

# The Visualization of Sensitivity Analysis of EVA by Means of Neuro-fuzzy Logics

## 1 Introduction

Some newly created theories and software programs enable unconventional attitude to solution of the problems in economy. One of them is the suggested methodology of visualization of sensitivity analysis of indices EVA (Economic Value Added is a trade mark of Stern Steward & Co.), where it is possible to use the created neural-fuzzy model for the visualization of analysis. The principle is based on the fact that we know both the input data which are given by pyramidal decomposition of EVA indices and corresponding output value EVA in single concrete cases. Since the calculation of indices EVA is given by equation, the contribution is in the possibility to make a visualization of analysis in this case. The importance of methodology increases in cases when the equations are not known.

## 2 The fuzzy processing

The fuzzy system contains three basic steps: fuzzification, fuzzy-inference and defuzzification. See fig.1.

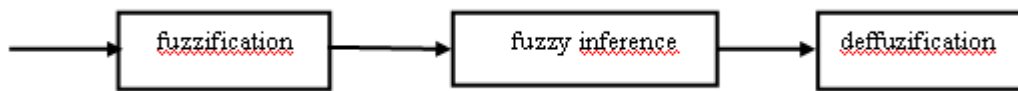


Fig.1 Fuzzy processing

- The fuzzification means that the real variables are transferred to linguistic variables. The definition of linguistic variables is based on fundamental linguistic terms, for example, with the variable NOPAT the following attributes are set up: a very low, low, medium, high, very high value. Usually three to seven attributes of variables are used. The attributes are defined by the so called membership function, such as  $\Lambda$ ,  $\pi$ , Z, S and some others. The membership function is set up for input and output variables.
- The fuzzy inference defines the behaviour of system by means of rules of type <When>, <Then> on linguistic level. The conditional clauses evaluate the state of input variables by the rules. The conditional clauses are known from logics:

$$\langle \text{When} \rangle \text{Input}_a \langle \text{And} \rangle \text{Input}_b \dots \text{Input}_x \langle \text{Or} \rangle \text{Input}_y \dots \dots \langle \text{Then} \rangle \text{Output}_1,$$

it means, when (the state occurs)  $\text{Input}_a$  and  $\text{Input}_b, \dots, \text{Input}_x$  or  $\text{Input}_y, \dots$ , then (the situation is)  $\text{Output}_1$ .

Each combination of attributes of variables entering the system and occurring in condition <When>, <Then> represents one rule. Every condition behind <When> has a corresponding result behind <Then>. It is necessary to determine every rule and its degree of supports (DoS - the weight of rule in the system).

- The defuzzification transfers the results of fuzzy inference to the output variables which describes the results verbally (for example, whether the indices EVA has a very low, low, medium, high, very high value).

The unconventional attitude of the above mentioned problems consists in the fact that the connection of fuzzy logics with artificial neural networks enables to use the process of learning. The process of learning sets up the course of membership functions of input and output variables and the mentioned degree of support (DoS) of rules. It is possible to use the created model for the simulation and to make a sensitivity analysis of output value depending on input values. The number of inputs depends on what level of analysis will be made. We will make the decomposition of indices EVA on the first (highest) sublevel.

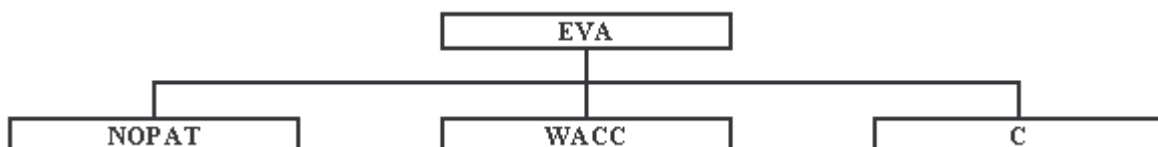


Fig.2 Decomposition of EVA - first sublevel

If we make a transformation of this graph to inputs NOPAT (Net Operating Profit After Tax), WACC (Weight Average Cost of Capital), C (Invested Capital) and outputs EVA (Economic Value Added), we obtain fig.3.



