Soft methodology of EVA performance measure in small opened economy- generalised sensitivity

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Abstract

One of a novel approach of performance measure is economic value added (EVA) indicator. The specific feature of computing and managing performance of industries or companies in small opened economy, is short-term series of financial indices, illiquid capital markets etc. Therefore, it is necessary to calculate and make financial decision-making under uncertain, vaguely and softly defined conditions. Application of the sensitivity analysis is important and required. One of generalised approaches to sensitivity analysis is an application of fuzzy methodology. The methodology is based on assumption that input data are introduced as fuzzy numbers and results are also expressed as fuzzy numbers. Decomposition principle is one of crucial instrument to calculation of the function of fuzzy numbers. Development of EVA measure and fuzzy sensitivity analysis is presented including illustrative example.

Keywords Performance measure, economic value added, small opened economy, sensitivity analysis, fuzzy methodology, fuzzy numbers, decomposition principle

1. Introduction

One of the innovative indicators of company performance is EVA (economic value added) measure, which is based on profit surplus of alternative cost of capital. This measure is applied in so developed both transition countries.

Financial analysis of financial performance measures could be analysed by pyramidal (Du Pont) methodology. Advantage of method is in exact mathematical formulation of problem. Disadvantage should be viewed in financial interpretation of any indices.

We can distinguish some analysis of the historical financial data or prediction (planned) data. In both cases the sensitivity analysis is important aspect of thinking out. Traditional sensitivity analysis is based on what-if methodology, or investigation chosen variants. The complex methodology for modelling the sensitivity analysis should be fuzzy approach. In this approach fuzzy numbers are used and generalised approach is possible to apply. Input data and results are fuzzy numbers as well.

The intention of the paper is to describe and explain a possibility of application the fuzzy methodology in EVA performance prediction sensitivity analysis. Fuzzy pyramidal analysis of EVA measure will be described and compared with traditional crisp pyramidal analysis.

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The paper is structured as follows: (1) description of the traditional pyramidal EVA prediction sensitivity analysis; (2) description and explanation of fuzzy methodology; (3) description and presentation of the fuzzy pyramidal EVA prediction sensitivity analysis.

2. Calculation of economic value added

General concept of EVA, as a measure of financial performance, expresses the difference between profit and cost of capital, which reflects a minimal rate of return of capital invested (equity and debt).

Data set availability and the way of the cost of capital calculation determine EVA calculation method. Moreover, it is also important, if we want to calculate an absolute or a relative value. Broadly speaking, there are two basic concepts of calculation: operating profit concept and value spread concept.

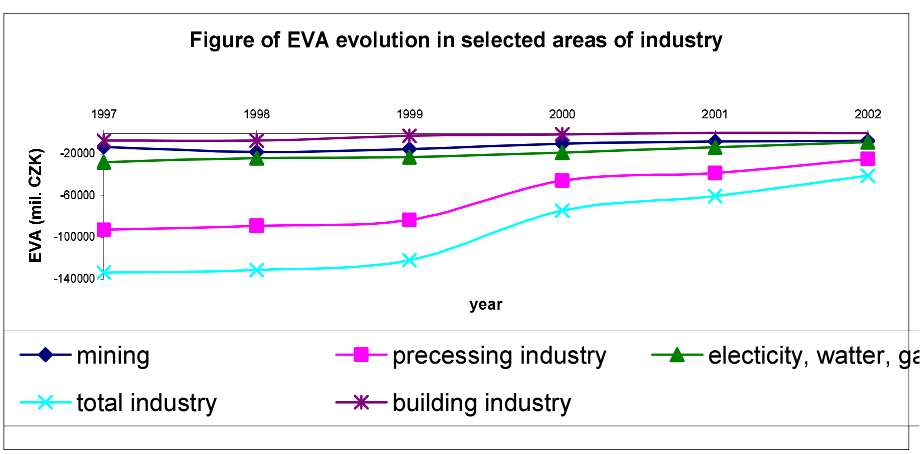
EVA calculation on base of operating profit is defined as follows:
$EVA = NOPAT - WACC \cdot C$, another narrow approach is formulated as follows
$EVA = (ROE - \mathrm{Re}) \cdot E$.

Development of EVA measure in Czech Republic, small opened economy is illustrated on Tab. 1 and Fig. 1.

