

SOCIAL CAPITAL EVALUATION OF INDUSTRIAL ENTERPRISES

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Abstract

The basic of this research is the social capital evaluation of the enterprise. Social capital, unlike other kinds - is an intangible capital, which makes it impossible to use classic methods to evaluation. Therefore, in this paper, the linguistic variable that refers to the method of fuzzy sets is used for social capital evaluation. Two fuzzy evaluation models of social capital: external and internal was developed in the research. As a result of evaluating quantitative values general indicators of external and internal social capital, its level of quality and accuracy, degree of affiliation quantitative importance of internal and external social capital, its quality level was obtained, the output value of linguistic variable was received.

Keywords: social capital, social capital evaluation, internal social capital, external social capital, method of linguistic variable.

INTRODUCTION

Currently formation of the theory of social capital are carried. The concept of "social capital" in the modern scientific revolution by P. Bourdieu (Bourdieu, 1986), James. Coleman (Coleman, 1988), R. Putnam (Putnam, 1993), F. Fukuyama (Fukuyama, 1999) are introduced. Methodology of social capital evaluation and theory of social capital was developed together. However, despite the fact that many aspects of social capital discussed and considered by many scientists, methodical support of its research is not formed yet, "quantitative research of the phenomenon of" suffered "from the imperfection of methodology and data quality" (Doronina, 2006). In their works, D.Narayan and M.Vulkok noted that accuracy evaluation of social capital is still small. Easy ways of complex relationships measuring are dangerous

because of their grounds can be made hasty conclusions, and poorly defined objects and borders analysis are endangering the very essence research. The first attempts to social capital evaluate took place at the macro level. Two main approaches to the evaluation of social capital that exist in the world by offering its own third approach was singled out by F. Fukuyama (Fukuyama, 1999). First - improved approach by R. Putnam provides censuses groups that operate in this scenario society and membership in these groups. The complexity of this approach lies in the impossibility of determining the number of groups (which now include groups participating in online discussions, chats, etc.) And in the analysis of quality of relationships within these groups. The second approach to the social capital evaluation involves the use survey data level of trust and civil society, such as "World Values Survey". The third possible way of social capital measuring, by F. Fukuyama - determining the difference in market assessment before and after acquisitions. According to the method R. Rose evaluation social capital is based on using of data-depth survey of the population participated in formal and informal networks their target guidance.

Methods of social capital evaluation in the family (D. Coleman, 1999) provides the following evaluation criteria: 1) the physical presence of both parents in the family; 2) the quality and amount of attention that adults paid to children.

Conducted research showed that by present day practical attempt to social capital cost evaluation at the micro level are almost absent. Research on this issue is largely theoretical. M. Fafchamps and B. Minten (Fafchamps, Minten, 1999) propose econometric method for social capital evaluation firms traders operating in the the agricultural sector, based on the production function.

So for social capital evaluation and analysis is necessary to use tools that would allow it to take into account the intangible nature.

METHODOLOGY

Currently, social capital acts as an important resource that stimulates innovation and practical transformation at all levels of social development, including separate enterprise level. Therefore, particular significance is science-based analysis and assessment of social capital, which by its nature is intangible capital and there are no clear quantitative characteristics. Proceeding from this it is not possible using classical models for its evaluation that creates objective conditions for the use of methods and models which are capable to work processes and phenomena that are characterized by uncertainty. These methods include fuzzy sets theory methods.

The internal and external social capital evaluation author appropriate considers to use the motivated linguistic variable method in the theory of fuzzy sets and fuzzy logic. Main stages of fuzzy logic are:

1. Input parameters fuzzification (determining the values) when are specified "clear" variable values of input for which values of the corresponding membership functions are calculated.
2. Rules base formation (Knowledge Base) fuzzy inference system, which is based on rules such as "if-then".
3. Aggregation (composition). At this stage, constructed "truncated" variable output membership functions, which are combined together to form one fuzzy set. This construction is carried out for each of input variable. Then constructed fuzzy set for final output variable.
4. Defuzzification (bringing sharpness). At this stage get a clear value of the output variable (Semenenko, 2013).

Two fuzzy evaluation model of social capital: external and internal in survey has been developed. General indicators external and internal levels of social capital are basic linguistic variables, partial indicators: network in the external environment; trust in network in the external environment, reputation; values, norms in the external environment; internal network; trust, reputation in the internal environment; corporate values, norms in the internal environment – are the input linguistic variables.

An expert survey is suggested for determining importance of internal and external components of social capital. This will help to identify the most significant aspects of the abovementioned problem, increase reliability, information and conclusions justification. Adequacy of expert opinions depends entirely on experts' numbers that participate in the survey. Minimum needed number of experts is calculated by the formula (Koshevoj, 2012):

$$N_{\min} = 0,5 \left(\frac{3}{d} + 0,5 \right)$$

where N_{\min} – minimum needed number of experts,

d – possible error of the expertise results ($0 < d < 1$).

If marginal sampling error is equal 0,01, then the calculated number of experts will be equal 15.

The success of the application of fuzzy set theory depends on the correct construction law of distribution and membership function. The process of finding membership function of fuzzy sets (terms) based on input called fuzzification (Rossoshanskaja, 2009). Construction of membership function carried out a survey of experts (Norvich, 1986). In this case is entered linguistic variable "indicator level X_i ", which takes the value "low level of indicator X_i ", "medium level indicator X_i ", "high level indicator X_i ". In most cases the experts representing partial criteria to describe linguistic level, using opinions about the degree of expression of positive (or negative) effect of certain parameters of its growth. On this basis, the membership function is constructed that the interval $[0, 1]$ reflects the degree of expression parameter that is given verbally (Diligenskij, 2004).

In a survey of experts used the nominal scale, which implements the simplest type of measurement. In this case, comparison between the properties of the object, the result is sorting binary scale are conducted, where 1 means belonging to terms that reflect the quality of the input level indicator, 0 - no accessories.

