Systems Analysis of Social Capital at the Firm Level

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1. Introduction

This paper describes how systems approach can be used in an analysis of social capital of a firm viewed in a very broad sense as a profit or non-profit organization, where people (workers, partners, etc.) work together to achieve its more or less precisely defined objectives and whose efforts can be measured by some accounting systems. We will use the analytical outcomes to asses, estimate and even measure the value of social capital of one such firm or another, a task which poses a big challenge for both theory and managerial practice in new economy (knowledge – based economy). The problem of how to measure the value of social capital was taken up by many researchers and probably most fully analysed by Edvinsson and Malone (1997) in their book "Intellectual Capital. The proven way to establish your company's real value by measuring its hidden brainpower".

In other words, we will use systems research principles to weigh the amount of social capital in an industrial/service company, research institution, university, consulting firm, sports club, professional organization, etc. As a by-product we will demonstrate how such principles can be used to contribute to better understanding of social capital, as a complex phenomenon in new economy. The paper is self-contained and do not require any prerequisite knowledge of systems analysis.

In Section 2 hereof we will divide a full capital (all assets) of a firm in four parts and study relations between them. Such a division will have numerous implications which will be brought up throughout the paper. In Section 3 we will introduce the concept of the virtual production line and demonstrate that it can be considered as a natural development (phase) of the well-known (classical) production (assembly) line concept.

In Section 4, we will expand Nahapiet and Ghoshal's proposition (1998) and study social capital of a firm as a three – dimensional entity.

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2. Four forms of capital of a firm

The entire capital (all assets) of a typical firm can be divided into the following four categories:

1. **Financial capital (FC),** which comprises all possible components of short–term and long–term financing of a firm (savings, loans, sale of stocks, sale of bonds, retained earnings etc.). Its value denoted as *v(FC)* can be calculated for any moment in the past and present as a sum of all components with a corresponding plus or minus sign and including a discount rate. Data for such calculations are available, in general, in banking and accounting records of the firm concerned. Future value of financial capital can be calculated using techniques of short-term or long-term financial forecasting.
2. **Physical capital (PC),** which comes in the form of buildings, machines, equipment, furniture, computers and software in its materialised form of license documents, etc., all collectively known as tangible property. For the purpose of this paper, we assume that the value of physical capital, denoted as *v(PC),* can for any given moment of the past, present and future be calculated using accounting and investment planning statistics.
3. **Human capital (HC),** which is a resource derived from competences, tacit knowledge, experiences, skills, education, training, etc. of workers considered as discrete individuals. The value of human capital of a firm, *v(HC),* is a subject of debate among practitioners and researchers (see Lin (2001), Edvinsson (2002)). Edvinsson and Malone (1997) suggest in the quoted book to measure *v(HC)* as a lump sum of compensation for all or specific workers, e.g. experts, in a firm over all years of their employment including corresponding discount rate.

4. **Social capital (SC),** which is composed of formal and/or informal relationships among workers, teams, organizational units, etc. within a firm, as well as its so-called organizational culture, viewed as a pool of formal/informal rules, principles, behaviour standards of people, procedures, etc.. The value of social capital of a firm, *v(SC),* is our main concern in this paper.

The ideal solution we are looking for can be described in formula (1)

market value of a firm = $v(FC)+ v(PC)+ v(HC)+ v(SC)$ (1)
for any moment of time in the past, present and future of a firm.

So far we know how to calculate *v(FC)* and *v(PC).* The sum is known in literature as bookkeeping value of a firm and is denoted as *v(BK).* So we can rewrite (1) as

market value of a firm = $v(BK)+v(HC)+ v(SC)$ (2)
for any moment of time in the past, present and future of a firm.

