use of location data from a tracking system which generates information about mobile devices with activated bluetooth senders, i.e. the information about the geographic location of people at a given point in time. The companies involved in the network aim to use new technologies to develop new products and services for business enterprises and end users who can make use of the data. The data on people's movements is, for example, potentially useful for shopkeepers, retailers' associations and shopping malls in order to support their marketing.

This network includes four main actors, which we choose to call: Sensor, Engineer, Mall and Union. Sensor is a small and flexible company, which acts as the technology provider of the network. This company owns the technical competences needed to create and improve a technology solution able to track people's movements. In particular, Sensor produces the Bluetooth units that detect mobile devices in a certain circumference. Engineer is a big and well-known consultancy company that acts as a bridge between Sensor and the customers, i.e. Mall and Union. This company's main task is to understand the customer's needs through its commercial competences and to convert them into relevant solutions though its technical knowledge. In other words, Engineer has to explain to the customers why they need Sensor's solution and to facilitate Sensor's putting more intelligence in the system in order to meet the needs of the customers. From the perspective of Sensor and Engineer, creating value means earning revenues from the bluetooth units and from the consulting hours sold to support and maintain the system.

Mall is a shopping center, which has been a test pilot for the tracking system. In particular, the center manager would like to know how long people stay in the shopping center, how they move around the shopping center, how they get to the shopping center and where they walk to afterwards. This kind of information can improve the manager's decisions on advertising, staffing, shop location and mixture and leasing contracts; as a consequence, it would increase Mall's value creation in terms of number of visitors, time spent by the visitors in the shopping center and the shops' turnover (profit). Union is the association of retailers in the city. Union's manager would like to know where people start their shopping trip, how much time they spend in each area of the city and the effects of special events on the number of visitors and the duration of their stay. The availability of this information can provide a much more precise picture of which areas in the city people are visiting, thus improving the decision-making process for event planning and shop location. As in the case of Mall, this improvement can affect Union's value creation process in terms of increasing member satisfaction and funds raised from sponsors (members, local government, companies, etc.).

Empirical intellectual capital research focusses mostly on the value creation process of single companies, essentially undervaluing the possibility that companies may generate value creation from a business network perspective. Perceiving companies merely in terms of value chains has been gradually overtaken by the idea of network-based business models (Allee, 2000). The nature of business relationships has changed from intimate and formal to free-flowing and flexible insomuch as the boundaries of the single companies cannot be clearly identified (Allee, 1999). A network consists of specific roles and value interactions oriented toward the achievement of a particular task or outcome (Allee, 2008) and other types of business relationships such as strategic alliances, joint planning activities and creative partnerships also emphasize the intangibles activated in the network (Allee, 2002).

Although network analysis is becoming more and more important in intellectual capital research, few studies have contemplated how the intangible resources of

companies interact to create value for the whole network (Green, 2006; Andreou and Bontis, 2007; Allee, 2008; Solitander and Tidström, 2010; Peng, 2011).

For this reason, then, the Gemini network studied poses an extremely interesting case because the interactions among the composing companies are very tightly knit. The existing knowledge resources and the relationships among them are fundamental for the development of the network itself. Sensor and Engineer are knowledge-intensive companies and their technical and commercial competences can enable the value creation for the whole network. The synergy between these companies is very strong: together they can reach collective goals they cannot achieve on their own. On the one hand, good relationships with customers are established through Engineer's reputation and image. This allows Sensor to access new customers and to further develop its business. On the other hand, Sensor is able to provide high-quality solutions, which can satisfy the customers' needs. Engineer is aware that it would be difficult to find other companies that can deliver the same technology. This network is highly dynamic because its purpose is to create new knowledge. Moreover, the involved competences and capabilities are highly specialized and manifold and the geographic proximity strengthens even further the unplanned information exchange. In other words, the Gemini network displays all the features of an innovation network (Pöyhönen and Smedlund, 2004), which can potentially provide highly valued services (Smedlund, 2008).

As a consequence, aligning tangible and intangible resources of the single companies to meet the customers' expectations and understanding their contribution to the value creation of the whole network is essential for feeding the network itself.