Fig.3 The simulation model EVA

When we create the model we have to know the values of inputs and outputs of single cases. The concrete realization is demonstrated on two examples.

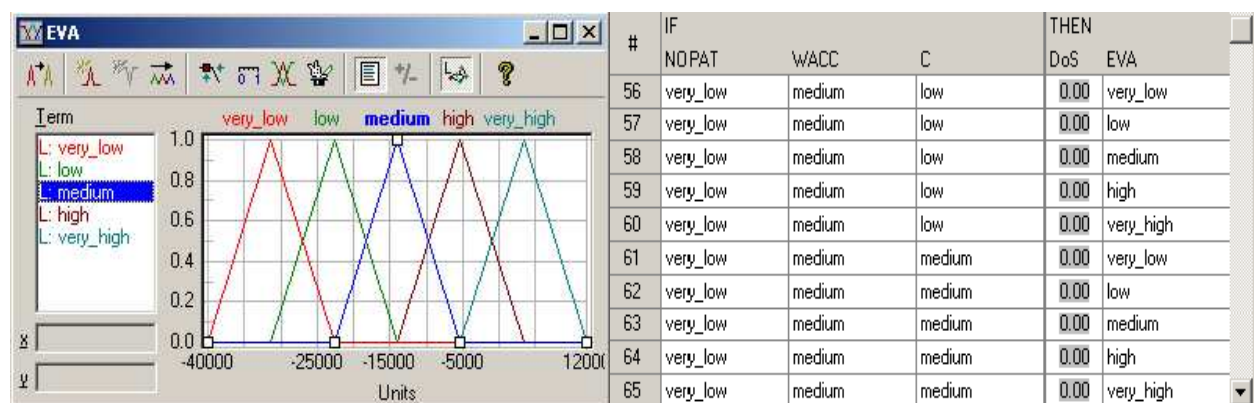
### 3 Case 1

The first case covers two factories where the sampling of data is one year. Tab.1 displays the input values NOPAT, WACC, C and output values of indices  $EVA_{equation}$  [calculated by equation  $EVA_{equation} = NOPAT - (C \times WACC)$ ] that are used for the creation of model. The FuzzyTech program of Inform GmbH firm is used for calculation. The manner of work with this program is described in the manual and it will not be introduced here.

Factory	Year	NOPAT	WACC	C	$EVA_{equation}$	$EVA_{model}$
Alfa Plastik a.s. <sup>1)</sup>	2003	29338	0,093	203410	10 338	9810
Alfa Plastik a.s. <sup>2)</sup>	2002	27261	0,114	187091	5 906	5615
Alfa Plastik a.s. <sup>3)</sup>	2001	30488	0,158	143052	7 861	8540
Alfa Plastik a.s. <sup>4)</sup>	2000	20027	0,175	150395	-6 243	-6753
Alfa Plastik a.s. <sup>5)</sup>	1999	18001	0,147	160894	-5 727	-5416
Alfa Plastik a.s. <sup>6)</sup>	1998	24452	0,180	168800	-5 921	-5887
GIO'STYLE PAP a.s. <sup>1)</sup>	2004	19639	0,107	482416	-32 083	-31908
GIO'STYLE PAP a.s. <sup>2)</sup>	2003	30152	0,100	453217	-15 303	-14137
GIO'STYLE PAP a.s. <sup>3)</sup>	2002	30521	0,113	351521	-9 276	-14137
GIO'STYLE PAP a.s. <sup>4)</sup>	2001	32150	0,128	276450	-3 206	-2623
GIO'STYLE PAP a.s. <sup>5)</sup>	2000	15026	0,133	298028	-24 648	-25205
GIO'STYLE PAP a.s. <sup>6)</sup>	1999	26668	0,145	299616	-16 708	-16495
GIO'STYLE PAP a.s. <sup>7)</sup>	1998	24206	0,176	357065	-38 612	-38612

Tab.1 Data - Case 1

Fig.4 shows the course of not tuned membership functions for output variable  $EVA_{model}$  and created rules without set up of degree of support (DoS).