The history of market operations in which a number of hi–tech organisations have been sold clearly demonstrates that their market value was 5 – 10 times higher than bookkeeping value. Formula (2) suggests that it seems reasonable to combine human and social capital in one, call the sum 'intellectual capital,' as is often done in literature (see *e.g.* Edvinsson and Malone (1997), Edvinsson (2002)), and then explore the combined concept. We will not follow this route however because of a very simple observation below:

Observation 1. In one-man company $v(SC) = 0$, *i.e.* there is no social capital.

It takes at least two staff members, two organizational units, etc to build any relationship in a firm.

We will use the concept of **one-man company** in our analysis of social capital in multi-staff organizations such as universities, research institutes, etc. To do so, we will introduce so-called **academic market** where human capital of scientists, experts, etc. could somehow be measured, mostly in an indirect way (academic market knows who is good and in what subject) or directly, by way of *e.g.* expert ranking lists. In this exercise we assume that a given

university, research institute, consulting company etc. is as a set of a particular number of one–man companies, each with a corresponding human capital. If such one-man companies cooperate well within a given institution, then they contribute to its prestige, reputation, etc., which can result in new projects, contracts, etc. (financial capital) and possible investment in physical capital. We note that academic market is also a part of general market where human capital of particular experts, scientists, etc. is measured by the amount of their compensation.

Relations between the four forms of capital above can even be better seen in a sports club. Take Manchester United, one of the richest football clubs in the world. Each of its top players represents best quality human capital (skills, experience, competence etc.) well defined in monetary terms during so-called transfer periods. Each player can be considered as a one-man company (in fact, they have a personal manager, lawyer and secretaries) with its objective to increase its human capital as much as possible. If players do well together, then the social capital of the club has a big value, with obvious implications for its financial and physical capital. And vice versa, one, single player can play brilliant and his/her human capital may be the highest on the sport arena , but his/her team is losing out because the social capital of the competitor is higher. The history of team sports is full of relevant evidence.

3. Virtual production line

To continue our discussion on relationships between human and social capital, we need general information about an assembly/production line, which we would like to explain with an example from the automotive industry.

Before 1910 cars were manufactured in so called production circles (see Fig.1), where a few highly skilled craftsmen produced a car from beginning to end using parts and raw materials. The division of labour in such a production process was very flexible, in fact, craftsmen could easily substitute for one another, and the obvious limit for productivity was the number of highly skilled craftsmen.

Fig. 1. The production circle

Henry Ford was the first who realized in practice the following observation: If we divide a complex car manufacturing process into a fixed number of simple operations (jobs) done by simple workers on a line (belt) (see Fig.2), then its productivity will increase and the problem of limited number of highly skilled craftsmen should be solved. It is one of the greatest achievements in management and economy. The idea of the assembly line was then applied in many production and service processes. With the many classical production/service lines manned by people or robots, we agreed for the purpose of our analysis to join them into one production/service line, which we will call the **classical production line (CPL)**.

Fig. 2. The classical production line (CPL)

Let us assume that a given worker has increased his skills (his human capital) and now can do the job assigned in half the previous time. Has it any impact on organization/productivity of production process? The answer is no. His extra skills may be used in the design and implementation of another production process on CPL, but not in the one in hand as its organization is fixed. We conclude that CPL does not allow of any self-organization.

Definition 1. Classical production line (CPL) is a division of a well defined and sufficiently described complex production/service process into a fixed number of simple operations (jobs) described to the smallest detail. Such a division is fixed for a time and does not allow of any self-organization.

We will make the following main assumption in this paper:

Main assumption. Application of knowledge by teams of scientist, experts, specialists, etc. is always connected with solving a problem. It may not be well-defined or described in a fuzzy way, but always has a creative, problem-solving nature.

When individuals apply science, they do it it in the private interest or to increase their human capital on academic market, *e.g.* to obtain Ph.D., a certificate, etc. The situation drastically changes when a team of experts apply science. It is our contention that they do it to solve a problem, however vague the problem seems to be. By way of example, although we have *e.g.* Ph.D. projects and the like, serious research money is assigned only to collective projects.

