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Prof. Dr. Gerhard Hube

INNOVATION RETURN FORMULA AND INNOVATION-RETURN-CALCULATOR

Development of an evaluation method for innovation ideas and projects

Report of research semester Summer term 2023

THWS Business School
Technical University of Applied Sciences
Würzburg-Schweinfurt

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Contents

1 A initial situation and motivation

"Innovations are often more like gambling than an investment"

(Hauschildt et al., 2016, p. 403)

The discussion about the great importance and high effectiveness of innovation for the survival of companies (Maaß/May-Strobl, 2016, p. 1), especially in the SME sector (Kaschny, et.al., 2015, p. 15) and even for societies as a whole has been intensively discussed both currently and for several decades (OECD, 2018, p.3). Building on the first paper on the innovation status formula (Hube, 2022), in which the "aggregate states" "was" and "is" of an innovation were discussed, the aggragate state of "will be" will now be analysed as the future potential of innovation ideas or projects. The development of innovation ideas and projects into successful solutions on the market is a major challenge and the result is still very low success rates (section 1.1). Success factor research and other studies have identified poor quality in the evaluation and selection of innovation ideas and projects as one of the reasons for this very low success rate (section 1.2). This gives rise to the need for a new evaluation methodology and also the objective of this thesis, which is presented in section 1.3. Finally, section 1.4 defines the requirements for the new evaluation methodology in order to be able to develop a methodology that is as effective and application-orientated as possible.

1.1 The three aggregate states of innovation and the low success rate of innovation ideas

Innovations can basically assume the three "aggregate states" "was", "is" and "will be". If we look at Apple's first smartphone in 2007, for example, it <u>was</u> an innovation consisting of novelty and a beneficial realisation. If you look at the smartphone from today's perspective, the benefits for both users and companies such as Apple have increased enormously, but there is no longer any novelty, so the smartphone <u>is</u> no longer an innovation (Hube, 2022, p. 7). The third aggregate state concerns the future, i.e. the question of whether an innovation idea or project can <u>become</u> an innovation and what potential the idea or project actually has. From Apple's perspective, for example, one could ask what potential the idea of "vision pro" has as a new product approach for virtual reality (Fäcknitz, 2023, n.p.). With the help of this tripartite division, a clear distinction can be made between innovation and non-innovation and thus often also the dilemma in understanding innovation, which can lead to serious mistakes in companies (Hube, 2022, p. 5). So once there is clarity about the current status, analogous to a kind of "innovation MOT" (Hube, 2022, p. 8), the next step can be to analyse the potential of the innovation ideas or projects in order to tackle the ideas and projects with the highest potential. **Figure 1** shows the three aggregate states of innovation as well as the innovation status formula for the review in presence.

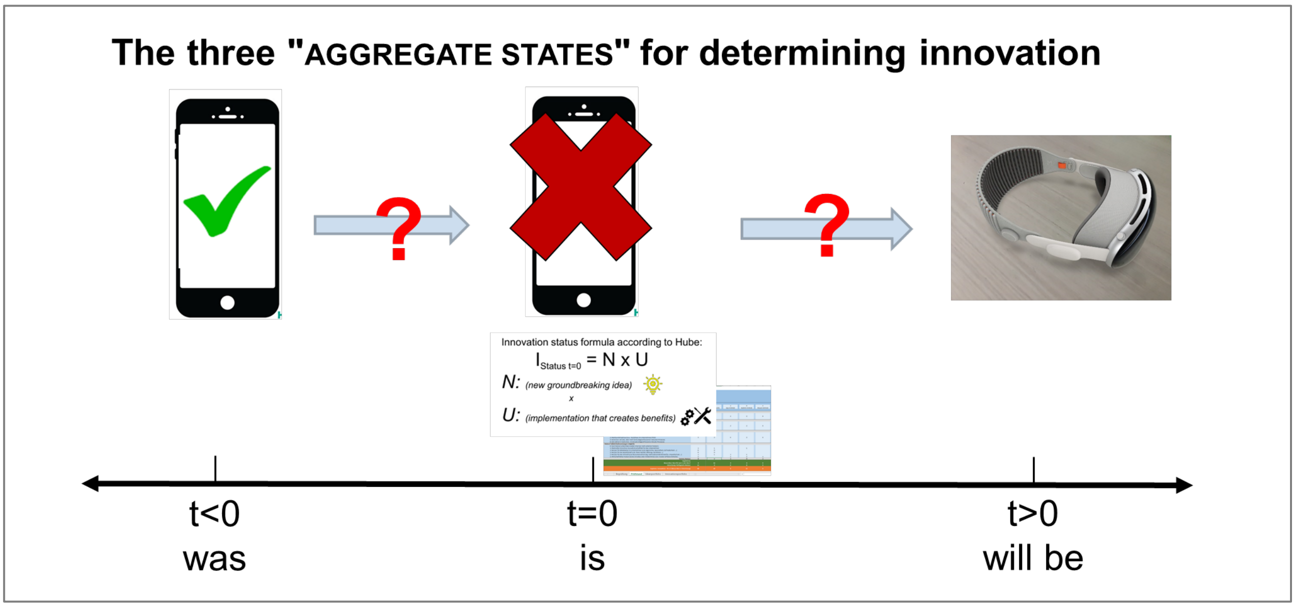

Figure 1: The three aggregate states of innovation according to Hube with examples.

Companies face a particular challenge when assessing and selecting new ideas, as the selection of new ideas is considered on one of the most difficult and risky management decisions in the course of an innovation process (Brentani, 1986, p. 109). Numerous studies, both from the 1980s and today, have repeatedly shown that, on the one hand, only a few innovation projects actually make it to the market and, on the other hand, only a few of these are successful on the market (Christensen/Raynor, 2003, p. 73; Stevens/Burley, 1997, p. 16; Wahren, 2004, p. 157; Lienert/Commes, 1983, p. 349). A study by Kerka et. al. from 2007 comes to the sobering conclusion that just 6% of all product ideas become a success on the market (**Figure 2**).

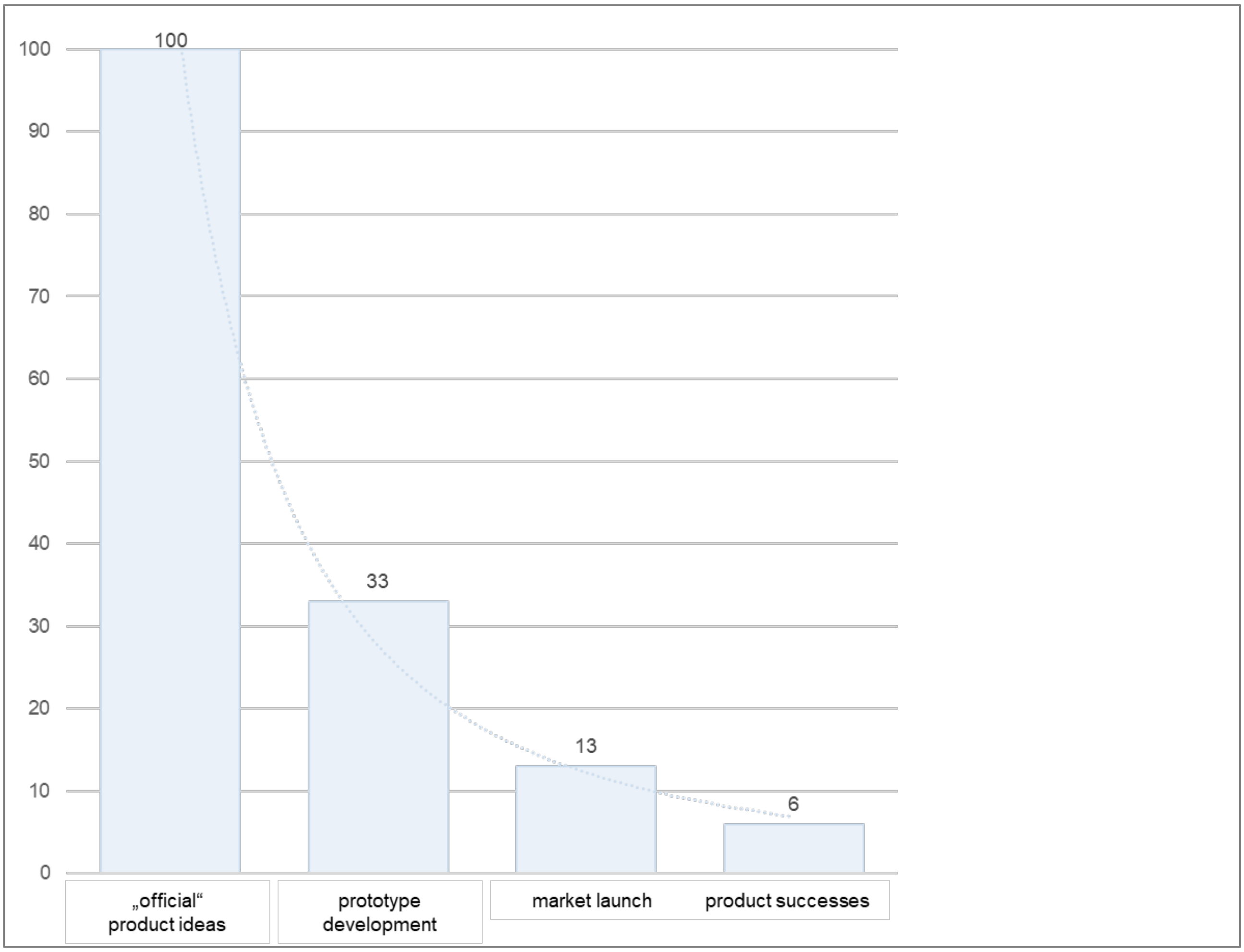

Figure 2: Success rate of product ideas, figure based on Kerka et. al. (Kerka et. al., 2007, p. 277)

1.2 Poor quality in the evaluation of innovation ideas and projects

Success factor research provides very interesting information on analysing the causes of the low success rate of innovation ideas. In this area of research, long attempts have been made to establish correlations between market success and the success factors leading to it (Vahs/Brem, 2013, p. 69). A distinction can be made between the success factors that relate to the process and execution quality (e.g. technical market-related activities) and the success factors that relate to the product and the product environment (e.g. synergies in the areas of technology and marketing), as shown in **Table 1**.

Significance for success (ranking)	Factors relating to the innovation process	Factors resulting from the product or the product environment
1	Product superiority	Product superiority
2	Well-defined product and project	

3		Technological synergy
4	Execution quality of technical activities	
5	Execution quality of pre-activities	
6		Marketing synergy
7	Execution quality of market-related activities	
8		Market attractiveness

Table 1: Success factors for innovations in companies, own presentation based on Kleinschmitt et. al. (Kleinschmitt, et. al., 1996, p. 28-29).

If we look at the factors that can be influenced by the company, the great importance of a careful and comprehensive evaluation of innovation ideas and projects becomes clear. In their study in 1996, Kleinschmitt et. al. identified the "execution quality of preliminary activities" as one of 8 success factors for successful innovation, as shown in **Table 1**. (Kleinschmitt et. al. 1996, p. 10). According to a cross-industry study by Jaruzelski et. al, companies with above-average success control their innovation ideas and projects early and strictly in the innovation process (Jaruzelski et. al., 2018, n.p.). Janovskji et. al. also identified in their study, the well-founded evaluation and selection of the right innovation ideas as an important success factor (Janovski, et. al. 2016, p. 48).

Therfore, the use of appropriate decision models appears to reduce this failure rate (Meffert, 1998, p. 417). It is of great importance to make a good selection as early as possible, already in the "fuzzy front end", which promises the highest possible success rate (Alam, 2006, p. 470). If you achieve a high quality in this decision, you also increase the probability of successful products on the market (Boeddrich, 2008, p.41, Cooper, 1979, p. 126).

