SOFT COMPUTING FOR MODELLING
THE VALUE OF SOCIAL CAPITAL AT RED HAT

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Abstract: The main objective of this paper is to predict the value of social capital at Red Hat Corporation, using a developed neural network model. Training data were collected and calculated based on balance sheets published for the years 2005 - 2012. Five variables were proposed as an input of the neural network. The output variable presented the value of social capital, calculated by fundamental equation [Walukiewicz 2006]. The artificial neural network had been trained in Statistica Automated Neural Network.

Keywords: artificial neural network, social capital, soft computing, open source software

INTRODUCTION

Social capital, which is the most valuable resource of all IT companies, is defined as all the formal and informal relationships between employees: their ability to cooperate, trust, solidarity, loyalty to each other, etc. These are extremely essential features, since the passion, commitment and enthusiasm of engineers developing software determine the success of such applications and company as well. That is why the competent and reliable measurement of those assets value should therefore be one of the priorities of the IT company. Literature presents and characterises plenty of tools which allow the evaluation of social capital. However, no widely accepted method using soft computing has been proposed so far. In 2013 the author applied an interesting method and conducted the analysis of using an artificial neural network to assess the value of social capital in IT companies [Siderska 2013]. This paper investigates the prediction of the value of social capital at Red Hat in the first quarter of 2013, using proposed model of the neural network.

THE HISTORY OF OPEN SOURCE MOVEMENT

To fully understand an open source development and its potential power it is necessary to assimilate some background information on this movement and its main pioneers and activists: Eric Raymond, Richard M. Stallman and Linus Torvalds. The origins of open source software date back to 1965 when a team of scientists from Bells Labs AT&T, MIT and General Electric Company developed a new operating system - Multics. In 1984 Richard Stallman from MIT started developing a free operating system called GNU [Stallman 1995]. One of the leading members of the GNU project, Eric Raymond, published in 1997 the paper "The Cathedral and the Bazaar", which has been recognised as one of the most fundamental texts in the history of open source. The essay proposed new and innovative models of free software development. Raymond discussed his theories in terms of fundamentally different development styles: the cathedral model and the bazaar model [Silvester 1991]. Raymond compared proprietary and commercial software to monumental cathedrals built in concentration and silence. He was convinced that "the most important software (especially operating systems) needed to be built like cathedrals, carefully crafted by individual wizards or small bands of mages working in splendid isolation, with no beta to be released before its time" [Raymond 1999].

Over 20 years ago a Finnish student - Linus Torvalds, decided to develop the new kernel of the operating system - Linux. The success of the software developed by him convinced Raymond that the bazaar model, because of the massive effort undertaken by a large number of developers, would bring profits to both authors and users. The fundamental statement defining bazaar models was an argument written by Raymond: "given a large enough beta-tester and co-developer base, almost every problem will be characterised quickly and the fix will be obvious to someone [Raymond 1999]".

RED HAT CORPOPRATION

Company background

Nowadays the biggest computer company making open source development a key part of its ongoing software strategy is Red Hat Inc. It has its corporate headquarters in the USA with satellite offices worldwide. The flagship product of the company is Red Hat Linux – one of the most popular distributors of the Linux operating system. As of May 31, 2014 Red Hat had approximately 6500 employees worldwide. However, the most important contribution of the company's success has been its developers - volunteers from all over the world. The number of individual developers working on Linux kernel has been increasing over the different versions of the programme. Over 12% of all the Linux kernel development has been done by developers who are employed by Red Hat. Nearly

18% of developers are doing this work on their own, with no financial contribution from any company [Corbet 2012]. Red Hat is the world leader in providing open source solutions for the enterprise community. Red Hat Linux is being disseminated under the GNU General Public License without any fees. However, the company benefits mostly from support and services [Red Hat 2013].

