Understanding Social Capital in Collaborative Networks

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Abstract. The characterization and assessment of the social capital of a member in collaborative networks is an important element to help promoting the success of collaborative networks. However, models to measure the social capital are lacking. Applying some concepts from social networks theory, this paper discusses some perspectives and criteria to identify and measure the value of social capital of a member in the context of a Virtual organization Breeding Environment (VBE).

Keywords: Social Capital, Social Network, Collaborative Networks

1 Introduction

According to various authors on Collaborative Networks (CNs), as well as reports from a growing number of practical case studies, the involvement in a collaborative network is commonly assumed to bring valuable (potential) benefits to the involved entities [1, 2], [3]. These benefits include an increase of the "survival capability" in a context of market turbulence, but also the possibility to better achieve common or compatible goals. On the basis of these expectations are, among others, the following factors: joining of complementary skills and capacities, access to new / wider markets and new knowledge, etc [4].

However, it is important to realize that, when an enterprise is a member of a long-term networked structure, for instance a Virtual Breeding Environment (VBE), its value is not given only by its tangible assets – economic capital (such as: cash, resources, and goods). In this context, the existence of cooperation agreements, norms, reciprocal relationships, mutual trust, common infrastructures and common ontologies, allows members to operate more effectively in pursuit of their goals. In other words, there is an intuitive assumption that a VBE structure represents a group of organizational entities that have developed intangible assets of "social capital" that bring added value to its members. However, in spite of this assumption, it is, in fact, difficult to prove its relevance due to the lack of objective measurements, clearly showing the social capital value for each member [5], [6], [7].

Social capital metrics tailored to collaborative networks or even an adequate conceptual basis for social capital analysis is not available yet and might be an obstacle for a wider acceptance of this paradigm.

Nevertheless, in recent years some preliminary studies have explored the importance of social capital in the context of networked organizations [8], [9], [10] , however none of them proposed methodologies, approaches or support tools to help managers of enterprises to analyze and measure their social capital in a Virtual organizations Breeding Environments (VBE) context.

This paper introduces some discussion of the nature of social capital as a contribution to a future identification of a set of indicators that are suitable for collaborative networks. This work aims at contributing to answer the following main questions:

- What are the main components that contribute to the formation of social capital of each member in a VBE context?
- How can social capital be measured in a VBE context?

2   Some Background

Although capital social is not new concept, its definition is not consensual among the various main disciplines that have addressed this topic (e.g. economy, sociology) and therefore several definitions can be found in the literature [11]. This problem results in part from the fact that the social capital needs to be analyzed from a multi-dimensional approach which has not occurred. For instance, the diversity of the perspectives on social capital varies according to this being focused on: the relationships that an actor has with other actors, the structure of relations among actors within a network, or both types of relationships [12].

As mentioned above, social capital has been defined from multiple and separated perspectives or for different purposes. From a sociological perspective, Bourdieu [13] defined social capital as "the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition," while for Portes [14] capital social is "the ability of actors to secure benefits by virtue of membership in social networks or other social structures". On the other hand, from an economic perspective Nahapiet and Ghoshal [15] defined social capital as "the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit. Social capital thus comprises both the network and the assets that may be mobilized through that network". For Fukuyama [16] "social capital can be defined simply as the existence of a certain set of informal values or norms shared among members of a group that permit cooperation among them".

Nevertheless, taking into account the above definitions, it is possible to conclude that social capital is a valuable asset which has some typical characteristics of economic capital such as: It can be invested with the expectation of future benefits [17] and, is convertible [13]. But, on the other hand, it is different, since its existence lies in the relationships that are established within the network while economic capital

can exist at the member level [18]. In other words, social capital cannot be traded by entities on an open market like as economic capital, but exclusively within a network [19].