Membership function

Fig.4

The rule box with DoS before learning

It is possible to trace the iteration process, when we start the calculation. See fig.5.

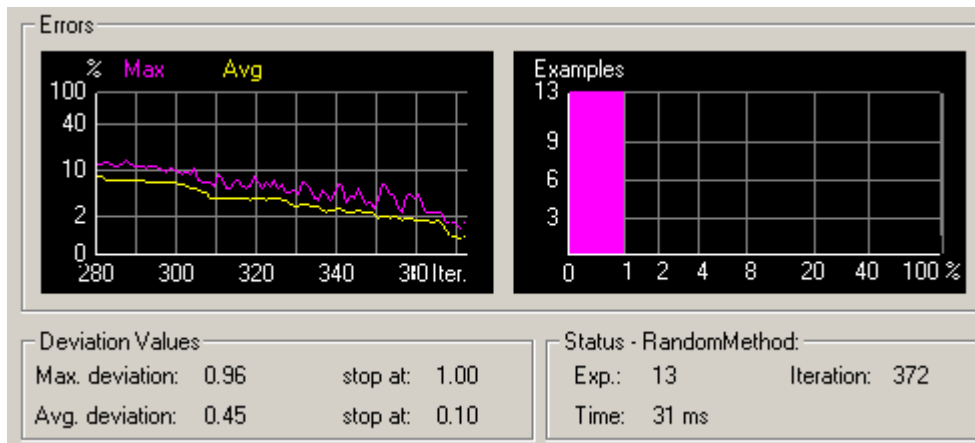
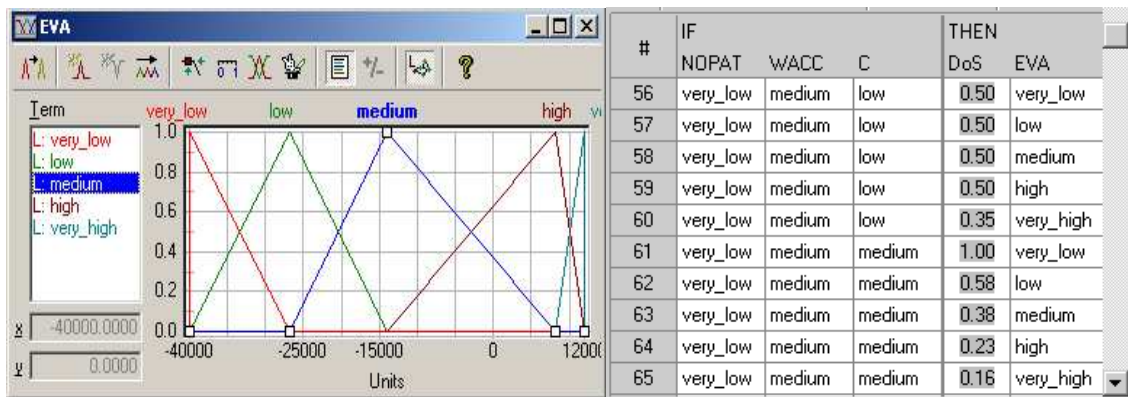


Fig.5 Process of learning

We obtain tuned courses of membership functions for input variables and output variable  $EVA_{model}$  after the process of learning. The created rules have set up the values of weights of degree of support (DoS). See fig. 6.



Membership function

Fig.6

The rule box with DoS after learning

It is possible to use the model for simulation as presented on fig. 7.