ANALYSIS & FINDINGS

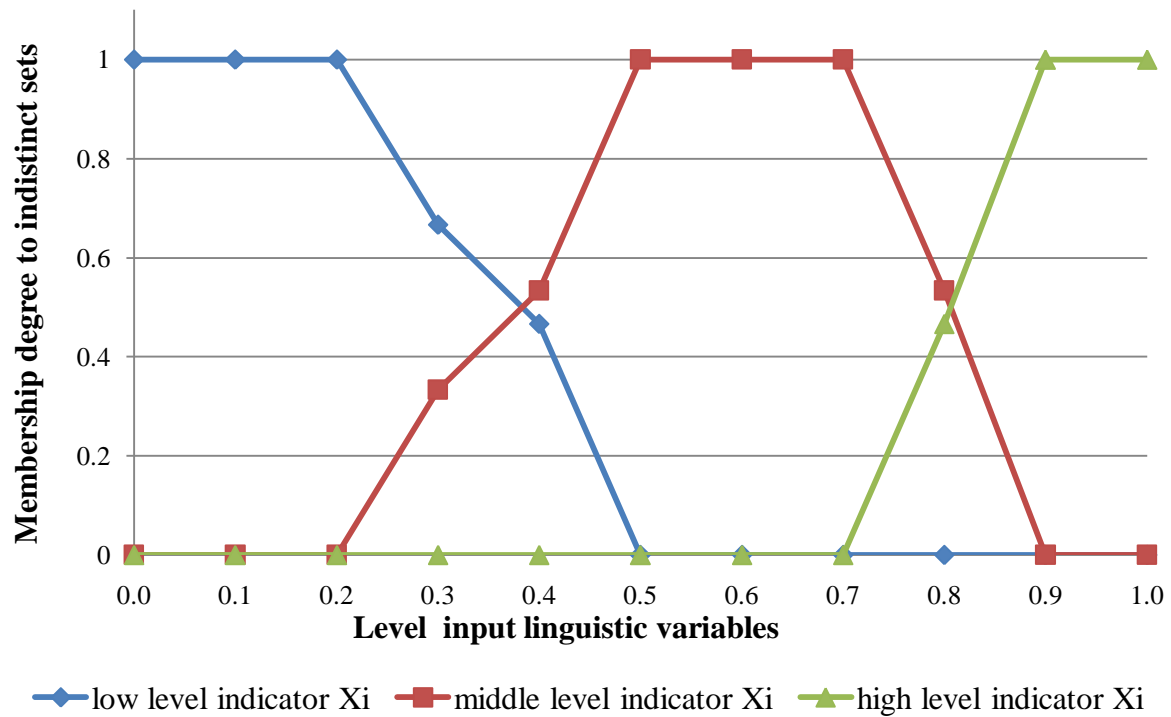
Calculating the degree of membership fuzzy set conditions of input variables is by processing the results survey of experts using generalized estimation, defined as the ratio of the amounts of points assigned by experts for each element of the universal set to the total number of experts (Tukkel', 2003). The results of processing of expert opinion are given in Table 1.

Table 1 The results of processing of expert opinions

Qualitative levels of input indicators	The amounts of points assigned by experts for each element of the universal set									
	Accessories degree of quantitative to quality indicator levels									
	Quantitative levels of input indicators									
	0-0,1	0,1-0,2	0,2-0,3	0,3-0,4	0,4-0,5	0,5-0,6	0,6-0,7	0,7-0,8	0,8-0,9	0,9-1
Low	15,00	15,00	10,00	7,00	0,00	0,00	0,00	0,00	0,00	0,00
	1,00	1,00	0,67	0,47	0,00	0,00	0,00	0,00	0,00	0,00
Middle	0,00	0,00	5,00	8,00	15,00	15,00	15,00	8,00	0,00	0,00
	0,00	0,00	0,33	0,53	1,00	1,00	1,00	0,53	0,00	0,00
High	0,00	0,00	0,00	0,00	0,00	0,00	0,00	7,00	15,00	15,00
	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,47	1,00	1,00

The membership functions graphics terms of linguistic variable "level indicator X" for of input linguistic variables, based on the results of the processing of expert opinion, is shown in Fig. 1.

Figure 1. The membership functions terms of linguistic variable "level indicator X" for of input linguistic variables



The graphs membership functions for processing the results of expert opinion allowed to set that the proposed membership function refers to the trapezoidal type. The parameters trapezoid function is a tuple $[abcd]$, where a and d describe the basis of the lower trapezoid, and b and c - upper base of the trapezoid (Shtovba).

So if linguistic variable takes the value of "low level indicator Xi", the parameters of membership function is equal to $[0\ 0\ 0.2\ 0.5]$; when it takes the value "middle level indicator Xi" parameter is $[0.2\ 0.5\ 0.7\ 0.9]$; in its meaning of "high level indicator Xi" - $[0.7\ 0.9\ 1\ 1]$.

Determining the of membership functions of linguistic variable "level indicator Xi" based on the method of statistical processing of expert opinion makes it possible to quantitatively describe the quality level scale for assessment of internal and external social capital firms. Thus, the quality level of "low" for internal and external components of social capital corresponds fuzzy quantitative range $0 - 0.5$; quality level "medium" - the interval $0.2 - 0.9$; quality level "high" – the interval $0.7 - 1$.

Methodical Approach of the evaluation the level of social capital proposed to implement based on Fuzzy Logic Toolbox component of Matlab 7.11 software. Fuzzy Logic module allows to build fuzzy system of two types - Mamdani and Sugeno. To solve the problem of fuzzy modeling of external / internal social capital is proposed to use fuzzy logic algorithm of Mamdani type. The result of determining input linguistic variables for external social capital (networks in the environment, trust in the external environment, reputation, values, norms in the external environment) and internal social capital (networks of internal environment, trust, reputation in the internal environment, corporate values, norms in internal environment) for fuzzy systems evaluation of social capital in MatLab environment shown in Fig. 2.

