Implementation of the Concept of Impression Evaluation Method

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Abstract: - This paper closes a series of papers related to the development and implementation of the concept of Impression Evaluation Method. It provides a complete mathematical apparatus for Impression Evaluation Method in dealing with products, services or activities in order to construct the so called "black box" of the impression formation process. The proposed algorithm is based on the conceptual definition of impression, conceptual model of impression formation process and the concept of Impression Evaluation Method developed in the authors' previous works. The developed algorithm contains well established and time-tested functions and statements from different areas. Some novel functions related to the implementation of Impression Evaluation Method are developed. The classical desirability function is modified in order to eliminate some shortages related to its usage in the current context. The constructed algorithm is presented in the object-oriented style in order to facilitate to the degree possible its translation into the programming languages. The directions of further research are described.

Key Words: - impression, evaluation, value function, psychological relative wealth function, modified desirability function

1 Introduction

The main purpose of this paper is to provide mathematical apparatus for the implementation of Impression Evaluation Method (IEM) algorithm. This paper continues a series of papers related to the research of impression formation process. The theoretical background, definitions and explanation of the developed algorithm are provided in the previous publications [1] - [3].

2 Problem Formulation

The concept of IEM is formulated in [1] and provides guidelines for its implementation. In order to implement IEM the mathematical apparatus for impression evaluation should be developed.

3 Problem Solution

The mathematical apparatus for impression evaluation is provided in this section. The equations syntax is provided in the object-oriented style in order to facilitate to the degree possible its translation into the programming languages. At the same time it allows keeping the text readable.

3.1 Abbreviations

The abbreviations used in this paper are as follows:

- $\mathrm{F}(X)$: function F with argument X.
- $B.C$: property C of object B. Each object can have several properties.
- $A[k]$: array's A object with sequential number k. The array works as collection of isomorphic objects: each array's object has the same set of properties.
- The abbreviations can be combined with each other, for example, abbreviation $\mathrm{F}(A[k].C)$ means function F taken from property C of the array's A object with sequential number k.

3.2 Definitions

Functions and definitions necessary for the calculation of impression evaluation are defined and described in this subsection.

3.2.1 Value function, v

The value function transforms physical intensity of the property to psychological value and is calculated in accordance with [4]:

$$\mathrm{v}(x)=\begin{cases} x^{\alpha} & \text{if } x \ge 0 \\ -\lambda(-x)^{\alpha} & \text{if } x < 0 \end{cases} \qquad (1)$$

Where:

$\mathrm{v}(x)$ - psychological value function.

x - objective value (physical intensity of the property): the objective value is positive for gains and negative for losses.

α - coefficient, $\alpha = 0.88$.

λ - coefficient, $\lambda = 2.25$.

The functional dependence between normalized measures for objective and psychological values arises from the equation (1) and is calculated as follows:

$$|x_n| = |p_n|^{\frac{1}{0.88}} \qquad (2)$$

Where:

$x_n = \dfrac{x}{x_{\max}}$ - normalized objective value.

$p_n = \dfrac{\mathrm{v}(x)}{\mathrm{v}(x_{\max})}$ - normalized psychological value.

3.2.2 Desirability function, d

The desirability function was developed by E. C. Jr. Harrington in 1965. It is calculated in accordance with [5]:

$$\mathrm{d}(X) = \exp(-\exp(-X)) \qquad (3)$$

Where:

$\mathrm{d}(X)$ - desirability function.

X - objective value scaled by selecting two values of the measured property: the objective value is positive for gains and negative for losses.

The interpretation of the desirability function d values, customized in accordance with the current context, is provided in Table 1.

Notwithstanding the fact that desirability function is well established and time-tested, there are two shortages limiting its use in the current context:

- The desirability function has asymptotic upper and lower limits 0 and 1, but is not defined within them. As a consequence of this fact the desirability function is not defined in the points “completely unacceptable” and “improvement beyond this point has no additional value”.
- Gains and losses values’ definition areas are symmetrical, but in the real life it could be different.