In such a context, in fact, measurement at a holistic network-level can be helpful in order to reach this target. Analyzing the performance of one company is not enough because it only represents a share of the whole value creation process. The performance of the whole network depends on the efficiency and the effectiveness of the interactions among the actors involved. In some cases, a performance improvement of an individual company can even lead to decreasing the performance of the network as a whole (Kulmala and Lönnqvist, 2006). Supplying measures at a network level and identifying the links among them can provide information on the cumulative value creation, which depends on the joint efforts of several companies. In other words, creating a set of indicators for the network as a whole can help to pinpoint the actual development needs in the networked processes. Inter-organizational performance measurement is becoming more and more important in fast-moving and knowledge-intensive environments. These arguments strengthen even further the choice of the Gemini network. Measuring and managing intellectual capital activated in the network and its dynamism should be a priority for the companies involved (Figure 1).

4. Methodology

The complex nature of intellectual capital makes the use of the case study research method particularly suitable (Mouritsen, 2006). This method, in fact, allows for a holistic and deep investigation of a complex phenomenon in the real-life context in which it takes place, especially when it is not possible, or even desirable, as in this case, to separate the phenomenon from the context (Yin, 2002; Lukka, 2005; Chiucchi, 2009). Through case study research, the researcher can directly observe the phenomenon investigated and come into direct contact with those who take part in it. Moreover, the choice of a single case makes it possible to increase the in-depth nature of the analysis by getting a richer and thicker understanding of the phenomenon and the context.

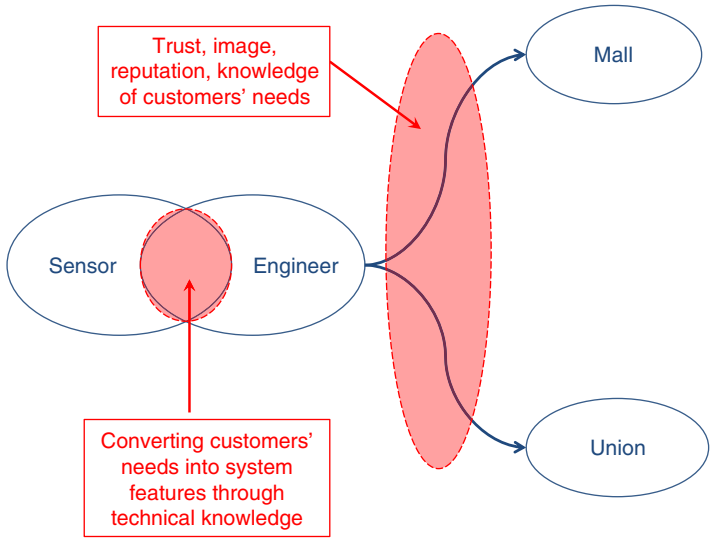

Figure 1.
The companies involved in the Gemini network

4.1 Data collection and analysis

The building process of a causal map aims at eliciting mental models triggered by actors in certain situations. The nature of these models is mainly implicit because they are deep-seated in individuals (Fiol and Huff, 1992). The conversion from implicit to explicit is a very hard task because the concepts and the relationships are difficult to stimulate and communicate so that the individuals themselves consider the explanation of their decision rules particularly critical (Ambrosini and Bowman, 2001). In management and organization research, several methods have been proposed in order to build causal maps. These methods differ mainly in two aspects: the technique used to elicit the cognitive material and the technique used to identify concepts and relationships. Concerning the first aspect, a distinction can be drawn between direct and indirect elicitation procedures (Hodgkinson and Clarkson, 2005), where the indirect procedures use secondary data sources such as texts written by the author, minutes of meetings, reports or other company documents (Fahey and Narayanan, 1989; Fiol, 1989; Barr *et al.*, 1992). By comparison, the direct procedures use primary data sources obtained specifically for the purposes of the research. The use of this data collection procedure allows for the building of causal maps that represent the management's thinking in a more precise manner than those built from secondary data sources (Eden and Ackermann, 1998).