In 2005 Red Hat became a part of the NASDAQ, an over-the counter, regulated stock market in the United States, under the symbol RHAT. In 2006 the company listed its shares on the New York Stock Exchange (NYSE) under the ticker symbol RHT. It boasts a number of powerful customers including Amazon, DreamWorks, Morgan Stanley etc. [Munga et al. 2009]. The company has achieved significant success in the software market. Over the last four quarters, the company's revenue rose by an average of 16% year-on-year. The largest growth was in the first quarter of 2013, when the revenue climbed by 19%. Notably, Red Hat became the first billion dollar open source company in its fiscal year 2012, reaching $1.13 billion in annual revenue [Babcock 2012]. For the past ten years the gross profit (difference between revenue and the cost of making a product or providing a service) has been constantly growing. These values are shown in Figure 1.

Figure 1. Red Hat's gross profit for years 2002 – 2013 (in millions USD)
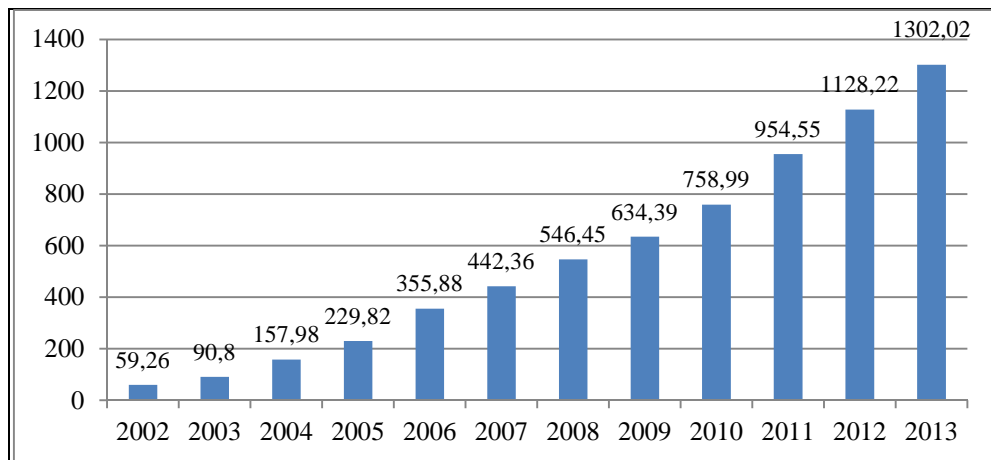
Source: own study (on the basis of annual financial reports)

All those mentioned issues prove that the most precious assets of Red Hat are software engineers, programmers and analysts who developed the Linux kernel. Their human capital builds up the social capital of the whole company, therefore it is essential to assess the value of those intangibles.

Business model

The literature lists and characterises many ways of adopting open source software in business models. Frank Hecker suggested some interesting business models and strategies in his paper "Setting up shop: the business of open source software". He summarised the following business models [Hecker 1999]: Service support seller, Accessorising, Widget frosting, Service enablers, Brand Licensing, Software Franchising, Loss - leader, Sell it, Free it.

Red Hat applied *service support seller* model - the most common business model for companies involved with open source software. The revenue comes from media distribution, branding, training, consulting, and post-sales support instead of traditional software licensing fees. This model was originally recommended by Richard M. Stallman in his GNU Manifesto, with Cygnus Solutions being the first company to implement such solutions. Nowadays the best known vendors applying the business model in question are Red Hat and Caldera Software. In the operating system market the company competes with a limited number of large and well-established companies that have significantly greater financial resources and larger development staff: Microsoft, HP, IBM, Oracle, Google [Wikiinvest.com 2013].

Linux is being developed through the joint effort of thousands of volunteers all over the world. They are creative people who share their knowledge and make constructive criticism of the work of other professionals by developing and improving these applications. The idea behind the development of open and free applications is common, parallel and creative work of a team of experts, who communicate with each other via the Internet. Therefore, such a process is a creative process, since such applications are unique, created for the first time. The informal relations between them make the products more perfect, secure, reliable and with less backbiting and less fallible than flag products of ICT giants (such as the Windows operating system developed by Microsoft). The passion, commitment and enthusiasm of the volunteers determine the success of such applications. Here, the Internet plays an important part: efficient communication and the rapid exchange of ideas between programmers have a significant impact on the progress in the development of such projects.

The value of Red Hat

The discussion of value should start with the notion of social capital (SC), according to Walukiewicz [Walukiewicz 2006]:
social capital (SC) is composed of formal and/or informal relations among workers, teams, organisational units, etc. within a firm (internal relations), as well as formal/informal relations with customers, suppliers, banks, regional/central governments, R&D institutions etc. (external relations).

