Cognitive-oriented Risk Evaluation with the Analytic Hierarchy Process

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Summary

The evaluation of risks discharges very often into subjective assessments of the probability of occurrence and / or the extent of loss. These assessments show a low transparency concerning the development of the judgements and are influenced by various different cognitive effects hindering the assessing persons to better accomplish this important step in the handling of risks. The Analytic Hierachy Process [AHP] is an instrument which has especially been used in the field of strategic decision making to solve similar problems of inducing people to make their tacit knowledge explicit. This way it seems reasonable to adopt the AHP methodology for the assessment of risks. For that purpose an AHP risk evaluation model is built up on the basis of the analysis of advantages and disadvantages of existing risk evaluation models. The elaborated risk evaluation using AHP is finally founded upon the separated judgement of the risk parameters and the quantification with the concept of fixed points. The model delivers an adequate base of operations for risk regulation and reduces the problem areas of low transparency and negative impacts of cognitive effects.

1 Introduction

When analysing risks, it is time and again necessary to assess subjectively the parameters of the risk situation, especially when statistical data are lacking. For the person in charge, quantifying the different risk weights and dimensions using relative numbers (percentage) is difficult.[1] Problems with statistical methods[2] and heuristics[3] partially derive from the individual character of the person or the special risk situation[4]. Besides these cognitive aspects, the transparency of the risk analysis process is often criticized.

The objective of this article is to develop an instrument that takes the cognitive effects of risk determination into account and offers a higher transparency regarding the formation of evaluation results. The targets of this instrument to assess risk parameters are principally restricted through ability aspects. Hence motivational effects only play a subordinated role.[5] Concentrating on the goal to reduce negative cognitive effects, **demands** of a risk evaluation instrument can be derived. On the one hand, this means a decomposition of the evaluation problem and its structuring.[6] On the other hand, the assessments should be objectified by integrating available data.

It could be demonstrated that the indirect determination of risk evaluation via comparison of alternatives has got a higher quality compared to assessing directly.[7] These findings are applicable to the Analytical Hierarchy Process [AHP].[8] From a cognitive viewpoint, AHP has got some advantages:[9]

- Decomposing the decision problem makes it possible for the deciding person to minimize the decision area and to diminish the amount of information to include.[10]
- The pairwise comparisons are natural to human ability of decision making.[11]
- The grade of differentiation via Saaty’s 1/9 scale is well suited to human evaluation processes. Excessive information processing demands overstrain the decision maker.[12]
- Verbalising the evaluation scale makes it possible for the decision maker to include his or her personal knowledge and experience in an intuitive and natural way.[13]
- The decision maker is forced to pass through a structured decision process, which supports more accurate judgements.[14]

Therefore, the AHP is used as the basis to develop a new model of risk evaluation. At first, the article analyses the existing AHP risk evaluation models. The transfer of the resulting useful parts in an own model is the content of the following section. Finally, the developed model will be valuated and a prospect will be given for further fields of research.

2 Critical appraisal of the use of AHP for risk evaluation

Until recently, the main focus of **application** and description of AHP was in the field of strategic planning[15] and sporadically in the field of management accounting[16].[17] Within the risk management literature the expositions of

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1 For general cognitive effects in relation to management accounting instruments see Gerling, P. G. / Jonen, A. (2006): p. 54ff.

2 Cf. Peterson, C. R. / Beach, L. R. (1967): p. 29ff., Schütt, K. -. P. (1981): p. 41.

3 Cf. Tversky, A. / Kahneman, D. (1974): p. 1124.

4 Cf. Cohen, M. / Jaffray, J. -. Y. / Said, T. (1987): p. 11.

5 To differentiate these aspects of ‘decision facilitation’, which is the focus of this article, and the decision influencing see Demski, J. S. / Feltham, G. A. (1976): p. 8ff.

6 Cf. Simon, H. A. (1997): p. 112.

7 Cf. Schütt, K. -. P. (1981): p. 235, 240.

8 For an explanation of these concepts see Harker, P. T. (1989): p. 13.

9 Cf. Moutinho, L. (1993): p. 101f., Deshmukh, A. / Millet, I. (1998): p. 94, Garuti, C. / Castro, C. P. / Spencer, I. (2001): p. 128. Barker, D. C. / Hansen, S. B. (2005) say: “…we consider AHP to be the best existing application of what we seek to model as systematic cognitive processing“. Barker, D. C. / Hansen, S. B. (2005): p. 327.