However, many companies do not seem to recognise this importance and tend to focus on later phases in the innovation process in which resources are already being used accordingly (Boeddrich, 2008, p. 41). This could be because benefits identified in an early evaluation phase cannot be quantified (Thomke/Bell, 2001, p. 311). For example, management often underestimates the importance of activities in the pre-development process (Jones/Stevens, 1999, p. 172). Verworn/Herstatt also point out the discrepancy between the high importance of the early phases in the innovation process and the lack of consideration by decision-makers (Herstatt/Verworn, 2007, p. 14). The quality of the activities prior to product development, i.e. in the selection of ideas and preliminary analyses of the market and technology, is one of the decisive factors for ideas and projects that are later successful on the market (Kleinschmidt, et. al., 1996, pp. 17-20). In addition, a transparent and comprehensible evaluation system in the early phase can be much more than an instrument for pre-selection; it can also be a strong signal and a living expression of an innovation culture (Kerka et. al., 2007, p. 290). However, despite the importance of evaluating ideas, these evaluation procedures are evidently rarely used and find little acceptance (Crawford, 1980, p. 35; Brentani, 1986, p. 108). In this phase, companies seem to favour simple and intuitive approaches and reject more complex analytical procedures (Cabral-Cardoso/Payne, 1996, p. 409; Chien, 2002, pp. 360-361). Therefore, the following chapter will examine the role of intuition in management decisions.

1.3 The role of intuition in the evaluation of innovation ideas and projects

"The idea that innovations are independent of individual interests being able to judge "objectively" is a misconception".

(Kerka et. al., 2007a, p. 281)

Even if previous approaches to the evaluation of innovation ideas are argued as objectively as possible and with the help of objective criteria, it is not realistic to assume that an objective and fact-based evaluation of innovation ideas is possible at all (Adam, 2012, p. 247). Assessing the novelty and suitability of an idea hardly seems to be possible objectively and is highly influenced by the intuitive nature of humans (Adarves-Yorno et. al., 2005, p. 4; Pratt/Zeckenhauser, 1987, p. 153). Particularly in situations such as the early innovation phase, when speculative considerations and "soft" arguments predominate, it is the entrepreneurial "instinct" that prevails in an assessment (Vahs, 2013, p. 317). In a 2007 study, 38% of respondents stated that they made intuitive decisions based on "gut feeling" when pre-selecting innovation ideas, see **Figure 3** (Kerka et. al., 2007, p. 291).

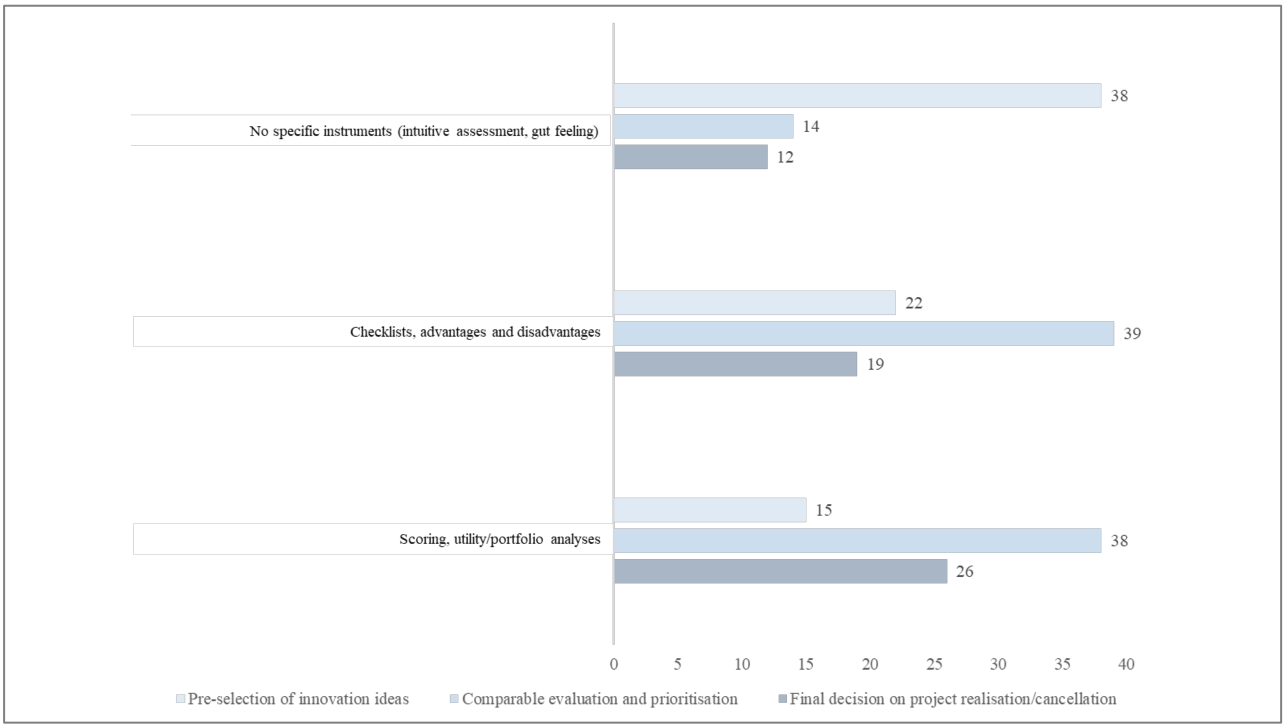

Figure 3: Use of instruments for evaluating innovation ideas, illustration based on Kerka et. al. (Kerka et. al., 2007, p. 291).

In another survey, a majority of over 166 managers stated that they were guided by technical feasibility and their intuition when making judgements (Hart et al., 2003, p. 28). Various other studies show that around 50% to 75% of management decisions are generally based on intuition (Gigerenzer / Gaissmaier, 2015, p. 33 ff.). It is interesting to note the differentiated use of intuition depending on existing experience. If there is still little experience for certain decision-making situations, "beginner intuition" is increasingly used, which then decreases with increasing experience and then increases again with a high level of experience with "expert intuition" (Baylor, 2001, p. 240). This results in the "U-model of intuition" according to Baylor, as shown in **Figure 4**.

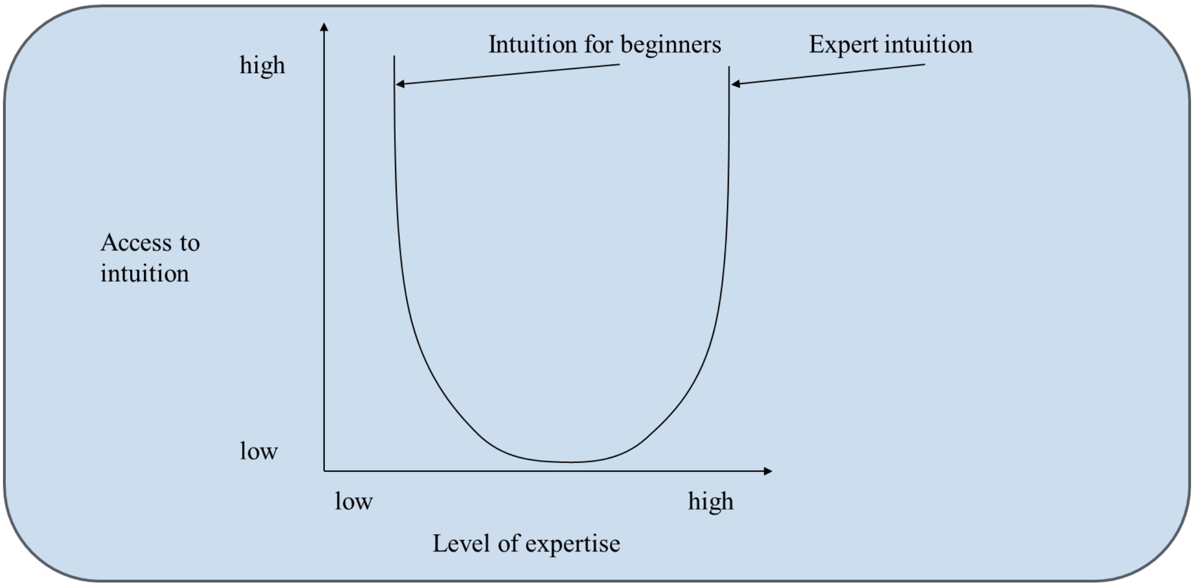

Figure 4: The U-model of intuition, illustration based on Baylor and Ahel (Baylor, 2001, p. 240; Ahel, 2020, p. 78).

Basically, the use of intuition in these situations is not all that surprising. Decisions on innovation ideas and projects often have to be made quickly in the face of high uncertainty and complexity, a situation in which intuition is and should automatically be used (Loitsch, 2021, p. 115). Decisions based on gut instinct are made relatively quickly on the basis of one's own experiences and what is known as "perceived knowledge" (Fröse/Kaudela-Baum, 2015, p. 20). Parikh sees the areas of research, personnel decisions and business start-ups in particular as having a high frequency of use of intuition, as shown in **Figure 5** according to Ahel (Parikh et. al., 1994, p. 60-65, Ahel, 2020, p.102).

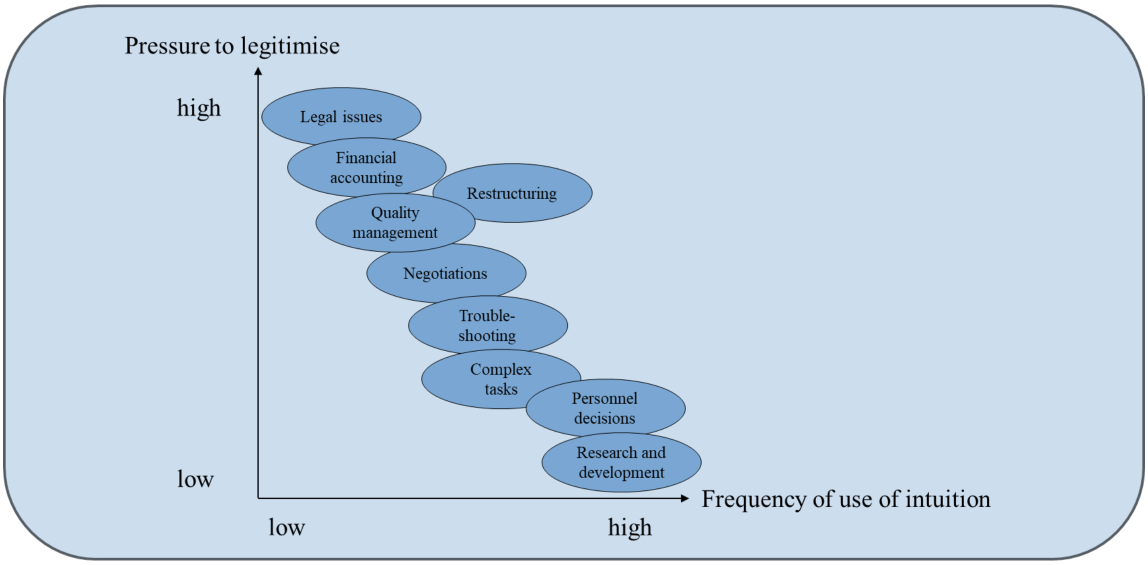

Figure 5: Management tasks between pressure to legitimise and frequency of use of intuition, own illustration based on Ahel (Ahel, 2020, p. 102).

Gigerenzer even considers intuition to be much more powerful for solving complex problems than consciously utilised rationality (Gigerenzer, 2008, p. 242). Krenzin also emphasises the greater effectiveness of intuition in decision-making situations with a high degree of ambiguity (Krenzin, 2008, p. 49). The difficulty in practice, however, is that decisions based on "gut instinct" cannot be explained logically and analytically, which is usually required for management decisions (Fröse/Kaudela-Baum, 2015, p. 20). As a result, although intuition is regularly used to make decisions, this is never publicly admitted; instead, reasons are sought after the fact to legitimise the decision (Gigerenzer / Gaissmaier, 2015, p. 33 ff.). Formal methods are apparently accepted and used, but in the end intuitive judgements sometimes dominate again (Alves et al., 2005, p. 12).

The influence of intuition, subjectivity, situational constraints and other factors in the evaluation of innovation ideas and projects can therefore definitely not be ignored (Adam, 2012, p. 247). Intuition should be deliberately included in the methodology as a qualitative evaluation criterion.

