

# Towards Ontology as Knowledge Representation for Intellectual Capital Measurement

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**Abstract.** For many years, physical asset indicators were the main evidence of an organization's successful performance. However, the situation has changed after information technology revolution in the knowledge-based economy. Since 1980's business performance has not been limited only to physical assets instead intellectual capital are increasingly playing a major role in business performance. In this paper, we utilize ontology as a tool for knowledge representation in the domain of intellectual capital measurement. The ontology classifies ways of intangible capital measurement.

**Keywords:** Intellectual capital measurement, market capital, social capital, human capital, ontology knowledge representation.

## 1 Introduction

One of the main responsibilities of managers in an organization is to make the organization more productive. For many years, physical asset indicators were the main evidence of an organization's successful performance. However, the situation has changed after information technology revolution in the knowledge-based economy. Since 1980's business performance has not been limited only to physical assets instead the different types of intellectual capital are going to play a main role in business performance. Human capital was one of the first intellectual capital that business owners understood its importance to achieve business goals. In 90's decade, business owners were focused more on customer value and due to the fast growth of communication tools, communication within organization between employees and between customers, knowledge sharing between market components is now one of the most important assets in knowledge-based economy. In knowledge based economy, knowledge is core competency and key competitive advantage for business. This knowledge comes from internal resource data or external resource data. Also knowledge validity and trust between agents of the business like customers-to- customers, employees-to-employees, employers-to-employees, employers-to- customers are the main parts of the modern

business environment. Sustainable business performance requires an effective system including all data resources and communication between these resources.

Feedback and business performance measurement is necessary to evaluate business and improve performance. Managers need to have a good view of their organisation for their short term planning and / or strategic planning in which the business performance methods can provide them. After the 1980s different measurement methods have been presented which focus on intellectual capital such as Balanced Scorecard method (BSC) [1], Skandia navigator model [1], Investor assigned market value [1], etc. All of these methods have mentioned different kinds of intangible assets and tried to measure them in different ways such as proxy measures, checklists, surveys, etc. Additionally, most of these methods focused on internal-based data and static data however the environment is very dynamic thus dynamic based measurement tools are needed.

In this paper, we propose an ontology as knowledge representation methodology for intellectual capital measurement. We utilize an ontology as a tool for knowledge representation in domain of intellectual capital measurement. It contributes to the following knowledge, experience and competence management tasks:

- Offer a sensible measurement tool to assess intellectual capital;
- A balance between different capital can be made within business activities to create business sustainability in future;
- Have a consensus view of intellectual capital measurement.

The ontology classifies ways of intangible capital measurement. We identify three components that constitute the concept of intellectual capital: social capital, market capital, and human capital. In the next sections, we discuss in detail about social capital, market capital, and human capital measurement. We then present the measurement in an ontology as knowledge representation of intellectual capital measurement. We conclude the work in the last section.

## 2 Social Capital Measurement

Social capital now plays an important role in economic development. Social capital is one of the key factors in an organization's success. It is a challenge to find suitable tools to measure the level of social capital. Fukuyama describes social capital as an ability of people to work together for common purposes in groups or organizations [2,3]. Putnam indicates that social capital is the norms and networks of civil society that enable groups of individuals to co-operate for mutual benefit (and perhaps for broader social benefit) and may allow social institutions to perform more productively [4]. Putnam also points out that social capital is embodied in forms such as civic and religious groups, bonds of family, informal community networks, kinship and friendship, and norms of reciprocity, volunteerism, altruism and trust [5]. From Deardorff's Glossary of International Economics, social capital is the network of relationships among persons, firms, and institutions in a society, together with the associated norms of behavior, trust, cooperation, etc., that enables a society to function effectively [6].