10 Cf. Kinoshita, E. (2005): p. 5.

11 Cf. Saaty, T. L. (2001): p. 397 and Kinoshita, E. (2005): p. 4.

12 “Human beings have difficulty establishing appropriate relationships when the ratios get beyond 9.” Saaty, T. L. (1994): p. 35. The limitation to only nine values ensures that the decision maker is aware of all possible scales. Cf. Saaty, T. L. (1996a): p. 54 and cf. the experiments with the tone series from Miller, G. A. (1956). Saaty has showed that the use of the 1/9 scale produced the most realistic results. Particularly the consistency of results is the higher the rougher the scales are. Cf. Saaty, T. L. (1977): p. 247. The 1/9 scale was discussed in Harker, P. T. / Vargas, L. G. (1987): p. 1388ff.

13 Cf. Dey, P. K. / Tabucanon, M. T. / Ogunalana, S. O. (1994): p. 24 and Dey, P. K. (2002): p. 16.

14 It “is the morphological way of thoroughly modelling the decision, inducing people to make explicit their tacit knowledge. This leads people to organize and harmonize their different feelings and understanding.” Saaty, T. L. (1994): p. 40.

using AHP are only rudimentary.[18] In the following, the existing models shall be analysed critically to transfer the results of this reflection into a separate model.

Existing expositions to combine AHP and risk management can mainly be found in the **project management literature**,[19] because here risks often can be described only vaguely. For this reason, subjectively adapted assessment procedures are necessary.[20] Within the examination of these publications additionally applications as **internal instruments**[21] within **government projects**[22] and **audits**[23] have been included. Further on the analysis of these applications will not be discussed separately, however, an examination will be done by forming groups of specific methods and assessing them. The existing models will be investigated by means of a standardized assessment structure. The investigation structure aims at examining mainly three fields: risk definition, assessment model and interpretation of results.

The **definition of risk** influences the fundamental construction of the model. It will be analysed which facts are included in the model, i.e. how the risk was interpreted and whether positive or negative deviations are implicated Additionally, the requirements regarding risk feature and repetition rate of assessment will be analysed in the course of "risk characteristics". For this purpose, the input factors and targets for the **assessment model** are determined. Here it is described how the evaluation will be executed, i.e. in which form the comparison of both risks is drawn, which risk parameters are ascertained with the model, how the hierarchy is built up within the AHP model and how the assessment and methodology is implemented related to the included persons. In the last part, the way of **interpreting results** is analyzed. Here it will be compared which transformations the single ranking orders have to undergo depending on the model used. At this point, the ordinal ranking order can be on the one hand used as a starting point for decision making. On the other hand, this ordinal ranking order can be transformed into an interval scale order. Figure 1 shows different fields of assessment structures and their interconnections.

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15 Cf. Bhusan, N. / Rai, K. (2004) and Saaty, T. L. / Vargas, L. G. (1982) with over 350 examples of use from the military, health system government and industry area. Strategic decision making examples are described in Madjid, T. / Banerjee, S. (1995): p. 119ff. and Searcy, D. L. (2004): p. 3ff. Examples concerning the choice of relevant business objectives can be seen in Moutinho, L. (1993): p. 102ff.

16 For example for balanced scorecard Searcy, D. L. (2004), for activity-based-costing see Schniederjans, M. J. / Garvin, T. (1997): p. 72ff.

17 Saaty, T. L. / Vargas, L. G. (1982) describes twelve types of problems on which the AHP model can be applied. See Saaty, T. L. / Vargas, L. G. (1982): p. 16.

18 Cf. for example Dey, P. K. (2002): p. 13ff. for an application in field of risk-project managements.

19 See Mustafa, A. / Al-Bahar, J. F. (1991), Dey, P. K. / Tabucanon, M. T. / Ogunalana, S. O. (1994), Dey, P. K. / Gupta, S. S. (2000): p. 69ff., Dey, P. K. (2002) and Huang, S. / Chang, I. / Li, S. / Lin, M. (2004).

20 Cf. Dey, P. K. / Tabucanon, M. T. / Ogunalana, S. O. (1994): p. 24.

21 See Suh, B. / Han, I. (2003), Braglia, M. / Bevilacqua, M. (2000): p. 125ff. (determination of risk standards at production systems via fuzzy-AHP), Akomode, J. O. / Lees, B. / Irgens, C. (1999): p. 35ff. with an application to evaluate risks at the development of new products and Bachu, K. K. (1993): p. 471ff. with an application to evaluate risks at acquisition processes.