2 Objectives and requirements

As shown in the previous chapter, methods for assessing and evaluating innovation ideas are either used too rarely in practice or are often only one-sidedly based on individual financial indicators. For this reason, the aim of this thesis is to develop a methodology that enables a simple and application-orientated evaluation that is as meaningful as possible. It is intended to be an aid for teaching and practice, which determines the possible benefit potential of an innovation idea or an existing project, taking into account the expected expenditure.

In order to develop such an evaluation methodology, the requirements are further concretised and specified in this chapter in order to evaluate the approaches and methods known and used to date from the literature against these requirements in chapter 3. The methodology is developed in Chapters 4 and 5 and implemented in an application-oriented tool in Chapter 6, which also provides corresponding analyses and interpretation support. In Chapter 7, the methodology is evaluated in the context of expert surveys and Chapter 8 concludes with a summary and an outlook on further possible research activities.

2.1 Requirements for the evaluation methodology to be developed

Numerous requirements for the evaluation methods for innovation ideas and projects can be found in the literature (Adam, 2012, p. 49). Brockhoff's proposal is frequently taken up and used in a similar form by other authors (Vahs/Brem, 2013, p. 320; Pleschak/Sabisch, 1996, p. 170; Granig, 2007, pp. 56-59; Heesen, 2009, pp. 102-104). According to Brockhoff, the following requirements are placed on the evaluation procedures for innovation ideas (Brockhoff, 1994, p. 252):

- **Realism**
  (consideration of several target contents through multidimensional evaluation, consideration of several restrictions, consideration of risks, recording over several time periods, foresight of future developments)
- **Wide range of applications in innovation management**
  (Applicability for the different stages of the innovation process, possibilities for simulation and optimisation, consideration of different evaluation criteria)
- **User-friendliness**
  (Familiar data as input variables, simplicity and comprehensibility of the evaluation, possibility of updating the calculations, computer support of the evaluation processes, integration into research and development processes)
- **Economic efficiency**
  minimising the time and financial outlay required to use the assessment procedures (Vahs/Brem, 2013, p. 320)

In addition to these fundamental requirements, there are other aspects that are important for the evaluation and effectiveness of the evaluation models. The evaluation methods should make decisions comprehensible for various interest groups and lead to greater transparency and better control (Ahsen et al. 2010, p. 8; Pleschak/Sabisch, 1996, pp. 171-172). However, in addition to the potential future benefits, the risk associated with the idea should also be considered (Ahsen 2010, p. 18; Pleschak and Sabisch 1996, pp. 173-174). In principle, both the potential for success and the implementation costs of an innovation idea must be considered in order to make a well-founded decision (Kerka et. al., 2007, p. 292). It is also often emphasised that qualitative criteria should be included alongside quantitative criteria, even if these are not objectively measurable, so as not to overlook characteristics that are critical to success (Pleschak, 1994, p. 178; Kerka et al. 2007a, p. 290) and not all arguments can be expressed quantitatively (Ahsen et al., 2010, p. 85). For a meaningful assessment of innovation ideas or projects, a feel for the markets of tomorrow, i.e. also trends and long-term future developments, should be considered, otherwise the assessment of prospects for success remains pure speculation, especially with a higher degree of novelty (Kerka et.al., 2007b, p. 283; Duncker/Schütte, 2017, p. 3).

Ozer recommends a combination of different assessment methods in order to balance out the respective method-specific advantages and disadvantages (Ozer, 2005, pp. 784-786). It is also recommended that the evaluation procedure supports cross-divisional and cross-functional communication so that interpersonal emotional aspects are included in addition to the pure facts (Souder/Mandakjovic, 1986, p. 39). Hauschild also sees the choice of evaluation methodology as a possible lever for bringing together the "technology-loving innovators" with the "stingy cost accountants" (Hauschildt et.al., 2016, p. 419).

The following requirements are formulated for the assessment methodology to be developed, based on the initial situation described and the references from the literature:

1. Determination of key performance indicators that are as clear and meaningful as possible and allow for comparison
2. Mandatory consideration of both benefits/opportunities and costs/risks
3. Multidimensional evaluation (economic, technical, social)
4. Flexibility in objectives and criteria
5. Broadest possible applicability during the innovation process
6. Simplicity in understanding and application

In addition to Brockhoff's requirements, the determination of key figures that are as tangible and meaningful as possible, which enable a comparison of innovation ideas and projects, should be added. This appears to be an important aspect for acceptance and effectiveness (Ahsen et al. 2010, p. 8; Pleschak/Sabisch, 1996, pp. 171-172). In addition, the mandatory consideration of both benefits/opportunities and costs/risks should be emphasised to avoid either only seeing the positive aspects ("technology-loving innovators") or arguing exclusively with the costs and risks ("unimaginative cost calculators") (Hauschildt et.al.; 2016, p. 419). An evaluation can only be considered appropriate if both input and output variables are considered (Hauschildt et al., 2016, p. 410)

2.2 Requirements for the evaluation criteria

Choosing the right evaluation method as described in the previous chapter is certainly an important aspect of effort and effectiveness, but using inappropriate evaluation dimensions within the method can distort the results and increase the risk of wrong decisions (Adam, 2012, p. 68; Sharma, 1999, p. 148).

Vahs/Brem call for the following categories to be considered to derive specific criteria for evaluating innovation ideas (Vahs/Brem, 2013, p. 316):

- Economic characteristics (e.g. turnover, return on investment ROI, profit,...)
- Product and process characteristics (e.g. product quality, performance,...)
- Technological features (e.g. synergies, ability to integrate into existing product programme, etc.)
- Sales characteristics (competitive situation, market growth,...)
- Structural characteristics (e.g. vertical integration, personnel capacities,...)
- Labour science characteristics (e.g. motivation, qualification and competence of the workforce, occupational safety, etc.)
- Temporal characteristics (e.g. duration of the innovation process, market entry, product life cycle, etc.)
- Other characteristics (e.g. ecological consequences, legal framework, etc.)

The criteria derived from these characteristics should be weighted (Vahs/Brem, 2013, p. 316).

Hauschildt et al. propose a three-way division of the criteria into technical, economic and other effects to evaluate the success of the innovation, whereby these are further subdivided into direct and indirect effects (Hauschildt et al., 2026, p. 399). This categorisation is discussed in more detail in the chapter on innovation benefits. Roterberg proposes the following groups of evaluation criteria in connection with the scoring procedures (Roterberg, 2018, p. 281):

- Strategic importance and fit
- Product attractiveness and competitiveness (e.g. perceptible benefit for the customer, barrier to entry for competitors, etc.)
- Market attractiveness (e.g. market size, market growth,...)
- Feasibility (e.g. development time, development costs,...)
- Synergy effects (e.g. learning effects, image,...)
- Return versus risks (e.g. net present value, amortisation period,...)

A special emphasis on customer benefit as a criterion reference comes from the success factor research for innovation, which was already used in Chapter 1. There, a product that is superior and "offers the customer unique benefits" is the most important success factor (Kleinschmitt, et. al., 1996, p. 28-29). A study by Jaruzelski et. al. came to a similar conclusion, identifying 6 key factors for successful innovative companies. In addition to the great importance of an innovation strategy, an innovation culture, the involvement of top management and an early evaluation of ideas, a strong focus on customer needs is of decisive importance in the development of innovation (Jaruzelski et. al., 2018, n.p.).

There are numerous other proposals for evaluation criteria for assessing innovation ideas, see also Adam (Adam, 2012, pp. 69-72), who sometimes propose up to 33 evaluation criteria (Udell/Baker, 1982, pp. 196-201), or the "Integrative Evaluation Procedure" by Vahs, which enables a very comprehensive evaluation using 4 forms with up to 9 criteria each (Vahs, 2013, pp. 338-346). Even if both quantitative and qualitative criteria are considered here, implementation could encounter difficulties in practice due to the high level of effort involved. Some authors also use the "novelty" of the idea or project for the assessment (Kristensson et. al., 2004, p. 6; Lüthje, 2000a, p. 192). This only seems to make sense in an indirect way, as it is not the degree of novelty that determines success, but the implications of this, such as higher internal costs or a lack of customer acceptance due to very high novelty. The other individual methods will not be discussed further at this point. Most authors try to cover as wide a range of content as possible with their proposals, which are located both inside and outside the company and include a combination of quantitative and qualitative factors.

In addition to the content of the criteria, their number also plays an important role. If the number of criteria increases, the complexity of the evaluation increases, the effort required to collect the data and the assessment increases, so that the result loses "clarity and informative value" (Vahs/Burmester, 2005, p. 329; Kerka et. al., 2007, p.291). The aim is "to limit the evaluation to the evaluation characteristics relevant to the decision or to transform as many evaluation characteristics as possible into one complex characteristic." (Pleschak/Sabisch, 1996, p. 178). However, it is emphasised that managers simplify the evaluation decision too much if only a few criteria are used for the evaluation (Brentani, 1986, p.155). In practice, between five and eight valuation factors seem to be considered relevant for the respective valuation (Brentani 1986, p. 114). It is therefore important to find the fewest possible but suitable assessment dimensions for evaluating innovation ideas (Cooper/de Brentani, 1984, p. 155, Baker/Albaum, 1986, p. 38) to minimise the effort involved in the evaluation.

Based on the above considerations and explanations, the following requirements for the evaluation criteria are to be defined for this work:

1. Consideration of economic characteristics
2. Consideration of environmental factors, 360° view if possible
3. Consideration of opportunities and risks

4. Consideration of product and process-related features
5. Consideration of internal company characteristics
6. As few evaluation criteria as possible
7. Consideration of intuition as an evaluation criterion

In the following chapter, some selected evaluation methods from research and practice are briefly presented and then evaluated with regard to their applicability for the evaluation methodology to be developed.

3 Overview and assessment of methods for evaluating innovation ideas and projects

In recent decades, many methods have been developed that can be used to evaluate ideas (Poh/Ang/Bai, 2001, p. 63, Souder/Mandakovic, 1986, p. 36). Section 3.1 presents some classifications of these methods before their suitability during the innovation process is discussed in section 3.2. In section 3.3, the methods are then critically assessed about the requirements from section 2 and recommendations for the methodology to be developed are derived.

3.1 Classification of methods

Due to the great diversity of assessment methods, the proposals for categorisation are sometimes very different and range from a dichotomy to a multitude of categories (Sandau, 2009, p. 63). Pleschak/Sabisch, for example, use a division of the valuation methods into one-dimensional and multidimensional methods. All financial quantitative methods are thus categorised as one-dimensional methods, while all qualitative and semi-quantitative methods are categorised as multidimensional methods (Pleschak/Sabisch, 1996, p. 178).

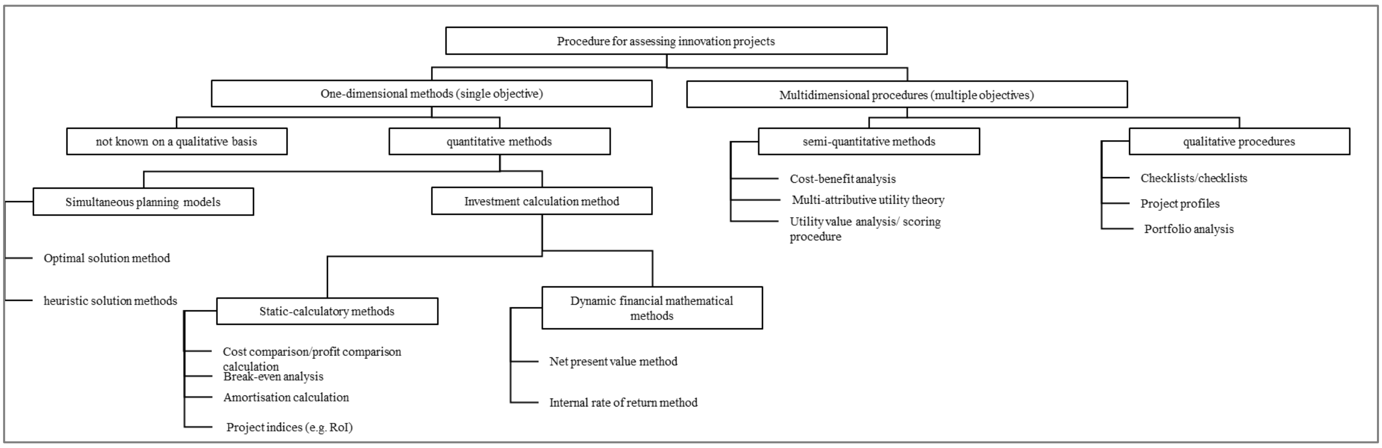

Figure 6: Categorisation of evaluation procedures based on Pleschak/Sabisch, (Pleschak/Sabisch, 1996, p.178).