Figure 2. Graphs of membership functions terms of input linguistic variable "level indicator Xi"
a) for internal capital

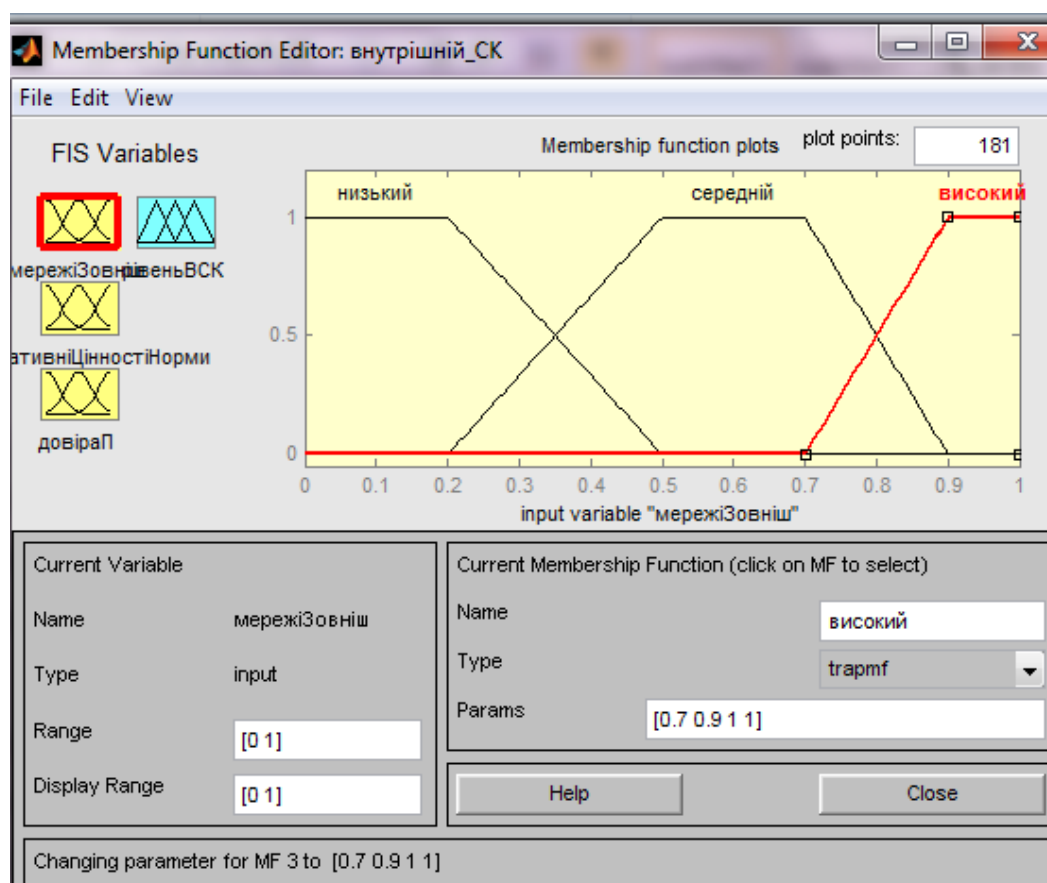
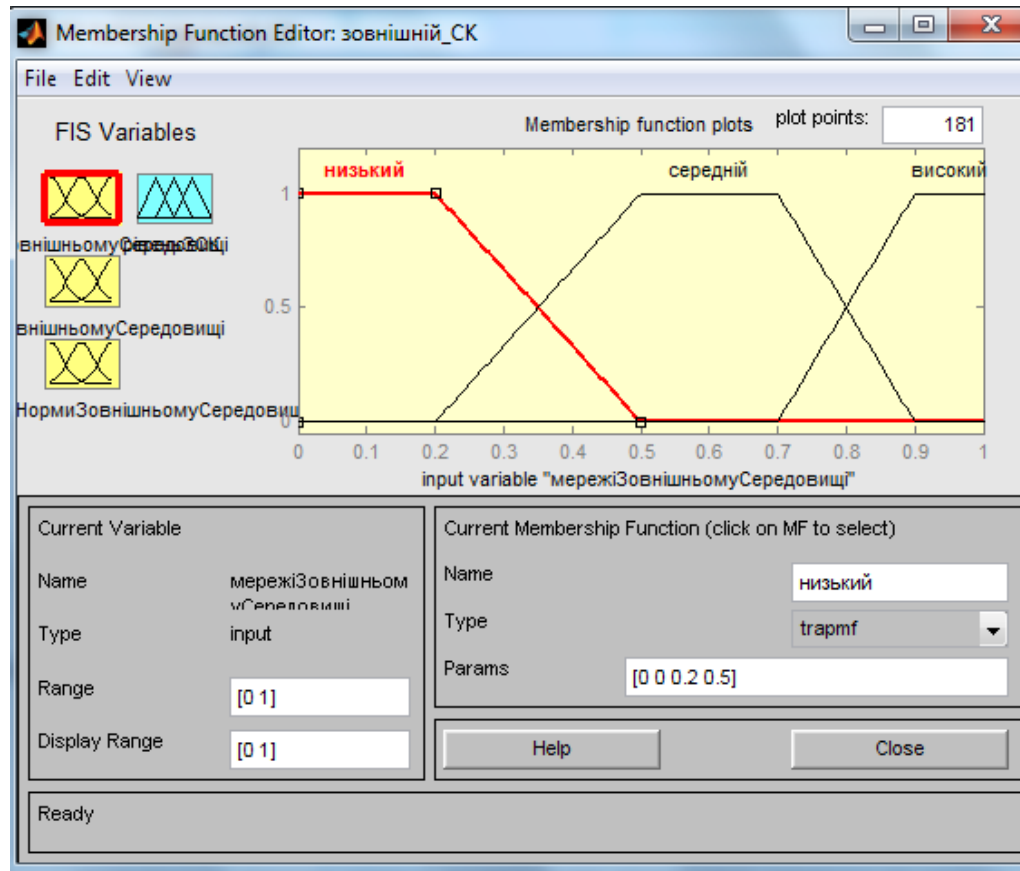


Figure 2. Graphs of membership functions terms of input linguistic variable "level indicator Xi"
b) for external capital