Tab.1: EVA in selected sectors of industry (mil. CZK)

	Area of industry				
Year	**Mining**	**Precessing industry**	**Electicity, watter, gas**	**Total industry**	**Building industry**
1997	-12822	-92354	-27723	-133358	-6868
1998	-17879	-88820	-23743	-130933	-6896
1999	-15059	-82971	-22699	-121445	-2321
2000	-9742	-45103	-18424	-74103	-916
2001	-7816	-37993	-13332	-60263	559
2002	-7276	-24355	-8342	-40613	147

Fig.1: Development of EVA in selected areas of industry (mil. CZK)



3. Crisp pyramidal prediction sensitivity analysis of EVA measure

We will compare and investigate the historical and planned EVA measures. The influence analysis of factors will be described. Calculation of the EVA measure could be formulated in pyramid by three equations.

$$EVA = (ROE - \mathrm{Re}) \cdot E, \tag{1}$$

$$ROE = ROA \cdot (EAT/EBIT) \cdot (A/E) \text{ and}$$

$$ROA = (EBIT/\mathrm{Re}v) \cdot (\mathrm{Re}v/A).$$

Here *ROE* is Return on Equity, *Re* is cost of Equity, *E* is Equity, *ROA* is Return on Assets, *EAT* is earnings after taxes, *EBIT* is earnings before interest and taxes, *A* is assets, R*ev* is revenue.

Indices should be analysed for multiplication relation, $x = a_1 \cdot a_2 \cdot \ldots\ldots \cdot a_n$, by logarithm method suitable for positive indexes and functional method for positive and negative indexes.

Logarithm method formulation is following

$$\Delta x_{a_i} = \ln(I_{a_i}) / \ln(I_x) \cdot \Delta y. \tag{2}$$

Functional method is formulated as follows

$$\Delta x_{a_1} = \frac{1}{R_x} \cdot R_{a_1} \cdot \left(1 + \frac{1}{2} \cdot R_{a_2} + \frac{1}{2} \cdot R_{a_3} + \frac{1}{3} \cdot R_{a_2} \cdot R_{a_3}\right) \Delta y_x,$$

$$\Delta x_{a_2} = \frac{1}{R_x} \cdot R_{a_2} \cdot \left(1 + \frac{1}{2} \cdot R_{a_1} + \frac{1}{2} \cdot R_{a_3} + \frac{1}{3} \cdot R_{a_1} \cdot R_{a_3}\right) \Delta y_x, \tag{3}$$

$$\Delta x_{a_3} = \frac{1}{R_x} \cdot R_{a_3} \cdot \left(1 + \frac{1}{2} \cdot R_{a_1} + \frac{1}{2} \cdot R_{a_2} + \frac{1}{3} \cdot R_{a_1} \cdot R_{a_2}\right) \Delta y_x.$$

Generalised formulation

$$\Delta x_{a_i} = \frac{1}{R_x} \cdot R_{a_i} \cdot \left(1 + \sum_{j \neq i} \frac{1}{2} \cdot R_{a_j} + \sum_{j \neq i} \sum_{\substack{k \neq i \\ k > j}} \frac{1}{3} \cdot R_{a_j} \cdot R_{a_k} + \sum_{j \neq i} \sum_{\substack{k \neq i \\ k > j}} \sum_{\substack{m \neq i \\ m > k}} \frac{1}{4} \cdot R_{a_j} \cdot R_{a_k} \cdot R_{a_m} + \ldots\right) \Delta y_x. \tag{4}$$