This categorisation makes it clear that quantitative methods of investment appraisal are only used to map one objective, namely the financial and monetary one.

As with Heesen, a tripartite division into "qualitative methods", "quantitative methods" and "semi-quantitative methods" as a third category is frequently used (Heesen, 2009, p. 107; Granig, 2007, p. 78; Vahs/Brem, 2013, p. 321; Specht et. al., 2002, p. 216).

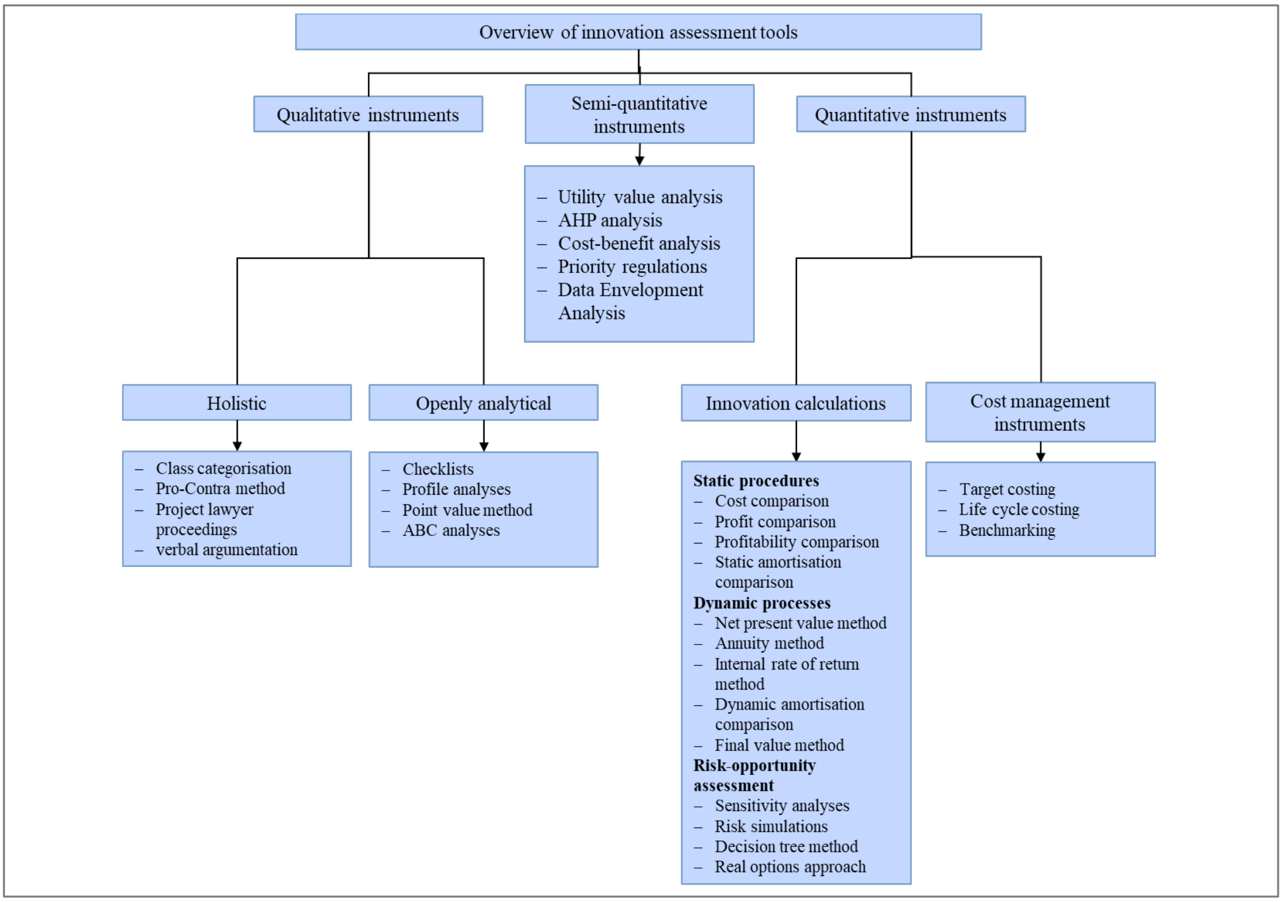

Figure 7: Threefold division of the assessment instruments based on Heesen (Heesen, 2009, p. 107).

In addition to these two or three categorisations, there are several other approaches. Wahren categorises the valuation methods into "classic", "comparative" and "idea-expanding" methods in addition to financial methods (Wahren, 2004, p. 173). Following Wahren, Adam proposes a categorisation of valuation methods that also considers the content-related aspects or the respective focus of the selection decision, which then leads to eight groups of valuation methods (Adam 2012, p. 63). Sandau in turn divides his total of 6 main categories into a further 20 subcategories, which also include, for example, "virtual technologies" and "scenario analyses" (Sandau, 2009, p. 67).

Even if the differentiated approaches of Sandau, Adam or Wahren illustrate the diversity of motivation, objectives and possible applications, the instruments can basically be categorised into qualitative, quantitative and mixed forms (Wahren, 2004, p. 172). For this reason, the basic assessment of the methods should be divided into the three categories "Qualitative methods", "Quantitative methods" and "Semi-quantitative methods" in order to simplify clarity. In any case, the allocation of the methods to the different categories also depends on the respective characteristics or evaluation dimensions and is therefore not always unambiguous (Martino, 1995, p. 89). For a full explanation of the individual methods mentioned in the categorisations, please refer to the work of Adam, Roterberg and Rebernik/Bradač. (Adam, 2012, pp. 257-290; Roterberg, 2018b; Rebernik/Bradač, 2008, pp. 16-62).

3.2 Suitability of the methods in the innovation process

As already indicated in the description of the various evaluation methods, the information requirements of the instruments are very different. For this reason, it makes sense to make them dependent on the degree of maturity and thus the increasingly better database (Vahs/Brem, 2013, p. 320). There is widespread agreement in the literature that qualitative methods should be used in the early phase and that quantitative methods are only useful and meaningful at a later stage (Roterberg, 2018, p. 271). In between, semi-quantitative methods are recommended both at an early stage and up to the market launch (Hessen, 2009, p. 133; Abele, 2013, p. 10; Granig, 2007, p. 78; Vahs/Brem, 2013, p. 321; Bürgel et al. 1996, p. 107). The following figure illustrates the different suitability of the methods in the innovation process.

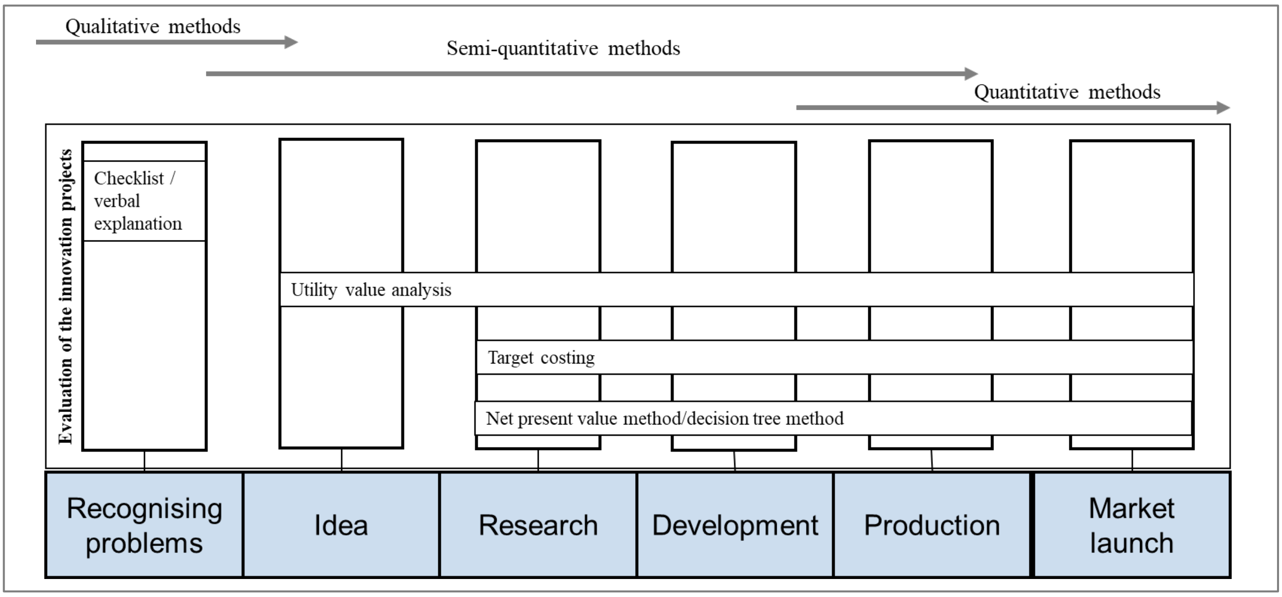

Figure 8: Use of evaluation methods over time/maturity level based on Heesen, Sammerl and Abele (Heesen, 2009, p. 133; Sammerl, 2006, p. 30; Abele, 2013, p. 10).

The wide range of applications of the semi-quantitative method is confirmed in practice and, in addition to the ease of use, lies in the possibility of also taking monetary variables into account (Scherer, 1995, p. 62).

3.3 Critical assessment of the methods

In this chapter, the various methods for evaluating innovation ideas and projects will be analysed for their suitability with the help of the requirements placed on the new evaluation tool to be developed in Chapter 2. To this end, the three categories of evaluation tools are described in the following chapters in terms of their basic advantages and disadvantages. A detailed assessment of the various individual instruments can be found, for example, in Adam or Heesen (Adam, 2012, pp. 257-290; Heesen, 2009, pp. 116-134).

3.3.1 *Advantages and disadvantages of qualitative assessment tools*

Qualitative instruments are based on multidimensional, intuitive and subjective judgements by individuals. These people evaluate purely qualitatively, i.e. hardly objectively measurable, by describing the advantages and disadvantages of selected innovation ideas or projects (Werner, 2002, p. 46). This means that the degree of target achievement can only be assessed qualitatively (Pleschak/Sabisch, 1996, p. 178). This means that no meaningful figures or value-based indicators are produced. Due to their ease of use, at least for the most part, and the low level of information required of the assessor, these instruments are used particularly in the early phases for initial rough preselections (Gerhard, 1998, p. 199). The disadvantages of these instruments are their strong subjectivity and the fact that it is not possible to establish a ranking (Heesen, 2009, p. 108).

3.3.2 *Advantages and disadvantages of quantitative valuation tools*

In this paper, quantitative valuation instruments are defined as monetary methods from investment appraisal or cost management, in line with Specht et al. (Specht et al., 2002, p. 216). They are therefore categorised as one-dimensional valuation instruments (Pleschak, 1996, p. 178). In contrast to the qualitative and semi-quantitative methods, a clear and unambiguous key figure can be calculated that reflects an objective statement about the financial attractiveness or profitability. It can also be used to create a ranking according to individual monetary values, such as profit, provided that certain framework data match. When using comprehensible financial data, the results are significantly more objective than with the other two categories (Heesen, 2009, p. 112). The disadvantage of these instruments lies in the difficulty of obtaining the detailed information required, such as information on sales prices, manufacturing costs, development costs, investments, sales and cash inflows and outflows over the entire life cycle of the product. As a result, they are hardly useful, especially in the early phases (Chang et al., 2008, p. 122; Roterberg, 2018, p. 277).