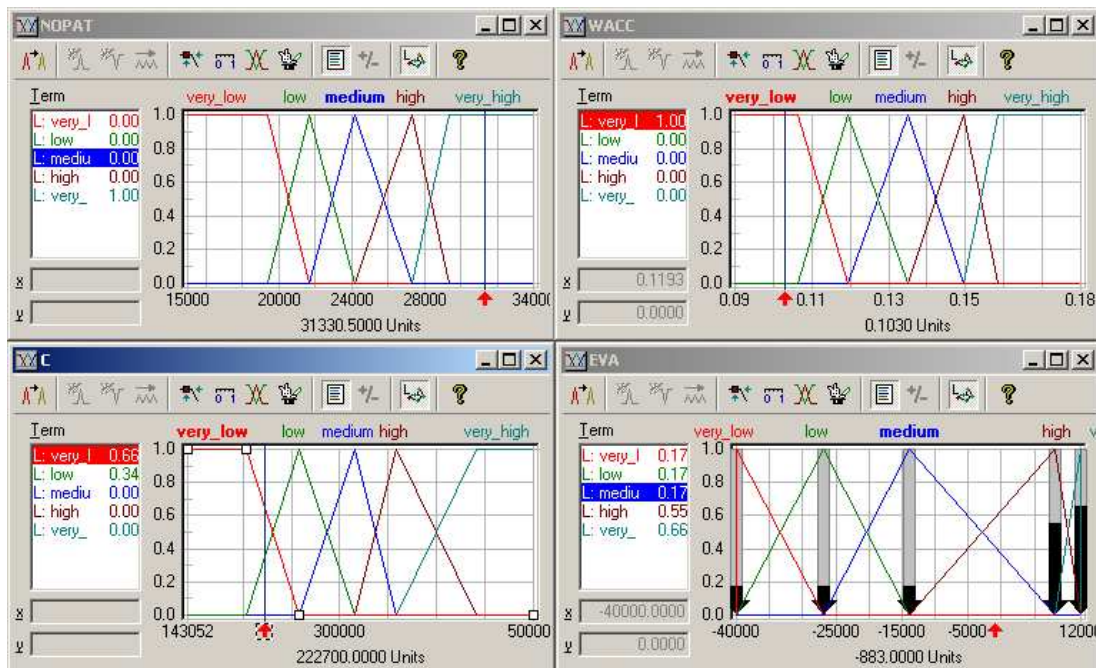


Fig.7 Process of simulation

If we move with the arrows near the horizontal axis at input variables NOPAT, WACC and C at every graph, we can trace the course of output value  $EVA_{model}$ . The simulation helps us to disclose the sensitivity of output value EVA on input values.

Fig.8 presents the process of simulation, where the values are set up on the left side and the value  $EVA_{model}$  is evaluated by the simulation on the right for the case of firm Alfa Plastik, a.s.<sup>4)</sup>



Fig.8 Process of simulation

The value calculated according to the equation is -6243 and the value evaluated by the simulation using the model is -6753. The values differ, but the difference is not significant. The evaluation of all results can be made by comparison of values  $EVA_{equation}$  and  $EVA_{model}$  in tab.1.

Other possible way of display is the use of three-dimensional graph, which is a cut of multidimensional equation  $EVA_{model} = f(NOPAT, WACC, C)$ . See fig.9. This concrete example presents the dependence of output value EVA on input values WACC and NOPAT. It is evident that it is possible to choose the combination of input and output values. Crosshair displays the case Alfa Plastik a.s.<sup>4)</sup>

