



**INSTYTUT BADAŃ SYSTEMOWYCH
POLSKIEJ AKADEMII NAUK**

TECHNIKI INFORMACYJNE TEORIA I ZASTOSOWANIA

Wybrane problemy
Tom 5 (17)

poprzednio

**ANALIZA SYSTEMOWA W FINANSACH
I ZARZĄDZANIU**

Pod redakcją
Andrzeja MYŚLIŃSKIEGO

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THE ROLE OF SOCIAL CAPITAL IN THE MODERN IT COMPANY

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Abstract. The aim of the article is to discuss the essential role of social capital of IT company, based on the example of Microsoft. The paper presents the historical perspective of the concept of human and social capital and introduces its precursors who first discussed this subject. It shows that for a few centuries there has been huge interest in human and social capital and it emphasizes the necessity to appraise their value in a reliable way. It also discusses the essence of the orthogonality principle and fundamental equation and applies them to estimate the value of social capital of Microsoft. Moreover, the model of neural network, proposed by the author in 2013, was also used to measure those values and both assessments were compared and analyzed.

Keywords: social capital, artificial neural network, fundamental equation, orthogonality principle

1 INTRODUCTION

Obviously, the most valuable resource of each IT enterprise is its staff: analysts, designers, programmers, testers, software engineers etc. They are high class specialists who develop cutting edge IT solutions. They constitute the social capital - the key resource of each company operating in the broadly understood IT industry, especially in the software sector. As defined by S. Walukiewicz in [11], **social capital** means: *the formal and informal relations between company employees, i.e. their ability to cooperate, trust, solidarity, mutual loyalty etc.* These are very essential features, as the passion, involvement and enthusiasm of programmers developing and creating software are largely decisive for the success of such applications. The software development process is a creative one. **Human capital** of each programmer, understood as their *talent, knowledge, experience and programming ability*, provide the basis for building the social capital of the whole enterprise.

In the author's opinion, they are the most valuable resources of a modern IT company; so the appropriate and reliable measurement of the value of such assets should be one of the priorities of the management. There exists a vast amount of studies in the area of social capital analysis, however the widely accepted method for extrapolating and predicting the values of social capital has not been proposed so far.

This identified research gap was the most essential premise for considerations in this sphere. Estimating the value of social capital using tools developed so far, especially those based on financial balance sheets, turns out to be a laborious and time-consuming task. The author suggests the application of neural network for analysis and modeling the value of intangible assets of IT companies. This paper discusses the social capital value of Microsoft - the leader of the global software market.

2 THE GENESIS AND ORIGINATORS OF THE CONCEPT OF HUMAN CAPITAL AND SOCIAL CAPITAL

The term *human capital* was introduced in the canon of economic vocabulary in the second half of the 20th century by scholars such as T.W. Schultz, J. Mincer and G.S. Becker [4]. They created the foundations of the human capital theory, which is still being developed in social sciences. The importance and significance of the theory was confirmed by awarding T.W. Schultz the Nobel Memorial Prize in Economic Sciences in 1979, and G.S. Becker, in 1992.

Literature review shows that the issue of human capital is not a new phenomenon. Even in the past, economists studied the issues of education, qualifications, skills and talents, namely elements described as components of human capital. In the 17th century, when the basic production factors such as land, capital and labour were discussed, human was also indirectly taken into consideration. The first economist who gave attention to the capital included in the labour factor was W. Petty (1623-1687) [2]. He considered "labour as the father of wealth and thought it therefore deserved attention". In his opinion, the capital associated with human has many similarities to fixed capital. W. Petty was one of the first scholars to try and estimate the value of human capital in the whole community of the contemporary England. He made calculations which showed that the value of capital accumulated in people was higher by approx. 70% than the combined value of movable and immovable property of England.