Semi-structured and unstructured interviews are the most widely used by researchers when building managers' causal maps (Eden and Spender, 1998). Their high degree of flexibility allows the interviewer to deeply understand the conceptual categories used by the interviewee as well as his/her interpretations of the reality. Moreover, the opportunity to conduct the interview on the basis of the answers given by the interviewee enhances the comprehension of the motivations that drive his/her decisions. Interviewing managers allows them to reflect on the actions that they usually put in place. In this way, the researcher can discover aspects of behavior which had remained tacit until that moment. The aim is to gradually uncover deeper and deeper layers of the managers' knowledge. For these reasons, this paper is based on five semi-structured interviews with the main actors of the Gemini network. These

interviews were conducted at the individual level because tacit knowledge is typically personal (Polanyi, 1962). For the aim of the paper, the researchers identified five relevant themes, which also represented the main sections of the interview guide:

(1) the respondent's tasks and company's overall business;

(2) causes of organizational success and value drivers;

(3) relationships with the main business partners;

(4) indicators used for the decision-making process; and

(5) specific information on the location data project.

During the interviews the interviewers made sure to ask reflexive questions and to ask for examples along the lines suggested by Kreiner and Mouritsen (2005). Asking for examples, storytelling and anecdotes forces the interviewees to explain what really happens, stimulating them to provide detailed information and triggering, in turn, other stories and thoughts. Through story and language, in fact, individuals give meaning to events that occur and to their actions and they can organize their experience. In this way, it is possible to discover how the value drivers come "into action" in the company under analysis. Regarding the identification of concepts and relationships, Abernethy *et al.* (2005) draw a distinction between three options: computerized discovery of causal links, ethnographic analysis of interview data, interactive mapping by expert participants. The first one relies on qualitative database software in order to code the qualitative data and to detect relations among concepts in the database of interview transcripts. The second one is the traditional method used to analyze qualitative data, i.e. the ethnographic interpretation of the interviews and the interview context. In this way, the researcher can identify the concepts and the relationships among them through his/her understanding of the context and by interpreting the perceptions of the interviewees. The third one directly involves the interviewees in the map-building process by asking them to identify the relationships among the concepts extracted from their prior interviews. This option emphasizes the causality experiences of the interviewees so the researcher merely has to support them to fulfill this task.

The use of this method would make the participants more committed to the resultant map. However, it entails some drawbacks which have to be considered. Engaging the participants in the map-building process is a very complex task from a cognitive perspective. There is a distinction between the individual beliefs, i.e. the interconnected beliefs about various contexts which belong to individuals, and the collective beliefs, i.e. the beliefs which belong to a group. It is essential to achieve a high level of agreement on the meaning of the concepts which are relevant to building the map. This is fundamental to identifying the relationships among concepts and to ensure that the process is reliable.

Some difficulties can surface during the building process if the participants do not form a tightly cohesive group, with a common language and shared meanings (Langfield-Smith, 1992). This risk is very high in the Gemini network, in which the participants belong to different organizations and they do not know each other very well since the relationship is quite young. On the contrary, in a highly cohesive work group, the problems arising from differences in meanings that participants attach to concepts would be minimal.

For the sake of this paper, the ethnographic analysis of interview data seemed to be particularly fruitful. One of the researchers, in fact, had a very good knowledge of the

companies involved in the network, i.e. the context in which the intellectual capital is deployed. The deep understanding of the context from his current and prior experience helped to identify the relevant concepts as well as to interpret the nature and the intensity of the causal links among them. As intellectual capital is context-specific, the use of this method increases the chance that the causal map reflects the real way in which it is deployed in the network rather than merely showing associations discovered by software or the partial points of view of single interviewees. However, the chosen method also presents some drawbacks. On the one hand, the researcher runs the risk of giving more weight to confirming facts rather than to disconfirming evidence. As a consequence, he/she could push into the background information that does not conform to his/her interpretation (Nisbett and Ross, 1980). On the other hand, building a causal map is a very complex task from a cognitive perspective and this could entail the risk of conducting a partial and incomplete analysis (Abernethy *et al.*, 2005).