As it comes to the definition of social capital, the social capital is related to people's willingness to make connections and density of the information that is transmitted in those connections. Also transmitted information has different influence and it

depends on the trust between the sending and transmitted agents. Overall social capital can be calculated by the numbers of connections, trust between agents, and information density in a particular time slot. The following formula shows our method to measure social capital measurement in a network with  $n$  members:

$$TSC(t) = \sum SC(R_{ij}) \text{ while } 0 \leq i \leq n \times (n-1)/2, 0 \leq j \leq n \times (n-1)/2$$

TSC: Total social capital

SC: Current social capital

$t$ : At time  $t$

$R_{ij}$ : Relation between agent  $i$  and agent  $j$

$n$ : Number of members in the network

The above equation shows that the total social capital can be calculated by all relations' value in the time  $t$ . The relation between social capital in time  $t_1$  and social capital in time  $t_0$  is shown below.

$$SC(R_{ij}, t_1) = SC(R_{ij}, t_0) + \sum TR_{ij} \times F(D_{ij}) \times F(V_{ij}) \text{ while } 0 \leq i \leq n \times (n-1)/2, 0 \leq j \leq n \times (n-1)/2$$

$SC(R_{ij}, t_0)$  = time + budget + opportunity cost spent to create current the social capital

$F(V)$  = time + budget + opportunity cost required to spend to increase social capital in the time slot

$F(D)$  = data density share in communication

TR: Trust value

As it is seen in the above equation, trust and information sharing between agent  $i$  and agent  $j$  and the cost of creating this relation can affect on the total social trust. The method we use to measure social capital is the Investment Method [7] which considers cost that persons spent to create or improve their social capital including time, direct cost, and opportunity cost.

$F(D)$  is the function of knowledge sharing. It depends on various factors including (i) people's marginal propensity to share data which is related to social trust and culture in society; (ii) the level of facilities that help people to share their knowledge, for example virtual environment helps to increase knowledge sharing; (iii) people's interest in the subject, for example some people like to follow political subjects and some people like to follow art news; (iv) knowledge level of sender and receiver agents in which if it is not the same level, it might be boring to both sides to share their knowledge and the efficiency of knowledge sharing will go down.

### 3 Human Capital Measurement

Human capital is defined in different ways; however, most of its definitions include knowledge as the main source for human capital. Hudson defines human capital as people's experience and education level, their attitudes about life and business, and their genetic inheritance (competency) [8]. Knowledge basically comes from formal education systems that can be calculated easily by the cost of the education, the time that people spent to learn the formal knowledge, and the opportunity cost. Also knowledge comes from casual thinking and it can be named innovation. This kind of knowledge has a great return rate of investment and can be calculated by their added value and their impacts on the business. Trust is very important in human capital as people's attitudes about life and business is related to their trust level for themselves and also for environment i.e. friends, managers, society, etc.

In order to measure human capital, we shall measure knowledge value of education, innovation, and skills. We can calculate knowledge value of education by calculating cost that one spends to gain the knowledge. In this method we suppose that education is a product that we buy and pay for it thus we shall calculate all of the costs involved in the process of gaining education. The main costs in this category are as follows:

**Investment** – Investment in a formal education system such as cost of education in school, university, and some short term courses or any tuition fee one spends to get formal knowledge.

**Time** – Time that one spends in the class including studying time and time related to education system.

**Opportunity cost** – Opportunity cost is related to the cost of the opportunities that one loses due to spending for the education. For example if one continues his/her master and does not work. Thus s/he can not earn money and loses some opportunities.

The second category in human capital is knowledge value of skills. Basically skills are gained from experience. In this category the main costs are as following:

**Cost of training** – this kind of cost is related to the job training, mentoring training and all the costs business firms spend to improve their employee's knowledge.

**Cost of experience** – practice can improve people's productivity and business firms spend huge amount of money on their employees to increase their experience. This experience is a valuable asset and most of the business firms try to recruit experienced people from their competitors.

**Time and opportunity cost** – business firms invest in new employee who has just been filled the position to improve knowledge up to the required level. Business firms also lose opportunities in labor market.