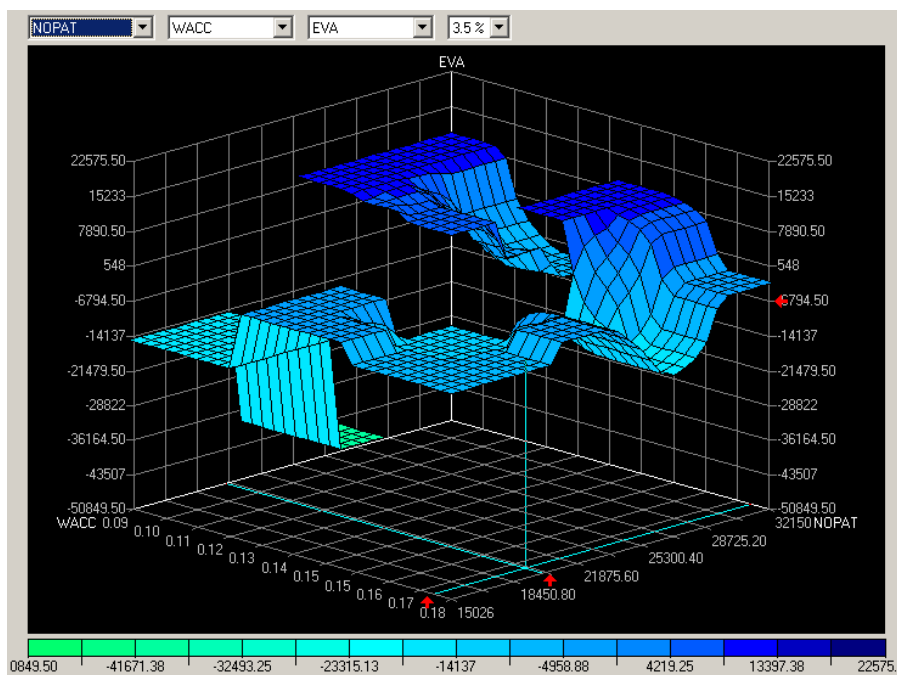
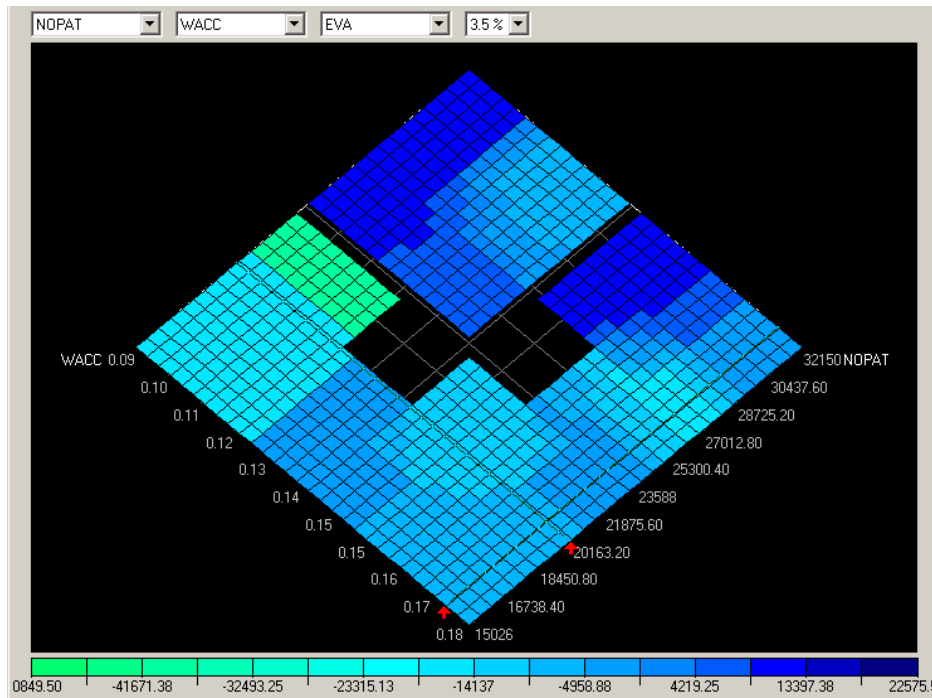


Fig.9 The visualization of analysis - graph  $EVA_{model} = f(WACC, NOPAT)$



**Fig.10** The visualization of analysis - graph of dependence WACC and NOPAT

Another point of view is on fig.10, where two-dimensional graph is used (the axis of variable  $EVA_{model}$  is not displayed). There are the areas, where the data were not known in the process of creation of model, and therefore the surface is not displayed (black area). The crosshair displays the case Alfa Plastik a.s.<sup>4)</sup>

#### 4 Case 2

The second case covers thirteen factories. Tab.2 displays the input values NOPAT, WACC, C and output values of indices  $EVA_{equation}$  used for calculation.