The aforementioned shortages are eliminated by the modified desirability function developed by the authors. The definition and description of the modified desirability function is provided in the next sub-subsection.

Table 1

The interpretation of the desirability function d values

d values	Interpretation
1.00	Improvement beyond this point has no additional value
0.80	Excellent
0.63	Best commercial quality
0.40	Insignificant gain
0.37	The reference point
0.30	Borderline
0.00	Completely unacceptable

3.2.3 Modified desirability function, DM

Modified desirability function is based on the previously explained desirability function d and is calculated as follows:

$$\mathrm{DM}(x_n, k) = \frac{\mathrm{d}(kx_n) - \mathrm{d}(-k)}{\mathrm{d}(k) - \mathrm{d}(-k)} \qquad (4)$$

Where:

$\mathrm{DM}(x_n, k)$ - modified desirability function.

k - exactingness coefficient.

The interpretation of the modified desirability function DM values is provided in Table 2. As follows from Table 2 the benchmark values of the modified desirability function depend on the exactingness coefficient k.

This circumstance provides information source for the exactingness coefficient k scaling. The data in Table 3 shows an extract of information with regard to useful range of exactingness coefficient values.

For example, when the exactingness coefficient is chosen $k = 3$, the products, services or activities are evaluated as excellent if they are realized by 50% from the maximum value.

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In the same case products, services or activities are evaluated as the best commercial quality, if they are realized by 26% from the maximum value.

Table 2

The interpretation of the modified desirability function DM values depending on the exactingness coefficient k

DM values	Interpretation
1.00	Improvement beyond this point has no additional value
$\frac{0.80-d(-k)}{d(k)-d(-k)}$	Excellent
$\frac{0.63-d(-k)}{d(k)-d(-k)}$	Best commercial quality
$\frac{0.40-d(-k)}{d(k)-d(-k)}$	Insignificant gain
$\frac{\exp(-1)-d(-k)}{d(k)-d(-k)}$	The reference point
$\frac{0.30-d(-k)}{d(k)-d(-k)}$	Borderline
0.00	Completely unacceptable

Table 3

The dependence of normalized objective values x_n on the exactingness coefficient k and the modified desirability function DM benchmarks

k	x_n for DM value interpretation as excellent	x_n for DM value interpretation as best commercial quality
2.50	0.60	0.31
2.60	0.58	0.30
2.70	0.56	0.29
2.80	0.54	0.28
2.90	0.52	0.27
3.00	0.50	0.26
3.10	0.48	0.25
3.20	0.47	0.24
3.30	0.45	0.23
3.40	0.44	0.23
3.50	0.43	0.22

As follows from data in Table 3 the increase of exactingness coefficient indicates the decrease of stakeholders' exactingness: smaller fraction of the maximum possible goodness is evaluated as excellent or best commercial quality. Otherwise, the decrease of exactingness coefficient indicates increase of stakeholders' exactingness. This pattern is clearly shown in Figure 1.