The third category in human capital is knowledge value of innovation and it is related to people's competency in innovation and creativity. Although basic knowledge is important in this category, the main important parameter in this category is environment. Dynamic environment can make a suitable environment to enact the people's competency and high level of trust is the important variable in creating this environment. The total value of human capital is the sum of these three categories.

## 4 Market Capital Measurement

The main part of market capital is knowledge sharing between different components of the business such as suppliers, customers, competitors and others. Bontis defines customer capital as a relational capital which in effect encompasses the knowledge embedded in all the relationships that an organization develops whether it is from customers, from the competitions, from suppliers, from trade associations, or from the government [9,10]. As we have seen in social capital, making and developing relationships is related to trust between agents. Thus, knowledge and trust are the core variables in the market capital. The market capital can be calculated from the knowledge sharing and trust.

In economy, we talk about marginal propensity to buy, sell, or replace and analyze business components. In this paper, we look at viewpoints of running business from knowledge and trust and measure market capital on the basis of our core variables i.e. knowledge and trust.

### 4.1 Supplier to Company (SPCO)

In the relation between suppliers and company, it relates to marginal propensity to sale (from the business firm view point). The market capital can be calculated as shown below.

Marginal propensity to sell ( $t_0$ ) = trust level x (time + money and opportunity cost to make relation) + replacement cost

Marginal propensity to sale ( $t_1$ ) = Marginal propensity to sale ( $t_0$ ) + trust in the new relation x (time + money and opportunity cost for the new relation)

Trust in the new relationship depends on the delivery time and also logistic  
 $-1 \leq \text{trust level} \leq 1$

### 4.2 Supplier to Competitor (SPCM)

When the trust level between the suppliers (or customers) and the business firm is less than the trust between the supplier (or customers) and other competitors, their market can be replaced. The market capital can be calculated as shown below.

Marginal propensity to replace = trust level for the other companies x (time + money and opportunity cost to make relation) + replacement cost

Trust level for other companies is very important variable in this part and depends on social trust. In liberal market due to the high level of social trust it can be replaced easily.

### 4.3 Company to Customer (COCS)

This part of business is the main part and businesses can not continue without this relationship. In general situation, people buy goods or use services from a firm when they have enough information as well as they trust the firm. Because of the high cost of the customer replacement for the firms (five times more than royal customers) it is very important that companies focus on this part of business. This capital can be calculated as shown below.

$$\text{Market capital for a royal customer} = \text{trust level} \times (\text{time} + \text{money} + \text{opportunity cost spent to make the current trust} - \text{loyal customer}) + \text{cost of replacement (to find a new customer} + \text{to make loyalty and to improve it up till the trust level)}$$

Increasing the level of the trust depends on the social trust and difference from one culture of location to the others.

### 4.4 Customer to Customer (CSCS)

This part of the business is going to be the most important part of the business based on the basis of the IT revolution. The new promotion plans such as “word of mouth” is created to improve the embedded market capital in this section. The most important variables in this part are related to knowledge and trust. Knowledge of the customers about a company and knowledge sharing between potential customers in market targets together with trust between them are the most important variables. The market capital in this section can be calculated as shown below.

$$\text{TMC}(t_0) = \sum \text{MC}(R_{ij}, t_0) \text{ while } 0 \leq i \leq n \times (n-1)/2, 0 \leq j \leq n \times (n-1)/2$$

$$\text{TMC}(t_1) = \text{TMC}(t_0) + \sum \text{TL}_{ij} \times \text{F}(\text{D}_{ij}) \times \text{F}(\text{V}_{ij})$$

TMC: Total market capital

MC: Current market capital

$R_{ij}$ : Relation between customer  $i$  and customer  $j$

$n$ : Number of the customers in target markets

$\text{TL}_{ij}$ : Trust level between customer  $i$  and customer  $j$

$\text{F}(\text{D}_{ij})$ : Knowledge sharing density between customer  $i$  and customer  $j$

$\text{F}(\text{V}_{ij})$ : Value of the shared knowledge between customer  $i$  and customer  $j$

### 4.5 Potential Customer to Company (PCCO)

This part of the market capital can be named Brand value. It depends of the trust level of the non-customers and also knowledge of the non customers about the business form. This part of the capital can be created in new markets or new products.