Another economist who highlighted the essence of the quality of human in the labour process was Adam Smith (1723-1790) [2]. He shared

Petty's view that *labour is a source of wealth growth, and its basis is the accumulation of capital*. Smith was of the opinion that „capital embodied in human is one of the components of fixed capital, beside the machines, production equipment, utility buildings and agricultural investments”. He considered health, knowledge and – first of all – acquired skills as human's personal assets, and those, in turn, the assets of the whole community [1]. J. B. Say (1767-1832) tried to combine the views of Petty and Smith and determined still another direction in the understanding of economic aspects of humans, i.e. he recognized the accumulated skills to be the national assets as part of immaterial funds of industrial capacity [7]. Say treated human capital from the quantitative point of view and he was the first to calculate the income of educated people, which illustrated the benefits of education expenditure. Friedrich List (1789-1846) also raised the issue of knowledge and skills vested in human and their impact on the functioning of economy. He even claimed that knowledge and skills embodied in humans were the most important component of the national capital and had to be taken into account in the analysis of the production and distribution processes [2]. Also other economists, such as J.S. Mill, J.R. McCulloch, L. Walras, J.H. von Tünen, A. Marshall, or I. Fisher, dealt with the issue of treating people in terms of capital; they also focused on education and the role it plays in the creation of national wealth [5].

The concept of human capital was first used in the literature of the subject by T.W. Schultz in 1961 – in the article *American Economic Review* [9]. He used the expression „human capital” to refer to *humans' knowledge and skills, emphasizing that individuals consciously invest in themselves to improve their economic results and welfare* [9]. The very term „capital” has no clear definition, so in the case of „human capital”, scientists have not yet agreed upon one acceptable definition either. The author uses the definition by S. Walukiewicz [11] in her research.

The concept of social capital was mainly popularized due to the works of F. Fukuyama, as well as J. Coleman and R. Putnam. J. Coleman was an American sociologist and the first scholar who used the term *social capital* in his work. He described social capital as a „feature of social relations structure, which supports specific actions of actors taken within the framework of this structure” [10]. Coleman is the author of the classic definition organizing the concept of social capital. He perceived social capital as the ability of cooperation between individuals within common interest groups and organizations [3]. Putnam continued Coleman's approach. He wrote: "social capital here refers to features of social organizations, such

as trust, norms, and networks that can improve the efficiency of society by facilitating coordinated actions" [6]. Furthermore, Putnam considered trust – which strengthens cooperation – as the most important factor affecting social capital [10].

3 THE MEANING OF THE TERM VALUE

The presented dimensions of human capital and social capital have specific values, hence they can be measured. This paper concentrates on estimating the intangible assets of the world's greatest software manufacturer, Microsoft, using a fundamental equation [11] and artificial neural network [8].

Before a detailed analysis of the role of social capital of Microsoft, the term **value** needs to be defined precisely, as it is very important in further deliberations. Everything in the world has its value. The value is always estimated on the real or conventional market (the latter being a market created especially for that purpose). These markets are free, which means that in market economy in the state of equilibrium, where demand and supply are balanced, the exchange of goods occurs as a result of voluntary transactions between the buyers and the sellers at the price freely determined by the two [12]. The first mentions of company goodwill appeared in literature in the 16th century, when judge Lord Eldon issued the following decision in a Cruttwell versus Lye case:

"The good-will, which has been the subject of sale is nothing more than the probability, that the old customers will resort to the old place" [13].

Interestingly, even 500 years ago the analysis of value of an enterprise referred to its intangible assets, not to material capital (such as buildings, machinery, real estate etc.) or financial resources (e.g. accumulated cash). The term "value" is described as the **economic equivalent** of **anything**, usually expressed in monetary units [11].

It was assumed that all the objects of the studies operate within a market economy in the state of economic equilibrium, when demand is balanced with supply (the law of supply and demand: *demand = supply*). Hence, both the left side of the equation (the value of demand) and its right side (the value of supply) must be measured in the same monetary units. It also shows that both material (real estate, computer equipment, devices etc.) and non-material assets (employees' knowledge, experience or talent) have their specific values, their economic equivalents measured in cash. Therefore, it can be concluded that **value** is the number of monetary units a person is ready to pay here and now as part of a real or conventional

transaction on a properly defined market [12]. The value is always defined on a real or conventional market.