For addition relations $x = a_1 + a_2 + \ldots\ldots + a_n$,

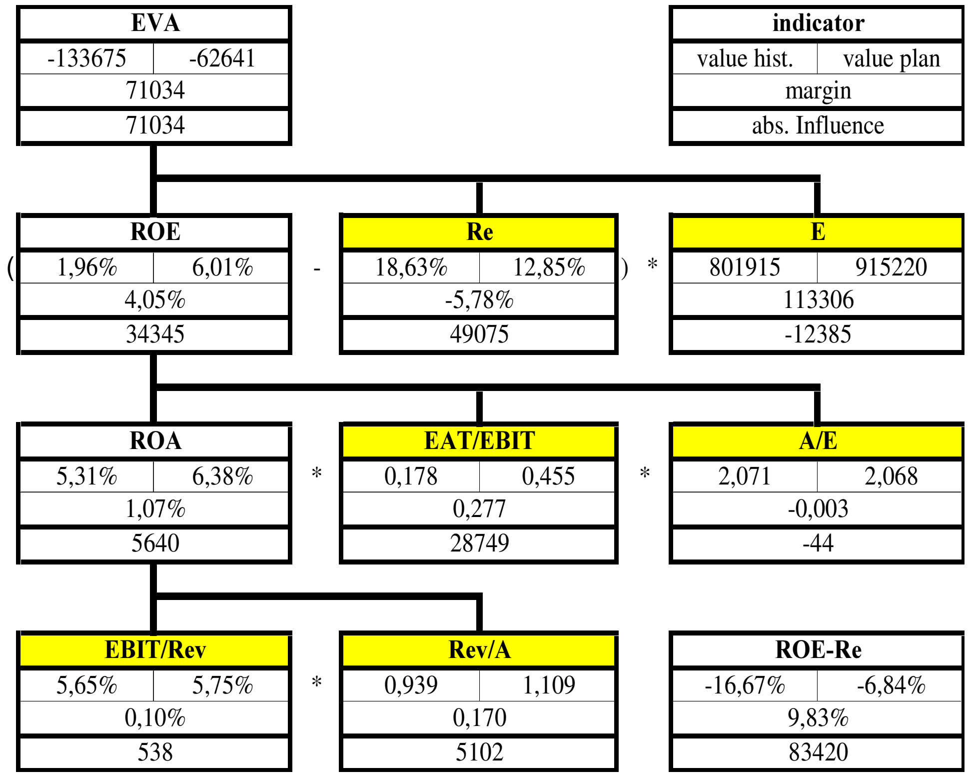
$$\Delta x_{a_i} = \Delta a_i / \left(\sum_i \Delta a_i\right) \cdot \Delta y. \tag{5}$$

Here Δx_{a_i} is absolute influence of a_i indices to x indices, Δy is analysed influence, $R_{a_j} = \frac{\Delta a_j}{a_{j,0}}$, $R_x = \frac{\Delta x}{x_0}$.

System of analysis is presented in Figure 2, where historical value, planned value, margin = planned value- historical value, index = planned value/historical value.

Computed crisp analysis is based on logarithm method due to (2) and (5), illustrated on Fig. 2, shadowed indices are input data. Input data are introduced in Tab 2.

Fig. 2 Crisp pyramidal sensitivity planned analysis



Tab. 2 Input data of crisp and fuzzy analysis

indicator	history crisp	Plan						
		Crisp	Fuzzy					
			s^L	s^U	s^{alfa}	s^{beta}	$^{-}s^0$	$^{+}s^0$
Re	18,63%	12,85%	12,85%	12,85%	1,70%	2,20%	11,15%	15,05%
E	801915	915220	915220	915220	20004	10006	895216	925226
EAT/EBIT	0,178	0,455	0,455	0,455	0,008	0,006	0,447	0,461
A/E	2,071	2,068	2,068	2,068	0,200	0,100	1,868	2,168
EBIT/Rev	5,65%	5,75%	5,75%	5,75%	0,02%	0,03%	5,73%	5,78%
Rev/A	0,9391	1,109	1,109	1,109	0,02	0,01	1,089	1,119

4. Fuzzy apparatus description

In fuzzy modelling, we apply fuzzy operations and functions between fuzzy numbers. For instance we suppose that input data are fuzzy numbers, and then equation (1) should be formulated as follows:

$$E\tilde{V}A = \left(R\tilde{O}E \simeq \tilde{\mathrm{Re}}\right) \tilde{\cdot}\, \tilde{E} \,. \tag{6}$$

By tilde the fuzzy numbers are depicted.

Following basic fuzzy-stochastic elements are very useful from an application point of view, (1) fuzzy set, (2) normal and T-number sets, (3) ε-cut, (4) extension principle, (5) decomposition principle.

Definition 1. A *fuzzy set* (depicted with tilde) is commonly defined by a membership function (μ) as representation from E^n (Euclid n-dimensional space, n > 1) to a set of E^1 especially to the interval of *[0;1]*, $\widetilde{s} \equiv \mu_{\widetilde{s}}(x)$, where $\widetilde{s}$ is fuzzy set, x is vector and $x \in X \subset E^n$, $\mu_{\widetilde{s}}(x)$ is membership function.

It is evident that many fuzzy sets could be created. The most common type of the fuzzy set meeting the specified preconditions of normality, convexity and continuity with upper semi-continuous membership function is very well known *normal fuzzy set*, see (e.g. Dubois and Prade (1980), Ramik and Vlach (2001)). The set of normal fuzzy sets are depicted $F_N(E^n)$. One of the most widely applied normal fuzzy set types is the *T-number*.