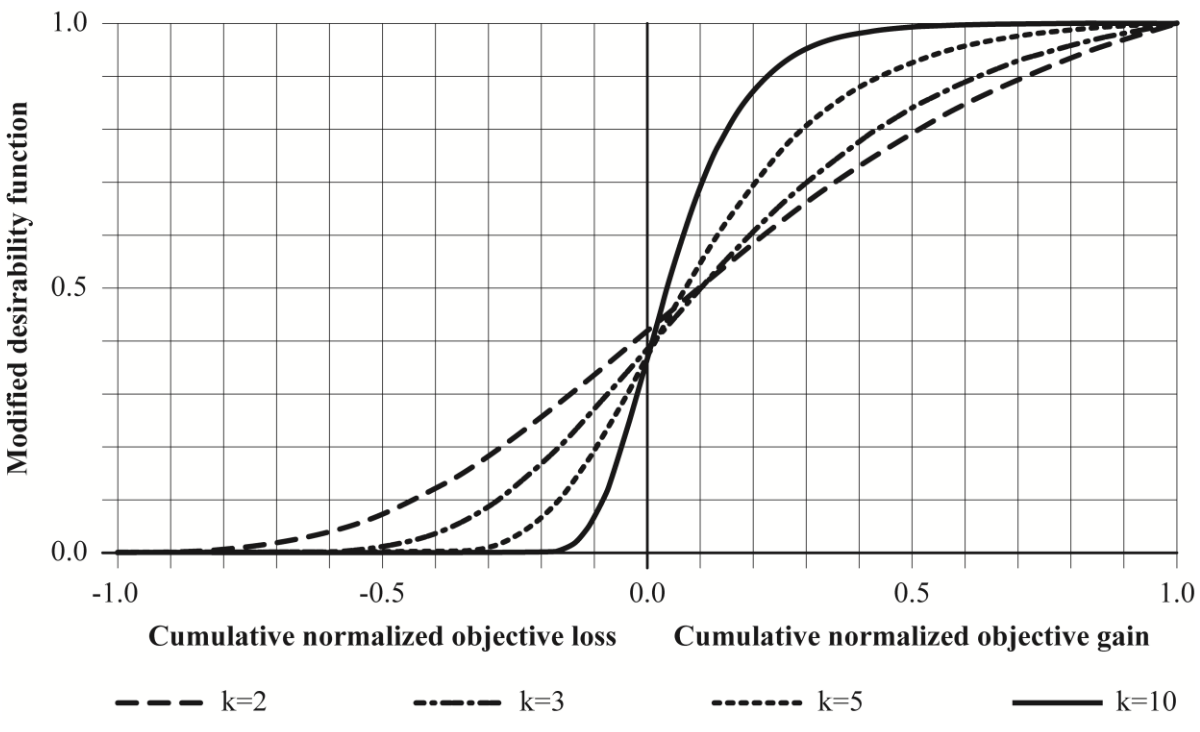

Fig. 1. Modified desirability function DM values depending on the exactingness coefficient k

Personal opinion of the authors is that it would be recommended to choose exactingness coefficient $k = 3$ for general purposes.

3.2.4 Gains and losses properties

Let's assume stakeholders consider some gains and losses related to organization's evaluated activities, products or services. The aforementioned gains constitute array G and losses constitute array L.

According to [1] gains and losses are objects with the following properties:

- $G[i].N$: name of a particular gain.
- $G[i].I$: particular gain importance.
- $G[i].VA$: particular gain actual normalized psychological value.
- $G[i].VE$: particular gain expected normalized psychological value.
- $L[i].N$ **:** name of a particular loss.
- $L[i].I$: particular loss importance.
- $L[i].VA$: particular loss actual normalized psychological value.
- $L[i].VE$: particular loss expected normalized psychological value.

3.2.5 Cumulative normalized objective values

Cumulative normalized objective values are integrated measures of actual and expected gains and losses and are not objects but interim values.

Those measures show a proportion of actual or expected cumulative gains and losses in the considered maximum cumulative gains and losses accordingly. They are calculated taking into account considerations provided by equation (2) for transformation of normalized psychological values to normalized objective values; it is assumed n gains and m losses are considered. In this case cumulative normalized objective gains and losses are calculated using algorithms provided in equations below:

- GA: actual cumulative normalized objective gain,

$$GA = \frac{\sum_{i=1}^{n}\left(G[i].I \times \left(G[i].VA\right)^{\frac{1}{0.88}}\right)}{\sum_{u=1}^{n} G[u].I} \quad (5)$$

- GE: expected cumulative normalized objective gain,

$$GE = \frac{\sum_{i=1}^{n}\left(G[i].I \times \left(G[i].VE\right)^{\frac{1}{0.88}}\right)}{\sum_{u=1}^{n} G[u].I} \quad (6)$$

