Incidents in Enterprise Models

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Abstract: Elements of fuzzy set theory are successfully used to solve a large number of economic problems. It is often difficult to find out explicitly how one factor influences another, especially in a complex model of enterprise functioning. The article presents the results of solving the problem of assessing the hidden impacts of factors on which the functioning of the enterprise as a whole depends. The enterprise model itself is not considered. The degrees of influence of one factor on another are obtained on the basis of expert assessments and are of a demonstrative nature.

1 INTRODUCTION

Let us consider the incidence of set A on set B , which we will denote as M_{AB} and the incidence of set B on the third set C – respectively M_{BC} . The successive application of two incidences leads to a second-order incidence, which is designated (Nikishov, 2017; Trifonov, 2009; Artamonova, Rakhmetova, Sakharova, 2019; Beilin, Khomenko,2017):

$$M_{AC}=M_{AB} \circ M_{VS} . \quad (1)$$

When calculating second-order incidences using formula (1), it should be remembered that the number of columns of the matrix M_{AB} must be equal to the number of rows of the matrix $_{MBC}$ (the well-known rule of matrix multiplication).

If all elements of an arbitrary matrix M_1 are not greater than the corresponding elements of another arbitrary matrix M_2 with the same addresses , then this fact is written in the form (Beilin, Khomenko, 2017; Groshev, Grosheva, Bezuevskaya, 2019):

$$M_1 \subset M_2 .$$

Let E — identity matrix, $\tilde{M}$ — fuzzy matrix, $\tilde{A}$ and $\tilde{B}$ are reflexive fuzzy matrices that determine the incidences of A on A and B on B , respectively, i.e.

$$\tilde{A} = M_{AA}, \ \tilde{B} = M_{BB} .$$

Because $E \subset \tilde{A}$ and $E \subset \tilde{B}$, then we get (Makarov, Kolesnikov, Shirokova, Nekrasova, Kadilnikova, 2018)

$$\tilde{M} = E \circ \tilde{M} \subset \tilde{A} \circ \tilde{M} \text{ And}$$

$$\tilde{M} = \tilde{M} \circ E \subset \tilde{M} \circ \tilde{B} .$$

Then

$$\tilde{M} \subset \tilde{A} \circ \tilde{M} \circ \tilde{B} . \quad (2)$$

The matrix defining the first and second order effects is

$$\tilde{M}^* = \tilde{A} \circ \tilde{M} \circ \tilde{B} \quad (3)$$

and hidden effects are detected after calculating the matrix (Dolgova, 2018; Lebedeva, 2019)

$$\tilde{D} = \tilde{M}^* - \tilde{M} . \quad (4)$$

Calculations according to formula (4) are possible, since according to formulas (2) and (3) the following is satisfied:

$$\tilde{M} \subset \tilde{M}^* .$$

2 RESULTS AND DISCUSSION

When performing research work dedicated to modeling the process of functioning of a small enterprise, one of the tasks to be solved was to assess

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the influence of external factors on the main parameters of the enterprise's functioning.

The model of functioning of an enterprise is considered, the input factors of which are (Sokolov, 2018; Anokhov, 2019):

a_1 — modernization of production equipment;

a_2 - expansion of the range and volume of inventory;

a_3 - release of new products;

a_4 - expansion of the retail network;

a_5 - advertising activities.

These factors form the set A .

The output factors form a set B , which consists of:

b_1 — growth in the number of sales (in physical units);

b_2 — change in selling prices;

b_3 — competitiveness;

b_4 — product quality;

b_5 - territorial distribution.

It is assumed that in this model the input a and output b parameters influence themselves and input factors influence output factors (Fenin, 2019; Burov, 2017).

Using expert assessment, the values of the elements of fuzzy matrices were compiled $\tilde{A}$ and $\tilde{B}$, which are incidences of the set A on the set A , B on B, respectively. The values of these matrices are given in Tables 1, 2.

Table 1: Input values.

A	a_1	a_2	a_3	a_4	a_5
a_1	1	0,7	0,5	0,1	0
a_2	0	1	0,1	0,4	0
a_3	0,7	0,9	1	0,5	0,8
a_4	0,5	0,8	0,7	1	0,9
a_5	0	0	0,4	0,7	1

Table 2: Output values enterprise factors enterprise factors.