4 SOCIAL CAPITAL OF MICROSOFT

Since everything in the world has its value, a very general way of efficient determination of this value must always be found. Thus, we need the definition of a decision model, which is an instrument used for such deliberations. **The decision model** is a very general pattern of the decision-maker's actions as part of the **decision-making process**, including three periods: the past („yesterday”), the present („today”) and the future („tomorrow”). The decision-maker always makes the decision „today” on the basis of information and data from „yesterday” so as to have the greatest profit or the lowest loss „tomorrow” [12]. The practical application of this model can be illustrated with the example of Microsoft. The investor (decision-maker) buys shares of the company on the stock exchange „today” on the basis of official and unofficial information about the company from „yesterday” so as to achieve an economic success „tomorrow”. The duration of each phase is different and depends on the investor. What is appraised on the IT market is the effects of creative work of hardware designers, programmers, analysts etc. The appraisal is the evaluation of its social capital here and now, meaning all the formal and informal relations between the actors of the market.

The analysis of social capital of each listed firm **F** first of all requires the estimation of its value at the moment t , i.e. $V(\mathbf{F}, t)$. By $V(F, t)$ we will denote the value of firm F at a given point in time t , worked out at the moment of its direct or indirect acquisition. It is assumed in the article that the market value of $V(\mathbf{F}, t)$ at the moment t equals the product of the listed shares $N(\mathbf{F})$ and the price $c(t)$ of one share at the moment t , that is [12]:

$$V(F, t) = N(F) * c(t) \quad (1)$$

Now we have to formulate Orthogonality Principle which regulates when two forms (concepts, categories, processes, dimensions etc.) A and B are disjoint or orthogonal.

Orthogonality Principle: Two forms (concepts, categories, processes, dimensions, etc.) A and B are **orthogonal** or **disjoint** if and only if there exists an objective, simple, one - dimensional decision rule of the yes - no type, by which we can always and everywhere decide whether an object from the considered part of reality X belongs either to A or to B . Since the

Orthogonality Principle plays a key role in our considerations, we shall represent it in a mathematical (set theory) format. The Orthogonality Principle partitions a nonempty set X into two and only two nonempty sets A and B such that:

$$X = A \cup B, A \cap B = \emptyset, A \neq \emptyset, B \neq \emptyset. \quad (2)$$

Using the Orthogonality Principle Walukiewicz [11] proved that tangible assets (capital) of firm F are disjoint or orthogonal to its intangible assets. The entire capital (all assets) of a typical firm (our firm F) is too complex to analyze it as one entity. Dividing it into two forms (parts), called **tangible assets** and **intangible assets**, is still too complex. We want the forms of capital to be disjoint, independent or orthogonal. Below we divide the entire capital of firm F into four forms (categories, parts, components), show that such a division is a new quality and source of our new results.

Human capital (HC) is 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 e.g. Lin (2001), Edvinsson (2002)), but until now, in contrast to the two above forms, there is no standardized, commonly accepted way of calculating or even estimating $v(HC)$. No doubt, $v(HC)$ is closely related to compensation for the work done, its volume (time), intensity, quality, conditions etc. Education, training, experiences, etc. from the past and present are, in general, investment for the future. Since the entire capital of firm F is partitioned into four forms, we can propose the following formula:

$$V(F,t) = v(FC,t) + v(PC,t) + v(HC,t) + v(SC,t)$$

for any moment t .

We will call it **Fundamental Equation** as it forms a base of the **accounting model** for socialcapital analysis. The formula says that in market economy, under the equilibrium conditions, when demand equals supply, the value of a firm F equals the aggregate sum of four component values of its capital: financial, physical, human and social at any moment t of the firm's past, present and future.

