Quantification of framing effect using ANP

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Abstract. When it comes to decision making the most influential components are the quality of the information and the size of the framing effect. In the decision-making process the framing effect arises as a set of opinions and expectations of involved subjects. Everyone making a decision has his own preferences and expectations that create his own unique view (frame). These unique views or frames may negatively influence the information sharing in the decision-making processes and therefore the analysis of the framing effect is important.
This paper shows how to use Analytic Network Process to do the determination and quantification of the framing effect and it shows the advantages of using this method. The result of this approach will be the set of weights of all viewpoints included into the frames. Values of these weights can serve to analyse the framing effect, because all subjects in the decision-making process will receive the information about the importance of different viewpoints and then they can rearrange their opinions and expectations. It will have positive impact on the overall outcome of the decision-making process too.

Keywords: Framing Effect, Analytic Network Process, Pairwise Comparison, Product Packaging

JEL Classification: C44
AMS Classification: 90C29

1 Introduction

The integral part of any decision-making processes is the information receiving process. As Fagley, Coleman and Simon [3] mention decision-making is influenced by the quality of the information and by the effect of information distortion (framing effect). And as mentioned by Tversky and Kahneman [15] the framing effect included in some information can significantly influence decisions. There are various views on a particular issue in decision process. This various views (or frames) may create several issues. As Bishop [1] believes that if information is not sorted according to its relevance because we cannot properly decide who has the most important view, we may face the problem of being overloaded with too much information resulting in either poor information acquisition or the whole process is very time consuming and thus very ineffective. On the contrary to this situation preferring the certain point of view we may lose the information needed for successful decision making. To limit these negative frames we need firstly to define and understand them, secondly, as pointed out by Druckman [2], we need to evaluate them, and thirdly we need to use the appropriate method to reduce them. For this kind of evaluation as Fagley, Coleman and Simon [3] write we need to know the importance of various frames and included points of view. These frames can be analyzed using multiple attribute decision-making methods.

The typical example of the frame's impact on decision is the information written on the product package. As Kozel [4] analyses in more details, the packaging inevitably influences our purchase decisions. In the current theories the packaging is presented as one of the forms of the marketing communication. According to Lindsey-Mullikin and Petty [5], the product packaging can attract our attention; affect our emotions, but on the other hand, by its information value it can contribute to the rational purchase decision. The main reason behind this is the fact, that consumers expect the products to meet their expectations and prefer them according to their own preferences. Each consumer has his unique view when buying a specific product (his unique way of perceiving the situation) based on his personality. His purchase decision is influenced by the preferences and expectations; we are talking about the framing effect of the decision situation, which discusses in detail Rydval [8], [9].

The Analytic Network Process is one of the multiple criteria decision making methods. It decomposes decision problems into a network of smaller parts (sub-problems) that can more easily by analysed and evaluated. It is specific for this method that the human judgment is involved. (Saaty [11])

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The goal of this paper is to quantify the framing effect, its main set of viewpoints and their components, and their evaluation using the Analytic Network Process and to show the impact of network on the evaluation of framing effect, opposite to a hierarchy.

2 Materials and methods

2.1 Framing effect

Individual decisions are influenced by the presented information and by the formulation of problems. Each subject has his own preferences and expectations that create his own view (frame). The framing effect is made up of these frames. Tversky and Kahneman [15] pointed out the framing effect influences the way of information interpretation or misinterpretation, so it may influence decision-making significantly. As Rydval and Hornická [7] mentioned we can therefore define the framing effect as a set of preferences and expectations of involved subjects belonging to a particular decision-making problem. To quantify framing effect, as indicated Rydval [8] , [9], the methods for quantifying preferences of decision maker can be used. Quantification of the framing effect in education is discussed by Rydval and Brožová [6].