3.3.3 *Advantages and disadvantages of semi-quantitative methods*

The advantages of semi-quantitative instruments over qualitative methods are that they allow a ranking to be created by calculating an overall value and that the information requirements are lower compared to quantitative assessment instruments (Pleschak/Sabisch, 1996, p. 176). In addition, the semi-quantitative valuation instruments are multidimensional, as they do not exclusively take financial criteria into account. They are also versatile and easy to use (Werner, 2002, p. 46). The disadvantage of these instruments, as with the qualitative methods, is that they are based on individual value judgements and are therefore highly subjective. In addition, although a ranking can be created by forming dimensionless evaluation figures, these overall figures have no value-based significance and there is a risk of pseudo-objectivity (Heesen, 2009, p. 110). Nevertheless, these methods are "on the rise", as they fulfil the practical need for clarity through concentrated content-related statements despite a wide range of criteria (Hauschildt et al., 2016, p. 401).

3.3.4 *Assessment of the methods according to the requirement criteria*

With the help of the requirements placed on the evaluation procedure in Chapter 2, the methods are to be evaluated below according to the three categories presented above.

Requirement 1 of a key figure that is as tangible as possible is only met by the quantitative methods. The other two methods work either with qualitative statements or with dimensionless point values from the scoring methods.

For requirement 2 on the consideration of benefits/opportunities and costs/risks, the selection of the respective method or the selection of corresponding criteria is decisive. For example, the ABC analysis as a qualitative method is not applicable in this point, but the pros and cons method or checklists, for example, are if the criteria are defined accordingly. In the case of quantitative methods, the cost comparison calculation, for example, does not fulfil the criterion, but the net present value method or profitability calculations do.

Multidimensionality (requirement 3) is only fulfilled for the semi-quantitative methods, while the flexibility of objectives and criteria (requirement 4) is only not fulfilled for the quantitative methods. The semi-quantitative methods have the broadest application over the course of the innovation process (requirement 5), as was shown in chapter 3.2.

In the first two categories, the simplicity of application and data procurement (requirement 6) again depends on the choice of methods and criteria. For example, checklists or utility value analyses can be designed very extensively and in detail, but also with fewer criteria and quick, simple implementations. This does not apply to quantitative methods. As concrete economic values are always required here, their procurement and reliability must be viewed as critical, as explained in Chapter 1, especially in the early phases.

- not fulfilled + fulfilled (+) only fulfilled for individual instruments in this category	1. key figure that is as catchy and meaningful as possible	2. mandatory consideration of both benefits/opportunities and costs/risks	3. multidimensional evaluation (economic, technical, social)	4. flexibility in objectives and criteria	5. broadest possible applicability in the course of the innovation process	6. simplicity of use and data retrieval
Qualitative methods	-	(+)	-	+	-	+
Semi-quanitative methods	-	(+)	+	+	+	(+)
Quantitative methods	+	(+)	-	-	-	-

Table 2: Assessment of the evaluation procedures about the requirements from Chapter 2.

Overall, the table clearly shows that the semi-quantitative methods fulfil almost all requirements, at least for some of their instruments and with the appropriate choice of evaluation criteria. The only requirement that the semi-quantitative methods cannot fulfil is the need for a clear and meaningful key figure. A mixture of semi-quantitative and quantitative instruments should therefore be used for the evaluation procedure to be developed.

4 Development of an innovation-return formula

In the following, a new evaluation procedure with corresponding evaluation criteria will be developed based on the considerations in the previous chapters. To this end, the basic idea of the return on innovation from a combination of quantitative and semi-quantitative methodology is first presented to fulfil the requirements from Chapter 2 (Chapter 4.1). Subsequently, the formulas for innovation profitability available in the literature are presented and checked for suitability for this work (section 4.2).

4.1 Basic idea of a return on innovation

As was worked out in Chapter 3, a combination of semi-quantitative methods with quantitative methods could fulfil almost all the requirements of Chapter 2 for the new methodology. To evaluate the future potential of an innovation idea or project, the basic formula for profitability should be used. As profitability always results from the ratio of an output to an input, both benefits and costs must be considered. This fulfils the requirement for mandatory consideration of costs and benefits. Comparative profitability calculations are also clear and recognised in terms of their comprehensibility and informative value (Heesen, 2009, p. 130, Vahs/Brem, 2013, p. 321).

The utility analysis should be used as a semi-quantitative method for this purpose. Many authors consider utility analysis to be particularly suitable in terms of its flexibility, suitability for evaluating innovation ideas, user-friendliness and acceptance (Adam, 2012, p. 259, Heesen, 2009, p. 127, Vahs/Brem, 2013, p. 333). In practice, utility analysis is also one of the most popular methods in decision support (Cooper, 1985, p. 36). The following figure illustrates the basic idea of the innovation return formula.

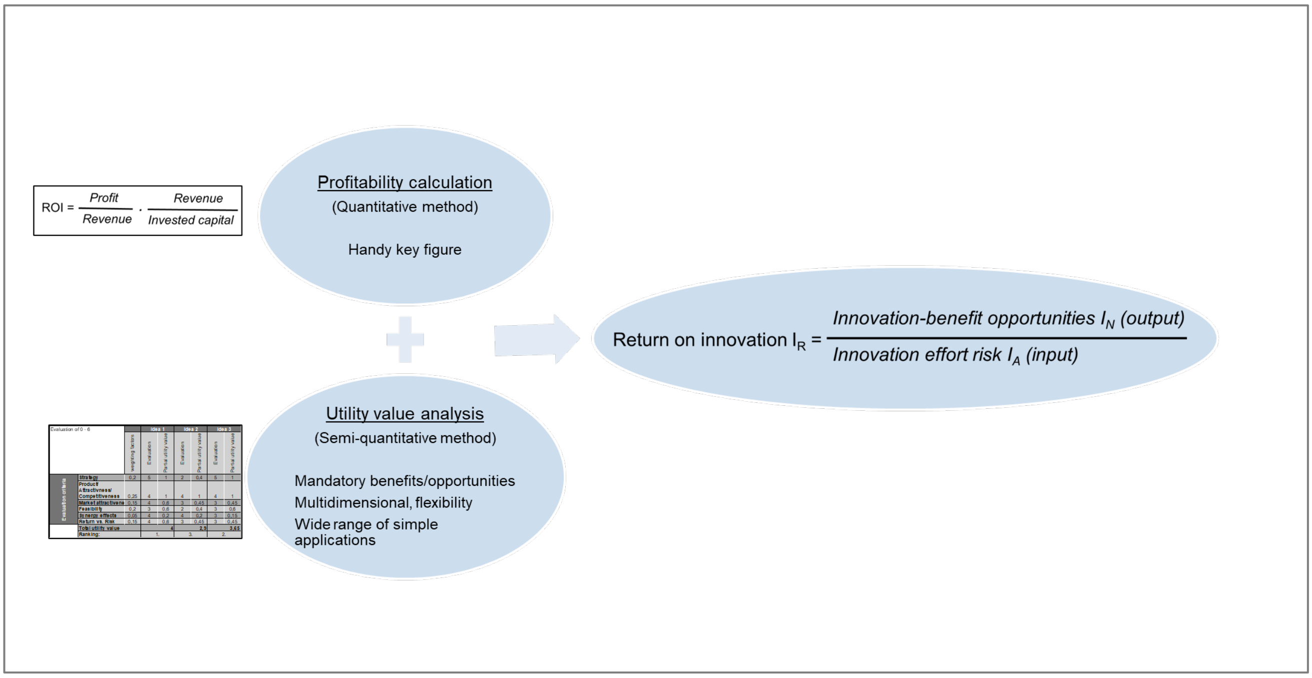

Figure 9: Basic idea of the return on innovation.

It should already be emphasised at this point that this "profitability" does not have a value-based character, such as a classic return on sales or ROI, but rather works with dimensionless figures like all scoring models. As with other semi-quantitative methods that work with non-metrically scaled criteria and weights, there is also a risk of pseudo-objectivity with this proposal (Plattfaut et. al., 2020, p. 1126, Hüsler et. al., 2017, p. 44). Nevertheless, such a combination of profitability comparison and utility analysis seems to offer some advantages:

- With this formula, it is therefore imperative that both the potential benefits and opportunities as well as the necessary effort and associated risks must be assessed.
- By using a semi-quantitative method, both quantitative factors such as the sales potential of the innovation idea or development costs can be included as quantitative financial data and qualitative criteria such as customer benefit, the risk of success or even intuition as an evaluation criterion.

- The ratio of benefits/opportunities (output) to costs/risks (input) provides an indication of the profitability of the innovation idea. If it is greater than one, a positive profitability can be assumed; if it is less than one, the innovation idea or project is not profitable.
- By using the same observation period and the same criteria, the indicator can be used for a comparative evaluation of different innovation ideas or projects.

Before further elaboration and concretisation of the basic idea of a return on innovation can take place, the status of approaches and formulas should first be examined with regard to their suitability for the task at hand.

4.2 Previous approaches and formulas for determining a return on innovation

In German-speaking innovation controlling, the term "innovation return" is not explicitly used. The term "return on investment" (ROI) for innovations is used (Roterberg, 2018, p. 54; Gleich, 2015, p. 205). Möller/Schmälzle list several relative variables such as "share of sales of new products in total sales", "annual sales/R&D budget" or "sales per R&D employee" as possible key figures for the subsequent evaluation of innovations, without referring to "profitability" or "return on investment" (Möller/Schmälzle, 2008, p. 35). To calculate a return on investment, Roterberg defines the ratio of the profit or savings from a business idea to the average capital investment (Roterberg, 2018b, p. 54). As a "refinement" of this key figure, he describes the return-on-investment (ROI) method from return on sales multiplied by the capital turnover as shown in **Figure 10**. Both the attribution of profits and the lack of consideration of risks must be viewed critically with this key figure (ibid.).

$$\text{Return on investment} = \frac{\textit{Profit per period or cost savings}}{\textit{Ø Capital investment}}$$

The **return on investment method** (RoI) is a simplification of the profitability calculation formula:

$$\text{Return on investment} = \text{Return on sales x capital turnover}$$

$$\text{Return on investment} = \frac{\textit{Profit per period}}{\textit{Revenue per period}} \times \frac{\textit{Revenue per period}}{\textit{Ø Capital investment}}$$

Figure 10: Return on investment and ROI, own illustration based on Roterberg (Roterberg, 2018b, p. 54).

Krause/Arora propose a slightly different approach for the "return on innovation". As an ex-post indicator, they put the profits from innovations in relation to the resulting costs (Krause/Arora, 2010, p. 45). Here, too, the project-related determination of revenues and expenses is viewed critically (Kaschny et. al., 2015, p. 379).

Return on innovation investment

$$\frac{\textit{Profit generated through new innovations}}{\textit{Innovation costs}}$$

Figure 11: Return on innovation investment according to Krause/Arora, illustration based on Krause/Arora (Krause/Arora, 2010, p. 45).

Astor et. al. uses the term "return on innovation" for companies as the ratio of profits from product or process innovations in relation to the company's innovation expenditure as a percentage (Astor et. al., 2016, p. 84). This ratio is used to interpret the degree of profitability of innovation activities and compare it with other companies or company sizes (ibid.). In this context, the so-called "innovation rate" is also frequently used to determine the share of innovation turnover in total turnover (Kaschny et. al., 2015, p. 374; Zapfl, 2021, n.p.). However, as with ROI, this key figure assumes that a meaningful allocation of sales or profits from new solutions takes place, which can be very difficult due to the subjectivity of the concept of novelty (Niculescu, 2021, p. 44).

Innovation rate

$$\frac{\textit{Sales with newly launched products}}{\textit{Total sales}} \times 100$$

Figure 12: Innovation rate, own illustration based on Kaschny (Kaschny et. al., 2015, p. 374).