Definition 2. A fuzzy set meeting preconditions of normality, convexity, continuity with upper semi-continuous membership function and closeness and being defined as quadruple $\widetilde{s} = (s^L, s^U, s^\alpha, s^\beta)_{\varphi\phi}$, where $s^L \le s^U$; $s^L, s^U, s^\alpha, s^\beta \in E^1; s^\alpha, s^\beta \ge 0$, $\phi(x)$ is a non-decreasing function and $\psi(x)$ is a non-increasing function, as follows,

$$\widetilde{s} \equiv \mu_{\widetilde{s}}(x) = \begin{Bmatrix} 0 \ \ for \ \ x \le s^L - s^\alpha; \ \ \phi(x) \ \ for \ \ s^L - s^\alpha < x < s^L; \\ 1 \ \ for \ \ s^L \le x \le s^U; \ \ \psi(x) \ \ for \ \ s^U < x < s^U + s^\beta; \\ 0 \ \ for \ \ x \ge s^U + s^\beta \end{Bmatrix},$$

is called the *T-number*. Let us denote the set of T-numbers by $F_T(E)$.

Definition 3. The linear T-number is defined as T-number (Definition 2) where functions, $\phi(x) = \frac{x - (s^L - s^\alpha)}{s^\alpha}$, $\psi(x) = \frac{(s^U + s^\beta) - x}{s^\beta}$ are linear, and is depicted as quadruple $\widetilde{s} = (s^L; s^U; s^\alpha; s^\beta)$, $\widetilde{s} \in F_{TL}(E) \subset F_T(E) \subset F(E)$.

Definition 4. The ε*-cut* of the fuzzy set $\widetilde{s}$, depicted $\widetilde{s}^\varepsilon$, is defined as follows.
$\widetilde{s}^\varepsilon = \{x \in E^n; \mu_{\widetilde{s}}(x) \ge \varepsilon\} = [{}^-s^\varepsilon, {}^+s^\varepsilon]$, where
${}^-s^\varepsilon = inf\{x \in E^n; \mu_{\widetilde{s}}(x) \ge \varepsilon\}$, ${}^+s^\varepsilon = sup\{x \in E^n; \mu_{\widetilde{s}}(x) \ge \varepsilon\}$.

Assuming a fuzzy set is of fuzzy number type (the T-number type as well) there is possible to solve function of fuzzy numbers $\widetilde{s} = f(\widetilde{x}_1 ... \widetilde{x}_n)$ by decomposition principle as the approximate procedure of ε-cuts.

Definition 5. *Decomposition principle (Resolution identity)* is defined as follows,

$$\mu_{\widetilde{s}}(y) = \sup_{\varepsilon}\{\varepsilon \cdot I_{\widetilde{s}^\varepsilon}; y \in \widetilde{s}^\varepsilon\} \quad \text{for any } y \in E^n \ \ and \ \varepsilon \in [0;1],$$

where $\widetilde{s}^\varepsilon = [{}^-s^\varepsilon, {}^+s^\varepsilon]$ is ε - cut, ${}^-s^\varepsilon(x) = \min_{x \in \widetilde{x}^\varepsilon \subset E^n} f(x)$, ${}^+s^\varepsilon(x) = \max_{x \in \widetilde{x}^\varepsilon \subset E^n} f(x)$. Here $I_{\widetilde{s}^\varepsilon}$ is characterisation function, $I_{\widetilde{s}^\varepsilon} = \begin{Bmatrix} 1 \ if \ y \in [{}^-s^\varepsilon, {}^+s^\varepsilon] \\ 0 \ if \ y \notin [{}^-s^\varepsilon, {}^+s^\varepsilon] \end{Bmatrix}$.

It is apparent that applying the Definition 5 the function of fuzzy numbers could be transformed and solved as several mathematical programming problems for ε by this way,

Problem 1

max (min) $s \equiv {}^+s^\varepsilon, ({}^-s^\varepsilon)$,

s.t. $s = f(x_1 .... x_n)$,

where $x_i \in [{}^-x_i^\varepsilon, {}^+x_i^\varepsilon]$ *for* $i \in \{1;2......n\}$, *and* $\varepsilon \in [0;1]$.

Advantage of procedure can be seen in generalised application possibility, mainly for convex, continuous, normal fuzzy numbers. Disadvantage consists in a computation difficulty and non-preciseness by approximation.

5. Fuzzy pyramidal prediction sensitivity analysis of EVA measure

In this part fuzzy pyramidal analysis will be presented. It is assumed, that structure of pyramid is the same as in Section 2. However, input data, Tab. 1, are introduced vaguely by fuzzy numbers of linear T-number type, Definition 3. The solution of the problem consist in solution the equations (1), (2), (5) and (6) with fuzzy numbers similarly to equation (6). Decomposition principle (Definition 5) is applied.