To emphasise even further the difference between human and social capital, let us consider top Manchester United players doing training. Doing so, each of them increases their human capital even though they may be practicing team actions. Their training is just a play with a ball, interesting for a small circle of specialists and enthusiasts. It is only at the time of match, when score is counted, that we develop extraordinary interest at the stadium or in front of the television, and big money is there because social capital is involved.

Let us consider a virtual production line (VPL), pictured in Fig. 3, where we have a number of experts (teams of experts), scientists, specialists, etc. with their laptops, computers, data bases, etc. (in Fig. 3 we show their keypads and monitors), connected via the Internet or any ICT networks, solving a more or less accurately defined problem of our firm during a creative process. Since there is no material representation of the VPL (our experts can be located in different parts of the world), we denoted it in Fig. 3 with the doted line.

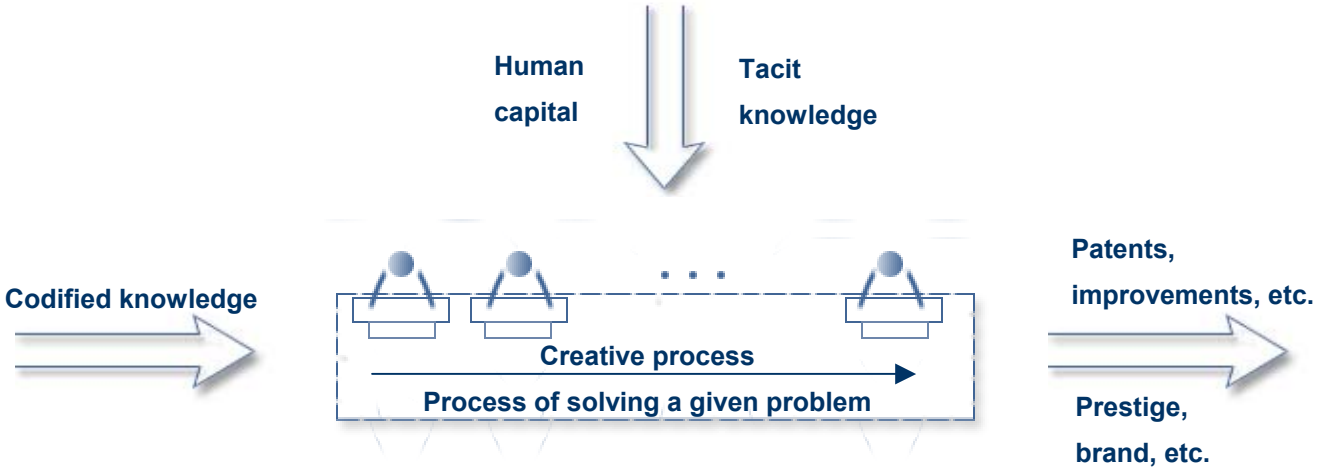

Fig.3. The virtual production (VPL)

The experts combine their human capital, mostly their tacit knowledge with the codified knowledge to solve in a creative process a problem which may be at the beginning not well defined and described in a murky way, but due to their efforts (self organization) more and more clear-cut, as shown in Fig. 4 .

Fig. 4.The CPL as a flexible division of labour

In Fig. 4 we see that at the beginning of the creative process, the considered problem was not well defined, which we denoted by dotted line along the perimeter. Tasks often overlapped each other and their limits were not well defined, which is symbolised by waved lines. After the self-organization the considered problem is much better defined (it is almost a circle), the overlappings of tasks are substantially smaller and their limits are almost straight lines. If at the beginning the considered problem is divided into n tasks T_1, T_2, ..., T_n, then after self-

organization the considered problem is divided into k tasks, $T_1, T_2, \ldots, T_k$ where k can be equal, bigger or smaller then n. We conclude that VPL allows of a **flexible division of labour**, while CPL is based on a **rigid (stiff) division of labour** (see Fig. 5), where production/service process is well defined –it is a circle - the jobs $J_1, J_2, \ldots, J_n$ do not overlap, the limits between them are straight lines.