Kolk/Eagar attempt to review the effectiveness and profitability of investments in innovation retrospectively with the help of an "ROI of innovation". This "ROI of innovation" is the ratio of investment expenditure to the added value from the innovations (Kolk/Eagar, 2014, p. 69). In their article, they address the difficulties of summarising both expenditure and added value for or through innovations, e.g. which activities should be considered in addition to direct R&D expenditure (ibid.). They also point out that one should not only rely on financial indicators such as net present value, but also on further qualitative analyses. However, this is not summarised in a modified ROI,

but expressed in general recommendations for action (ibid., pp. 80-82). In English-speaking countries, there are other terms such as Frankenfield's "Return on Research Capital" (RORC), which relates the company's total profit to the costs of R&D (Frankenfield, 2023, n.p.). This does not explicitly consider the profit from the new (innovative) products or services, but rather the company's total profit, which means that it is not possible to relate this to the success of innovation.
Other authors such as Hayes et. al. only compares the profit from innovations with the R&D expenditure and then speak of the "return on innovation investment", abbreviated to "R2I" or "ROI2", in order to determine how effective the expenditure on innovation is (Hayes, 2021, n.p.).

$$\text{Return on research capital (RORC)} = \frac{\textit{Total company profit (current year)}}{\textit{R\&D expenditure last year}}$$

$$\text{Return on innovation investment (R2I or ROI2)} = \frac{\textit{Profit from innovations}}{\textit{R\&D expenditure}}$$

Figure 13: Formulas for innovation returns and rates, own illustration based on Frankenfield, Hayes and Zapfl (Frankenfield, 2023, n.p.; Hayes et. al., 2021).

In contrast to the German-speaking authors from the field of innovation controlling, Bieger explicitly uses the term "innovation return" to assess the expected success or expenditure. Although he also sets the innovation gain in relation to the investment, he multiplies it by a probability of success and speaks of a "perceived innovation return" (Bieger, 2019, p. 172).

$$\text{Perceived return on innovation} = \frac{\textit{Innovation gain x probability of success}}{\textit{Innovation investments}}$$

Figure 14: Return on innovation according to Bieger, figure based on Bieger (Bieger, 2019, p. 171).

However, Bieger does not elaborate further on the concrete operational implementation of the return on innovation but uses it to explain economies of scale between small and large companies in the economic realisation of innovations (ibid.).

In their publication, Augsten et. al. cite a practical example in which a company specified an "innovation return" for its innovation projects and also reviewed it after the end of the project (Augsten et. al. 2017, p. 39-40). The innovation return was defined as the cumulative turnover with the product over 3 years minus cumulative manufacturing costs divided by one-off expenditure for the innovation as development expenditure plus investments (see Figure 15)

$$\text{Return on innovation} = \frac{\textit{Cumulative contribution margin*}}{\textit{One-off expenses for the innovation**}}$$

** defined as cumulative sales of the product over 3 years minus cumulative manufacturing costs.*
** defined as development costs plus investments.

Figure 15: Return on innovation from a practical example, own illustration (Augsten, 2017, p. 39).

The target was to achieve a return of 3, i.e. the contribution margin had to exceed the investments by a factor of three after the three years, which led to great unrest in product management and sales but was in line with the management's desire for transparency (ibid.)

The creation of a return on innovation, as developed as an idea in chapter 4.1, as a combination of qualitative and semi-quantitative methods for determining the future innovation potential of innovation ideas or projects is not yet used in this way according to previous research. In most cases, the return on innovation or profitability is understood as a purely financial indicator, which is calculated from the ratio of innovation sales or profits to the costs and expenses caused by the innovation and is used retrospectively to evaluate completed innovation projects.

5 Concretisation and elaboration of the innovation return methodology with example

When selecting the criteria and their factor values for the denominator and numerator, a certain balance should be achieved so as not to distort the comparison. In addition, the same time period should be selected for the comparison, i.e. the point in time in the future for which the results on benefits/opportunities and costs/risks are assessed. The evaluation of innovations, ideas and inventions is highly dependent on the context of the company and the organisation, as well as on the type of innovation and the period under consideration. It is therefore extremely difficult to define generally applicable criteria. However, an attempt will be made in the following two chapters to propose a set of criteria for the potential benefits/opportunities of an innovation idea (section 5.1) and the necessary effort/risk (section 5.2). These should serve as a point of reference and can be adapted to the specific situation in the company in the excel tool presented subsequently.

5.1 Proposed criteria for the benefit/opportunity potential as the numerator of the return formula

Hauschildt et.al. define the overall benefit of an innovation in the three dimensions of "technical effects", "economic effects" and "other effects", whereby he believes that there is unanimity in the literature on at least the first two dimensions. The technical and economic effects are subdivided into direct and indirect effects and the other effects into system-related and individual effects (Hauschildt et al., 2016, p. 399).

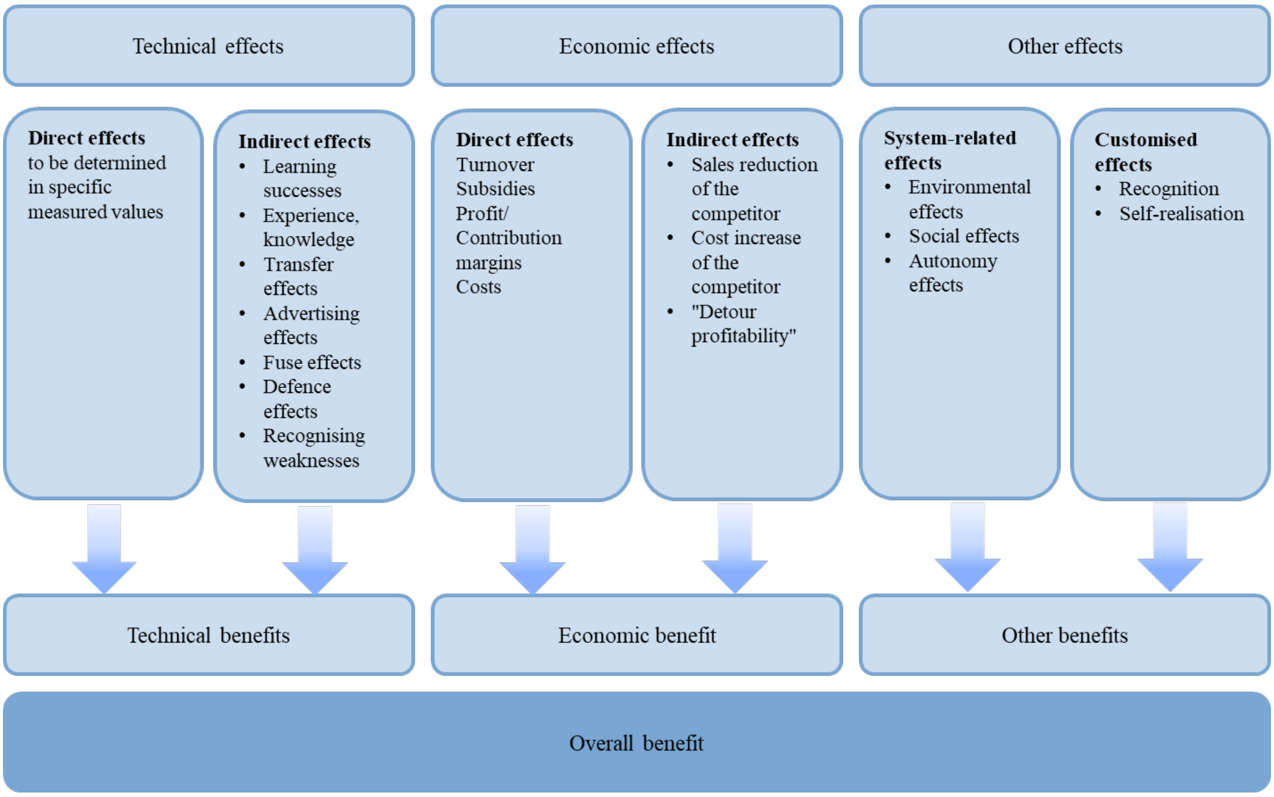

Figure 16: Criteria for evaluating innovation success based on Hauschildt (Hauschildt et.al., 2016, p. 399).

The direct technical benefit can be measured quantitatively, for example as a reduction in weight, an increase in performance or a reduction in energy requirements. Non-measurable technical benefits mainly include any knowledge gain and transfer resulting from the innovation process (Vahs/Brem, 2013, p. 68). The measurable direct economic benefits include, for example, turnover or profit from the innovation; indirect economic benefits can occur if, for example, competitors are motivated to increase their research expenditure by innovations from other companies (Granig, et al., 2014, p. 44).

Even though Hauschildt emphasises the great importance and necessity of economic criteria for evaluation, he also considers qualitative aspects such as customer satisfaction, image effects and ecological sustainability (Hauschildt et.al., 2016, p. 399-400). Customer benefits are seen by other authors as the most important prerequisite and critical success factor for the market success of an innovation idea, i.e. the potential user must perceive the advantages of the idea, a circumstance that is unfortunately often neglected when evaluating innovation ideas (Kerka et. al., 2007, p. 293). Research into success factors for innovations also confirms the benefits perceived by the customer as

the most influential evaluation criterion for successful innovations (Kleinschmidt, 1996, pp. 9-10). In a cross-industry study, Jaruzelski et. al. found that companies with above-average profit and growth focus their innovation activities very much on the insights gained from end users (Jaruzelski et. al., 2018, n.p.).
However, the assessment of customer benefit is a difficult task, as little is known about the later application in the early phase and individual preferences of potential users must be assumed (Stewart-Knox/Mitchell, 2003, p. 62; Cooper/Kleinschmidt, 1987, p. 222). In addition to this difficulty of evaluation, there is also the risk of only pursuing incremental innovations if the customer focus is too short-term, as the customer benefit can be determined more clearly and long-term strategic innovations are lost sight of as a result (Janovsky, et al., 2016, p. 196).

In addition to the qualitative value of customer benefit, the great importance and significance of economic criteria is emphasised. According to Kerka et. al., anyone who wants to develop innovations must also be able to "calculate their innovation" to gain a hearing and acceptance from decision-makers and controlling (Kerka et. al., 2007, p. 303). According to Vahs/Brem, the main objective of innovation activities is to achieve competitive advantages, which can then be measured in economic parameters such as turnover, profit and profitability (Vahs/Brem, 2013, p. 40). However, it is undisputed that even in the event of economic failure, important benefits can materialise, such as image effects, customer loyalty or the creation of barriers to market entry (Janovsky, et al., 2016, p. 7). Bad investments can also lead to learning successes and insights into weak points within the company, which should be utilised for further innovation activities (Hauschildt et al., 2016, p. 399).

Against the background of these findings from the literature and the requirements placed on the evaluation criteria in Chapter 1, the following 5 benefit/opportunity criteria are proposed:

1. Economic benefit
   (As a quantitative criterion, a statement should be made about the economic benefit. For this purpose, concrete reference points or figures should be selected, e.g. profit in relation to the current annual profit or cost savings in relation to previous costs. This quantitative criterion must be defined before use, e.g. whether static or dynamic methods are to be used)
2. Perceived benefits and significance for customers
   (the aim is to assess how high the perceived benefits and significance are from the perspective of potential users or customers. Does the innovation idea really hit a "pain point" and

does it create tangible added value? These can also be internal company users or customers (e.g. process innovations)

3. Benefits through the development of competences and skills
   (a general assessment should be made as to whether the further pursuit of the innovation idea will build up competences and skills in the company that could be valuable for the company as a whole, for other business areas or for future business activities)
4. Opportunities through future market with long-term significance
   (at this point, it should be assessed whether the innovation idea is in a future market that could enable long-term opportunities and potential based on one or more trends)
5. Sustainability benefits
   (In addition to the economic component in the second criterion, an assessment should be made regarding ecological or social benefits.)
6. Total benefits & opportunities based on gut feeling
   As explained in section 1, intuition should be considered as an independent criterion. This applies both to the assessment of the benefits/opportunities of the innovation idea and to the effort and risk involved. By accompanying this subjective and hardly objectively explainable criterion with the other criteria already proposed, an attempt is made to consciously integrate intuition, but at the same time to avoid a one-sided (over)weighting of emotions and intuitions in decision-making processes, which should also not be the case (Sulzberger, 2014, p. V). The best decisions are made when both analytical and intuitive thinking are combined and not seen as opposites (Hildenbrandt/Neumüller, 2021, p. IX).

