Economic-mathematical methods for evaluating the performance of corporate social responsibility

Natalya Simchenko

National Technical University of Ukraine „Kyiv Polytechnic Institute", 37 Peremohy ave., Kyiv, 03056 Ukraine,
e-mail: solnce.hp@gmail.com

The aim of this paper is to examine the applying of economic-mathematical methods for evaluating the performance of corporate social responsibility in Ukraine. We identified a set of quantitative and qualitative indicators which can estimate the state of socially oriented business management. The results of the integral indicators calculating of socially oriented management allowed defining the coefficients which show the level of company's reputation. The applying of fuzzy sets theory, methods of cointegration analysis, correlation analysis and multiple regression allowed evaluating the performance of corporate social responsibility. The most important activities which impact on the performance of corporate social responsibility are good business practice in relation to suppliers and other business partners, competency management system, charity, sponsorship activities and regional employment rate.

Keywords: corporate social responsibility, company's reputation, fuzzy sets theory, methods of cointegration analysis.

Introduction

Corporate social responsibility (CSR) is one of the key factors for creating an effective dialogue between the government, business and civil society. The development of CSR displays the level of partnership between companies, governments and main persons of civil society in solving social problems and accelerating the quality development of society.

Conceptual development of term 'corporate social responsibility' is represented in surveys of the famous foreign scientists such as Blundel, Carroll, Spence L., Schwartz, Steurer, Van Marrewijk, Velasquez, Wood and others. Modern literature uses the CSR concept as the base point, building block, or point-of-departure for other related concepts and themes, many of which embraced CSR-thinking and were quite compatible with it [1–3]. CSR, stakeholder-theory, business ethics theory, and corporate citizenship were the major themes that took center stage in the surveys [4, 5]. Corporate social responsibility is not the same as ethical behaviour, but it is 'an important component of such action' [6]. The European Commission has put forward a new, simpler definition of corporate social responsibility as 'the responsibility of enterprises for their impacts on society' [7]. At the same time the term of corporate social responsibility has been clearly defined in ISO 26000:2010. Due to this international standard social responsibility is 'responsibility of an organization for the impacts of its decisions and activities on society and the environment, through transparent and ethical behaviour that contributes to sustainable development, including health and the welfare of society; takes into account the expectations of stakeholders; is in compliance with applicable law and consistent with international norms of behaviour; and is integrated throughout the organization and practised in its relationships' [8].

It should be noted, that an organization's performance in relation to the society has become a critical part of measuring its overall performance and its ability to continue operating effectively. The perception of an organization's performance on social responsibility 'can influence, among other things: its competitive advantage; its reputation; its ability to attract and retain workers or members, customers, clients or users; its relationship with companies, governments, the media, suppliers, peers, customers and the community and so on' [8].

In Ukraine the majority of companies is not aware of their role and responsibility in the social-economic development of the country. The social partnership

between companies, business, government and community of Ukraine is characterized by fragmentariness and lack of systematicness. Nevertheless, the most successful enterprises start to put attention to aspects such as company's reputation, corporate brand, corporate loyalty of staff, sustainable development. Ukrainian businessmen suggest that social activity can improve the company's reputation but deny the necessity of realization of CSR programs on a voluntary basis.

Problem definition

Evaluation of the impact of corporate social responsibility on company's reputation can be divided into three parts, and each of them can be treated as hypothesis:

— *Hypothesis 1:* "Strategy of corporate social responsibility aims to create conditions favourable to sustainable growth and employment generation in the medium and long term".
— *Hypothesis 2:* "The impact of CSR programs on company's business reputation should be evaluated with the using of economic-mathematical methods of fuzzy sets".

Our aim was to adjust existing economic-mathematical methods of analysis for evaluation of the impact of corporate social responsibility on company's reputation and testing mentioned hypotheses.

Taking into account the complexity of social-economical researches of corporate social responsibility,

it is important to make economical measuring the impact of corporate social responsibility on company's reputation with adjusting of economic-mathematical methods for this evaluation. The international standard ISO 26000:2010 "Guidance on social responsibility" was taken into consideration in the process for applying of the evaluating methods.

The simulation of the impact of corporate social responsibility on company's reputation

This study is based on results of activities of 57 industrial enterprises in four areas of engineering (heavy engineering industry, chemical engineering, electrical engineering, mechanical engineering) in three regions of Ukraine (Eastern, Western, Central). The results of researches are based on surveys and questionnaires of managers. 175 people were involved in the process of the research, 75 of whom worked as managers in big companies, 46 in medium enterprises and 54 in small firms.