Factory	NOPAT	WACC	C	$EVA_{equation}$	$EVA_{model}$
Greiner PURtec CZ, spol. s r. o.	1323	0,097	63301	-4829	-4858
Ept Connector, spol. s r. o.	-918	0,118	75780	-9842	-9842
Orvard Plast, spol. s r. o.	-1634	0,100	22962	-3920	3880
HPQ-Plast, spol. s r. o.	8834	0,099	39080	4953	4904
LINAPLAST, spol. s r. o.	1092	0,119	13225	-479	-426
Peguform Composites, spol. s r.o.	-6781	0,119	336	-6820	-6992
POLYPILTAN, spol. s r. o.	3788	0,084	71079	-2158	-2161
RIM-Tech, a. s.	8628	0,087	83965	1302	1093
Apea, spol. s r. o.	1076	0,126	22539	-1756	-1834
PLASTVALM, spol. s r. o.	767	0,089	4269	386	614
Thermolast, k.s.	1236	0,099	41048	-2827	-2161
UNITOOLS CZ, a.s.	6118	0,129	105607	-7501	-7467
Böhm Plast – technik, spol. s r. o.	9140	0,099	36583	5519	5294

**Tab.2** Data - Case 2

Fig.11 shows the three-dimensional graph. This concrete example presents the dependence of output value EVA on input values NOPAT and C. Crosshair displays the case UNITOOLS CZ a.s.

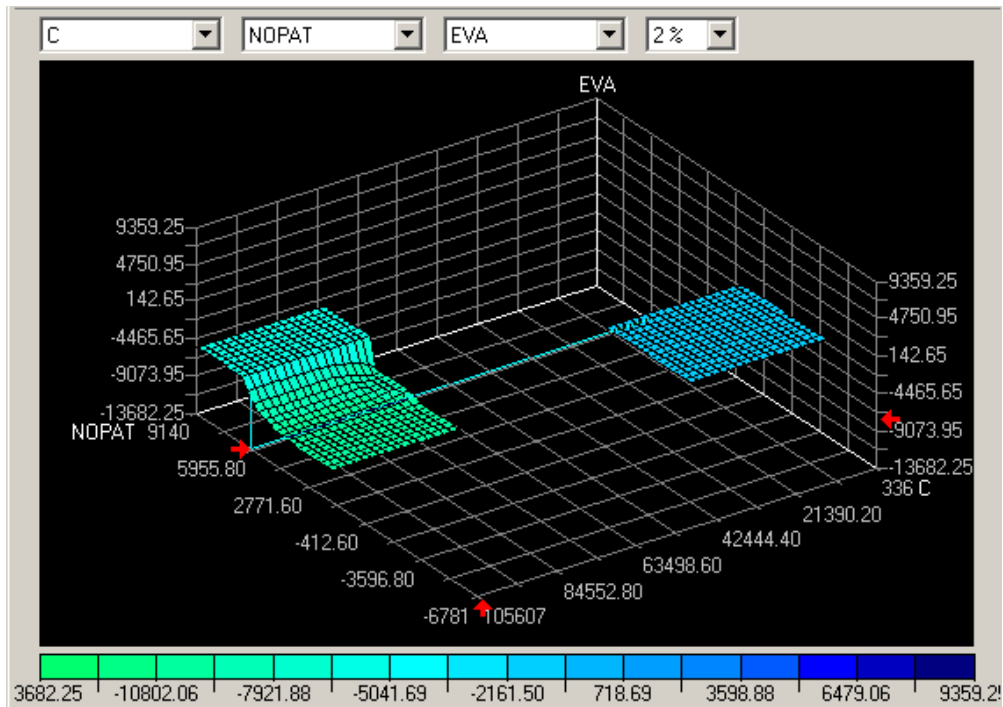


Fig.11 The visualization of analysis - graph  $EVA_{model} = f(NOPAT, C)$

Other corner of view is on fig.12, where two-dimensional graph is used (the axis of variable  $EVA_{model}$  is not displayed). There are the areas, where the data were not known in the process of creation of model, and therefore the surface is not displayed (black area). The crosshair displays the case UNITOOLS CZ.