In order to categorize the components associated with the concept of social capital, several authors have proposed a multi-dimensional approach (see eg [15]). However, the current limitations of existing methods and a poor understanding of the components that are the source of social capital have acted as a barrier to the development of this concept in other fields of application such as the collaborative networks. Therefore, identifying and characterizing the components that make up the social capital tailored to collaborative networks, is a necessary first step. Based on the literature, and taking into account the context of collaborative networks, the most relevant components, as a first approach, include:

- Type of interaction among members – related to the forms of interrelationship that can occur between enterprises within a network. For instance, the following types of relationships can be identified:
    o Subordinate relationships – which characterize the authority and/or dependence structure within a network.
    o Peer relationships – which characterize the friendly relations within a network.
- Frequency of contact – related to the number of contacts between network members.
- Intensity of contact – related to the strength and nature of relationship in terms of potential benefits or losses.
- Geographical dispersion of network members – related to the geographical distance among members.
- Values – related to the behaviour of members, such as: trust, solidarity, reciprocity, values systems alignment, rules and norms of governance.
- Resources – related to the number and type of resources that can be mobilized through the network. Such as: capital, raw-material, workforce, energy, goods, services, etc.
- Knowledge - related to the type of knowledge that can be made available through the network, such as: skill, markets information, lobbying information, etc.

3 A Model to Analyze Social Capital

As mentioned above, one of the main weaknesses in this area in terms of social capital is the lack of appropriate formal methods to analyze social capital in the context of the networked organizations paradigm. We depart from the assumption that, the capital social of an enterprise is related to the "level of health" of the relationships that it establishes with other enterprises within a network.

In order to analyze the social capital of each member in a collaborative network, it is necessary to develop a model that supports the analysis of the relationships among members and the assets that may be accessed through the network of contacts.

Therefore, as a first approach, these relationships are modelled using graphs, as illustrated in Figure 1. The main objective is to represent a network in symbolic terms from the perspective of analysis, abstracting reality through a set of connecting nodes.
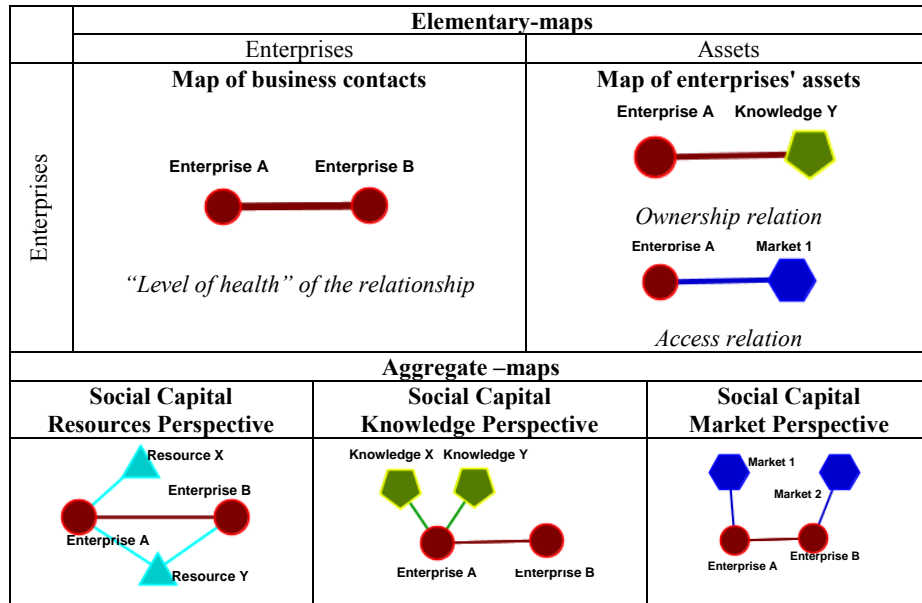

Elementary-maps	
Enterprises	Assets
Map of business contacts	**Map of enterprises' assets**

Fig. 1. Simple model to analyze Social Capital in CN's.