CSR evaluation process is one of the main conditions in effective simulation of impact of social indicators on business reputation's level. In economics, a model is a theoretical construct that represents economic processes by a set of variables and a set of logical and/or quantitative relationships. We identified a set of quantitative and qualitative indicators which can estimate the level of socially-oriented business management (Table 1 about here).

Table 1. The quantitative and qualitative indicators of CSR evaluation process

| Quantitative indicators		Qualitative indicators	
Marking	Indicator	Marking	Indicator
x_1	Net profit	y_1	Social policy of enterprise
x_2	Net income	y_2	Quality of corporate management system
x_3	Net Assets	y_3	Level of top management competence
x_4	Share ratio of assets	y_4	System of training and staff development
x_5	Share of fixed assets in total assets	y_5	Level of employees' social protection
x_6	Return on assets	y_6	Corporate Culture
x_7	Return on equity	y_7	Business practices in relation to consumers
x_8	Profitability	y_8	Business practices in relation to suppliers and other business partners
x_9	Value Debt and equity	y_9	Correspondence with legislation of Ukraine
x_{10}	Gross profit margin	y_{10}	Regularly compilation of social accounting
x_{11}	Liquidity	y_{11}	Regional employment rate
x_{12}	Number of employees	y_{12}	Implementation of environmental programs
x_{13}	Labour productivity	y_{13}	Participation in regional social development programs
x_{14}	Labour costs	y_{14}	Charity and sponsorship
x_{15}	Salary	y_{15}	Informatization of social programs implementation
x_{16}	Net revenue per employee		
x_{17}	The share of voluntary social costs in net income		
x_{18}	The share of social costs in total costs		
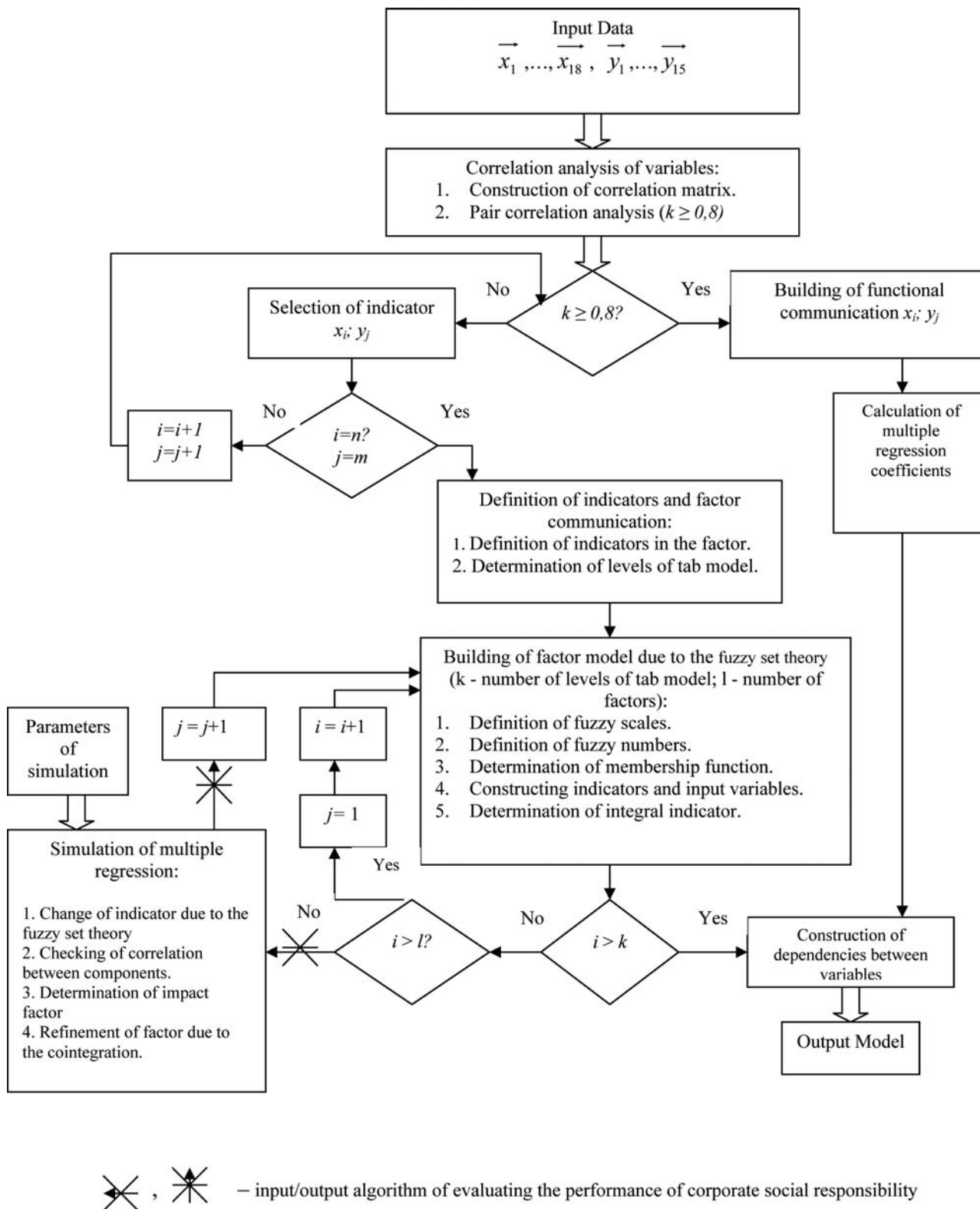
Fig. 1. The economic-mathematical algorithm of evaluating the performance of corporate social responsibility.