2.2 Saaty's method of pairwise comparison

It is a quantitative pairwise comparison method for the criteria, which analyzes in detail Saaty [12, 13]. A nine point scale is provided to quantify pairwise importance of criteria and it is possible to use intermediate values (values 2, 4, 6, 8):

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgement slightly favour one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgement strongly favour one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation

Table 1 The fundamental scale of absolute numbers

Expert compares each pair of criteria and he records the size of the preferences of the *i* criterion to the *j* criterion in the Saaty matrix $S = (s_{ij})$:

$$S = \begin{pmatrix} 1 & s_{12} & \cdots & s_{1n} \\ 1/s_{12} & 1 & \cdots & s_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ 1/s_{1k} & 1/s_{12} & \cdots & 1 \end{pmatrix} \qquad (1)$$

If the *i* and *j* criterion are equal then $s_{ij} = 1$; If the *i* is slightly stronger than *j* criterion then $s_{ij} = 3$; If the *i* is stronger than *j* criterion then $s_{ij} = 5$; If the *i* is much stronger than *j* criterion then $s_{ij} = 7$; If the *i* is absolutely stronger than *j* criterion then $s_{ij} = 9$; If *j* is preferred instead of *i*, inverted values are entered into the Saaty matrix ($s_{ij} = 1/3$ for a weak preference, $s_{ij} = 1/5$ for a strong preference, etc.).

It is a square matrix of order $n \times n$, reciprocal, i.e. $s_{ij} = 1/s_{ji}$, and expresses actually the estimate of weights of i and j criterion. On the diagonal of Saaty matrix values are always one (each criterion is equivalent to itself).

The elements of this matrix are not usually perfectly consistent, $s_{hj} = s_{hi} \times s_{ij}$ is not valid for all $h, i, j = 1, 2, ..., n$. If we compiled a matrix $V = (v_{ij})$, whose elements would be real weights ($v_{ij} = v_i / v_j$), for elements of this matrix, the above condition is applied. The rate of consistency is measured by a consistency index defined by Saaty:

$$I_S = \frac{l_{\max} - n}{n-1}, \qquad (2)$$

where l_{max} is the largest eigenvalue of Saaty's matrix and n is the number of criteria. Saaty's matrix is considered to be sufficiently consistent if $I_S < 0.1$.

To determine the weights Saaty suggested several wals we can use to estimate the weights vj. The most commonly used procedure to calculate the weights as normalized geometric mean of the rows of the Saaty's matrix (logarithmic least squares method). Calculate the value bi as the geometric mean of the rows of the Saaty's matrix:

$$b_i = \sqrt[n]{\prod_{j=1}^{n} s_{ij}} \qquad (3)$$

The weights are calculated by normalization of values b_i:

$$v_i = \frac{b_i}{\sum_{i=1}^{n} b_i} \qquad (4)$$

Saaty's method can be used not only to determine the preferences between the criteria, but also among the variants.

2.3 Analytic network process

The Analytic Network Process (ANP) is a generalization of the Analytic Hierarchy Process (AHP), by considering the dependence between the elements of the hierarchy. Many decision problems cannot be structured hierarchically because they involve the interaction and dependence of higher-level elements in a hierarchy on lower level elements. Therefore, ANP is represented by a network, rather than a hierarchy. (Saaty [10], [12]), [13]))

The basic elements of the ANP method are following:

- The first step of ANP is based on the creation of a control network which describes dependency among decision elements. The ANP allows
  - inner dependence within a set (clusters) of elements, and
  - outer dependence among different sets (clusters).
- In the second step pairwise comparisons of the elements within the clusters and among the clusters are performed according to their influence on each element in another cluster or elements in their own cluster. So the ANP prioritizes not only decision elements but also their groups or clusters as it is often the case in the real world. The consistency of these comparisons has to be controlled.
- The third step consists of the supermatrix construction. The priorities derived from the pairwise comparisons are entered into the appropriate position in this supermatrix. This supermatrix has to be normalized using clusters weights.
- In the fourth step the limiting supermatrix is computed and global preferences of decision elements are obtained. These preferences serve as the best decision selection or for the purpose of analysis of preferences of decision-making elements. (Saaty [10], [11])

2.4 SuperDecisions software

This method is carried out by the SuperDecisions software system (SuperDecisions [14]). The SuperDecisions software implements the ANP developed by Dr. Thomas Saaty. The program was written by the Creative Decisions Foundation.