The proposed model considers elementary-maps and aggregate-maps. The elementary maps are:

Map of business contacts - A graph showing the network of contacts among members belonging to the network. In this case, the link's width represents the "level of health - LH" of the relationship between two enterprises, and its value is given by the following equation:

$$LH_{ij} = w_1 \times SRFC_{ij} \times SRIC_{ij} + w_2 \times PRFC_{ij} \times PRIC_{ij} + w_3 \times VS_{ij} \tag{1}$$

$$\sum_{j=1}^{n} w_j = 1 \text{ and } w_j > 0$$

Where:

LH_{ij} - Level of health of the relationship between enterprise i and enterprise j

$SRFC_{ij}$ - Frequency of contact between enterprise i and enterprise j, based on subordinate relation.

$SRIC_{ij}$ - Intensity of contact between enterprise i and enterprise j, based on subordinate relation.

$PRFC_{ij}$ - Frequency of contact between enterprise i and enterprise j, based on peer relation.

$PRIC_{ij}$ - Intensity of contact between enterprise i and enterprise j, based on peer relation.

VS_{ij} - Value systems alignment between enterprise i and enterprise j.

However, the main difficulty is naturally the determination of each of the five components mentioned above. To collect and record those values without being intrusive in the network members' "life" requires further research and development.

Combining these notions with concepts from the Social Network Analysis area, a useful tool to analyze in detail the map of business contacts can be obtained, as illustrated in Table 1.

Table 1. Mapping between SNA and Map of Business contact

Social Network Analysis (SNA)	Map of Business Contact
Key concepts	
Node - A social discrete entity such as: enterprises, actors, corporate or collective social units	Enterprises, organizations, people
Relational tie - Type of ties or links between nodes	Subordinate relation Informal relation
Dyad – consists of a pair of actors and the possible ties between them	Subordinate relation Peer relation
Structural Variables – measure ties of a specific kind between pairs of actors.	Frequency of contact Intensity of contact Value systems alignment
Composition variables – are measurements of actors' attributes.	Geographical localization Number of assets
Basic Analysis	
Nodal Degree – is a measure of the activity of the actor. Define indicators in order to measure: - Actor degree centrality - Group degree centralization - Actor closeness centrality - Group closeness centralization - Actor betweenness centrality - Group betweenness centralization - Degree of prestige - Proximity prestige - Status or Rank prestige	Measures the ability to have access to others nodes through the network
Network Size	Number of members of the CN
Density of network	Level of contacts
Connectivity of network - Cutpoints - Bridges - Walks	Measures the concept of reachability between pairs of nodes.

- Trials - Tours - Cycles	
Cohesive Subgroups - Clique - n-cliques - n-clans - n-clubs	Identification of subsets of actors among whom there are relatively strong, direct, intense and frequent ties

Map of enterprises' assets - This graph shows the assets held by each enterprise and how they are shared. In this case, there are two sets of nodes: enterprises and assets. The nodes are connected by ownership/access relations.

Aggregate-map – Graph showing how an enterprise may have access to assets held by another enterprise. It results from the aggregation between the map of business contacts and map of enterprises' assets. Based on this map, it is now possible to analyze the social capital of each enterprise through a visual representation of the components that make up the social capital. Therefore, this map will be composed of two sets of nodes (enterprises and assets), and two types of links.

Assuming that the assets are classified into classes in accordance with their purposes, then, in this context it becomes possible to analyse the social capital of an enterprise according to different perspectives, such as:
- Capacity perspective – related to the ability of accessing to external resources.
- Innovation perspective – related to the ability of accessing to external knowledge.
- Market perspective – related to the ability of accessing to new markets.

Therefore, it is possible to define three notions of social capital that can be measured using a quantitative or a quantitative scale. However, in this discussion social capital is assumed as an abstract quantifiable value with the same meaning as utility concept.

Partial Social Capital (PSC) – Corresponds to the social capital of an enterprise under a single perspective. Its value is given by the following equation[1]:

$$PSC_{ik} = \sum_{j=1}^{n} LH_{ij} \times (v_{A1i} + v_{A2i} + ... + v_{Ani}) \quad i \neq j \tag{2}$$

Where:

PSC_{ik} - Partial social capital of enterprise i according to perspective k

LH_{ij} - "Level of health" of the relationship between enterprise i and enterprise j

v_{Ani} - Value assigned to asset *An*. The worth of the asset *An* is decided by enterprise i and depends on the relative importance/utility of each asset.