22 See Garuti, C. / Castro, C. P. / Spencer, I. (2001), Finan, J. S. / Macnamara, W. D. (2001): p. 30ff. and Azis, I. J. (1990). For a government project, a cost-benefit analysis has been carried out observing the negative consequences compared with the risks. Cf. Azis, I. J. (1990): p. 40f.

23 See Deshmukh, A. / Millet, I. (1998) and Apostolou, B. A. / Hassell, J. M. / Webber, S. A. / Sumners, G. E. (2001): p. 4ff.

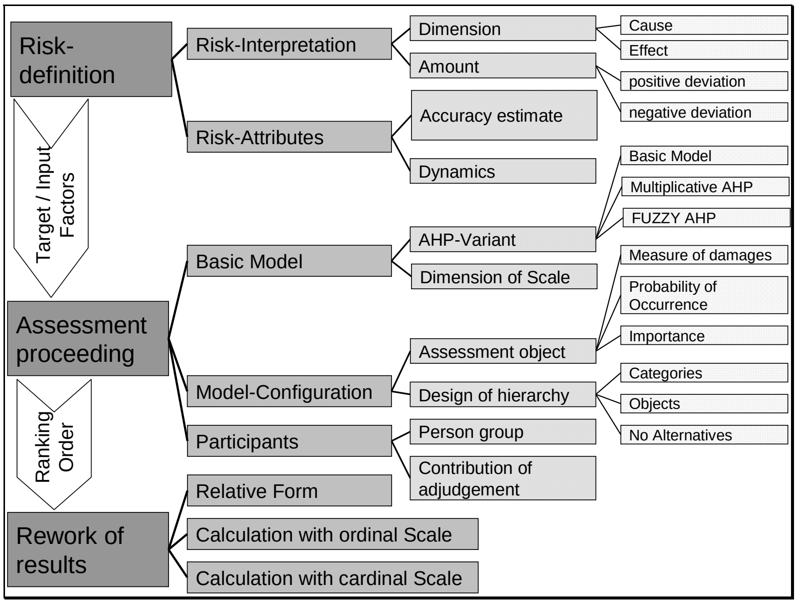

Figure 1: Evaluation pattern

In the following paragraphs, different possibilities of building up a model are analyzed to be able to construct a target concept. This concept will be used as an orientation for the model which is built up in chapter 4. Starting with the risk definition, the variations of interpreting risks and existing risk attributes are analyzed:

- Risk interpretation:
  - Having in mind the causes and / or the effects of a risk, different dimensions of a risk interpretation are addressed.[24] Within this context, the results of an isolated examination are not useful for the selection of risk management alternatives.[25] Both dimensions should be taken into account.
  - Inclusion of positive deviations:[26] Looking at the difficulties of the separation of chance and risk categories and the high claims, especially concerning the initial ascertainment of chances, the evaluation of positive deviations should not be included.
- Risk attributes:
  - The accuracy requirements in the different models range from subjective relevance evaluations[27] to detailed evaluations on a monetary base[28]. The choice depends on the further utilization of information. If possible, a quantification of the data should be included.
  - The dynamic of the situation dictates how often the risk assessment has to be done. The AHP method should be used for situations where at least a medium-term time frame exists.[29]

The next step of the examination of the AHP evaluation models analyzes the evaluation process:

- Basic model:
  - The models sometimes use multiplicative AHP[30] or Fuzzy AHP[31]. The use of the multiplicative AHP is criticized in the literature.[32] The Fuzzy AHP has got some positive aspects[33] and could be an enlargement of the basic model.

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24 This approach has only been applied by two models. See Deshmukh, A. / Millet, I. (1998) and Apostolou, B. A. / Hassell, J. M. / Webber, S. A. / Sumners, G. E. (2001): p. 7f.

25 Cf. Jonen, A. (2005): p. 68f.

26 None of the two models has included chances.

27 See Mustafa, A. / Al-Bahar, J. F. (1991).

28 See Dey, P. K. (2002).

29 Cf. Saaty, T. L. (1987): p. 159.

30 Cf. Ramanathan, R. (1997): p. 545ff.

  - A narrowed[34] scale, the normal scale or a broader scale can be used. The narrowed one has got limitations concerning the reciprocity; the broader scales provoke a polarisation. In this context the normal scale should be used.