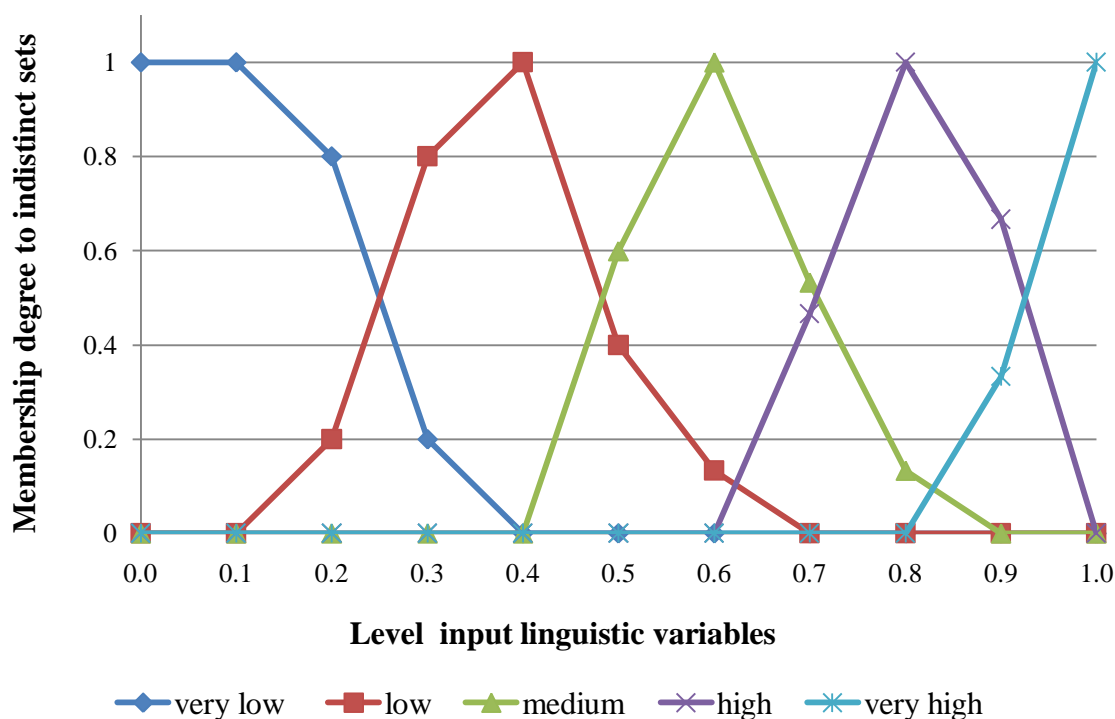


By analogy on the basis of statistical processing of expert opinions presented in tabl.3.4 was conducted fuzzification output linguistic variables "level of internal social capital" and "level of external social capital", taking five values: "very low" "low", "medium", "high", "very high". As a result of processing of expert opinion the certain degree of membership to the output variable fuzzy subsets (Table. 2), on which constructed graphs membership functions (Fig. 3).

Table 2 Results of processing the expert opinions

Qualitative levels of output indicators	The amounts of points assigned by experts for each element of the universal set									
	Accessories degree of quantitative to quality indicator levels									
	Quantitative levels of output indicators									
	0-0,1	0,1-0,2	0,2-0,3	0,3-0,4	0,4-0,5	0,5-0,6	0,6-0,7	0,7-0,8	0,8-0,9	0,9-1
	1,0	0,8	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	0,0	0,2	0,8	1,0	0,4	0,1	0,0	0,0	0,0	0,0
	0,0	0,0	0,0	0,0	0,6	1,0	0,5	0,1	0,0	0,0
	0,0	0,0	0,0	0,0	0,0	0,0	0,5	1,0	0,7	0,0
	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3	1,0

Figure 3. Graphs terms of membership functions of output linguistic variable "level of internal / external social capital"



So, with graphs output variable membership functions (Fig. 8) it is clear that a subset of trapezoidal and triangular set functions belonging. Options triangular membership function describes tuple $[abc]$, a and c - base triangle, b - its top (Shtovba) and its value at the point x is calculated according to the expression:

$$\mu(x) = \begin{cases} 0, & x \leq a \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ \frac{c-x}{c-b}, & b \leq x \leq c \\ 0, & c \leq x \end{cases}$$

Trapezoidal membership function given by the following analytical formula:

$$\mu(x) = \begin{cases} 0, & x \leq a \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ 1, & b \leq x \leq c \\ \frac{d-x}{d-c}, & c \leq x \leq d \\ 0, & d \leq x \end{cases}$$

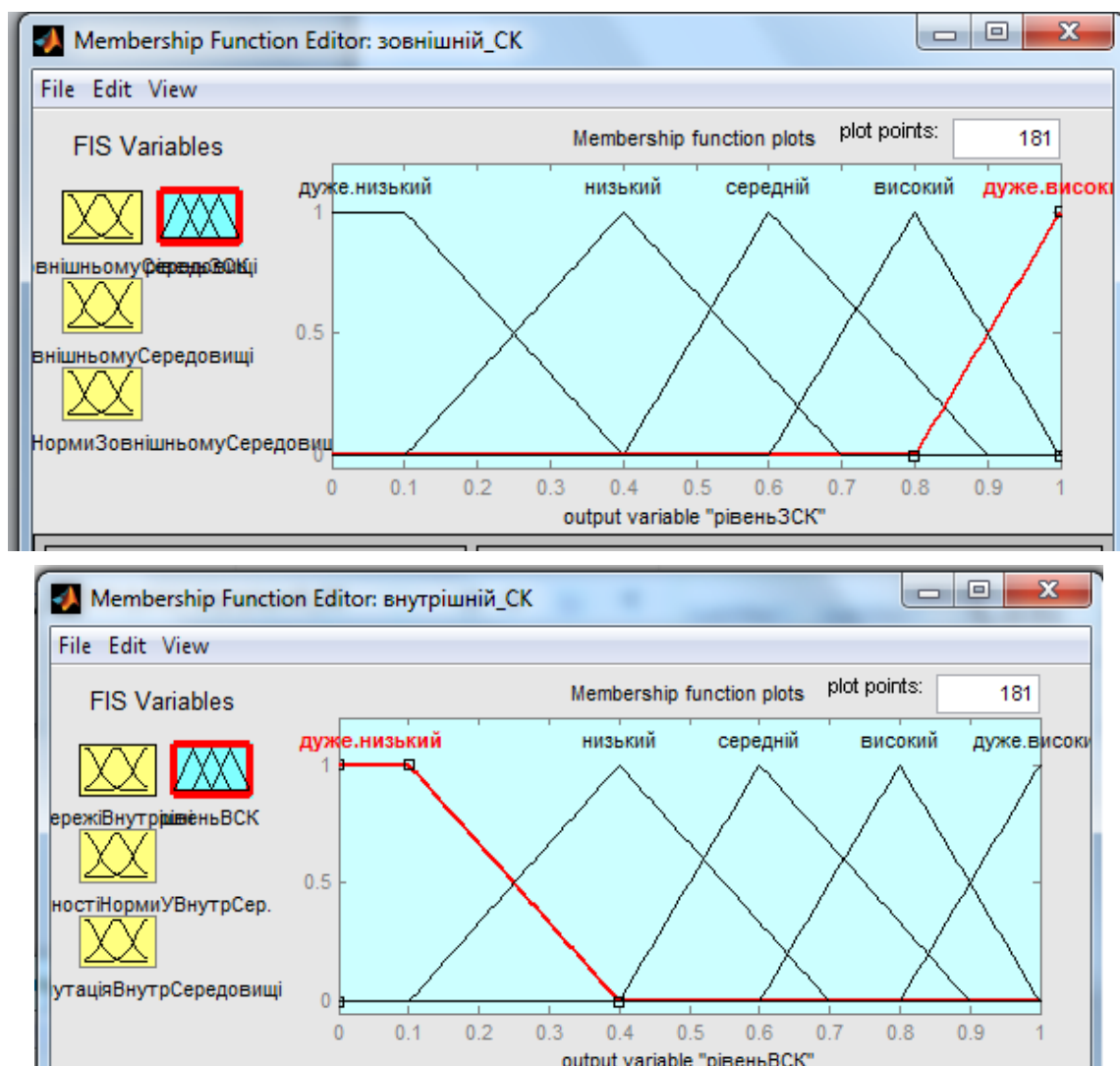
To describe these subsets was introduced a system of appropriate membership functions, which are presented in Table. 3.