Let's consider the case of Microsoft and the social capital of this company. According to Wikipedia, Microsoft is an American corporation headquartered in Redmond, that develops, manufactures, licenses, supports and

sells computer software, consumer electronics and personal computers and services. It was founded by Bill Gates and Paul Allen in 1975. In 1986 Microsoft debuted its IPO at New York Stock Exchange. Let's consider the market value of the company. There were 8.239.848.789 stocks and the stock price was closed at US \$ 40,99 in September 2014, 30, so the market value of Microsoft at the end of this trading day was US \$ 337.751.410.500. The book value of Microsoft, for the third quarter of 2014 equaled circa 160 billion US \$. It is a typical situation for almost all stock exchange listed companies. The market value is higher - in knowledge-intensive sectors much higher - than the corresponding book value. The difference between the market value and the total registered assets of Microsoft in this period equaled about 177 billion US \$. This means that nearly 60% of the Microsoft's market value was not registered by classical accounting in its balance sheets. The author claims that this difference corresponds with the values of intangible assets of Microsoft. Assuming that 1/3 of this difference is associated with human capital and the rest with social capital (software production is a team work), we can present those values in the Figure 1.

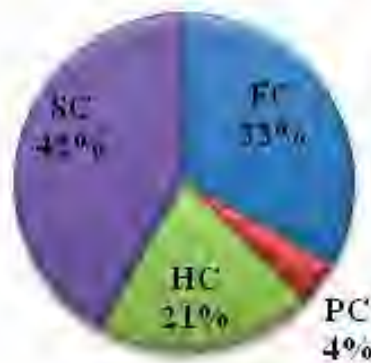


Fig. 1. The partition of the value of Microsoft into four forms of capital. Source: own study

where:

- HC-human capital,
- SC-social capital,
- FC-financial capital,

- PC-physical capital.

This example should be considered as a first application of fundamental equation to the value estimation of human capital and social capital. It also demonstrates a possible way of modification of classical accounting. Microsoft is a typical company of the knowledge-based economy so more than half of its market value is produced by its intangible assets (21% by its human capital and 42% by its social capital), 33% financial capital and the remaining 4% by its physical capital.

5 NEURAL NETWORK FOR SOCIAL CAPITAL ASSESSMENTS

Let's investigate the value of social capital of Microsoft using artificial neural network model MLP 7-3-1, which was proposed by author in 2013 [8]. The main idea of this method bases on the assumption that there are seven input variables significantly affecting the output dependent variable, i.e. the value of social capital. This presumption allows to analyse seven neurons in the input layer. Modeling the value of social capital is a problem of regression, that is why only one neuron, characterized by the dependent variable is presented on the output. The analysis covered the following input, independent variables: X_1 -market value, X_2 -book value, X_3 -stock price, X_4 -number of shares, X_5 -employment, X_6 -total assets and X_7 -liabilities. The output (dependent) variable Y represents the value of social capital, calculated by Fundamental Equation. The model was built and all the simulations were carried out in the package STATISTICA Automated Neural Networks.

In the present case a supervised, learning-with-a-trainer approach was adopted. This type of training is characterised by the fact that the networks receive examples of normal operation that they imitate. Besides the input signals, the expected answers (the output signal) should be determined. The network is trained on the basis of the knowledge of the social capital value. The developed network model was trained using back propagation, which is one of the most frequently used and the most effective learning algorithms of multilayer neural network.

Before the final construction of the network was chosen many structures and parameters had been checked. The examined neural networks differed in terms of parameters such as: number of hidden neurons, activation function, learning algorithm etc. Generator STATISTICA Neural Networks allows to implement only one hidden layer. However the considering problem was not so complicated to use two hidden layers. The

proper choice of the number of neurons in the hidden layer is a very essential issue – the excess can cause that the network learns relations on memory; their scarcity may deprive the network’s capacity for learning. Finally, the following ones were adopted as the activation functions: the hyperbolic tangent in the hidden layer and the linear function in the output layer. This choice did not allow for the loss of the prediction ability and it also improved the ability to extrapolate the results.