- Model configuration:
  - Objects to be evaluated can be the extent of loss, the probability of occurring loss or the relative relevance of the risk.[35] Particularly, a separated ascertainment of extent of loss and probability[36] seems to be the best way to have relevant data for risk management.
  - The hierarchy conception of the AHP can be oriented on risk possibility classes,[37] risk objects[38] or no alternatives[39]. Hereby, the classification makes high demands on the information processing abilities of the responsible person. Especially the results of the risk objects are often biased if two alternatives have a similar risk profile[40]. Therefore, an evaluation of single risks should be preferred.

- Participants:
  - Different groups of persons can be integrated in the existing AHP models.[41] The costs of the integration should be the relevant decision base.
  - To integrate different persons' opinions, methods like the Delphi method can be used.[42]

Interpreting the results can be done in different ways:

- The rank order is left in relative form,[43] which is enough for some situations.[44]
- The relative values are used in a not quantified way for further calculation,[45] which is inaccurate if arithmetic operations are used.
- A further quantification of the results is done before they are used in another way.[46]

For the risk evaluation model, the fix point concept[47] should be used to realize a further evaluation of the relative data. Table 1 shows a summary of the examination of the existing models.

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31 Cf. Leung, L. C. / Cao, D. (2000): p. 108ff.

32 Cf. Eickemeier, S. (2002): p. 392.

33 Cf. Eickemeier, S. (2002): p. 395f.

34 Saaty, T. L. (1990) recommends the use of closer scales, "when the elements being compared are closer together than indicated by the scale." Saaty, T. L. (1990): p. 16.

35 Cf. Deshmukh, A. / Millet, I. (1998): p. 95ff., Garuti, C. / Castro, C. P. / Spencer, I. (2001): p. 123 and Huang, S. / Chang, I. / Li, S. / Lin, M. (2004): p. 683.

36 „One must consider all observed factors, and then establish priorities in the two senses mentioned above: importance and likelihood of occurrence." Saaty, T. L. / Vargas, L. G. (1991): p. 28 regarding the recommended approach to observe risks via AHP.

37 Cf. Mustafa, A. / Al-Bahar, J. F. (1991), Dey, P. K. / Tabucanon, M. T. / Ogunalana, S. O. (1994), Deshmukh, A. / Millet, I. (1998) and Finan, J. S. / Macnamara, W. D. (2001).

38 Cf. Azis, I. J. (1990) (risk objects are political strategies), Bachu, K. K. (1993) (risk objects are alternatives) Akomode, J. O. / Lees, B. / Irgens, C. (1999) (risk objects are new product develop-ments), Garuti, C. / Castro, C. P. / Spencer, I. (2001) (risk objects are cities) and Dey, P. K. (2003): p. 215 (risk objects are sections of planned oil pipelines).

39 See Apostolou, B. A. / Hassell, J. M. / Webber, S. A. / Sumners, G. E. (2001) and Huang, S. / Chang, I. / Li, S. / Lin, M. (2004).

40 This case contradicts Harker's demand for "truly unique" alternatives. Harker, P. T. (1989): p. 17.

41 Cf. Huang, S. / Chang, I. / Li, S. / Lin, M. (2004), Dey, P. K. (2002) and Garuti, C. / Castro, C. P. / Spencer, I. (2001).

42 The strong structure of the Delphi method can prevent creativity; therefore it should be used carefully.

43 See Mustafa, A. / Al-Bahar, J. F. (1991), Dey, P. K. / Tabucanon, M. T. / Ogunalana, S. O. (1994), Garuti, C. / Castro, C. P. / Spencer, I. (2001), Apostolou, B. A. / Hassell, J. M. / Webber, S. A. / Sumners, G. E. (2001), Finan, J. S. / Macnamara, W. D. (2001) and Huang, S. / Chang, I. / Li, S. / Lin, M. (2004).

44 For example in Apostolou, B. A. / Hassell, J. M. / Webber, S. A. / Sumners, G. E. (2001) where a prioritization of risk indicators for management fraud is described, the ranking is the assessment target. It is similar at Finan, J. S. / Macnamara, W. D. (2001), which carries out a priori-tization of national security risks.