Results are presented in Tab. 4. Solution of procedure is apparent from Fig. 4.

Fig. 3 Fuzzy pyramidal sensitivity planned analysis1`

indicator name			
value sL	value sU	value salfa	value sbeta
margin sL	margin sU	margin salfa	margin sbeta
infl. sL	infl. sU	infl. salfa	infl. sbeta

EVA			
-62641	-62641	27368	19809
71034	71034	27368	19809
71034	71034	27368	19809

(ROE - Re) * E

ROE			
6,01%	6,01%	0,79%	0,46%
4,05%	4,05%	0,79%	0,46%
34345	34345	9052	12158

Re			
12,85%	12,85%	1,70%	2,20%
-5,78%	-5,78%	1,70%	2,20%
49075	49075	12158	9052

E			
915220	915220	20004	10006
113306	113306	20004	10006
-12385	-12385	20469	8163

ROA * EAT/EBIT * A/E

ROA			
6,38%	6,38%	0,14%	0,09%
5,31%	5,31%	0,14%	0,09%
5640	5640	976	1311

EAT/EBIT			
0,4554	0,4554	0,0080	0,0060
0,1964	0,1964	0,0080	0,0060
28749	28749	2303	4606

A/E			
2,068	2,068	0,200	0,100
-0,003	0,000	0,200	0,100
-44	-44	3576	44

EBIT/Rev * Rev/A

EBIT/Rev			
5,75%	5,75%	0,02%	0,03%
0,10%	0,10%	0,02%	0,03%
538	538	138	253

Rev/A			
1,1090	1,1090	0,0200	0,0100
0,1699	0,1699	0,0200	0,0100
5102	5102	884	994

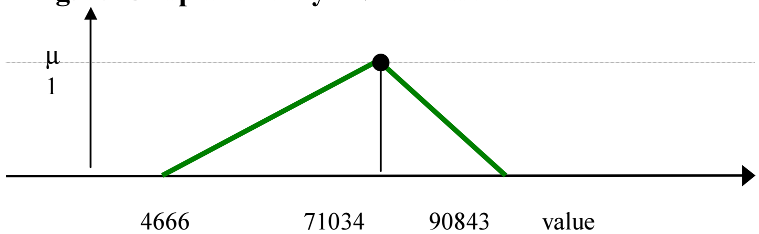
ROE-Re			
-6,84%	-6,84%	2,49%	2,66%
9,83%	9,83%	2,49%	2,66%
83420	83420	29081	46213

Tab. 3 Fuzzy and crisp results of pyramidal influence analysis

indicator	crisp	fuzzy					
		s^L	s^U	s^{alfa}	s^{beta}	$^{-}s^0$	$^{+}s^0$
EVA	71034	71034	71034	27368	19809	43666	90843
ROE	34345	34345	34345	9052	12158	25293	46503
Re	49075	49075	49075	12158	9052	36917	58127
E	-12385	-12385	-12385	20469	8163	-32855	-4223
ROA	5640	5640	5640	976	1311	4664	6951
EAT/EBIT	28749	28749	28749	2303	4606	26446	33355
A/E	-44	-44	-44	3576	44	-3621	0
EBIT/Rev	538	538	538	138	253	400	791

Rev/A	5102	5102	5102	884	994	4218	6096

Fig. 4. Crisp and fuzzy EVA measure



Results show that under soft conditions the fuzzy Eva indicator is (71034; 71034; 27368; 19809) or expressed by interval in 0-cut (43666; 90843). The main positive influence show indices of Re and EAT/EBIT. The greatest negative influence shows equity, which is due to negative relative spread.

6. Conclusion

Financial data analysis and performance measure influence quality of financial decision-making. This situation is typical for emerging markets, transition economics, poor financial market and small opened economies. Usually, long-term quality data of comparable methodology are not in to disposal. Under these conditions, financial analysis and decision-making have to be done with non/precise and vaguely defined data.

In the paper development of EVA measure in small opened economy was presented and the possibility of application of the soft pyramidal financial analysis was described, explained and illustrative examples were presented.

The procedure and approach presented could be applied in process of financial analysis. Fuzzy methodology allows applying soft input data in financial planning and prediction. These conditions often coincide with decision-making circumstances in small economies with weak financial market. Thus described methodology might be considered to be advanced approach to the sensitivity analysis.

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