- LA: actual cumulative normalized objective loss,

$$LA = \frac{\sum_{i=1}^{m}\left(L[i].I \times \left(L[i].VA\right)^{\frac{1}{0.88}}\right)}{\sum_{u=1}^{m} L[u].I} \quad (7)$$

- LE: expected cumulative normalized objective loss,

$$LE = \frac{\sum_{i=1}^{m}\left(L[i].I \times \left(L[i].VE\right)^{\frac{1}{0.88}}\right)}{\sum_{u=1}^{m} L[u].I} \quad (8)$$

3.2.6 Normalized psychological relative wealth function NPRW

The normalized psychological relative wealth is the sum of psychological values of expected changes in cumulative normalized objective values of losses and gains for the evaluated point after products, services or activities implementation.

The normalized psychological relative wealth function is calculated in accordance with [3] by equation (9).

$$\mathrm{NPRW}\left(LE, GE, LA, GA\right) = \begin{cases} \left(\dfrac{GA}{LA}\right) \times \mathrm{v}\left(LA - LE\right) + \mathrm{v}\left(GE - GA\right) & \text{if } LA \times GA \neq 0 \\ \mathrm{v}\left(LA - LE\right) + \mathrm{v}\left(GE - GA\right) & \text{if } LA \times GA = 0 \end{cases} \quad (9)$$

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3.2.7 Desirability of normalized psychological relative wealth function, DNPRW

The desirability of normalized psychological relative wealth provides a measure for impression evaluation and is calculated in accordance with equation (10).

$$\mathrm{DNPRW}\left(LE,GE,LA,GA,k\right)=\begin{cases}\mathrm{DM}\left(\dfrac{\mathrm{NPRW}\left(LE,GE,LA,GA\right)}{\mathrm{NPRW}\left(0,1,LA,GA\right)},k\right) & \text{if NPRWE} \geq 0\\ \mathrm{DM}\left(\dfrac{\mathrm{NPRW}\left(LE,GE,LA,GA\right)}{\mathrm{NPRW}\left(1,0,LA,GA\right)},k\right) & \text{if NPRWE} < 0\end{cases} \quad (10)$$

3.3 Workflow

The workflow of impression evaluation algorithm and interpretation of results is shown in Figure 2.

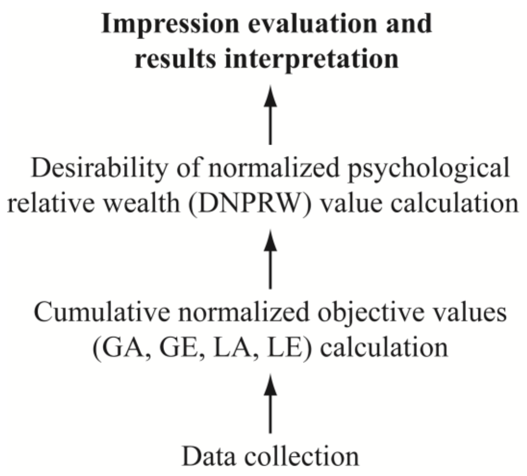

Fig.2. The workflow of impression evaluation

The implementation of workflow procedures is described in the next subsections; interim calculations were described in section 3.2.

3.4 Data collection

In order to collect the data for impression evaluation it is necessary to identify a list of gains and losses considered by stakeholders with relation to organization’s activities, products or services.

After the first step is completed, the questionnaire should be developed in order to obtain information from stakeholders about gains and losses normalized psychological values and importance.

Normalized psychological values and importance are measured putting them into conformity with some linguistic labels. Depending on the questionnaire design a seven-point Likert scale or visual analogue scale is suggested to be used to transform the aforementioned labels into numbers between 0 and 1. The obtained numerical values will constitute the collection of gains’ and losses’ properties. Those properties are described in further sub-subsections.