45 See Akomode, J. O. / Lees, B. / Irgens, C. (1999), Dey, P. K. (2002) and Suh, B. / Han, I. (2003).

46 None of the analysed models has quantified the results before further use.

47 See Helmke, S. / Risse, R. (1999): p. 277ff.

Trail of Design			Sample
Risk definition	Risk interpretation	Dimension	Inclusion of the dimensions of cause and effect.
		Amount	Restriction on the reflection of negative variations.
	Risk attributes	Accuracy	Validation of the subjective approximations with objective values, if procurable.
		Dynamics	Assignment of the AHP-Risk-Assessment-Model for risks which at least have got a middle-term reference point in time.
Assessment proceeding	Basic Model	AHP-Variant	Assignment of the Basic Model with the opportunity of enlargement by dint of the Fuzzy-AHP.
		Dimension of Scale	Assignment of the ‚normal Scale' valid from 1 to 9.
	Model configuration	Assessment object	Split survey of measures of extent of loss and probability of occurrence.
		Design of hierarchy	Assessment of single risks.
	Participants	Group of persons	Combination of spread expertise considering the costs
		Contribution of judgement	Assignment of group evaluation processes (e.g. Delphi method) in the context of risk assessment.
Rework of results	Further quantification of the upraised rage by dint of the fix point concept		

Table 1: Target Concept

Analyzing the applications of the AHP in the risk area, as presented in the literature, showed that none of the existing AHP risk models can meet the demands of the established target concept in all elements. Furthermore, with the comparative analysis it could be demonstrated, that there is a series of proposals with regard to design, which could be helpful in the construction of a new instrument to support risk management. For this, the individual design alternatives were discussed and the most suitable were chosen for the model to be developed. For quantifying the occurrence probability and the extent of loss, there are no methods with satisfying results yet. Therefore, the development of an interface by means of the concept of fixed points for supplemental quantifying methods is required in the following.

3 Construction of the risk evaluation model with AHP

Building on the findings of the analysis of existing AHP risk evaluation models, the phases of a readjusted evaluation process still relying on AHP will be described. Figure 2 shows the necessary steps to evaluate risks regarding the extent of loss and the probability of loss occurring.

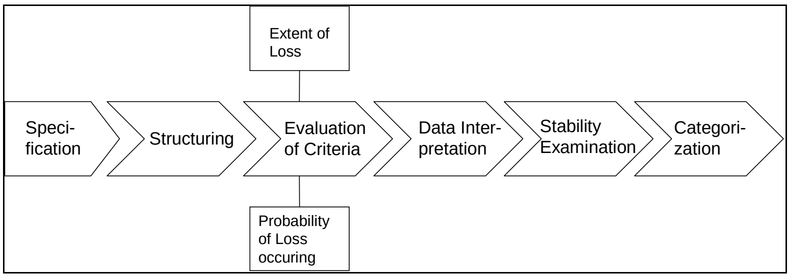

Figure 2: Risk-AHP-Process

During the introductory **phase of specification,** singular risks, their assessment base[48] as well as their degree of risk quantification[49] are determined. Fixing the assessment base and the degree of quantification serves as a starting point for defining the data that has to be objectified and the additional quantifying procedures necessary.

The **phase of structuring** corresponds with the categorizing step of the risk management process.[50] A hierarchical description of the specified risks is the result. Special requirements are the comparability of cluster elements[51], their disjunctiveness and an utmost low size of the risk category.

48 In terms of early warning indicators. Cf. Lück, W. (1998): p. 12.

49 Referring to the model of Dey, P. K. / Tabucanon, M. T. / Ogunalana, S. O. (1994), risk parameters are classified as being ‚undefined', ‚poorly defined', ‚fairly defined' and ‚reasonably well defined'. See Dey, P. K. / Tabucanon, M. T. / Ogunalana, S. O. (1994): p. 28f.

50 Cf. Jonen, A. / Lingnau, V. (2004): p. 24.

For the **evaluation of criteria**, questionnaires can be used. At any one time two risk categories or singular risks get compared with each other – separately concerning extent of loss and probability of loss occurring – as shown in *Figure 3*. As the arrangement of the questions could possibly influence their judgment, the integration of more than one evaluator should be done by using differently composed questionnaires for different participants.[52] Concerning the responds, a contextual use of group interviews[53] via Delphi techniques can be helpful.[54] The decision for a procedure or a combination should be made according to their costs, relevance and according to the complexity of evaluation.[55]