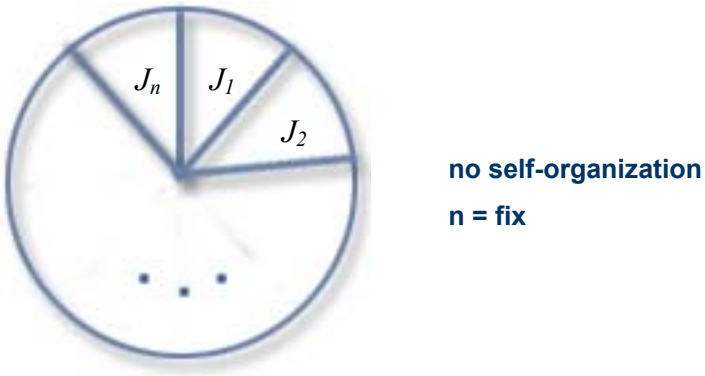

Fig. 5. CPL as a rigid division of labour

Definition 2. The virtual production line (VPL) is a division into more or less precisely described tasks (jobs) of a complex, perhaps not so well-defined problem-solving process (creative process), combined with modern ICT. The division of labour into tasks as well as the number of tasks may be changed during the creative process by experts (team of experts) involved in the process. Such a modification is called **self-organization of virtual production line.** Obviously, self-organization may recur over the creative process.

We note that unlike CPL, VPL is not a division of labour alone but combination of labour division with modern ICT. Therefore, we can make two conclusions.

Conclusion 1. (The Past). Without modern ICT, the value of social capital of the firm is negligible.

This is true, inasmuch as we realise that social capital became a subject of serious studies only in 90's when we began to be able to send information, data, etc. to virtually every corner of the world at almost zero cost.

Conclusion 2. (The Future). The history of improvement/development of CPL delineates directions for research on VPL. In fact, VPL is a natural development (phase) of CPL.

We may say that VPL is an instrument (a transition belt) experts use to combine codified knowledge with their tacit knowledge, competence, experience etc., to produce improvements in products, services, technology and management, and contribute to the stocks of knowledge, codified and tacit (see Fig 3). Otherwise stated, it is a device on which social capital of the firm is making money (financial capital), using human capital of its experts and its physical capital (computers with software, data bases, communication networks, patents, licenses, books, etc., acquired with a view to creative process).

In fact, VCL sometimes is very similar to the classical assembly line. Let us consider, for instance, designing a new car using the latest achievements of material science, electronics, satellite communication, engine construction, etc. What experts do is assembly on VPL parts of knowledge from those respective sciences using their tacit knowledge and expertise to produce a project of a new car, documented in databases and in hard copy, with computer codes for robots, strategy for marketing of the car, etc.

In conclusion of this Section we argue that in new economy a big organisation combines CPL with VPL. In fact, generally speaking, such a business runs a number of classical production/service lines, turning out goods and/or services, and a number of virtual production lines, as different problems may be solved there at the same time. A virtual production line makes innovations and improvements, viewed in a very broad sense as a change for the better on a 'here and now' basis, accepted by the market. Since for a vast majority of SME`s creating VPL is practically impossible, they turn attention to clusters where alongside research institutions, universities, etc. they build a virtual production line to solve problems faced by respective clusters. This is the essence of the innovative industry in new economy.

4. Three dimensions of social capital

In Section 2 we said that social capital of a firm is formed by formal/informal relationships between its workers, teams, organizational units, etc. as well as by its organizational culture. We start here with the assumption that if we study at length those relationships, then, as a byproduct, we will acquire plentiful insights into the organizational culture and its impact on *v(SC)*.