Setting thresholds for quality indicators of socially-oriented management were also defined in the work. We have analyzed key performance indicators of industrial enterprises in four areas of engineering (heavy engineering industry, chemical engineering, electrical engineering, mechanical engineering) in Eastern, Western and Central regions of Ukraine for 2004–2009. The complex and ambiguous dependency between different groups of quantitative and qualitative indicators was defined. In such way, we decided to use the methodology of fuzzy sets in the analysis of parameters that have indirect statistical relationships among the indicators of measuring of corporate social responsibility.

In fact, the fuzzy set theory allows for approximate values and inferences as well as incomplete or ambiguous data (fuzzy data) as opposed to only relying on crisp data (binary yes/no choices). Fuzzy logic is able to process incomplete data and provide approximate solutions to problems other methods find difficult to solve [9]. Figure 1 presents the algorithm of evaluating the performance of corporate social responsibility.

To evaluate the impact of quantitative and qualitative indicators of CSR on company's reputation it is worth applying the correlation analysis to the evaluation of mutual influence of quantitative and qualitative indicators. Let us suppose that x_i, $i = 1, …, n;$ are the quantitative indicators and y_j, $j = 1, …, m$ are the qualitative indicators. In addition, the input data have the set of autocorrelation relationships. It should be noted that some coefficients in the matrix of pair correlations are linearly depended. In this way the determinant of matrix is equal to zero. Thus, it is necessary to make a rejection of input data for the level of pair correlation parameter k > = 0,7–0,8 for groups of variables x_i and y_j, which are the elements of correlation matrix K = || kx_p, x_q ||:

$$kx_p, x_q = cov\ (x_p, x_q)/(D[x_p^2]*D[x_q^2]), \qquad (1)$$

where: $cov\ (x_p, x_q)$ — the covariance between the sets of variables x_p, x_q;
$D[x_p^2]$, $D[x_q^2]$ — the variance of variables.

Furthermore, the correlation between data which is less than level k, can be united in groups to determine the indicators by fuzzy sets method. If the correlation between the data is more than level k, then these data should be analyzed to find out the linear statistical relationship. In addition, these data are characterised by approximating linear dependence in the form: $x_p = a*x_q + b$, або $y_p = c*y_q + d$. Thus, the results of correlation analysis allow defining the pair of functions:

$$X \rightarrow f \in \{d1,…,dl\} \qquad (2)$$

$$Y \rightarrow g \in \{h1,…,hk\}, \qquad (3)$$

where — {d1,…,dl}, {h1,…,hk} — sets of l and k elements which are created due to the correlation characteristics.

It is important to define the fuzzy scale of features classification and select the type of fuzzy number [10]. Let us choose the 5-interval scale classification of fuzzy sets, namely: «VL» — a very low level of indicator (30%), «L» — low level of indicator (50%), «M» — satisfactory level of indicator (70%), «H» — high level of indicator (80%), «VH» — very high level of indicator (90%).