Moving on, **the market value** of a given firm F at a given moment t, denoted by V(F,t), equals the number of issued stocks multiplied by their current

stock price. In other words, the market value is the price investors are ready to pay for firm F at a given moment t of its present (history), taking into account information about the past.

V(RH,t) will denote the value of Red Hat at a given point in time t. Since the entire capital of the firm is conceived of as consisting of four parts (finance capital, physical capital, human capital and social capital) the following formula can be proposed:

$$V(RH, t) = v(FC, t) + v(PC, t) + v(HC, t) + v(SC, t) \qquad (1)$$

This is called **fundamental equation** as it forms a base of the accounting model for the social capital analysis. The formula says that in a market economy, under the conditions of equilibrium, when demand equals supply, the value of Red Hat equals the aggregate sum of the four component values of its capital: financial, physical, human and social at any moment t of the firm's past, present and future [Walukiewicz 2006].

The market value of Red Hat at a given moment t, denoted by V(RH,t), equals the number of issued stocks multiplied by their stock price. For instance, in 2009 there were 193 024 423 stocks and the stock price closed at $30.49. The market value of Red Hat was hence $5 964 454 671. In other words, the market value is the price investors are ready to pay for a company at a given moment t of its present (history). **The book value** of Red Hat at a given moment t, denoted by BV(RH,t), is defined as the difference between its total assets and its total liabilities, calculated at the end of a reporting period (year, quarter or month), when balance sheets are prepared. Consequently, the book value is a step-wise function of time. Red Hat's book value in 2009 was $1 304 605 000. The book value is commonly understood as the value of the company calculated in accordance with the accounting principles at the moment t defined as above.

For almost all stock exchange listed companies, the market value is higher – in knowledge-intensive sectors much higher - than the corresponding book value. The author claims that the difference between the market value and the book value of each firm is simply the value of a company's social capital. This means that in traditional accounting a significant share of companies' market value is not included on the company's balance sheets. The difference between the market value and the total registered assets equalled $4 659 849 671 ($4.66 billion) in 2009. This means that 78% of the Red Hat's market value was ignored by traditional accounting and not recorded on its balance sheets. It is assumed that 1/3 of this difference is associated with the human capital and the rest with the social capital (software production is team work). Red Hat is a typical company of the knowledge-based economy in a sense that more than a half of its market value is produced by its social capital. The accounting items: goodwill and intangible assets should be considered as an attempt of Red Hat to account for its social capital, but the value of social capital recorded so far is less than 2% of its market value.

ARTIFICIAL NEURAL NETWORK MODEL

The training data contained information concerning each quarter from 2005 till 2012 and were gathered from the balance sheets published by Red Hat Corporation, Microsoft and IBM. Taking into consideration the data concerning these additional two companies, allowed the enlargement of the whole training set – it contained 96 cases (3 companies, 32 quarters - 4 quarters per each year). Moreover, such procedure resulted in an increase in the ability to generalise the data. For artificial neural network the Statistica 10.0 Automated Neural Networks module was used. For instance, the values of input and output variables for the fourth quarter of 2012 are shown in Table 1. All variables are demonstrated in USD, except employment which is shown in units. For simplicity the values of social capital, assets, liabilities, market value and book value are converted to millions of USD. The volume of employment X_3 is presented in units.

Table 1. Values of input and output variables in the fourth quarter of 2012
(in millions of USD)

Market value	Book value	Employment (in units)	Total asssets	Liabilities	Social capital
X_1	X_2	X_3	X_4	X_5	Y
10 231	1 599	4 500	2 492	892	5 622

Source: own study

80% of the data set was chosen for the training set, 10% of the samples constituted the cross-validation set and another 10% of the samples were used for testing. Measures were determined based on the training set and allowed to assess the capacity for approximation. They point to the precision in determining the output variable value for input vectors presented during learning. The most significant is correctness for input vectors that were not presented in the training process (ability to generalise the data).