Table 3 Functions belonging to subsets term-set "The level of internal / external social capital"

Subset	The type and parameters of membership function	The membership function	
		Value	Interval
Very low	Trapezoidal [0 0 0,1 0,4]	1	$0 \leq x \leq 0,1$
		$\frac{0,4-x}{0,4-0,1}$	$0,1 \leq x \leq 0,4$
		0	$0,4 \leq x \leq 1$
		0	$0 \leq x \leq 0,1$
Low	Triangle [0,1 0,4 0,7]	$\frac{x-0,1}{0,4-0,1}$	$0,1 \leq x \leq 0,4$
		$\frac{0,7-x}{0,7-0,4}$	$0,4 \leq x \leq 0,7$
		0	$0,7 \leq x \leq 1$
		0	$0 \leq x \leq 0,4$
Middle	Triangle [0,4 0,6 0,9]	$\frac{x-0,4}{0,6-0,4}$	$0,4 \leq x \leq 0,6$
		$\frac{0,9-x}{0,9-0,6}$	$0,6 \leq x \leq 0,9$
		0	$0,9 \leq x \leq 1$
		0	$0 \leq x \leq 0,6$
High	Triangle [0,6 0,8 1]	$\frac{x-0,6}{0,8-0,6}$	$0,6 \leq x \leq 0,8$
		$\frac{1-x}{1-0,8}$	$0,8 \leq x \leq 1$
		0	$0 \leq x \leq 0,8$
		1	$x=1$
Very high	Triangle [0,8 1 1]	$\frac{x-0,8}{1-0,8}$	$0,8 \leq x \leq 1$
		1	$x=1$

On the next stage performance membership functions of output linguistic variables "level of internal social capital" and "level of external social capital" in the system of fuzzy evaluation of internal and external capital in the medium MatLab 7.11 was were given (Fig. 4).

Figure 4. Charts terms of membership functions of output linguistic variable "level of internal / external social capital" are built environment in MatLab 7.11



The next step in building a fuzzy system is the stage of direct fuzzy inference, based on specially developed fuzzy knowledge base. Unsharp knowledge base is the set of fuzzy rules "if-then" that determine the relationship between inputs and outputs, the object under study. Synthesis format fuzzy rules as follows:

"IF premise rules – rules of inference"

Reference type approval rules are «x is low», where "low" - a term (linguistic meaning), given fuzzy set on a universal set of linguistic variable x. As Mamdani type systems knowledge base consists of rules of the form "IF $x_1 = x_2 = \text{Low}$ and Mean, $y = \text{high maintenance}$." When creating rules in Fuzzy Logic may use the operator "AND" or "OR", which allows you to combine among themselves certain rules.

To achieve the objectives fuzzy modeling system used fuzzy inference Mamdani type. Options fuzzy models developed, leave those offered by Matlab system default, ie, logical operations (min - for fuzzy logic "AND», max -for fuzzy logic "OR") method of implication (min), aggregation method (max) and Defuzzification method (centroid) (Fig. 5 - 6).