In addition, the trapezoidal fuzzy numbers (T number) with variable threshold data 0,3 ± a; 0,7 ± b must be defined. The factor model will be based on indicators which can be represented by 20-bit fuzzy number.

Determining the membership function $\mu \in \{0; 1\}$ is based on histogram which characterises the entering of input data in the observed interval fuzzy scale.

The membership function can be described as:

$$\mu_i^j(X,Y,Z), \qquad (4)$$

where: X, Y — input variables;
Z — output variable,
i — input indicator,
j — term of 5-interval scale.

Moreover, the method of multiple regressions was applied to define the influence coefficients. The quantitative and qualitative indicators of socially oriented management in the 16 enterprises were defined in different regions of Ukraine. The data for analysis of level of social orientation which were used in the process of social orientation defining are represented in Tables 2–3.

Due to the results of researches, four groups of variable sets: $x_2 = f_1 (x_3, x_{11})$, $x_{13} = f_2 (x_3, x_{11})$, $y_1 = f_3 (y_5)$, $y_2 = f_4 (y_8)$ and two levels of tab model were designed and demonstrated the correlation matrix and linear approximation between the dependences of variables: first level of tab model: $x_2 = f_1 (x_3, x_{11})$, $x_{13} = f_2 (x_3, x_{11})$, $y_1 = f_3 (y_5)$, $y_2 = f_4 (y_8)$; second level of tab model: $z_1 = f_5 (x_2, x_{13}, y_1, y_2)$, where z_1 — company's reputation.

Furthermore, according to the levels of tab model, impact coefficients of social responsibility on company's reputation were simulated (Fig. 2).

As shown in Fig. 2, the most influential factors which cause the improving of corporate reputation are business practices in relation to suppliers and other business partners (y_8), level of top management competence (y_3), charity and sponsorship (y_{14}), participation in regional social development programs (y_{11}). The levels of companies' reputation are represented in Table 4.

It should be noted that there are only two enterprises of all which have the highest level of company's reputation. Such results are conditioned by high share of social costs in total costs, active participation in regional social development programs, high level of top management competence, development of corporate culture, business practices in relation to consumers and other measures.

In addition, the forecasting of the company's reputation change was made. The methods of Bartlett and Thompson were used in forecasting process of the company's reputation. The stabilization, falling and rising scenarios were offered for 2013–2015.

Social Sciences in Technology

Table 2. Quantitative indicators of socially oriented management (mechanical engineering enterprise, central region of Ukraine).

Indicators	Years				
	2006	2007	2008	2009	2010
Net profit	15,616.00	22,662.00	23,866.00	17, 291.00	8,279.00
Net income	389.00	237.00	252.00	178.00	-11.00
Net Assets	4,171.00	4,312.00	4,475.00	4,645.00	4,602.00
Share ratio of assets	52.00	42.00	43.00	42.00	47.00
Share of fixed assets in total assets	6.00	10.00	11.00	9.00	7.00
Return on assets	7.20	2.75	3,42	2,27	0,14
Return on equity	9,33	5,49	5,84	3,98	-0,24
Profitability	2.00	1.00	1.00	1.00	0.00
Value Debt and equity	107.00	71.00	75.00	72.00	89.00
Gross profit margin	8.00	8.00	8.00	8.00	12.00
Liquidity	176.00	202.00	187.00	204.00	186.00
The number of employees	173.00	179.00	166.00	165.00	143.00
Labour productivity	90,26	126,38	143,77	104,79	57,89
Labour costs	2,343.00	3,678.00	4,608.00	4,311.00	3,152.00
Salary	1,128.61	1,712.29	2,400.00	2,245.31	1,641.67
Net revenue per employee	90.27	126.60	149.16	108.07	51.74
The share of voluntary social costs on social programs in net income	0,21	0,29	0,49	0,36	0,31
The share of social costs in total costs	3,98	4,02	5,07	4,96	3,85

Table 3. Qualitative indicators of socially oriented management (mechanical engineering enterprise, central region of Ukraine).