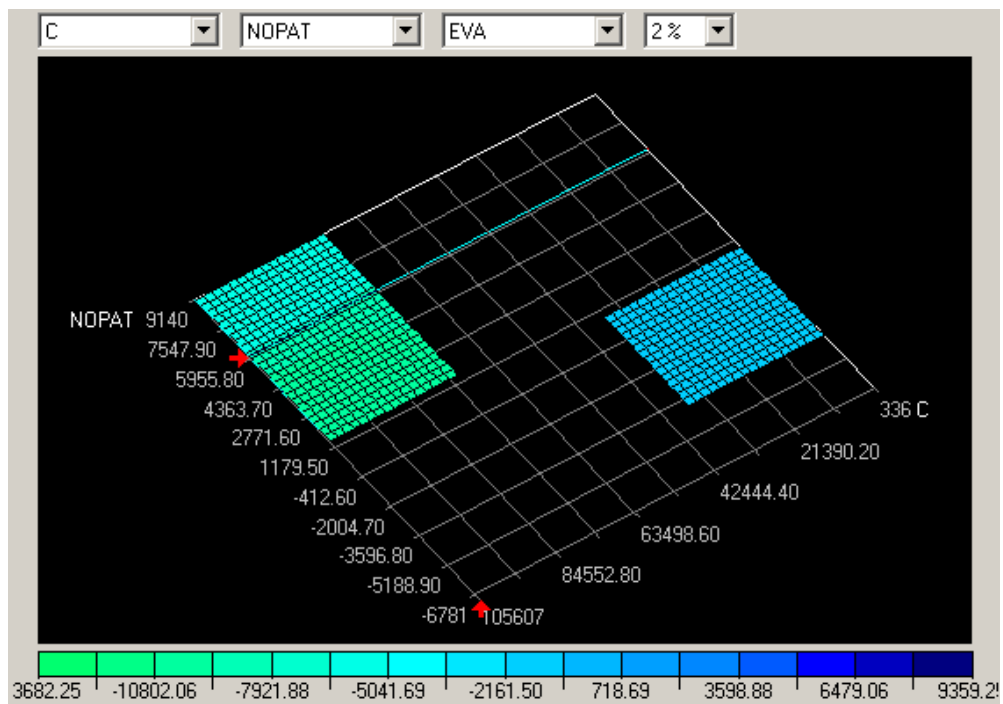


Fig.12 The visualization of analysis - graph of dependence NOPAT and C

Fig.13 presents the process of simulation, where the values are set up on the left side and the value  $EVA_{model}$  is evaluated by the simulation on the right for the case of firm UNITOOLS CZ.



**Fig.13** Process of simulation

The value calculated according to the equation is -7501 and the value evaluated by the simulation using the model is -7467. The values differ, but the difference is not significant. The evaluation of all results can be made by comparison of values  $EVA_{equation}$  and  $EVA_{model}$  in tab.2.

## 5 Evaluation

Many tests of created models based on the principle of neuro-fuzzy logic (two of them were presented in the article) prove the evidence of functionality of proposed methodology. We can rarely meet with the problem of creation of model because of the fact, that the task is an optimization problem. It is possible to solve this situation by omission of some (in interval marginal) values. From the tests it follows that it is not possible to do the sensitive analyses in distant areas that are not covered by data. The use of extrapolation of distant areas could give us the wrong values.

## 6 Conclusion

The initial research focused on visualization of sensitivity analysis of indices Eva proved the possibility of use of methodology in practice. The methodology enables the visualization and it is the support for the analyses of the type "What If".