Figure 5. Model definition of external social capital

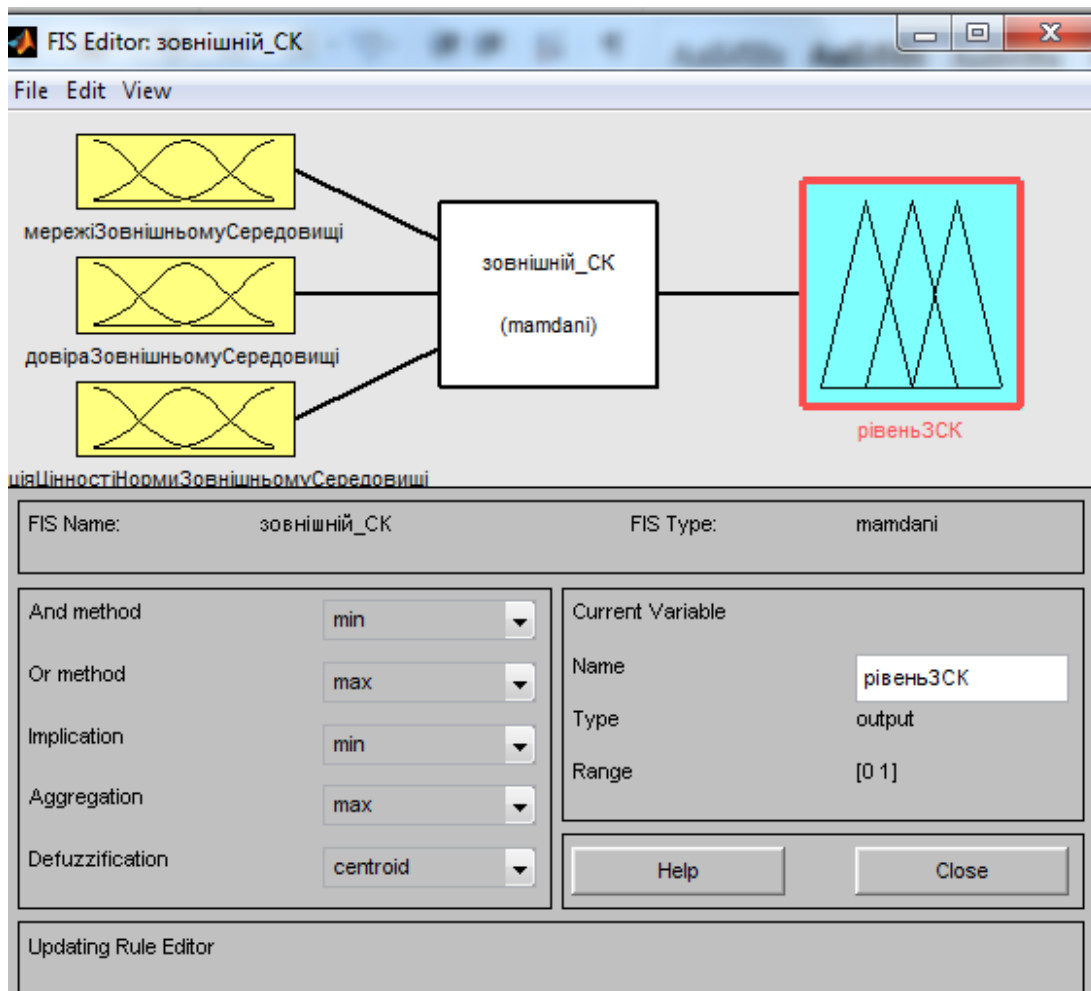
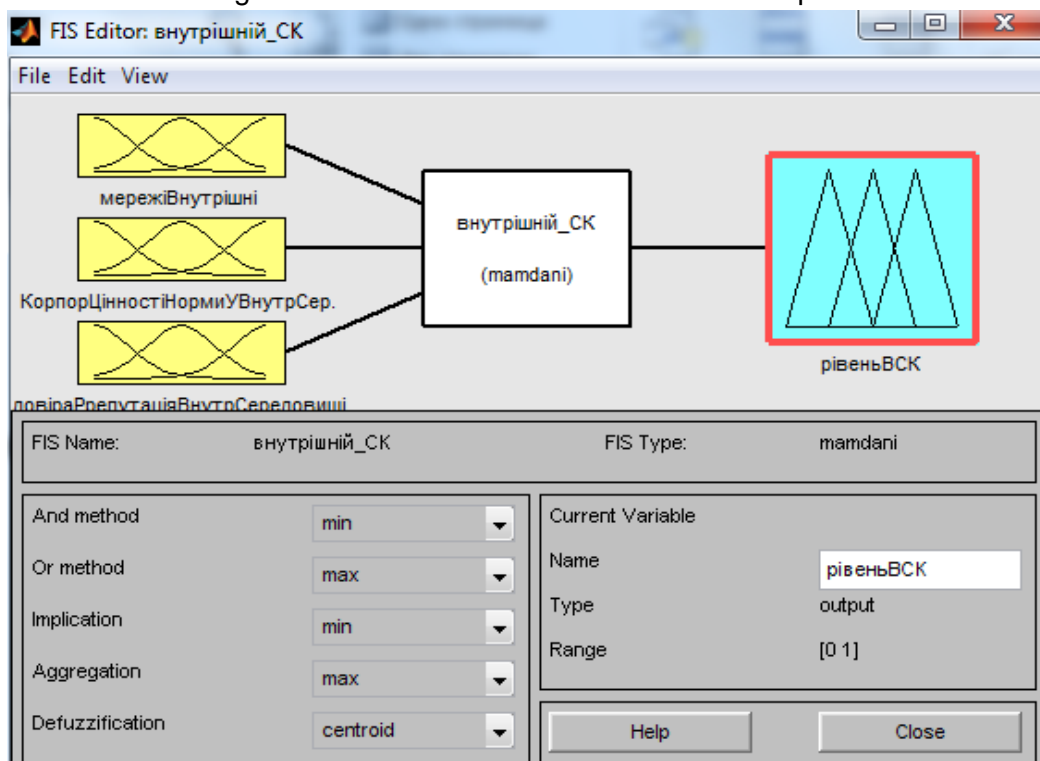


Figure 6. Model definition of internal social capital



Base model rules for determining the level of internal and external capital, including expert knowledge about the importance of social capital criteria are presented in Table. 4 and Table. 5 respectively.

Table 4. The base rules for determining the level of internal social capital

№	Levels of linguistic variables			
	Input			Output
	network in the environment	trust in the environment, reputation	values, norms in the environment	The level of external social capital
1	2	3	4	7
1	–	–	Low	Very low
2	Low	Low	–	Very low
3	Low	–	Low	Low
4		Low	Low	Low
5	Low	Low	Low	Low
6	Middle	Middle	–	Low
7	Middle	Middle	Middle	Middle
8	High	Middle	Middle	Middle
9	Middle	High	Middle	Middle
10	High	High	Middle	High
11	High	Middle	High	High
12	Middle	High	High	High
13	High	High	High	Very high

Table 5. The base rules for determining the level of external social capital

№	Levels of linguistic variables			
	Input			Output
	internal networks	trust, reputation in the internal environment	corporate norms in the internal environment	values, the level of internal social capital
1	2	3	4	7
1	Low	–	–	Very low
2	–	Low	Low	Very low
3	Low	–	Low	Low
4	Low	Low	–	Low
5	Low	Low	Low	Low
6	–	Middle	Middle	Middle
7	Middle	Middle	Middle	Middle
8	Middle	Middle	High	Middle
9	Middle	High	Middle	Middle
10	Middle	High	High	High
11	High	Middle	High	High
12	High	High	Middle	High
13	High	High	High	Very high

Using the OR operator allowed to combine the third and fourth rules from the table. 4, and the third, fourth rule from the table. 5 as follows:

"IF available networks in the external environment IS low OR the level of trust and reputation in the environment IS low OR the level of values, norms in the environment IS low THEN the level external capital IS low."