Indicators	Years				
	2006	2007	2008	2009	2010
Social policy of enterprise	0,4	0,5	0,7	0,6	0,6
Quality of corporate management system	0,45	0,3	0,6	0,7	0,8
Level of top management competence	0,5	0,8	0,7	0,7	0,6
System of training and staff development	0,6	0,4	0,6	0,5	0,5
Level of employees' social protection	0,5	0,3	0,2	0,2	0,3
Corporate Culture	0,2	-0,2	0,4	-0,3	0,1
Business practices in relation to consumers	0,7	0,6	0,6	0,5	0,5
Business practices in relation to suppliers and other business partners	0,5	0,7	0,8	0,2	0,4
Correspondence with legislation of Ukraine	0,5	0,4	0,4	0,2	0,3
Regularly compilation of social accounting	-0,5	-0,5	-0,5	-0,4	-0,1
Regional employment rate	0,008	0,056	0,015	0,02	0,025
Implementation of environmental programs	0,7	0,5	0,6	0,2	-0,2
Participation in regional social development programs	0,2	0,2	0,2	0,4	0,3
Charity and sponsorship	0,2	0,3	0,4	0,2	0,25
Informatization of social programs implementation	0.1	0,3	0,2	-0,1	-0,2

Moreover, we proposed three levels of company's reputation: high level ($z \in (0,7–1]$); satisfactory level ($z \in [0,4–0,7]$); critical level ($-0,3 < z < 0,4$). The results of forecasting were corrected by using the methodology of cointegration analysis with the Dickey–Fuller test. The results of forecasting of satisfactory level of company's reputation based on the rising scenario for the mechanical engineering enterprise are represented in Fig. 5. The implementation of economic forecasting with mathematical methods allowed defining the strategies of socially-oriented development in mechanical engineering companies in the long-term period.

All things considered, there are key factors which make the significant impact for the company's reputation: quality of corporate management system, level of top management competence, business practices in relation to consumers, business practices in relation to suppliers
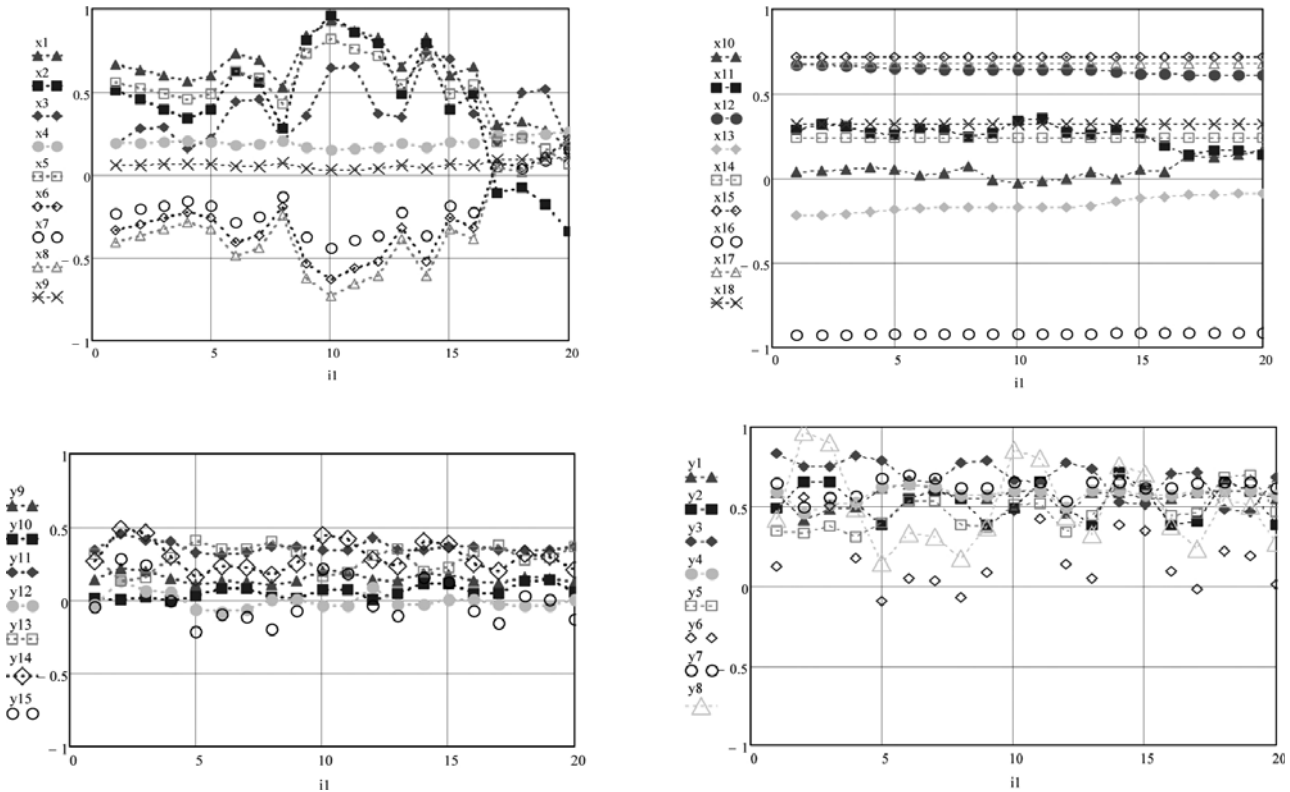
Fig. 2. Impact coefficients of social responsibility on company's reputation (mechanical engineering enterprise, central region of Ukraine).