Effective Social Capital (ESC) – corresponds to the social capital that an enterprise uses in carrying out its activities. Its value is given by the following equation:

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[1] It shall be noted however that this equation does not properly capture all situations. For instance, it does not cover the cases in which an enterprise has relationships with two or more enterprises that hold identical assets.

$$ESC_{il} = \sum_{k=1}^{n} PSC_{ikl} \tag{3}$$

Where:

ESC_{il} - Effective social capital of enterprise i to perform an activity l

PSC_{ikl} - Partial social capital of enterprise i according to perspective k to perform an activity l

Total Social Capital (TSC) – corresponds to the maximum social capital that an enterprise can get from the network. Its value can be obtained through the sum of partial social capital. Its value is given by the following equation:

$$TSC_i = \sum_{k=1}^{n} PSC_{ik} \tag{4}$$

Where:

TSC_i - Total social capital of enterprise i

PSC_{ik} - Partial social capital of enterprise i according to perspective k

4 Potential Application

In order to analyze and measure the social capital of members in a collaborative network, the following example illustrates how the proposed approach can be used.

Let us consider a scenario, where we have a *VO breeding environment* (VBE) which contains seven organizations, as illustrated in Figure 2. Please note that the purpose of this example is only to illustrate the potential of this analysis, and in the network of business contacts, the "level of health" of the relationship among enterprises (LH_{ij}) (see, Equation 1) is identical for all enterprises.
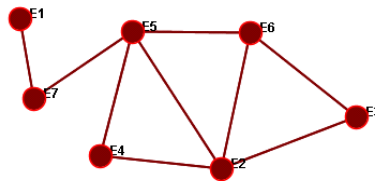

Fig. 2. Map of business contacts

Let us suppose the existence of three distinct classes of assets (Knowledge, Market, and Resources), as illustrated in Figure 3. Analyzing the graphs of enterprises' assets, it is possible to identify that in terms of knowledge (graph 3A) enterprise E4 does not have any asset while enterprise E7 has an exclusive asset K4. On the other hand, according to the analysis of resources (graph 3C), it is possible to verify that resource R2 is shared by both enterprises E4 and E7.

In order to analyze the social capital of an enterprise according to different perspectives, the following graphs are generated (Figure 4). From the perspective of innovation (graph 4A), it is possible to verify that enterprises E5 and E1 might have

access to knowledge K4 (exclusive in this network) via the enterprise E7. On the other hand, from the perspective of market (graph 4B) enterprise E7, through enterprise E1, might access to market M1.

From the perspective of resources (graph 4C) enterprise E4 might have access to all available resources within the network through enterprise E2 and E5.
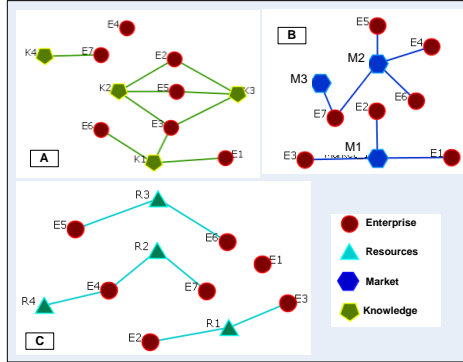

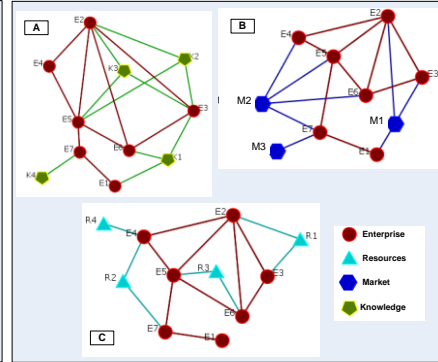**Fig. 3.** Map of enterprises' assets - (A) Knowledge (B) Market and (C)

Fig. 4. Social Capital Analysis - (A) Innovation (B) Market, and (C) Capacity perspective

In order to illustrate how to estimate the social capital in a VBE context, let us make the following assumptions:

- There are records of the enterprises' past involvement in collaboration activities at the VBE management level, which makes possible to quantify the *"level of health"* of the relationship between enterprises (LH_{ij}), such as: type of interaction among enterprises, number of contacts between members, value system alignment indicators, strength and nature of relationships in terms of potential benefits or losses.