It was sought to minimize these drawbacks through investigator triangulation (Ryan *et al.*, 2002) in order to reduce the biases related to the personal convictions of the researchers and to enable a deeper analysis. All the interviews were transcribed in their full length, and the researchers applied a structural coding approach in the analysis of them (Krippendorff, 1980), through a coding tree reflecting the sections included in the interview guide. After coding the interviews, the researchers drew up a list containing the value drivers considered critical by the interviewees, i.e. the nodes of the map. The data analysis was initiated by identifying the relationships among the nodes and followed by identifying the causality types (positive or negative) among them.

Finally, the resultant causal map was used as a platform from which to extract appropriate indicators oriented to measuring the dynamic aspect of the intellectual capital deployed in the network. Indicators are financial and non-financial metrics used to evaluate success in achieving objectives, solving problems, containing risks and enhancing strengths (Ferreira and Otley, 2009). Their design process can be sorted into identifying the key objectives to be measured and creating the indicators (Bourne *et al.*, 2000).

Even though some authors have proposed performance measurement at the organizational network level (Leseure *et al.*, 2001; Zhao, 2002; Bullinger *et al.*, 2002; Bititci *et al.*, 2005), there is still a lack of contributions aimed at measuring and managing the key factors in collaborative activities and inter-organizational relationships (Verdecho *et al.*, 2009). These frameworks do not provide methods to identify all the particularities of the business network and to eliminate contradictions existing among actors who attempt to increase local performance to the detriment of network's objectives. Moreover, there is a lack of tools able to support the creation and the control of performance measures in an analytical way, both on a network and on a single company level (Alfaro *et al.*, 2007).

The causal map aims to reflect the network's understanding of relationships among key knowledge resources and capabilities, key objectives, key problems and key decisions. The identification of these key elements is the starting point for designing the indicators. In other words, the map answers the question "what should we measure?" so it contributes to enhancing the process of identification and selection of indicators because it increases the chances that measures:

- are related to specific and achievable goals (Goold and Quinn, 1990);
- are based on quantities that can be influenced, or controlled, by the user alone or the user in cooperation with others (Lynch and Cross, 1991);
- have an explicit purpose (Neely *et al.*, 1997);

- reflect system causality (Kaplan and Norton, 1996a); and
- provide a network vision (Gunasekaran *et al.*, 2001).

One or more indicators for each node of the map have been identified in order to monitor the critical aspects of each key element. The main aim is to provide each manager with information useful for handling his/her part of the network without losing sight of the whole picture.

5. Analysis and discussion

5.1 Visualizing and understanding the intellectual capital dynamism in the Gemini network

The creation of the causal map permits a visualization of the tangible and the intangible flows established in the Gemini network. Figure 2 provides a representation of the map displaying the intellectual capital dynamism in the specific business context in which it is used. The nodes of the map are the value drivers considered relevant by the interviewees, while the arrows identify the relationships among the value drivers.

The colors of the arrows describe the nature of the link: green arrows depict the positive relationships, i.e. one value driver positively affects another one; red arrows show the negative links, i.e. one value driver negatively affects another one. Moreover, green and red dotted arrows represent potential positive and negative relations. Analyzing the causal map may allow the managers to understand how intellectual capital really works in the Gemini network. The causal map can represent the particular way in which value is generated or destroyed, i.e. it has the potential to bring out strengths and weaknesses of the network. The map shows that the intellectual capital flows between Engineer and Sensor work quite well. There is a strong synergy because these two companies are highly integrated at both a commercial and a technological level. From the Sensor side, the relationship with Engineer is fundamental for its value creation process.

Through the Gemini network, Sensor is able to access new customers and to further develop its business through the goodwill that Engineer brings into the network in terms of reputation and image. Therefore, the exploitation of Engineer's intellectual capital element is profitable for Sensor too, which would otherwise be forced to build relationships with the customers from scratch. From the perspective of Engineer, deploying Sensor's technical competences is very important in order to satisfy customer expectations. In particular, the technical knowledge held by Sensor makes it possible to convert customer needs into system features by including a greater degree of intelligence in the solutions. Engineer's managers are aware that only Sensor's technical solutions have the necessary level of quality to be used in practice. So, the intellectual capital interactions between these two companies are very intense, because they both know that the reciprocal exploitation of their respective intellectual capital elements is advantageous for both of them.