## 5 Ontology for Intellectual Capital Measurement

Ontology in this paper is an explicit formal specification [11] of the concepts in the domain of intellectual capital of measurement and relationships among concepts. In the ontology, we model human capital, social capital, and market capital and their measurement in detail as stated in the above section. Ontology helps to map intellectual capital measurement and represent a set of relevant concepts with their properties and concept relationships. The ontology helps to come to an agreement on the intellectual capital measurement within an organization.

There are lacks and incompleteness of existing ontologies focusing on intellectual capital measurement in 3 main capital i.e. human capital, social capital, and market capital. The existing ontologies e.g. the enterprise ontology, TOVE, Doblin Core, etc. are too general [12]. They do not take intangibles into account and lack good representation of intangibles [12].

The main role of an ontology for intellectual capital measurement is to represent and share the common understanding of intellectual capital measurement assumptions and the informational structure within an organization.

Figure 1 shows an overview of intellectual capital ontology.

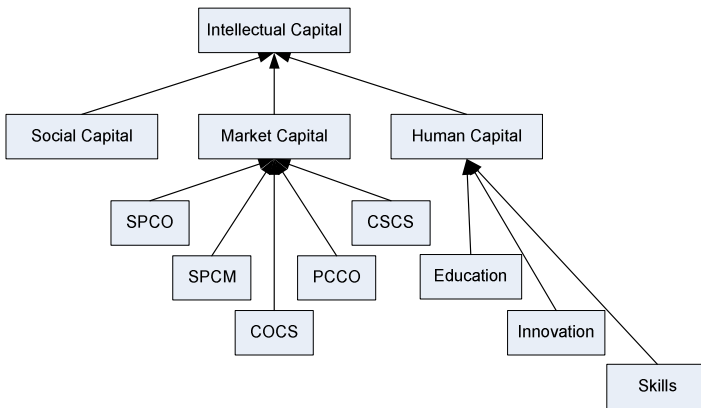


Fig. 1. Overview of Intellectual Capital Ontology

Company, supplier, competitor and customer can be illustrated as agent which relationships can be made between different persons in these kinds of agent. Figure 2 shows agent classification in the ontology.

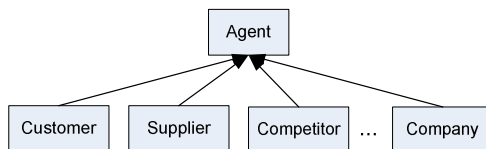


Fig. 2. Classification of agents

In the social capital measurement, the ontology classifies such bodies of knowledge along with a number of properties and constraints i.e. related agent, relating agent, the number of persons in the network, value of a connection, strength of a connection, time slot, kinds of relationships within network, etc. In human capital, the ontology expresses the classification of education, skills, and creation within human resource. Human capital measurement properties and constraints include cost of investment, time, opportunity, etc. In market capital, the ontology classifies into 5 categories i.e. SPCO, SPCM, COCS, CSCS, and PCCO. Generally speaking, an ontology is used to explicitly express how the intellectual capital is valued and thus results are sensible for managers. Additionally, the ontology enables evidence-based formation of knowledge valuation.

## 6 Conclusion

We have presented intellectual capital constituent and their measurement methods at a conceptual level utilizing a particular type of knowledge based technology, the ontology. Each intellectual capital constituent i.e. social capital, human capital, and market capital has been defined and its measurement has been presented. In our future work we will be focusing its development in each capital.

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