- There are records of the type of assets that can be mobilized through the network at the VBE management level, and each enterprise decides on the relative importance/utility of each one of those assets.

In this scenario, let us suppose that enterprise E4 needs to have access to some assets in order to accomplish two business opportunities, as illustrated in the table 2. Table 3 shows the relative importance of each asset regarding the increase of the "survival capability" according to enterprise E4 perspective.

Considering that the "level of health" of the relationships among enterprise is identical and equal to 1 (LH_{ij} =1), table 4 shows the effective social capital for each business opportunity and the total social capital for a radius of 1 around enterprise E4 (see, Figure 2). For instance, in order to achieve the Partial Social Capital (PSC) value for business opportunity 1, applying Equation 2, we get the following equation: $PSC_{4k} = LH_{42} \times v_{Ak_2} = 1 \times 9 = 9$, where: PSC_{4k} - Partial social capital of enterprise E4 according to the knowledge perspective, LH_{42} - "Level of health" of the relationship between enterprise E4 and enterprise E2 and, v_{Ak_2} - Value assigned to asset k₂ (see,

Table 3). Based on Equation 3, the Effective Social Capital (ESC) is worth 9 units in this case $(ESC_{41} = PSC_{4k1})$, where: ESC_{41} - Effective social capital of enterprise E4 to perform the business opportunity 1 and PSC_{ikl} - Partial social capital of enterprise E4 according to the knowledge perspective to perform business opportunity l

Table 4 shows that for business opportunity 1 the effective social capital that enterprise E4 can get from the network is greater than for business opportunity 2, despite the amount of assets involved being smaller (table 2). Furthermore, as the effective social capital is positive for both business opportunities (table 4) means that enterprise E4 can operate more effectively compared to a scenario of working alone out of this VBE. On the other hand, based on this model, it is possible to analyse the potential maximum of social capital that an enterprise may have access through the network. As an example, by applying the Equation 4, the Total Social Capital value (TSC) for a radius of 1 around enterprise E4, is given by the following equation: $TSC_4 = PSC_{4k} + PSC_{4R} + PSC_{4M} = 11 + 5 + 3 = 19$, where: TSC_4 - Total Social Capital of enterprise E4, and PSC_{4x} - Partial Social Capital of enterprise E4 according to perspective x, where x is knowledge, resources, and markets.

In this example, as the worth of effective social capital is lower than the total social capital, it means that E4 is not extracting all advantages of belonging to this community.

Table 2 – Assets required

Business Opportunity	Assets required
1	K2
2	K3, R3, R1

Table 3 – Assets utility

Asset (An)	Value assigned to asset An (Van)
R1	3
R3	2
K2	9
K3	2
M1	3

Table 4 – Social capital as an abstract value

Business Opportunity	Effective Social Capital	Total Social Capital
1	9	19
2	7	

5 Conclusion

Reaching a better characterization and understanding of the role of social capital in collaborative processes is an important element for a better understanding of the behavioural aspects in the collaborative networks paradigm in its various manifestation forms.

The definition of a set of indicators to capture and measure the capital social can be a useful instrument to the VBE manager, as a way to support the promotion of collaborative behaviours, and for a VBE member as a way to extract the advantages of belonging to a network. Using simple calculations as illustrated above, it is possible to extract some indicators. Some preliminary steps in this direction, inspired by the Social Networks analysis, were presented. The proposed model, although simplistic, has the advantage of providing a visual/graphical representation which is easy to understand.

However, the development of practical indicators and a software tool to analyze the social capital in collaborative networks still requires further work.