The causal map also highlights the fact that the intellectual capital flows between Engineer and the customers do not work properly. Through its commercial competences, Engineer should be able to understand the customers' expectations in terms of information needs. In other words, Engineer should recognize how to improve the information quality for Mall and Union in order to allow Sensor to convert these needs into features in the solution. However, Engineer does not seem to be deploying its commercial competences in the right manner. There seems to be a misalignment between the perspectives of Engineer, Mall and Union. The customers see the previous meetings with Engineer like sales meetings rather than network sessions focussing on

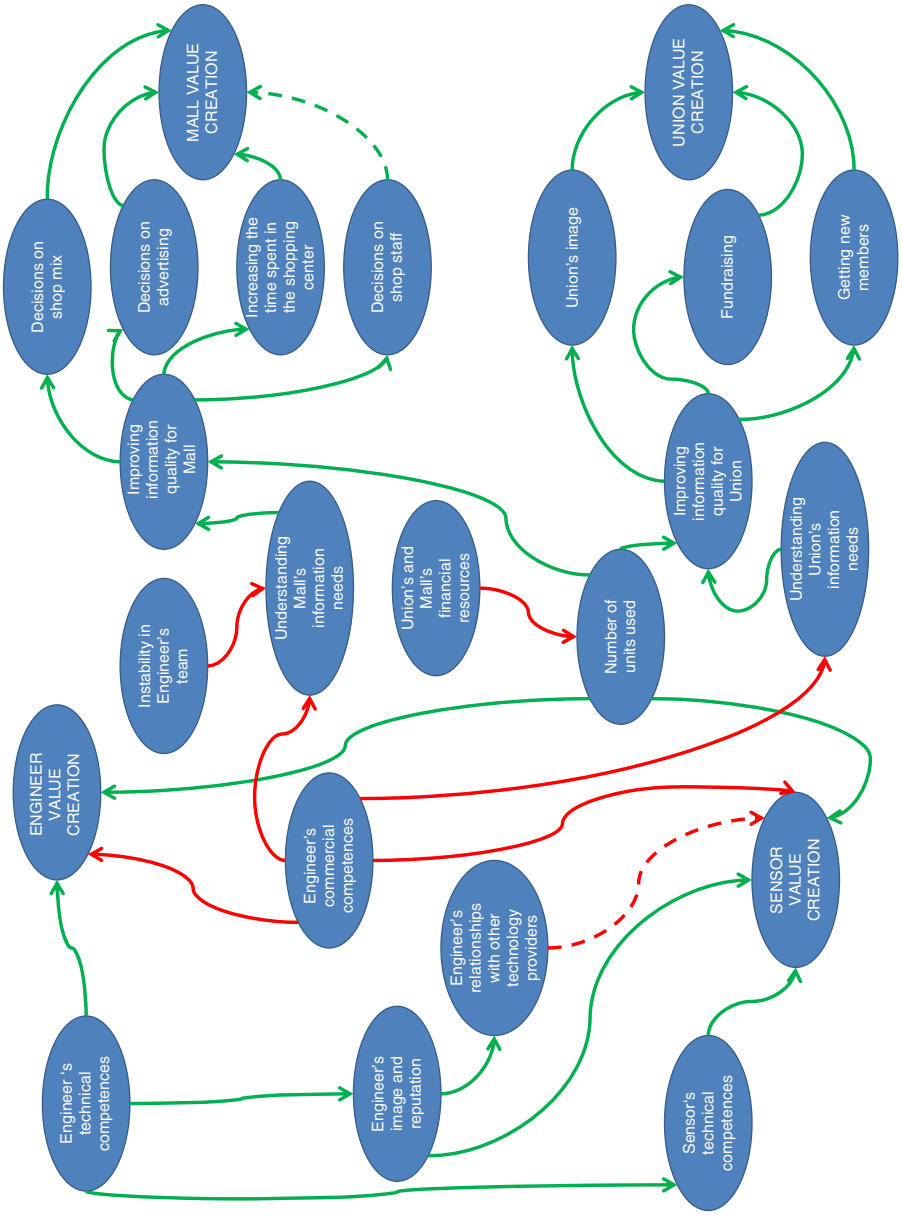

Figure 2.
The causal map of the Gemini network

their information needs. As a consequence, Mall and Union are not willing to pay for the solution because they still do not have a clear view of its strengths and weaknesses. Moreover, the understanding of the customers' information needs is also hindered by the relatively large turnover in Engineer's team that is in touch with Mall and Union. The team has changed members from time to time and so the clients have noticed that they cannot identify a stable team with which to build a closer relationship based on more frequent interaction. This problem could also be related to the lack of proper and timely communication between the parties.

In a sense, the commercial competences of Engineer are the weakest point in the network because they are not sufficiently able to show and explain to customers the added value which they can get from Sensor's solutions. As a consequence, this intellectual capital element blocks the value creation for the companies involved. The awareness of the strong and weak points provides the managers with the opportunity to maximize the former and minimize the latter. In this way, managers can make the network's value creation process less fragile and vulnerable. Moreover, the causal map stresses a potential non-linear effect that could destabilize the network as a whole. Engineer's image and reputation is also relevant in order to build relationships with other technology providers. The flow between these intellectual capital elements can potentially destabilize the entire system. The entrance of a new technology provider and the resulting exclusion of Sensor would mean redefining all the tangible and intangible value drivers activated in the network as well as the relations among them. The map also shows that intellectual capital "in action" creates emergent properties, which cannot be traced back to the individual value drivers (Nielsen and Dane-Nielsen, 2010). Value creation is thus related to the emergent properties that result from the coupling of the tangible and intangible value drivers, which takes place in this particular context, i.e. the Gemini network.

5.2 Measuring the intellectual capital dynamism in the Gemini network