3 Results and discussion

3.1 A case study – Measuring the framing effect using the ANP through the analysis of information on pork

Information published on the product packaging is very important when analyzing consumer behavior and it has a major impact on consumer demand. Consumer's own criteria create a consumer's view on the product purchase. Because it participates in the formation of preferences, it is necessary to adequately define and quantify it. Criteria, on which customer put emphasis when buying products, can be defined using questionnaires. However, to obtain information appropriate for the quantification of consumer's criteria, we must properly structure questionnaires.

This case study follows the case study analyzing the product information using AHP, in which Rydval [9] analyzes information on the packaging of pork. The survey was carried out in Prague and the responses were obtained from 86 customers and 9 meat sellers. Average pork meat contains from 35 to 55% fat, while lean pork only from 15 to 20% (Caloric tables). Purchasing pork can be simply characterized as multi-criteria analysis model of variants. The consumer decides between variants based on his criteria. He decides which one he will buy. On the other hand, the producer bases his decision about the information he publishes about the product to attract the customer on the existing legislation and his own criteria. It is important for the producer to know not only the legislation and his preferences when publishing information, but also the consumer's preferences. These two sets of preferences, respectively two views on the same issue, must be defined in an appropriate way and based on the way we want to present our product. For a situation where the consumer decides between multiple variants the crucial are the criteria, on which customer bases his decisions. The criteria can be determined by questionnaire. We can use the same approach for producer.

In this case study, the important for consumers when purchasing meat, were the following criteria:

- Price (the price of the product in CZK)
- Quality (measured by the meat texture according to standards ISO 11036, 1997 and by weight loss during heat treatment in %)
- Manufacturer (the name of manufacturer or importer respectively supplier’s name and the country of origin)
- Availability (measured by the availability of the product in retail network)
- Production Ecology (the product is labeled as "organic product" with organic logo, measured by the criteria specified in Act No. 242/2000 on organic agriculture, as amended)

When considering what information about the product to publish, the following criteria were the most important for the producers (sellers):

- Quality (measured by the meat texture according to standards ISO 11036, 1997 and by weight loss during heat treatment in %)
- The originality of the product (a combination of technological processing of the product and the creative adaptation of the product packaging)
- Price (the price of the product in CZK)
- Manufacturer (the name of manufacturer or importer respectively supplier’s name and the country of origin)
- Production Ecology (the product is labeled as "organic product" with organic logo, measured by the criteria specified in Act No. 242/2000 on organic agriculture, as amended)

Rydval [9] used for the criteria quantification the AHP model in his case study. Figure 1 shows the structure. In this case, the ANP model is used to quantify the criteria. The structure of this model is shown in Figure 2