$\tilde{A}\tilde{M}$	1	2	3	4	5
1	0,9	0,3	0,5	0,9	0,6
2	0,8	0,2	0,4	0	0,6
3	1	0,6	0,8	0,7	0,6
4	0,9	0,6	0,7	0,5	1
5	1	0,6	0,7	0	0,7

The experts also compiled a matrix $\tilde{M}$ of incidences of set A on set B (Table 3) . Using the composition rule maxmin, the matrix was calculated $\tilde{A} \circ \tilde{M}$ (Table 4). In the table (and in the tables below), the row numbers correspond to the numbers of the input factors, and the column numbers correspond to the numbers of the output factors (Korchagina, Starikova, 2017; Kicha, 2016; Borisova, 2018).

Table 3: Expert matrix table $\tilde{M}$.

$\tilde{M}$	b_1	b_2	b_3	b_4	b_5
a_1	0,9	0,3	0,1	0,9	0
a_2	0,8	0,2	0,3	0	0,6
a_3	1	0	0,8	0	0,6
a_4	1	0,2	0,7	0	1
a_5	1	0,6	0,7	0	0,1

Table 4: Calculation values matrices $\tilde{A} \circ \tilde{M}$.

$\tilde{A}\tilde{M}$	1	2	3	4	5
1	0,9	0,3	0,5	0,9	0,6
2	0,8	0,2	0,4	0	0,6
3	1	0,6	0,8	0,7	0,6
4	0,9	0,6	0,7	0,5	1
5	1	0,6	0,7	0	0,7

Second order incidences were calculated using the matrix

$$\tilde{M}^* = \tilde{A} \circ \tilde{M} \circ \tilde{B},$$

which is presented in the form of table 5.

And finally, the difference between the matrices was determined $\tilde{D} = \tilde{M}^* - \tilde{M}$, the values of which are given in Table 6.

Table 5: Values incidence of the second matrix.

$\tilde{M}^*$	1	2	3	4	5
1	0,9	0,9	0,9	0,9	0,6
2	0,8	0,6	0,8	0,1	0,6
3	1	0,7	1	0,7	0,6
4	1	0,6	0,9	0,5	1

5	1	0,6	1	0,5	0,7

Table 6. Difference values Order.

$\tilde{D}$	1	2	3	4	5
1	0	0,6	0,8	0	0,6
2	0	0,4	0,5	0,1	0
3	0	0,7	0,2	0,7	0
4	0	0,4	0,2	0,5	0
5	0	0	0,3	0,5	0,6

Matrix $\tilde{D}$ allows us to establish the hidden impacts of input parameters on output ones. Let's consider the most significant of them (see Table 6):

(1 → 3) equipment modernization - with the degree of influence of one factor on another of 0.8;

(3 → 2) release of new products - change in selling prices;

(3 → 4) release of new products - product quality;

(1 → 2) equipment modernization - price change;

(1 → 5) equipment modernization - territorial distribution;

(5 → 5) Advertising activities - territorial distribution.

To detect hidden effects, we establish intermediate incidences. By looking through all paths leading from input parameters to output parameters and selecting <u>the largest of the minima</u> between each input element and output element, we determine incidences according to Tables 1-6, for example, for the pair (1 → 3):

$$1\xrightarrow[A_{11}]{1}1\xrightarrow[AM_{11}]{0,9}1\xrightarrow[B_{13}]{1}3 \qquad \underset{\min}{0,9};$$

$$1\xrightarrow[A_{11}]{1}1\xrightarrow[AM_{12}]{0,3}2\xrightarrow[B_{23}]{1}3 \qquad \underset{\min}{0,3};$$

$$1\xrightarrow[A_{13}]{0,5}3\xrightarrow[AM_{33}]{0,8}3\xrightarrow[B_{33}]{1}3 \qquad \underset{\min}{0,5}$$

$$1\xrightarrow[A_{11}]{1}1\xrightarrow[AM_{14}]{0,9}4\xrightarrow[B_{43}]{0,9}3 \qquad \underset{\min}{0,9}$$

The arrows show the matrices - tables from which the paths and values of the matrix element were selected; the element address is indicated as an index in the matrix.