Let us assume that we have *n* experts (teams of experts, organizational units etc) in a firm: $E_1, E_2, \ldots, E_n$. Nahapiet and Goshal (1998) suggest that there are the following three dimensions (aspects) of social capital:

1. **The structural dimension x_{ij}** which reflects the existence of cooperation, contacts, connections, etc, between E_i and E_j. Obviously, we will have to specify notions of 'cooperation', 'contact', and 'connection' for every single case apart from others.
2. **The relational (qualitative) dimension q_{ij}** which describes the quality, the nature of relationships between E_i and E_j, *e.g.* trust, intimacy, openness, liking and so forth.
3. **The cognitive dimension c_{ij}** which identifies the extent to which E_i and E_j are ready to participate in problem solving in a firm (creative process), to what extent they share common perspectives and understanding, how much they intend to contribute to *v(SC)*.

We note that these dimensions are introduced in a natural order: first people know each other, than they trust each other and only after that they get to solve problems together.

Clearly, x_{ij} can be treated as a binary variable

$$x_{ij} = \begin{cases} 1, \textit{if } E_i \textit{ cooperates with } E_j \\ 0, \textit{otherwise} \end{cases}$$

$i, j = 1,2, \ldots, n$.

So we have a binary matrix $X = [x_{ij}], \quad i, j = 1,2, \ldots, n.$

Without loss of generality we may assume that q_{ij} and c_{ij} are real figures obtained *e.g.* by means of questionnaires designed for a given case. Therefore, we have two n*n matrices.

$Q = [q_{ij}]$ and $C = [c_{ij}], \quad i, j = 1,2,\ldots,n.$

If we define x-multiplication as

$XQ = [x_{ij}q_{ij}]$ and $XC = [x_{ij}c_{ij}]$ for $i, j = 1,2,\ldots,n$,

then we can formulate

Observation 2. *v(SC) = f(X,Q,C) = f(XQ,XC).*

We claim that the value of social capital can be calculated as a function of three variables, one of which is binary. The function *f(X,Q,C)* can be studied in a way similar as GDP (gross domestic product). GDP may be considered as a function of three variables: capital *C*, labour *L*, and technology *T*. Recently, often the fourth variable is added – networking *N,* which reflects the importance of social capital. *N* is an indicator of how easily networks of cooperation are established. Thus we can write

GDP = f(C,L,T) or *GDP = f(C,L,T,N).*

The function *f(C,L,T)* or *f(C,L,T,N)* can be calculated or estimated using econometrics' models and statistics data from the past and present. Clearly enough, gathering statistical data relating to social capital is of key importance for a study on *v(SC)=f(X,Q,C).*

One of possible way is to consider data from questionnaires A and C run for industrial firms under the IKINET project from social capital perspective. That is to say, such data as describe structural, relational and cognitive aspects of social capital in industrial companies concerned.

For structural aspect (dimension) of social capital we can use a rich set of methods and techniques of graph theory. In this paper we describe briefly only two of them.

For our firm with n-experts $E_1, E_2, \ldots, E_n$ we define a **structural graph** $G=<V,L>$, where V is a set of its vertices $V=\{ E_1, E_2, \ldots, E_n \}$ and L is a set of its links (edges). The link between E_i and E_j exist if and only if $x_i = 1$. A subgraph G' of G is defined as $G'=<V',L'>$, where V' is a subset of V, and L' is a subset of L. Studying social capital is worthwhile to consider two extreme subgraphs of the structural graph *G*, namely:

- *k*-hole, is a subgraph with k-vertices and no links between them (see Fig. 6),
- *k*-clique, is a subgraph with k vertices connected all possible ways.

Fig.6. Examples of 4-hole and 4-clique

A path in the graph G is a set of its links so that the end of previous link coincides with the beginning of the next one. A path in which links are not repeated is called an elementary one. An analysis of elementary paths can be useful for social capital research. Let us consider the simple example in Fig. 7. We see that there is a cooperation between E_i and E_j as well as between E_j and $E_{k,,}$ but it may be useful to know why experts E_i and E_k do not cooperate.