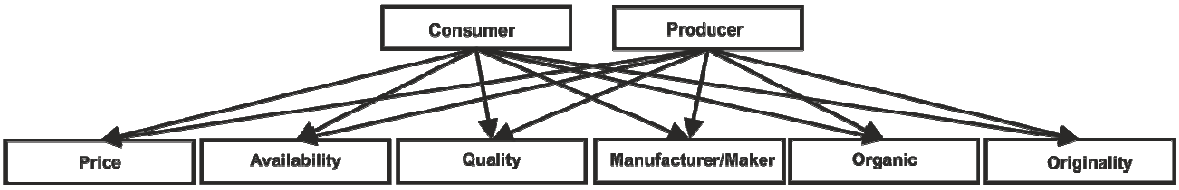

Figure 1 Hierarchical structure of decision-making model; Information on pork

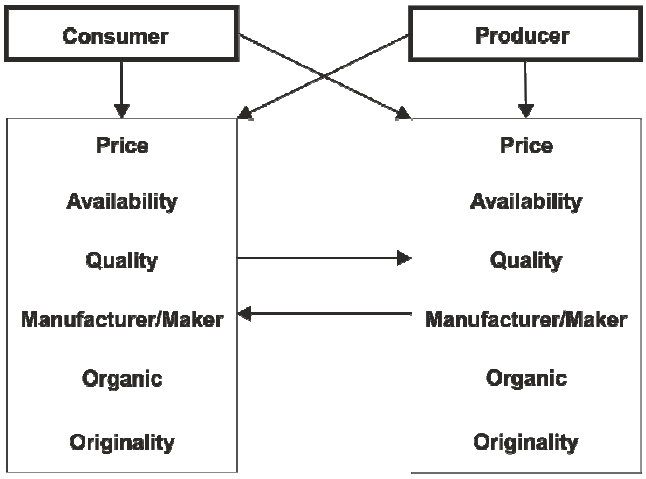

Figure 2 Network structure of decision-making model; Information on pork

Based on values obtained from the questionnaires and using Saaty methods of pairwise comparisons of criteria, weights of particular customers' and producers' criteria were compiled. In a case study Rydval [9] conducted pairwise comparisons based on the hierarchical structure of the problem, as shown in Table 2 in the column "AHP Structure". In this case study pairwise comparisons were conducted based on the network structure of the problem, as shown in Table 2 in the column "ANP Structure".

	AHP Structure		**ANP Structure**	
	Frame of Consumer	**Frame of Producer**	**Frame of Consumer**	**Frame of Producer**
Price	0,51	0,18	0,65	0,38
Quality	0,24	0,43	0,28	0,36
Originality	0,03	0,21	0,02	0,14
Producer	0,13	0,10	0,09	0,05
Organic	0,04	0,06	0,01	0,03
Availability	0,05	0,02	0,01	0,04

Table 2 Criteria frames using AHP and ANP

Criteria frames (each subject of the particular issue has its own quantified criteria frame) play an important role when choosing product to purchase. Therefore, as the seller we decide to present not only by us preferred quality, but mainly the price the consumer prefers. But we still can see that quality of the purchased product is very important for the consumer.

This case study shows how ANP helps to model the user's preferences, and serves to quantify the criteria for his purchase. Thus it helps to decide on what information to show on the product packaging and make the product more attractive for the consumers. ANP may thus serve as a supporting tool in the marketing strategy. As the table shows the results in the AHP and the ANP structure are very different. This is mainly due diametrical difference in the structure of models. Individual elements of AHP structure are independent of each other at various levels, while elements in the ANP structure influence each other. Another big advantage of the ANP model is the possibility of obtaining weights of individual criteria from the perspective of other criteria, not only from the perspective of the assessor. Therefore, in more complex situations ANP models serve better than AHP models.

We can therefore define the framing as a set of weights of individual aspects (preferences and expectations) affecting the decision of the decision maker that can be quantified using multicriteria analysis of variants. In this case, because of the complexity of the situation, the method ANP method seems to be a suitable.

4 Conclusion

This paper deals with the factors affecting our rational thinking, with our ability to make rational decisions, and in particular it serves to explain the framing effect in decision-making process and its quantification using the ANP method. The framing effect affects the ability to reach the rational choice mostly in a negative way and therefore it can make decision-making processes very difficult and minimize the quality of decisions. It may have fatal consequences and it can negatively affect passing the information when making a purchase decision.

In its case study this paper shows the rise of the two dominant frames that influence the outcome of the purchase decision in a market place. Using the ANP method, views (frames) from the whole perspective were created. In these new frames all previous dominant frames are aggregated and their influence is minimized. It can help the decision maker to move closer to a more suitable rational decision and positively influence the overall outcome of the purchasing process.