The analysis highlights that the building of a causal map could be very relevant for managers because, by identifying problems, risks and opportunities, it may enable interventions. However, the usefulness of the map for managerial purposes could increase even further if it is used as a platform for identifying indicators to measure the intellectual capital dynamics. Indicators can potentially reflect the value creation process because they are "tailored" to the specific value drivers and relationships that take place in the network. In particular, the indicators should be coupled to the nodes of the map, i.e. the value drivers. Table I contains the set of indicators derived from the causal map. First of all, using the causal map as the foundation from which to extract a set of indicators may improve the selectiveness of the measurement system. The map forces the company to focus only on the critical value drivers and the relationships among them. This can increase the likelihood of being able to provide a moderate number of indicators with high information content, avoiding the risk of focussing the attention of managers on secondary aspects. Moreover, extracting indicators from a causal map may provide a balance between lagging measures, typically financial and leading measures, typically quantitative-physical and qualitative. Lagging indicators are for example suitable for the nodes associated with the value drivers directly linked to the value creation.

Table I also contains proxy indicators. Some "soft" aspects, like the level of competences or customer satisfaction, are very difficult to measure because of cost, complexity and timeliness of data collection. Proxies approximate the phenomenon in the absence of direct measures. For example, "R&D expenses/total expenses" can approximate the level of "Sensor technical competences." Similarly, "training

Table I.
The indicators extracted from the causal map

Indicators for sensor	Indicators for engineer	Indicators for mall	Indicators for union
R&D expenses/total expenses	Training expenses	Financial resources to invest in the location data project	Financial resources to invest in the location data project
Revenues from location data project	Hours spent for training on the job	Number of features satisfied/number of features requested	Number of features satisfied/number of features requested
Average earnings per unit	Revenues from location data project	Variation (increase or decrease) in number of visitors to the shopping center	Variation (increase or decrease) in funds raised
Sales from Engineer's customers/total sales	Number of meetings with Sensor	Variation (increase or decrease) in time spent by visitors in the shopping center	Variation (increase or decrease) of members
Total revenues/man hours	Average earnings per unit	Turnover	
Number of units sold to Engineer	Total revenues/man hours	Total amount of leasing contracts/number of tenants	
Number of meetings with Engineer	Team turnover		
	Number of interactions with Mall		
	Number of interactions with Union		
	Number of units sold to Mall		
	Number of units sold to Union		
	Number of interactions with other technology providers		