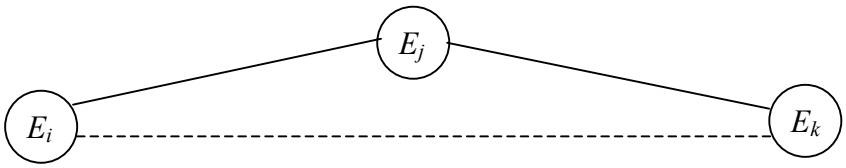

Fig. 7. Example of an elementary path analysis

The value of social capital $v(SC) = f(X,Q,C)$ can be considered as a function of a time t. Then we can use all methods and techniques of mathematical analysis to study the changes of $v(SC)$ in time. For instance, the derivative of $v(SC)$ calculated for a given moment shows the speed of increase or decrease of the value of social capital in a given moment.

5. Conclusions

We have divided all assets of a firm in the following four parts: **financial capital (FC),** which is, generally speaking, everything that is shown in the firm's banking accounts, **physical capital (PC) –** anything of some material existence , **human capital (HC)** anything that is in the heads, hands and legs of workers regarded as individuals, and finally, **social capital (SC)** – all the rest. When the value of those parts is concerned, we will assume for the purpose of our work that both *v(FC)*and *v(PC)* are known, although there is a debate among the accounting community on how to calculate the present value of computers, software, patents, etc. bought some time ago. Even *v(HC)* can be estimated somehow using the statistical records of wages and benefits in a firm. In our opinion, in research on *v(SC)* we are as early as the beginning of a serious analysis and the works on Skandia Navigator (Edvinsson and Malone (1997)) seem to be an interesting direction.

We can consider all assets and its four parts as a system. We define **a system** as a set of elements, called **subsystems**, cooperating in achieving specified goals. According to this conception, the entire capital of a company has four subsystems (see Fig. 8), cooperating is achieving goals defined in a more or less formal way in the company mission and strategy.

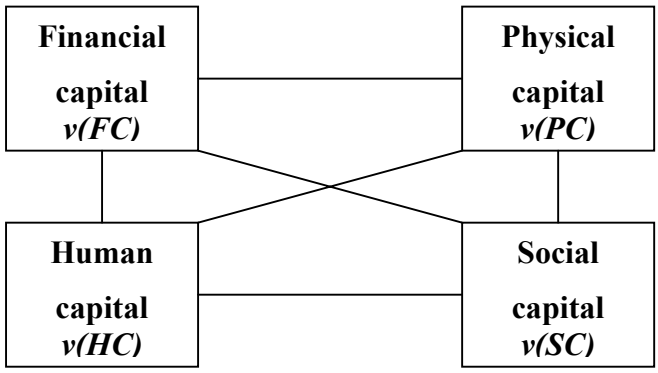

Fig. 8. Four subsystems of the entire capital of a firm comprising a system

Throughout this paper we used a well known principle of systems research 'from general to particular.' Under this principle we divided all company assets into four parts and showed that such a division can contribute to better understanding of social capital as a complex phenomenon in new economy. For social capital research we do rephrase the above principle into 'from general to particular and never in reverse,' *e.g.* we do not consider very reasonable

to design a questionnaire, of say, 200 questions to study social capital and then cross out questions which are irrelevant to specific applications.

In conclusion, our intention was to describe briefly one more direction for future studies. Let us consider each project of the EU Framework Programmes from the past or present, *i.e.* the 6th Framework Programme, as a virtual production line. We can see how self-organization mechanism worked in each project and how much respective projects contributed to increasing social capital (networking) of the EU research community. It is a fact that integrated projects are designed to assemble more experts (teams of experts) to encourage social capital, while networks of excellence are more oriented towards institutional aspects of networking. The role of coordinator deserves special studies at this point. In any event, once the value of social capital can bring a new light on the input – output analysis of projects; this may be used in the 7th FP.

6. References

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