ANP is a more general form of the AHP used in multi-criteria decision analysis. AHP structures a decision problem into a hierarchy with a goal, decision criteria, and alternatives, while the ANP structures a decision problem as a network. Both of them use a system of pairwise comparisons to measure the weights of the components of the structure, and finally to rank the alternatives in the purchase decision. In the AHP method, each element in the hierarchy is considered to be independent of all the others. The decision criteria are considered to be independent of each other, and the alternatives are considered to be independent of the decision criteria and of one another. But in many real-world cases, there is interdependence among the items and the alternatives. ANP does not require independence among elements, so it can be used as an effective tool in these cases. Another big advantage of the ANP model is the possibility of obtaining weights of individual criteria from the perspective of other criteria, not only from the perspective of the assessor. Therefore, in more complex situations ANP models serve better than AHP models. Therefore the weights determined by AHP for the particular preferences vary from the ones determined by ANP. This can be clearly seen in the case of the preferences "Price" and "Quality". And because of the interdependence among the items and the alternatives, where there are preferences and expectations dependent on each other, it is better to use ANP in these situations.

The more detailed interpretation of its results can be achieved when using the ANP method. The results can be interpreted from the view of individual preferences of participating subjects. The purchasing process can be adjusted according to the results of this case study.

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References

[1] Bishop, J.: *Chapter 15 Drinking from the Fountain of Knowledge: Student Incentive to Study and Learn – Externalities, Information Problems and Peer Pressure*. Handbook of the Economics of Education, 2006, Volume 2, Pages 909-944, ISBN: 978-0-444-52819-3

[2] Druckman, J. N.: *Evaluating framing effects.* Journal of Economic Psychology, 2001, Volume 22, Issue 1, ISSN 0167-4870.

[3] Fagley, N. S., Coleman, J. G., Simon A. F.: *Effects of framing, perspective taking, and perspective (affective focus) on choice.* Personality and Individual Differences, 2010, Vol: 48, Issue: 3, ISSN 0191-8869.

[4] Kozel, R.: *Moderní marketingový výzkum*. Grada, Praha, 2006.

[5] Lindsey-Mullikin, J., Petty, R. S.: *Marketing tactics discouraging price search: Deception and competition.* Journal of Business Research, 2011, Volume 64, Issue 1, ISSN 0148-2963.

[6] Rydval, J., Brožová, H.: Quantification of Framing effect in education Process using ANP. Proceedings of Efficiency and Responsibility in Education International Conference 2011, Prague, CULS, 2011, ISBN 978-80-213-2183-0.

[7] Rydval, J., Hornická A.: *Reduction of framing effect in transport logistic using decision support system.* Sborník - Think Together 2011, Praha, ČZU, 2011, ISBN 978-80-213-2169-4

[8] Rydval, J.: *Reducing The Framing Effect in Decision Processes*. Proceedings of UCOLIS 2010 - University Conference in Life Sciences – Proceedings, Praha, ČZU, 2010, ISBN 978-80-213-2141-0.

[9] Rydval, J.: *Using AHP for analysing product information*. Proceedings of Think Together 2012, Praha, ČZU, 2012.
[10] Saaty, T. L.: *Decision Making with Dependence and Feedback: The Analytic Network Process*. 1996, ISBN 0-9620317-9-8, RWS
[11] Saaty, T. L.: *Decision Making with Dependence and Feedback: The Analytic Network Process, The Analytic Hierarchy Process Series*. Pittsburgh: 2001, IX, RWS Publications.
[12] Saaty, T. L.: *How to make a decision: The analytic hierarchy process*. European Journal of Operational Research, 1990, Volume 48, Issue 1,
[13] Saaty, T.L.: *The Analytic Hierarchy Process (AHP) for Decision Making and the Analytic Network Process (ANP) for Decision Making with Dependence and Feedback, Creative Decisions Foundation*. 2003
[14] SuperDecisions Software for Decision-Making. URL <http://www.superdecisions.com/>
[15] Tversky, A., Kahneman, D.: *The framing of decisions and the psychology of choice*. Science 211, 1981