For models of indistinct output levels of external and internal social capital were inquired rules using the Rule Editor, as shown in Fig. 7 and Fig. 8.

Figure 7. Development of rules base of indistinct output levels of external and internal social capital model in Matlab Rules Editor

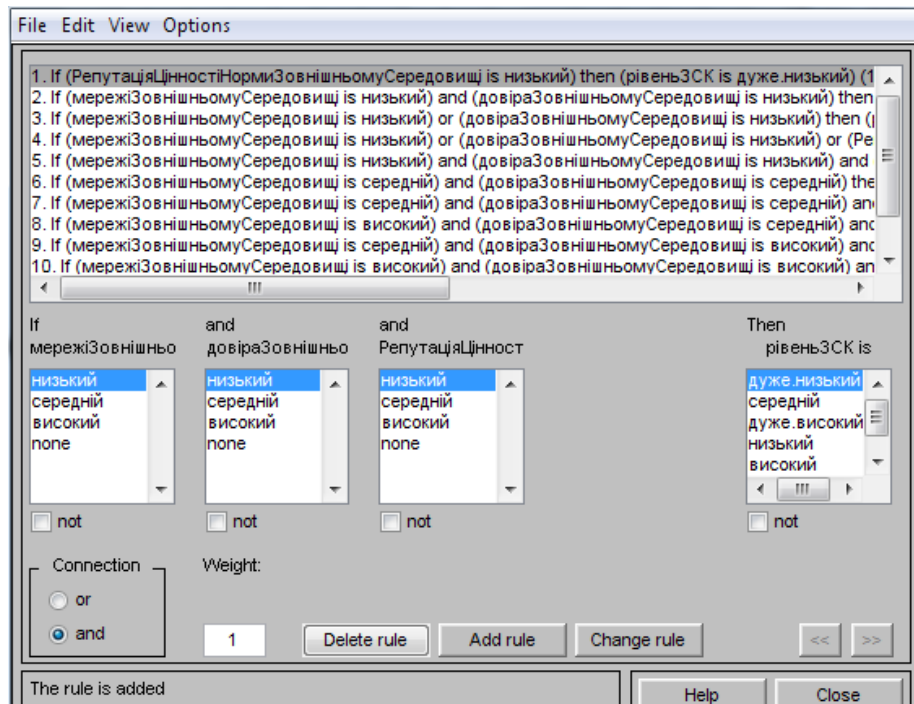
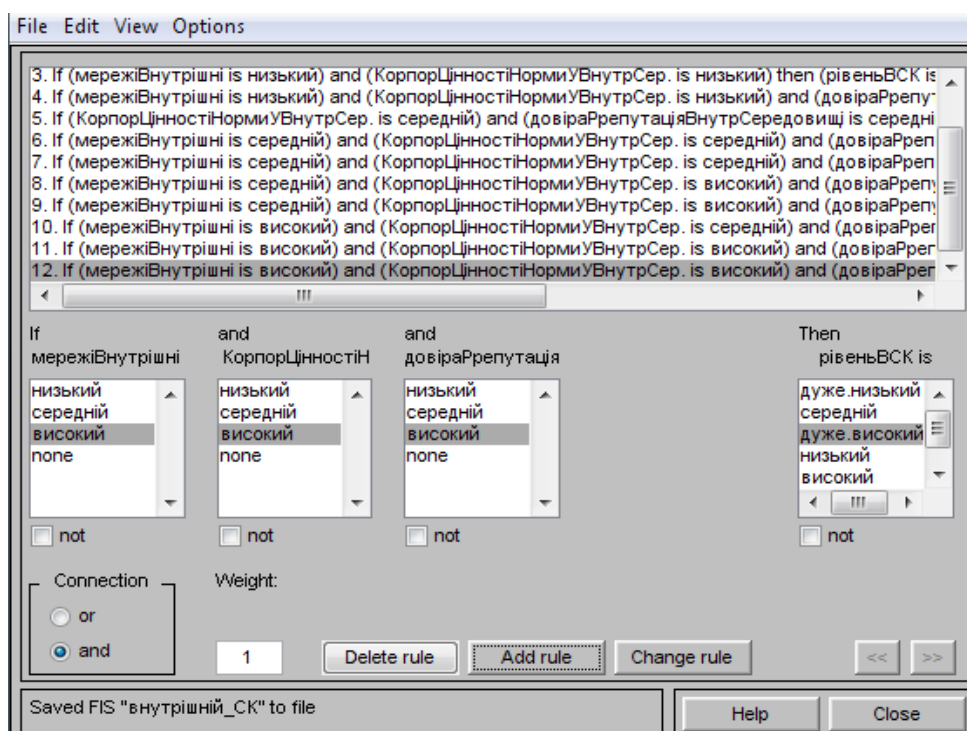


Figure 8. Development of rules base of indistinct output levels of external and internal social capital model in Matlab Rules Editor



After forming the base of rules fuzzy inference system analysis can be performed for evaluation of level of external and internal social capital. To do this, set input linguistic variables in window of rules, fuzzy inference procedure, performed by Matlab for developed fuzzy model, will give the value of output linguistic variable "level of external/ internal social capital" (Fig. 9, Fig. 10).