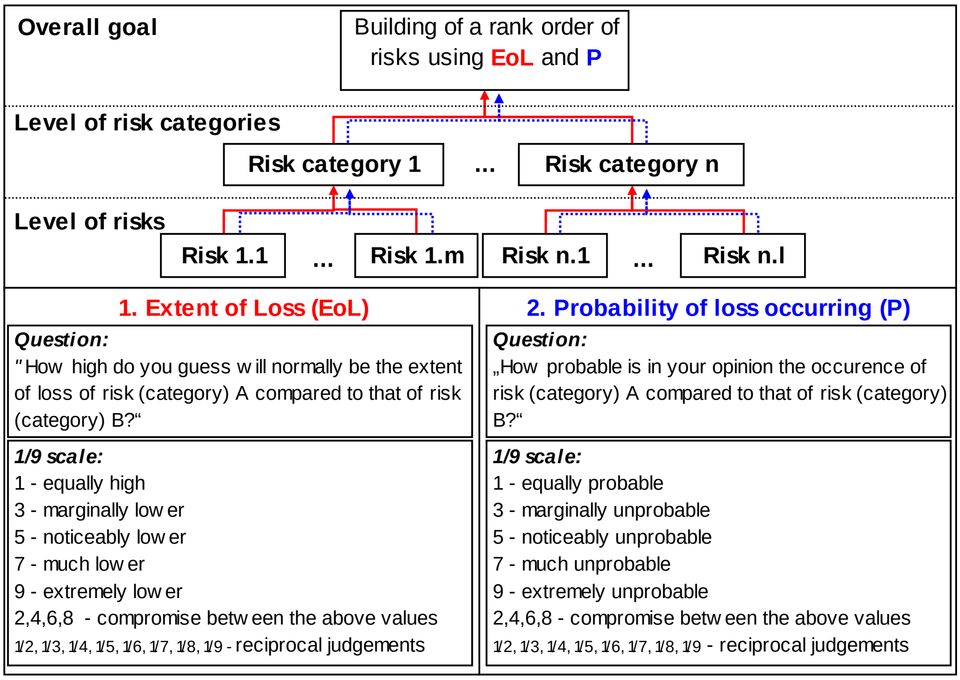

Figure 3: Proposal for a configuration of an evaluation model

The **interpretation** of the judgements, which are part of pairwise comparison matrices, is done by calculating the eigenvektor of each row.[56] Local and global weights of the singular risks are the results of this step, as exemplified in Table 2. A ranking order of risk categories and singular risks – broken according to extent of loss and probability of loss occurring – can now be built.

Illustrating this point, the information technology department of an enterprise could be used as an example: Risk categories are identified in project risks, software risks and hardware risks. Inside the software risks category, singular risks such as the breakdown of an online-portal, failures of the intranet because of exceptional maintenance work or necessary configurations with the customer resource management software can be found.

51 Risks within a cluster have to be chosen in a way „that it is meaningful to compare them among themselves" Saaty, T. L. (1990): p. 10. Saaty, T. L. (1990) illustrates this factor describing the meaningless comparison of height between a football and the Mount Everest. Cf. Saaty, T. L. (1990): p. 9.

52 Cf. Apostolou, B. A. / Hassell, J. M. / Webber, S. A. / Sumners, G. E. (2001): p. 7.

53 See the model of Dey, P. K. (2002): p. 19 and Suh, B. / Han, I. (2003): p. 152.

54 If the consistencies of the individual judgements differ to an extent of more than 10% (CR), partial re-evaluations take place. See also Huang, S. / Chang, I. / Li, S. / Lin, M. (2004), p. 685: inconsistent judgements were discarded from the evaluation.

55 In case of an insuperable dissent, in lieu of reaching a consensus, the geometric mean of all judgements can be used. The geometric mean is more robust against outliers than the arithmetic mean. Furthermore it represents a realistic estimated value. Basak, I. (1988) and Bryson, N. (1996) present methods to prove the degree of accordance between the opinions. Cf. Basak, I. (1988): p. 395ff. and Bryson, N. (1996): p. 28ff.

56 See for instance the models described in Garuti, C. / Castro, C. P. / Spencer, I. (2001) and Dey, P. K. (2004): p. 595.