5.2 Proposed criteria for the cost/risk assessment as the denominator of the return formula

Schumpeter already stated that the implementation of innovations in the economy requires production resources such as labour, raw and auxiliary materials or tools, which can lead to "increased deprivation" or "increased effort" (Schumpeter, 1934, p. 103). Even today, it is undisputed that it initially requires increased effort and investment to create innovations (Vahs/Brem, 2013, p. 68). However, there is no unanimous picture when it comes to innovation assessment and evaluation. On the one hand, there is often the phenomenon of pure "budget thinking", i.e. that the effort side is overemphasised in the evaluation of innovations and the potential and actual revenues hardly play a role (Hauschildt et.al., 2016, p. 413). On the other hand, innovations are often uneconomical in retrospect because the actual costs for skills development, changes to production and sales and the conversion of processes were not considered comprehensively and realistically (Kerka et. al., 2007,

p. 304). Therefore, not only should the investments for research and development R&D, cost calculation be included, but also for necessary changes in production, market launch, sales and, if necessary, service should be estimated (BMBF, 2018, n.p.; Roterberg, 2018, p. 279).
In addition to the increased expenditure, innovations are generally always associated with a risk (Block et al., 2013, p. 699). For example, it is not certain to what extent potential customers and users will accept the new product or service and be willing to pay for it. Competitive aspects are also playing an increasingly important role in the implementation of innovations on the market (Vahs/Brem, 2013, p. 8). In particular, the risks posed by intense competition, the superiority of competing products and the price level on the target market represent a risk to success (Kerka et. al., 2007a, p. 296).
The effort required to overcome internal resistance and convince people within the company to implement the innovation idea can also be considerable and can be expressed as "preventing", "delaying" or "deforming" (Hauschildt, et. al., 2016, p. 33). The higher the degree of novelty and the complexity of an innovation idea, the higher the factor of uncertainty of the people involved in the company and the higher the risk of conflicts during implementation (Vahs, 2013, p. 35-37).
The following criteria are proposed for the denominator of the return on innovation, i.e. for effort/risk. Here too, as with the benefit/opportunity criteria, it is not possible to generalise and ensure the accuracy of the criteria due to the different starting conditions and objectives of companies. However, an attempt should be made to formulate criteria that are as overarching and comprehensive as possible and provide a holistic picture.

1. Investment expenditure for development and capacity building in R&D
   (here, the investment expenditure required to develop the innovation idea in R&D up to market launch should be estimated as comprehensively and quantitatively as possible. This may also include the cost of additional capacity building in the form of further training, external support or new staff. If possible, this total expenditure should be estimated in terms of value and set in relation to the current R&D expenditure. As with the economic benefit, the figure to be used and its calculation method must be determined in advance)
2. Effort to convince customers
   (it should be assessed whether greater effort is required to convince potential users or customers to use the new offering. Is it necessary to change previous habits or does the potential customer have to switch from a competitor's solution?)
3. Success risk (technical) feasibility
   (how is the successful and complete feasibility of the innovation idea assessed? This should

include aspects such as technical complexity, the availability of necessary competences and other conceivable uncertainties that may arise during implementation).

4. Market and competition success risk (VUCA world)
   (the success risk should assess the extent to which a success risk exists or may occur in the future, e.g. due to high volatility or ambiguity (keyword VUCA world) in the target market of the innovation idea. The possible risk of success due to the competitive situation or legal framework conditions should also be included in the assessment)
5. Effort to convince internally and further conversion effort
   (If the implementation of the innovation idea requires major changes and adjustments within the company, the greater the resistance to it is likely to be and the greater the effort required to overcome it. This criterion should therefore be used as a measure to qualitatively assess further changes that are necessary within the company. As far as possible, all aspects other than R&D expenditure should be assessed, i.e. in management/administration, production, marketing, sales and service).
6. Total cost & risk according to gut feeling
   (see the notes on total benefit & opportunity according to gut feeling)

5.3 Presentation and evaluation of the proposed criteria

In the following figure, the criteria of both categories are shown in full within the formula.

Return on innovation I_R =

Criteria for benefits/opportunities
1. economic benefit (quantitative)
2. customer benefit (current or future)
3. benefits through new competences and skills
4. opportunities through future market/trend
5. sustainability benefits (ecological, social)
6. total benefits/opportunities according to gut feeling
Total

divided by

Criteria for expense/risk
1. capital expenditure R&D (quantitative)
2. effort to convince customers
3. success risk (technical) feasibility
4. success risk market/competition (VUCA)
5. effort to convince internally (resistance)
6. total cost/risk according to gut feeling
Total

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Figure 17: Illustration of the complete list of criteria for the innovation return.

The selection should now be checked for suitability based on the requirements from chapter 1 (possibly better in tabular form).

1. Consideration of economic characteristics?
   Fulfilled, for benefit/opportunity the economic benefit is queried and for cost/risk the investment expenditure in the R&D area is queried.
2. Consideration of environmental factors, 360° view if possible?
   Partially fulfilled, legal as well as competitive and other characteristics are queried via success risk market and competition, long-term trends are considered via opportunities through future market. There is no explicit enquiry about other stakeholders such as society or NGOs.
3. Consideration of opportunities and risks
   Fulfilled, both sides are queried using 6 criteria each.
4. Consideration of product and process-related characteristics
   Fulfilled Product or process-related characteristics are queried via the success risk of technical feasibility.
5. Consideration of internal company characteristics
   Yes, for benefits/opportunities the development of competences and skills is queried and for costs/risks the technical feasibility, internal investment costs and internal hurdles and conversion costs are discussed.
6. As few evaluation criteria as possible
   With 6 criteria each, i.e. a total of 12 questions, the instrument does not appear to be too extensive and thus also fulfils the economic efficiency requirements for use.
7. Consideration of intuition as an evaluation criterion
   fully met, both in terms of benefit & opportunity and cost & risk

Table nn: Review of the proposed criteria according to the requirements from Chapter 2

5.4 Example of the calculation of a return on innovation

In order to explain the basic approach of the methodology, the return on innovation will be calculated using a small example:

A company is planning an innovation project for an AI-supported control system for the batteries of an electric vehicle to increase the performance of the batteries. The innovation return in 5 years is to be determined using the innovation return formula. It is decided to weight the criteria for the economic benefit and the investment expenditure as well as the intuition criteria with 20 per cent each. The other qualitative criteria should remain equally weighted at 15 per cent each. The evaluation scheme for the quantitative criteria is defined as shown in table nn. With the support of sales and R&D, a cumulative profit of 30 million euros over 5 years is calculated for the new system and 5 million euros for additional personnel and technical equipment cumulatively over 5 years for the investment expenditure in R&D. With a current annual profit of 150 million euros and an annual R&D budget of 10 million euros, the economic benefit is 3 (medium benefit) and the investment expenditure is 3 (medium investment expenditure).

Cumulative economic benefit in 5 years	**Rating scale**	**Capital expenditure R&D cumulated over 5 years**	**Rating scale**
There is no economic benefit	0 No economic benefit	No additional expenses are incurred	0 No capital expenditure
Cum. Profit with the innovation corresponds to max. 5 % of today's total profit	1 Very low economic benefit	The cumulative investment expenditure corresponds to a maximum of 10% of today's annual R&D expenditure	1 Very low investment outlay
Cum. Profit with the innovation corresponds to max. 10 % of today's total profit	2 Low economic benefit	The cumulative investment expenditure corresponds to a maximum of 20% of today's annual R&D expenditure	2 Low investment outlay
Cum. Profit with the innovation corresponds to max. 20% of today's total profit	3 Medium economic benefit	The cumulative investment expenditure corresponds to a maximum of 50% of today's annual R&D expenditure	3 Medium investment outlay
Cum. Profit with the innovation corresponds to 20-30% of today's total profit	4 High economic benefit	The cumulative investment expenditure corresponds to a maximum of 100% of today's annual R&D expenditure	4 High capital expenditure
Cum. Profit from innovation corresponds to more than 30% of today's total profit	5 Very high economic benefit	The cumulative investment expenditure corresponds to a maximum of 200% of today's annual R&D expenditure	5 Very high capital expenditure

Table 3: Evaluation grid for economic benefits and investment costs in the calculation example.

A team from the R&D, sales, production and service departments is formed to assess the qualitative criteria. There is a consensus that this project could be used to develop valuable expertise for numerous other future markets, and the costs appear manageable as a strong IT department is already in place. However, a high level of internal resistance is expected, as development experience with the automotive industry has been very poor to date. To assess the gut feeling, each person in the team makes their own judgement and an average value is calculated and entered. The final assessment is shown in **Figure 18** This means that the benefits and opportunities outweigh the costs and risks in 5 years, the indicator is therefore greater than 1 and the innovation is therefore considered to be profitable. When evaluating several innovation ideas or projects, this indicator can be used to compare different levels of profitability.

Return on innovation I_R = (benefits/opportunities) / (expense/risk) = 1,35

Criteria for benefits/opportunities	%	0-5	Erg.
1. economic benefit (quantitative)*	20	3	0,6
2. customer benefit (current or future)	15	4	0,6
3. benefits through new competences and skills	15	5	0,75
4. opportunities through future market/trend	15	5	0,75
5. sustainability benefits (ecological, social)	15	2	0,3
6. total benefits/opportunities according to gut feeling	20	4	0,8
Total	100		3,8

Criteria for expense/risk	%	0-5	Erg.
1. capital expenditure R&D (quantitative)*	20	3	0,6
2. effort to convince customers	15	2	0,3
3. success risk (technical) feasibility	15	3	0,45
4. success risk market/competition (VUCA)	15	2	0,3
5. effort to convince internally (resistance)	15	4	0,6
6. total cost/risk according to gut feeling	20	3	0,6
Total	100		2,8

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Figure 18: Sample calculation to determine the return on innovation.

6 The innovation return calculator

Now that the methodology of the innovation return formula for determining a potential return on innovation ideas and projects has been worked out in chapter 5, a tool is to be derived from it that enables it to be used in practice. In contrast to the innovation test bench, which determines the "aggregate state in the actual state" (Hube, 2022, p. 13-17), the innovation return calculator is intended to analyse the "aggregate state in the making", i.e. the future return potential of innovation ideas or projects. To this end, requirements are first placed on the tool (section 6.1), before the various dialogues and evaluation options are presented (section 6.2, section 6.3 and section 6.4).

6.1 Requirements and prerequisites

Based on the findings and conclusions of the previous chapters, the tool should fulfil the following requirements:

- Simple software environment with as few access barriers and intuitive operation as possible
- Complete content mapping of the fundamental considerations and criteria
- Possibility of comparative evaluation of several innovation ideas or projects as well as comparative assessment by different people
- First graphical analyses for interpretation and decision support
- Use for both market innovations and internal projects allows flexibility in the weighting of criteria

As with the innovation test bench, Excel was again used as the environment for implementing the tool, as this software is widely used and is generally used in all areas of a company. The fulfilment of the other requirements should result from the description of the dialogues and evaluations in the following chapters.

6.2 Initial dialogue

The first dialogue is used to welcome and explain the tool. After a brief introduction to the background and the innovation formula, you can select whether the tool should be used in multi-project or multi-assessor mode and how the project to be assessed should be labelled. The number of projects or assessors to be assessed can be set up to 50. The period over which the return on innovation ideas or projects is to be determined should also be entered here.