Table 4. The levels of companies' reputation.

Region of Ukraine	Scope of activity	Level of reputation
Central	mechanical engineering enterprise	0.85
	electrical engineering enterprise	0.53
	chemical engineering enterprise	0.73
	mechanical engineering enterprise	0.54
	mechanical engineering enterprise	0.57
South-Eastern	heavy engineering industry enterprise	0.97
	heavy engineering industry enterprise	0.92
	mechanical engineering enterprise	0.30
	heavy engineering industry enterprise	0.40
	heavy engineering industry enterprise	0.96
	mechanical engineering enterprise	0.31
	mechanical engineering enterprise	-0.62
	electrical engineering enterprise	0.52
Western	electrical engineering enterprise	-0.56
	chemical engineering enterprise	0.97
	heavy engineering industry enterprise	0.37

and other business partners, implementation of environmental programs, participation in regional social development programs, charity projects and so on. However, these social factors must not deny the priority of economical interests of an enterprise. In this way the results of our researches confirmed our hypothesis that impact of CSR programs on company's business reputation should be evaluated with the use of economic--mathematical methods of fuzzy sets. Thus, the features of socially oriented enterprises are characterised by validity and trustworthiness.

Conclusions

Current paper represents the main ideas for applying of the economic-mathematical methods for evaluating the performance of corporate social responsibility. Such economic-mathematical methods as the method of fuzzy

sets, method of cointegration analysis, methods of correlation analysis and multiple regression were used to evaluate the performance of corporate social responsibility. The implementation of economic forecasting with mathematical methods allowed defining the strategies of socially-oriented development in mechanical engineering companies in the long-term period. The most important activities which impact on the corporate reputation are quality of corporate management system, level of top management competence, business practices in relation to consumers, business practices in relation to suppliers and other business partners, implementation of environmental programs, participation in regional social development programs, charity projects and so on. However, these social factors must not deny the priority of economical interests of an enterprise. In this way the results of our researches confirmed our hypothesis that impact of CSR programs on company's business reputation should be evaluated with the use of economic--mathematical methods of fuzzy sets.

In Ukraine, social responsibility business begins to develop and requires the adoption of civilization legislative acts. Ukrainian legislation provides the mandatory levy of social payments in budget, however, this process is accompanied by lack of business motivation to realize social and ecological programs on a voluntary basis. The share of mandatory social payments is nearly 41,7% of enterprise' net in fact. By doing this the majority of employers try to implement the 'shadow' wages. In addition, Ukrainian legislation provides the minimum set of preferences which can increase business motivation to implement the socially oriented projects.

The justification of maintaining the company's reputation remains conditional on maximising profit. Further, there is potential for this situation to undermine the reputation of all companies claiming to act responsibly, because the community knows that profit remains the only real bottom line. For this reason, the law needs to be relaxed to allow company directors to make decisions based on social and environmental grounds without having to justify them also on fiduciary grounds. Currently, enterprises making socially or environmentally based decisions must justify them based on shareholder interests. It is better in the long run. By behaving in a socially responsible manner, an enterprise can earn a good reputation.

The company can increase profitability while the community recognises that the company is acting responsibly. The results of researches allowed defining the most important activities which impact on the corporate reputation are quality of corporate management system, level of top management competence, business practices in relation to consumers, business practices in relation to suppliers and other business partners, implementation of environmental programs, participation in regional social development programs, charity projects and so on.

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