expenses" and "number of features satisfied/number of features requested" by Mall and Union can be considered proxies for the level of "Engineer technical competences" and the level of "Engineer commercial competences," respectively. Regarding the node "understand the information needs" of Mall and Union, the "number of units sold" can approximate this ability.

Moreover, the table includes measures such as revenues from the location data project for Engineer, the average earnings per unit sold for Sensor's and Mall's profits. These indicators express the bottom line of the value creation process, i.e. the final effects of the managerial actions. As a consequence, they are oriented to the past and they do not have the ability to measure the current actions. For this reason, the creation of leading indicators has the potential to monitor and govern the causes that affect the value creation. In the Gemini network, Union's indicator "Financial resources to invest in the location data project" could be leading compared to the measure "Number of units sold to Union." Similarly, Mall's indicator "Number of features satisfied/number of features requested" can potentially affect the trend of the measures "Variation (increase or decrease) in number of visitors to the shopping center" and "Variation (increase or decrease) in time spent by visitors in the shopping center." This might happen because the improvement in the quality of the information on people movements can support and improve the decision-making process of Mall, enabling the shopping center manager to take decisions directed to increasing the number of visitors and the time spent by visitors in the shopping center. However, the distinction between leading and lagging indicators is relative. For example, the "Variation (increase or decrease) in number of visitors to the shopping center" could be lagging compared to the "Number of features satisfied/number of features requested," but, at the same time, it could be leading when related to Mall's profits.

In addition, the indicators extracted from the map could provide the management with relevant information on the timing of actions on the value drivers. In particular, monitoring the trend of indicators over time could help to "capture" the length of the lag, that is the time it takes for an indicator of a value driver to begin to influence the indicators of related value drivers, first, and the financial performance, later. For example, a measure that "captures" Sensor's technical competences (e.g. investments in R&D) is not likely to affect the financial performance in the short term. Rather it would need a temporal lag of several months. In contrast, leading indicators related to the units sold (e.g.: number of units sold to Engineer) could influence the financial indicators with a shorter lag. Managers should pay attention to this aspect because the lack of an immediate effect on financial performance may simply mean that actions take time before generating an economic benefit. Therefore, management actions that may be deleted or changed because they generate no immediate effects, might instead be reconsidered when managers become aware of their potential effects in the medium and long term.

Furthermore, the indicators extracted from the map can potentially provide useful information on the persistence of the effect of a particular action. In fact, the effect might be only temporary and affect the indicator trend of the value driver to which the action is directed only for a short period of time. Or, the effect might persist and influence the indicator trend for longer periods of time. For example, a managerial action directed toward increasing the level of Engineer's technical competences might affect this value driver and the trend of its indicators (e.g. hours of training on the job) for a long period of time. On the contrary, the effect of an action geared to increasing the number of units sold to Mall might persist only in the short term.

Finally, indicators could play a leading role in the refining and updating process of the map. Relationships among intellectual capital elements are not steady by nature: they can change in intensity or nature. So, the bundle of indicators might help to test the existence of the relations as well as to understand if and how the intensity and the nature of the links vary over time. In other words, the trend of indicators may signal timing, persistence or intensity, which are not consistent with those considered in the "initial" causal map. This could provide useful information on possible changes to be made in order to refine and update the map over time. For example, Engineer's commercial competences have been identified as the weakest point in the network because this negatively influences value creation for both Engineer and Sensor as well as the understanding of the information needs of Mall and Union. The effects of managerial actions directed to improve this value driver should be reflected in the trend of the indicator "Number of features satisfied/number of features requested" by Mall and Union. The improvement of this indicator over time could mean a change in the nature (from negative to positive) of the relationship between the Engineer's commercial competences and the other value drivers connected.