Figure 9. Graphical interface of fuzzy evaluation of external social capital level

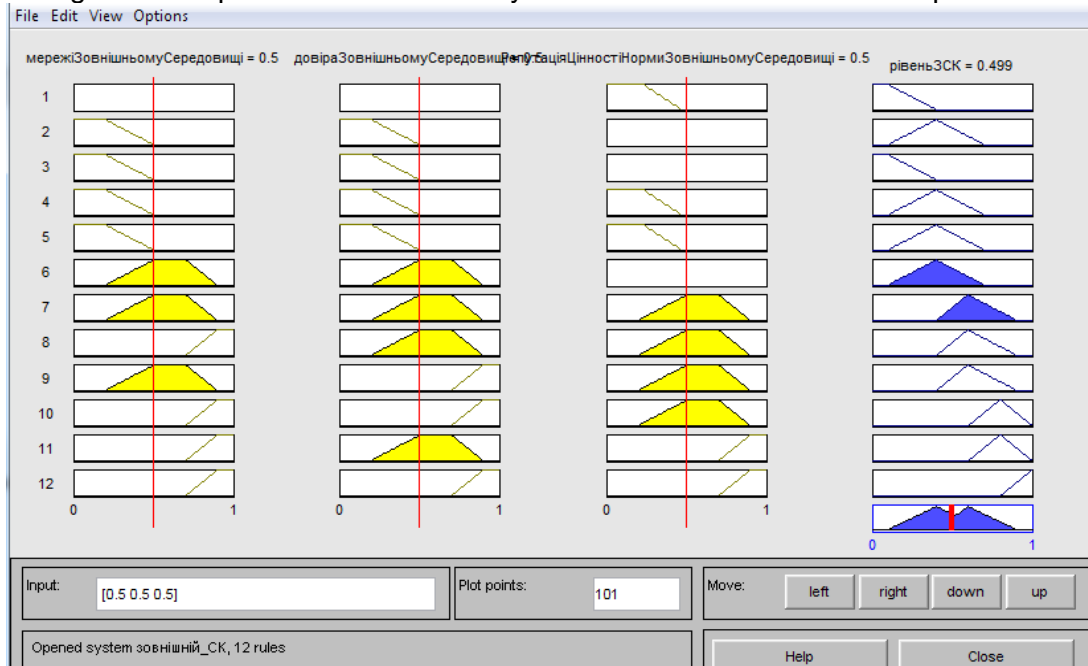
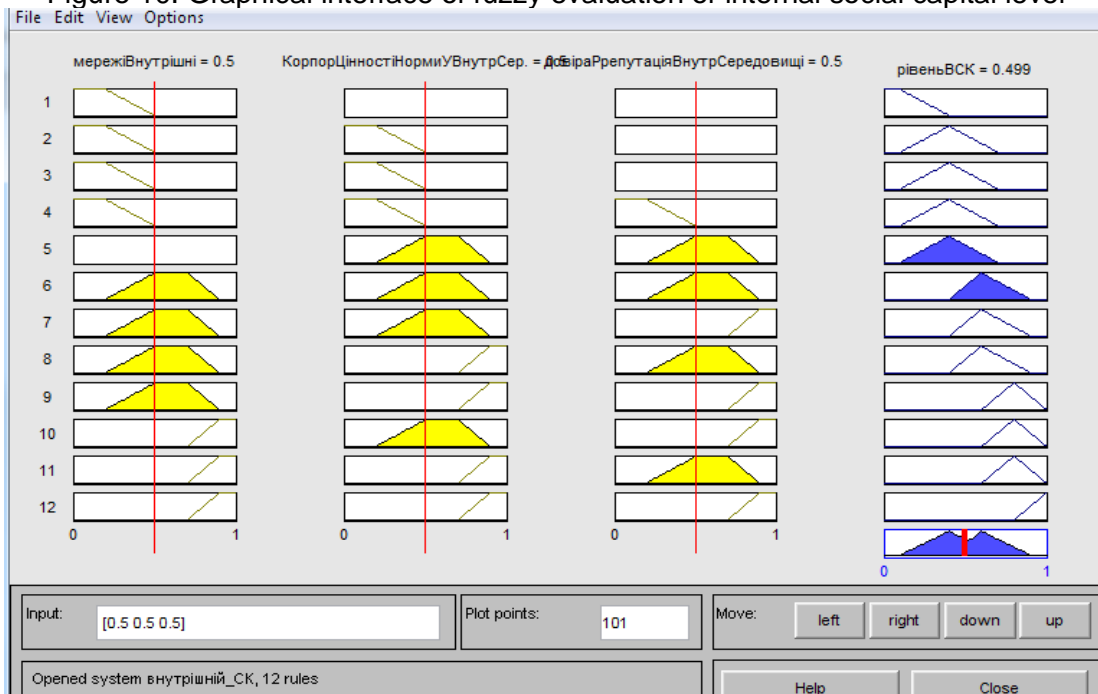


Figure 10. Graphical interface of fuzzy evaluation of internal social capital level



The methodical approach to the social capital assessment in machine-building enterprises of the Kharkiv region was approved. An evaluation of internal and external social capital using systems fuzzy was carried out and quantitative values obtained general indicators of external and internal social capital received, its level of quality and accuracy of the degree of affiliation quantitative importance of internal and external social capital its quality level that is expressed value, which takes the output linguistic variable. The results obtained by PJSC "electric machine" given in Table. 6.

Table 6. PJSC "electric machine" output

Year	Social capital components					
External social capital degree evaluation						
	network in the external environment	trust in the external environmen, reputation	values, norms in the external environment	External social capital level		The degree of credibility
				calculated	qualitative	
2011	0,3	0,3	0,5	0,366	very low	0,13
					low	0,87
2012	0,4	0,5	0,5	0,451	low	0,83
					middle	0,26
2013	0,6	0,5	0,7	0,499	low	0,67
					middle	0,5
Internal social capital degree evaluation						
	network in the internal environment	trust in the internal environment , reputation	corporate values, norms in the internal environment	Internal social capital level		The degree of credibility
				calculated	qualitative	
2011	0,7	0,7	0,8	0,5	low	0,66
					middle	0,5
2012	0,6	0,7	0,7	0,499	low	0,67
					middle	0,5
2013	0,7	0,8	0,6	0,5	low	0,66
					middle	0,5

If the value of the output variable "level of external / internal social capital" gets into fuzzy interval are emitted several rules and the result can be interpreted ambiguously, in this case attention is drawn to level of reliability of the various statements (see Table. 6).

CONCLUSIVE REMARKS

An evaluation of level of external and internal social capital was carried out, using developed systems of fuzzy evaluation quantitative values of general indicators of external and internal social capital are obtained, its qualitative level, and accuracy degree of affiliation of quantitative value of external and internal social capital level to its qualitative level that is expressed by value, which takes output linguistic variable.

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