References

1. Beckett, R.C., *Perceptions of value that sustain collaborative networks*, in *Collaborative Networks and Their Breeding Enviroments*, L.M. Camarinha-Matos, H. Afsarmanesh, and A. Ortiz, Editors. Springer (2005).
2. Afsarmanesh, H., V. Marik, and L.M. Camarinha-Matos, *Challenges of collaborative networks in Europe*, in *Collaborative Networked Organizations: A research agenda for emerging business models*, L.M. Camarinha-Matos and H. Afsarmanesh, Editors, Kluwer Academic Publishers (2004).
3. Tenera, A. and A. Abreu, *A TOC perspective to improve the management of collaborative networks*, in *Pervasive Collaborative Networks*, L.M. Camarinha-Matos and W. Picard, Editors. Spriger: Boston. p. 167 - 176 (2008).
4. Camarinha-Matos, L.M. and A. Abreu, *A contribution to understand collaboration benefits*, in *Emerging Solutions for Future Manufacturing Systems*, L.M. Camarinha-Matos, Editor. Springer (2004).
5. Durlauf, S.N., *Symposium on social capital: Introduction.* The Economic Journal, 112: p. 417 - 418 (2002).
6. Adam, F. and B. Roncevic, *Social Capital: Recent Debates and Research Trends.* Social Science Information. 42: p. 155 - 183 (2003).
7. Sabatini, F. *The Empirics of Social Capital and Economic Development: A Critical Perspective*. http://www.feem.it/Feem/Pub/Publications/WPapers/default.htm.
8. Yu, K., *A new idea for the research on cluster innovation network system model-based on the view of the use and creation of social capital*, in *PROCEEDING OF CHINA PRIVATE ECONOMY INNOVATION INTERNATIONAL FORUM*, S. L and W. CB, Editors. AMERICAN SCHOLARS PRESS, MARIETTA, USA Taizhou, PEOPLES R CHINA p. 129 - 140 (2007).
9. Molina-Morales, F.X. and M.T. Martines-Fernandez, *Does homogeneity exist within industrial districts? A social capital-based approach.* PAPERS IN REGIONAL SCIENCE. 88(1): p. 209 - 229 (2009).
10. Francis, J., A. Mukherji, and J. Mukherji, *Examining relational and resource influences on the performance of border region SMEs.* International Business Review. 18(4): p. 331 - 343 (2009).
11. Bankston, C.L. and M. Zhou, *Social Capital as a Process: The Meanings and Problems of a Theoretical Metaphor?* Sociological Inquiry, 72(2): p. 285 - 317 (2002).
12. Adler, P.S. and S.-W. Kwon, *Social Capital: Prospects for a new concept.* The Academy of Management Review, 27: p. 17 40 (2002).
13. Bourdieu, P., *The Forms of Capital*, in *Handbook of Theory and Research for Sociology of Education* J.G. Richardson, Editor. Greenwood Press: New York. p. 241 - 258 (1986).
14. Portes, A., *Social Capital its origins and applications in modern sociology.* Annual Review of Sociology, 24: p. 1-25 (1998).
15. Nahaiet, J. and S. Ghoshal, *Social Capital, Intellectual Capital, and the organizational advantage* Academy of Management Review. 23(2): p. 242-266 (1998).
16. Fukuyama, F., *Social Capital and the modern capitalist economy: Creating a high trust worplace*, in *Stern Business Magazine*. (1997).
17. Camarinha-Matos, L.M. and A. Abreu, *Performance indicators based on colaborative benefits*, in *Collaborative Networks and Their Breeding Enviroments*, L.M. Camarinha-Matos, H. Afsarmanesh, and A. Ortiz, Editors, Springer (2005).
18. Robison, L.J., A. Schimid, and M.E. Siles, *Is social capital really capital?* Review of Social Economy. 60: p. 1-24 (2002).
19. Gant, J., C. Ichniowski, and K. Shaw, *Social capital and organisational change in high involvement and traditional work organisations.* Journal of Economics and Management, 11: p. 289-328 (2002).