In the same way, the "initial" causal map displays a negative link between the instability in Engineer's team and the ability to understand Mall's information needs. A decrease of the indicator "Team turnover" could diminish the negative impact of the former value driver on the latter. Consequently, this might provide managers with relevant information in order to update the map. The opportunity to refine the causal map over time might provide the measurement system with a high degree of flexibility and adaptability, which is consistent with the intellectual capital dynamism, i.e. the real nature of intangible assets.

6. Conclusion

The analysis of intellectual capital dynamics represents a relevant research area, which is receiving growing attention in the literature. Measuring the dynamic aspects of intellectual capital is essential for companies to obtain information in order to govern their value creation process. However, the existing frameworks for intellectual capital measurement are not able to achieve this goal because they are mainly anchored to the static dimension of this phenomenon. The conceptualization of intellectual capital as a complex web of intangible assets entails a reconsideration of the tools by which it is visualized, measured and managed. For this reason, this paper has presented an empirical study into the intellectual capital dynamics of a network of companies through the use of the causal mapping. The creation of a causal map can help to visualize and understand how intellectual capital really works in the specific business context in which it is deployed. This potentially would permit the domination of the real nature of this phenomenon by understanding the relationships among its elements and the creation of value, its potential non-linear effects, its strengths and its weaknesses.

The causal map has also been used as the foundation for creating an ICMS. Exploiting the map as a platform for identifying a set of indicators can contribute to filling our research gap in three different but linked ways: by offering the opportunity to reach a balance between leading and lagging indicators; by providing information on the length of the lag and the persistence of the effects of managerial actions; by signaling when and how to refine and update the causal map.

The combination of these factors can support the measurement and the management of intellectual capital dynamism. From a static perspective, the causal map may allow the switch to a dynamic view by examining, first, the direct impact of managerial

actions also on indicators of other related value drivers and, where possible, the indirect impact on value creation. This matching potentially permits the measurement not only of the individual value drivers, but also of the relationships among them, providing the opportunity to manage the links and to increase the positive impact of a value driver on the related ones. Such a measurement system is strongly oriented toward action as it can provide relevant and timely information to support the managers' decision making. The identification of indicators from the mental model of managers who manage the value creation process can increase the overall quality as well as the signaling ability of the measurement system. This can lead to an increased likelihood that decisions cause a series of multiple effects consistent with the expected results.

In other words, extracting indicators from the intellectual capital causal map can increase the information content and improve the predictive ability of the measurement system, enhancing, as a consequence, the chances for managers' interventions. On the one hand, the building of the causal map makes it possible to "deconstruct" intellectual capital elements and to "reassemble" them in order to ascertain their identity and use in specific settings (Mouritsen, 2006). On the other hand, extracting indicators from the causal map allows us to measure intangibles "in action," avoiding the "extraction" of the resources from the specific operational setting in which they are employed (Mouritsen, 2009). Consequently one of the main implications of this paper is that the existing ICMSs may also improve their usefulness by including these dimensions. In closing, it is important to acknowledge the limitations of this paper. First, the use of a single case study to provide in-depth and rich data limits the generalizability of the observations. Second, the proposed approach has not been implemented in practice. Even though the discussion is based on a review of the intellectual capital literature, the arguments are the authors' interpretation of the facts.

The causal map proposed in this paper could be used as the foundation for applying the interactive method in the subsequent steps of the research. It allows the researchers to explain to the participants how the map is built, the meanings of the nodes and why they identify those relationships, providing them the opportunity to discuss the concepts, to change them and the relationships among them. This initial alignment on method, meanings and relationships among the managers is fundamental to attaining a common platform and to starting the construction of a consistent map.

Thus, we call for further research to investigate the measurement of intellectual capital dynamism through interventionist case studies in order to put the causal mapping approach into practice. Compared to non-interventionist case studies, interventionist research makes it possible to reach a much deeper knowledge level on the individuals involved, the context analyzed, the attached meanings and the triggered effects (Lukka, 2005; Jönsson and Lukka, 2005).

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