There is no doubt that artificial neural network performance depends on learning rather than programming. The main use of a neural network is developing models - the formal structures or mapping a process or a phenomenon. The neural network can be an excellent model of any system. The learning process is an iterative process, repeated many times, step by step, with the fundamental objective to optimise the network parameters, i.e. the weighing factors. Each of the input variables initially gets randomly assigned weight, the strength of its effect on the value of the output variable. The values of the weighing factors are determined in the learning process, by which neurons acquire the knowledge and intelligence. The higher the weight, the more important the variable given [Lula et al. 2007].

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 [Lula et al. 2007]. 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. Its essence was based on minimising the sum of squared errors of the network. Errors that occur at the output of the network are propagated in the opposite direction than the signals passing through the network, i.e., from the output layer to the input [Rutkowska et al. 1997]. In the input layer of the network five neurons are analysed, since it is assumed that this is exactly the number of input variables affecting the output variable. The modelling of the social capital value is a regression task, so only one neuron - characterised by the dependent variable - is presented on the output. The analysis covered the following input, independent variables: *market value* - quantitative variable, calculated by multiplying the number of shares and the price per share at the end of the quarter; *book value* - quantitative variable, calculated as the difference between the sum of total assets and the total liabilities; *total assets* - quantitative variable*; liabilities* - quantitative variable; *employment* - a quantitative variable, defined as the number of employees.

The output (dependent) variable represented the value of social capital. Necessary calculations of the social capital value were made using the fundamental equation, formulated by S. Walukiewicz in 2006. Many parameters of the model had been investigated before the final structure was proposed. The author compared many models with different numbers of hidden neurons, the activation function, the learning algorithm etc. Table 2 presents a summary of the parameters of obtained three-layer perceptron. These parameters allowed to accomplish the best quality in the validation set.

Table 2. Parameters characterising the proposed neural network model

Neural network	Activation function (hidden neurons)	Activation function (output neurons)	Error	Learning algorithm
MLP 5-3-1	Tanh	Linear	SOS – sum of squares	BFGS

Source: own study

The results of social capital value estimated using the fundamental equation and using the constructed model, the MLP 5-3-1 network, were compared. For this purpose, the function: *predictions for new data* was used. The value of the predicted social capital has been provided by the trained neural network.

Table 3 presents the results of the predicted value of social capital (Y*) of Red Hat for the first quarter of 2013.

Table 3. The value of social capital in the first quarter of 2013 (in millions of USD)

Market value	Book value	Employment (in units)	Total asssets	Liabilities	Social capital (Fundamental Equation)	Social capital (MLP 5-3-1)
X_1	X_2	X_3	X_4	X_5	Y	Y*
9 229	1 499	5 500	24 845	986	4 955	5 121

Source: own study

The anticipated value of social capital (Y*) in the first quarter of 2013 was predicted using the proposed three-layer perceptron MLP 5-3-1. The value of social capital (Y) was calculated using Fundamental Equation. The difference between those values is only about 4%. Those values authenticate the proposed method as a reliable tool for credible estimations of the value of social capital.

SUMMARY

Artificial intelligence tools, including neural networks, are increasingly being used not only in the areas of engineering (pattern recognition, signal processing, control, optimisation), but also in economics and management. Neural network models are often used in the forecasting of economic phenomena, such as in predicting trends in the stock market, sales forecasting, pricing, identifying risks of the granting of credit. Artificial neural networks are among the methods of data analysis which are a very powerful application and are therefore increasingly used as an alternative to traditional analytical methods, providing more reliable results [Tadeusiewicz, 1993].

The human factor is the most precious resource of any company from the ICT sector, including Red Hat. Despite numerous methods for estimating the social capital value, no widely accepted tools have yet been proposed. At the same time, no soft computing techniques for modelling the value of social capital as well as for analysing the independent (explanatory) variables have been developed either. This paper presents the draft of an artificial neural network for modelling the value of social capital at Red Hat.

Further research will focus on the feasibility of the application of a neural network model as was built for the world's biggest companies in the information technology industry: Microsoft, IBM, Oracle, Novell, SAP. Moreover, it would be interesting to develop a similar tool (using soft computing) to assess the value of social capital of companies whose shares are not listed on the stock exchanges.

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