Category of Risk			Singular Risks			Global Weight	
Name	local		Descrip-tion	local		Extent of Loss	Probability of Loss occurring
	Extent of Loss	Probability of Loss occurring		Extent of Loss	Probability of Loss occur-ring		
Category A	0,32	0,44	Risk 1	0,61	0,09	0,20	0,04
			Risk 2	0,19	0,22	0,06	0,10
			Risk 3	0,20	0,69	0,06	0,30
Category B	0,23	0,36	Risk 4	0,21	0,26	0,05	0,10
			Risk 5	0,05	0,66	0,01	0,24
			Risk 6	0,74	0,08	0,17	0,03
Category C	0,45	0,20	Risk 7	0,09	0,31	0,04	0,06
			Risk 8	0,34	0,1	0,15	0,02
			Risk 9	0,53	0,04	0,24	0,01
			Risk 10	0,04	0,55	0,02	0,11
Total	1,00	1,00		1,00	1,00	1,00	1,00

Table 2: Global Weights of Risk

Examining the stability of the results, a sensitivity analysis is carried out. Changing the weights of the risk categories, reactions of singular risks are watched closely. Symptomatic for the chosen AHP-model without alternatives is, on one hand that the overall ranking order of singular risks can change through weight variations. On the other hand, singular risks inside a risk category still keep their rank. The result of a sensitivity analysis as shown in figure 4 demonstrates a strongly positive reaction of risk 1 on a change of weight of category A. In contrast, risk 9 shows a strongly negative dependence from the weight of category A. One finding of the sensitivity analysis could be for the risk evaluator to review his or her own judgements.

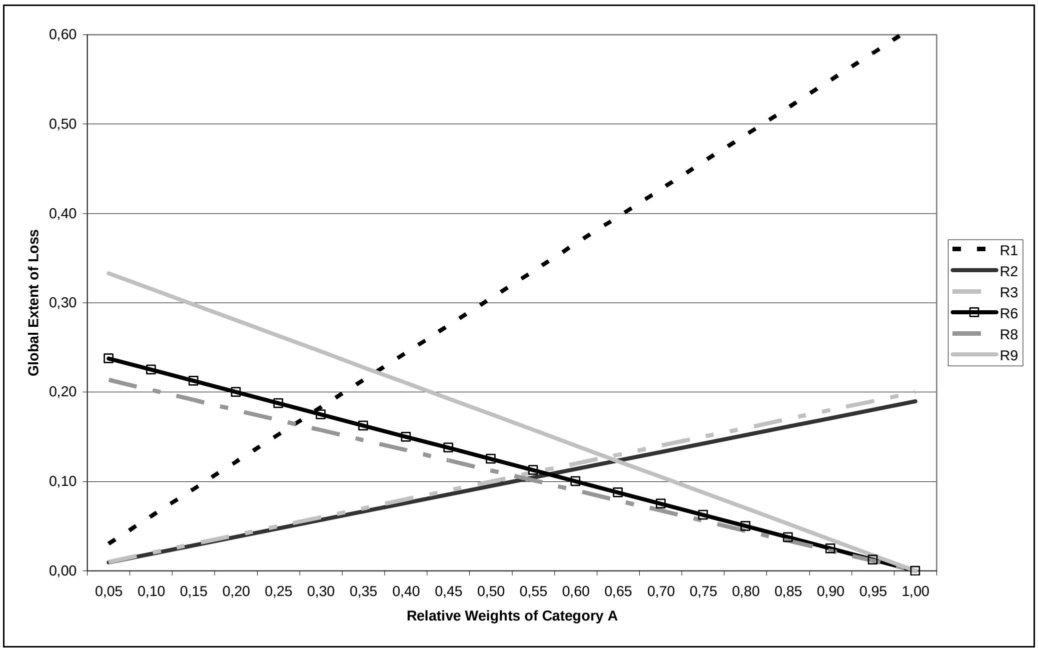

figure 4: Sensitivity Analysis concerning the Extent of Loss[57]

The last step of the risk AHP process is the one of **categorizing** the data that exist up to then only in a relative mode via fixed points. Therefore, intervals of extent of loss and probabilities of loss occurring have to be built. The use of a fixed point concept requires first that the risk evaluations are available in an ordinal scaled succession. The second precondition is the existence of objective data concerning some risks.[58] Drawing on the above described example, we assume that it is known that risk 2 has an extent of loss of 30.000€ and risk 6 of 250.000€. Furthermore, statistics show that the probability of loss occurred is 30% for risk 5. Taking those information as fixed points, intervals as drawn in Figure 5 can be built.

57 Risks showing only a low reaction to the change of category A were eliminated in this figure. The change of weight in category A was separated according to the relation of the former weights of category B (0,23) and category C (0,45).