The summary of the parameters of obtained three-layer perception are presented in the Table 1.

Table 1. Parameters of obtained neural network model

Neural network	Activation function (hidden neurons)	Activation function (output neurons)	Error	Learning algorithm
MLP7-3-1	Hiperbolic tangent $y = tgh\left(\frac{\alpha\varphi}{2}\right) = \frac{1 - \exp(-\alpha\varphi)}{1 + \exp(-\alpha\varphi)}$	Linear $y(x)=ax+b$	Sum of squares (SOS)	BFGS

Table 2 presents the results of predicted value of social capital of Microsoft for fourth quarter of 2014. The data concerning fourth quarter of 2014 were not in the training set, therefore, were not trained in the network learning process. The value of anticipated social capital was provided by proposed MLP 7-3-1.

Table 2. The value of social capital of Microsoft in the fourth quarter of 2014 (in millions USD)

Market value	Book value	Stock price (in USD)	Number of shares	Employment (in units)	Total assets	Liabilities	Social capital (Fund. Eq.)	Social capital (MLP 7-3-1)
X_1	X_2	X_3	X_4	X_5	X_6	X_7	Y	Y^*
382 748	90 170	40.99	8 240	128 000	169 656	79 486	159 416	167 332

The predicted value of social capital (Y^*) in the fourth quarter of 2014 equaled over 167,3 billion USD and was forecasted using obtained three-layer perceptron MLP 7-3-1. The value of social capital (Y) equaled nearly 160 billion USD and was calculated using Fundamental Equation. The difference between those values is only about 5%. This result authenticates proposed model as a reliable tool for credible estimations of the social capital value.

6 Conclusions

The United States of America has the most advanced software industry and IT services in the world. Companies operating in the US software market operate on well-developed and harmonized market. They provide reliable and effective solutions. They are the market leader in proprietary software (package software) and in custom software and are competitive in almost all segments of the IT market. Currently, about 75% of the largest software companies in the world has its headquarters in the United States. Although the software market in Europe and Asia is growing fast, it will not change the US hegemony in the software world, because the American giants of the IT industry have enough funds to buy the attractive, fast-growing software companies in Europe and Asia. It is generally known that success and competitiveness of IT company, including Microsoft, depends mostly on its employees: analysts, developers, software engineers etc. Microsoft, as the largest software manufacturer in the world, appears as a typical company of the knowledge-based economy in a sense that about a half of its market value is produced by its social capital.

This contribution examined using fundamental equation and proposed artificial neural network for modeling and estimating the value of social capital of Microsoft. The results of the conducted survey confirmed the research hypothesis that intangible assets are the most valuable resource of IT company. Further research will focus on the feasibility of the application of the neural network model to assess the social capital values of the other IT giants: IBM, Oracle, Novell, SAP, etc.

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ROLA KAPITAŁU SPOŁECZNEGO W NOWOCZESNYM PRZEDSIĘBIORSTWIE INFORMATYCZNYM

Streszczenie. Zasadniczym celem artykułu jest omówienie roli kapitału społecznego przedsiębiorstwa informatycznego, na przykładzie firmy Microsoft. Przedstawiono historyczne spojrzenie na kapitał ludzki i społeczny oraz wskazano prekursorów podejmujących pierwsze rozważania w tej tematyce. Pokazano, że od kilku stuleci zainteresowanie kapitałem ludzkim i społecznym jest ogromne oraz podkreślono konieczność rzetelnego szacowania ich wartości. Omówiono istotę zasady ortogonalności i równania fundamentalnego oraz zastosowano je do oszacowania wartości kapitału społecznego firmy Microsoft. Otrzymane wyniki porównano z obliczeniami wykonanymi z zastosowaniem opracowanej przez autorkę sztucznej sieci neuronowej MLP 7-3-1.

Słowa kluczowe: kapitał społeczny, sztuczne sieci neuronowe, równanie fundamentalne, zasada ortogonalności

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