Let us select the most significant of them, equal to 0.9 (the first and fourth rows), and compare them with the $\tilde{M}$ incidence matrix of set A on set B (Table 3):

$$1\xrightarrow[A_{11}]{1}1\xrightarrow[AM_{11}]{0,9}1\xrightarrow[B_{13}]{1}3 \qquad \underset{\min}{0,9};$$

$$1\xrightarrow[A_{11}]{1}1\xrightarrow[AM_{14}]{0,9}4\xrightarrow[B_{43}]{0,9}3 \qquad \underset{\min}{0,9};$$

$$1\xrightarrow[\tilde{M}_{13}]{0,1}3 \qquad \underset{\tilde{M}_{13}}{0,1} \qquad \underset{\tilde{D}_{13}}{0.9 - 0.1 = 0.8.}$$

We carry out similar comparisons for the remaining pairs accepted as significant in the discussion in Table 6 (the order of paths and intermediate calculations are completely analogous to the pair (1 – 3)):

(3 → 2)

$$3\xrightarrow[A_{31}]{0,7}1\xrightarrow[AM_{14}]{0,9}4\xrightarrow[B_{42}]{1}2 \qquad \underset{\min}{0,7};$$

$$3\xrightarrow[\tilde{M}_{32}]{0}2 \qquad \underset{\tilde{M}_{32}}{0} \qquad \underset{\tilde{D}_{32}}{0.7 - 0 = 0.7.}$$

(3 → 4)

$$3\xrightarrow[A_{31}]{0,7}1\xrightarrow[AM_{14}]{0,9}4\xrightarrow[B_{44}]{1}4 \qquad \underset{\min}{0,7};$$

$$3\xrightarrow[\tilde{M}_{34}]{0}4 \qquad \underset{\tilde{M}_{34}}{0} \qquad \underset{\tilde{D}_{34}}{0.7 - 0 = 0.7.}$$

(1 → 2)

$$1\xrightarrow[A_{11}]{1}1\xrightarrow[AM_{14}]{0,9}4\xrightarrow[B_{42}]{1}2 \qquad \underset{\min}{0,9};$$

$$1\xrightarrow[\tilde{M}_{12}]{0,1}2 \qquad \underset{\tilde{M}_{12}}{0,3} \qquad \underset{\tilde{D}_{12}}{0.9 - 0.3 = 0.6.}$$

$(1 \rightarrow 5)$

$$1 \xrightarrow{0,7} 2 \xrightarrow{0,8} 5 \xrightarrow{1} 5 \qquad 0.7;$$

$$A_{12} \quad AM_{25} \quad B_{55} \qquad \min$$

$$1 \xrightarrow{\quad 0,1 \quad} 5 \quad 0,1 \; 0.7 - 0.1 = 0.6.$$

$$\tilde{M}_{15} \qquad \tilde{M}_{15} \qquad \tilde{D}_{15}$$

$(5 \rightarrow 5)$

$$5 \xrightarrow{0,7} 4 \xrightarrow{1} 5 \xrightarrow{1} 5 \qquad 0,7$$

$$A_{54} \quad AM_{45} \quad B_{55} \qquad \min$$

$$5 \xrightarrow{\quad 0,1 \quad} 5 \quad 0,1 \; 0.7 - 0.1 = 0.6.$$

$$\tilde{M}_{55} \qquad \tilde{M}_{55} \qquad \tilde{D}_{55}$$

3 CONCLUSIONS

The results of the calculations allow us to draw the following conclusions about the paths of hidden influences of the factors considered in the article:

1. Equipment modernization affects the competitiveness of the enterprise through the growth of sales and product quality.
2. The release of new products influences changes in sales prices through equipment modernization and product quality.
3. The release of new products also affects the quality of products through the modernization of production.
4. Modernization of production influences price changes through product quality and territorial distribution through expansion of product range and volume of inventory.
5. Advertising activities influence territorial distribution through expansion of the retail network.

Thus, when developing a strategy for enterprise development, the theory of fuzzy sets allows solving quantitative problems in assessing the degree of influence of some production factors on others through hidden effects.

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