58 Cf. Helmke, S. / Risse, R. (1999): p. 281.

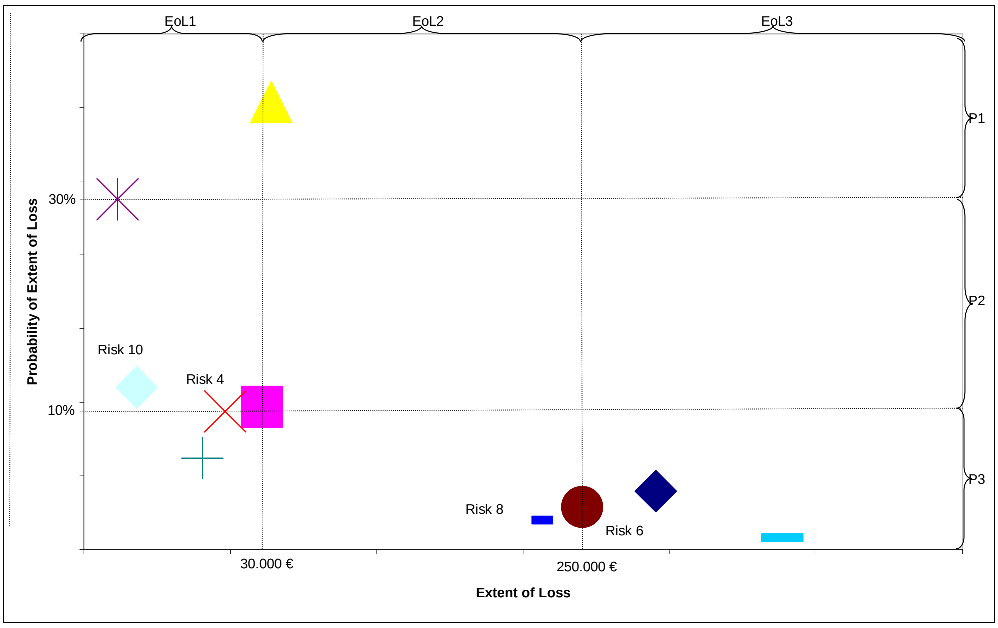

Figure 5: Absolute Risk Portfolio with Fixed Point Intervals

Concerning the unknown extent of loss and probability of loss occurring of all other risks, no absolute values can be derived. Accepting inconsistencies and subjectivity during the evaluation process to a certain degree does not permit the assumption of linearity inside the intervals. Despite that, limiting values can be indicated for each risk. With the help of this specification, the management of risks can set in.

4 Conclusion

Numerous applications of the AHP to assist in decision making situations showed its adequacy to reveal preferences in a structured way[59] and to reduce cognitive limitations. For several years there have been attempts to use this model in the field of risk evaluation. In this context a series of examples, especially in the Anglo-American literature, exists, mostly referring to concrete applications. These attempts to connect the AHP to risk evaluation provided important information for the design of the model developed in this paper. However, they show significant gaps with regard to implementation, in some essential points, e.g. quantification, being resolved with the instrument developed here. Besides the various advantages, due to the synthesis of elements of the existing models and the integration of the concept of fixed points, the model, on the other hand, reveals three points of criticism, which at the same time show the need for further development.

The consideration of **risk-interdependencies** is entirely excluded by the AHP-foundation. The **Analytic Network Process [ANP]**, a decision methodology which is related to the AHP and which can present conditional criteria-dependencies,[60] possibly would be able to assess the risk-interdependencies adequately and to integrate them into an extensive model.

Usually different probabilities of loss occurring arise, depending on the different extents of loss of a risk. Therefore, **distributions** considering every possible extent of loss can be determined for every risk. This could be achieved by integration of several versions of a single risk with fixed extents of losses.

After the model was developed, an **experimental check** should show to what extend the AHP-method in the risk area can lead to better (more precise, faster and more consistent) results.[61] As standards of comparison, simple methods as well as methods comparable to the AHP, like for example ZAPROS,[62] should be taken into consideration.

5 Literature

Akomode, J. O. / Lees, B. / Irgens, C. (1999): Evaluation risks in new product development and assessing the satisfaction of customers through information technology. In: Production Planning & Control, 10 (1999), H. 1, p. 35 - 47.

59 Cf. Harker, P. T. (1989): p. 25, Saaty, T. L. (1989): p. 59ff. and Barker, D. C. / Hansen, S. B. (2005): p. 335.

60 Cf. Saaty, T. L. (1996b): p. 179ff. and Forman, E. H. / Selly, M. A. (2002): p. 324ff.

61 For the possibilities to measure method-effectiveness see Larichev, O. I. (1992): p. 128ff.

62 See Larichev, O. I. / Moshkovich, H. M. (1995): p. 503ff.

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