3.4.1 Name property

Gains and losses names, formulated by stakeholders, will constitute name properties of the respective object to facilitate its further identification, results tracing, conclusions and development of recommendations.

3.4.2 Normalized psychological value property

Normalized psychological values are evaluated by stakeholders as actual or expected intensity of particular gain or loss implementation compared with the best or worst scenario of the respective gain and loss implementation in terms “nothing”, “maximum” or gradations between these extremes.

3.4.3 Importance property

Importance property is evaluated by stakeholders as accordant gain contribution in “improvement beyond this point has no additional value” state or accordant loss contribution in “completely unacceptable” state expressed in terms “not important”, “vitally important” or gradations between these extremes.

3.5 Impression evaluation and results interpretation

Impression is evaluated by comparison of the calculated value of desirability of normalized psychological relative wealth DNPRW with benchmarks provided in Table 3. The example of impression evaluation is shown in Figure 3.

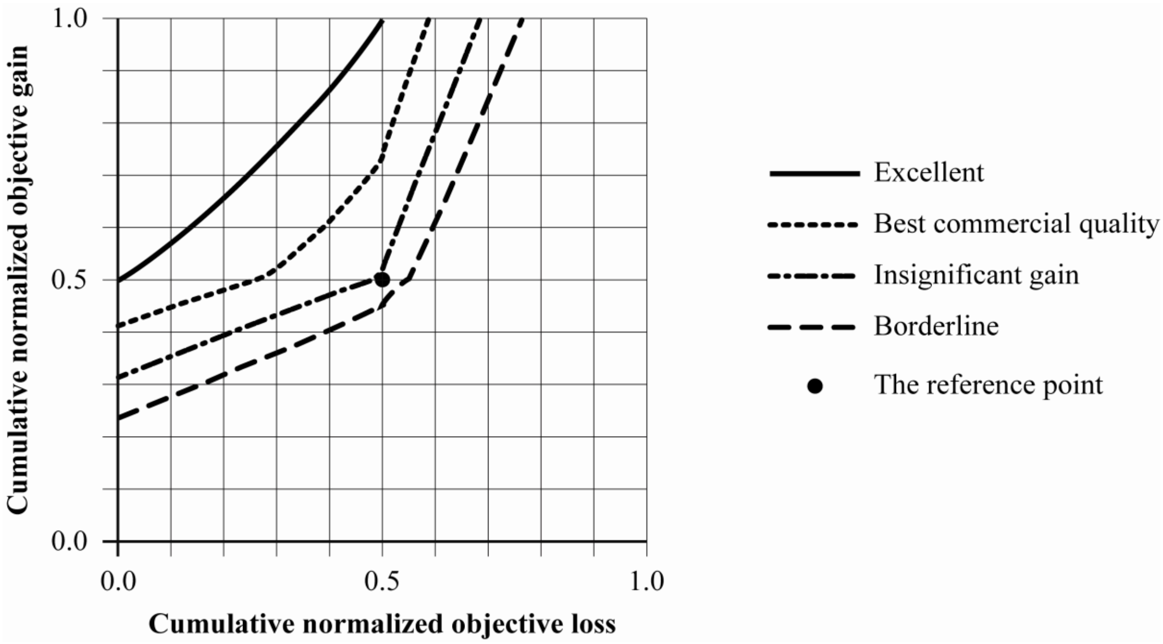

Fig.3. The example of impression evaluation

The guidelines for impression evaluation results and target area of gains and losses parameters analysis are similar to guidelines described in [6].

4 Conclusion

This paper closes the first phase of the so called “black box” constructing of the impression formation process. The algorithm of IEM implementation provides a basis for a web-based and standing alone versions of software tool development. The developed software is expected to provide user friendly interface for IEM algorithm use and interpretation of the results.

According to the “black box” strategy the developed conceptual assumptions and algorithm could be rejected, corrected, or accepted during tests by experts in the field. The authors plan to study this direction during further research.

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