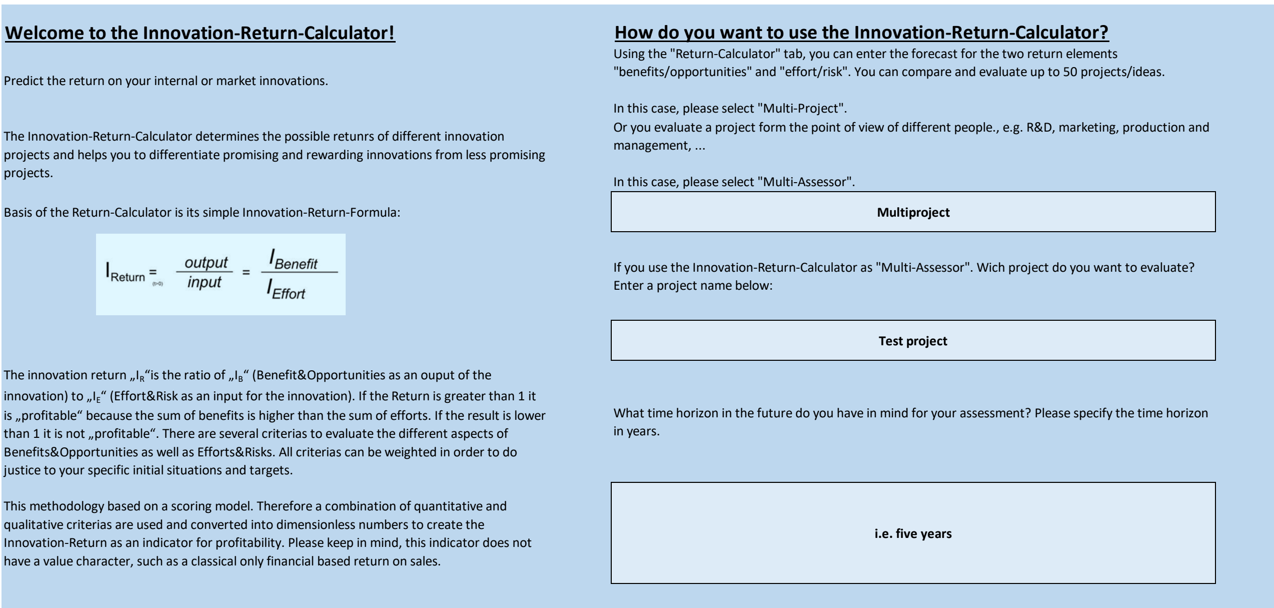

Figure 19: Welcome dialogue to explain and select the multi-project or multi-assessor assessment mode.

6.3 Evaluation dialogue

The centrepiece of the tool is the evaluation using the criteria developed in the previous chapters. For this purpose, the criteria can initially be weighted, but the equal distribution, which is initially entered by default, can also be retained. For the potential benefits/opportunities, the six benefit/opportunity criteria defined in Chapter 3 are now queried and can each be assessed on a scale of 0 to 5 (0: not present, 1: very low, 5: very high). For the only quantitative criterion for which the economic benefit is to be assessed, the key figure and benchmark must be defined in advance. As suggested in the calculation example in section 3.7, revenue shares or profit shares can be used to make an assessment in the scaling. These financial forecasts can be determined using both static and dynamic methods but must be defined in advance. As soon as these values are available and the scaling has been defined, an assessment can be made for this quantitative criterion.

Innovation-Return-Calculator Prof. Hube

How many evaluations do you want to do in total?
Type a whole number 1 - 50:

Then click here: **4**

Use as: Multi project: **Time horizon in the future:**	**Multiproject** **i.e. five years**				
Project number: **Please enter a project name:**		1 battery cells		2 AI-powered battery	
Innovation benefit potential, opportunities per assesment: (Scale: 0: not existing, 1: very low to 5:very high)	**Please enter a weighting percentage per criterion**	**Assessment 1**	**Weighted assessment**	**Assessment 2**	**Weighted assessment**
Economic benefit through innovation idea as sales/profit or savings potential (preliminary definition of parameters and scaling necessary, e.g. (0: no profit, 1: very low with max. 3% profit share, 2: low with max. 5% profit share)., 3: medium with max. 20% profit share, 4: high with max. 30% profit share, 5: very high with more	20	3	0,6	4	0,8
Perceived customer benefit (can also be internal customer)	15	2	0,3	4	0,6
Benefit through new skills and abilities (through the implementation of the innovation idea, competencies and skills are built up that could be valuable for the company as a whole, i.e. also for other fields of application or	15	4	0,6	5	0,75
Opportunities through future market/trend with long-term importance (Does the innovation idea move in a subject area that is associated with great opportunities and potential as a long-term trend)	15	4	0,6	5	0,75
Sustainability benefits (In addition to the economic benefits, it should be assessed to what extent the innovation idea could also bring ecological and/or social benefits)	15	3	0,45	5	0,75
Overall benefits & opportunities based on gut feeling	20	3	0,6	5	1
Sum of weights (The sum must be 100)	100,00%	Sum of weight benefits	3,15		4,65

Figure 20: Dialogue on the assessment of benefits/opportunities.

Similarly, the cost/risk is assessed using the 6 criteria with a scale of 0 to 5 (0: not present, 1: very low, 5: very high). Here too, before estimating the economic cost, the only quantitative criterion, it is necessary to determine the cost factor and the ratio to be used for the assessment. In the calculation example in section 3.7, the expected cumulative costs of the innovation idea or project for R&D were set in relation to the current R&D budget. This and the calculation methodology must be defined before answering this question.

6.4 Analyses

A portfolio visualisation is used for an initial evaluation of the innovation returns. Portfolio representations allow for simple and easy-to-understand visualisation, and initial recommendations for action can already be given for each result field (Fig 22). To analyse individual projects from the different perspectives within a company, e.g. from the point of view of R&D, marketing and service, the multi-assessment mode can be used as an alternative to the multi-project mode. In this case, the cost/benefit portfolio could be analysed as shown in **Figure 22** as an example. This can now serve as a basis for discussing the causes of different judgements and, in the best case, eliminate possible obstacles to implementation.

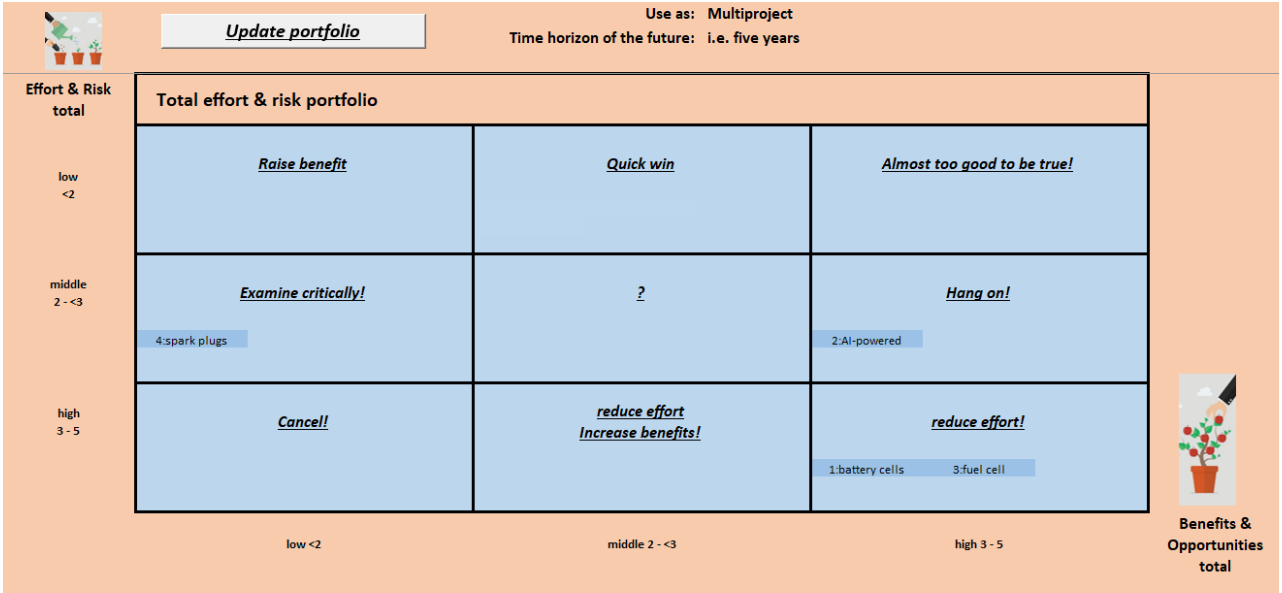

Figure 21: Portfolio display multi-project mode.

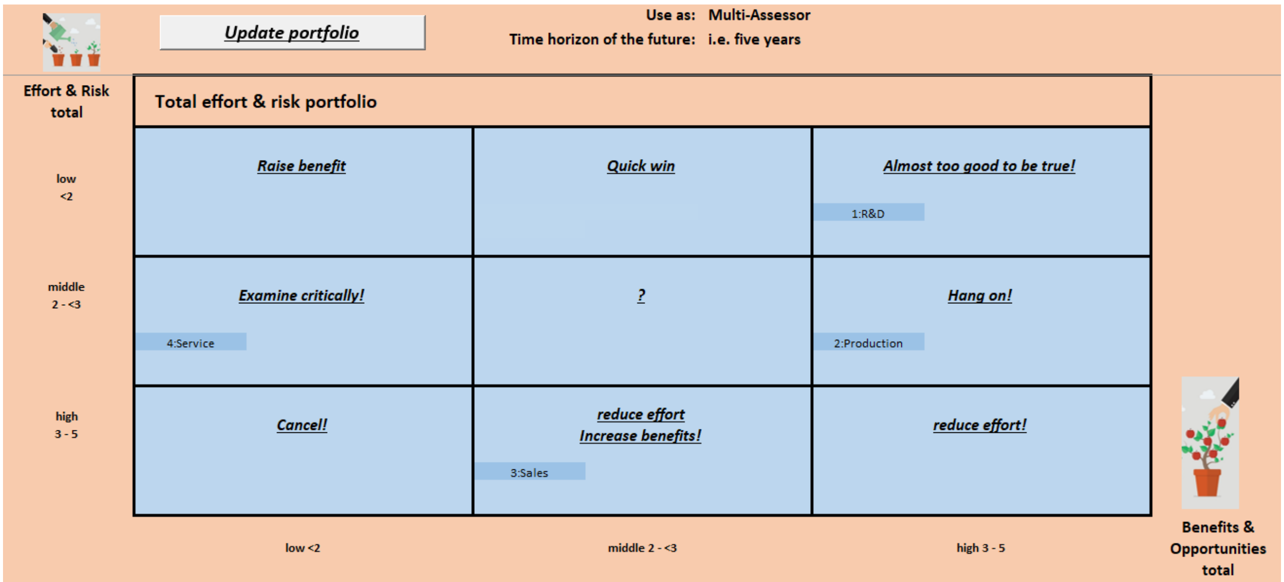

Figure 22: Portfolio display in multi-assessment mode.

Further analyses are offered in the form of return and balance sheet charts. The positive or negative return (return chart) or the relationship between benefit/opportunity and expense/risk (balance sheet chart) is emphasised.

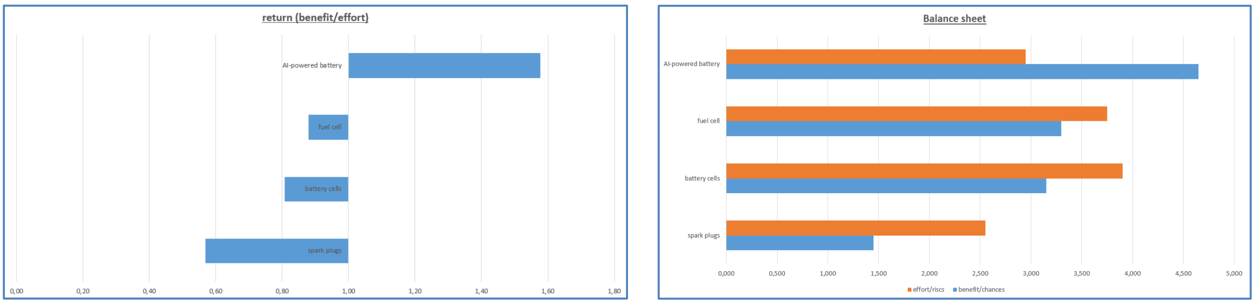

Figure 23: Return and balance sheet chart.

A further graphic shows the characteristics of all 12 criteria for the various projects and persons in a network diagram and comparison (**Figure 24**). The benefit/opportunity criteria are arranged on the right-hand side and the cost/risk criteria on the left-hand side.

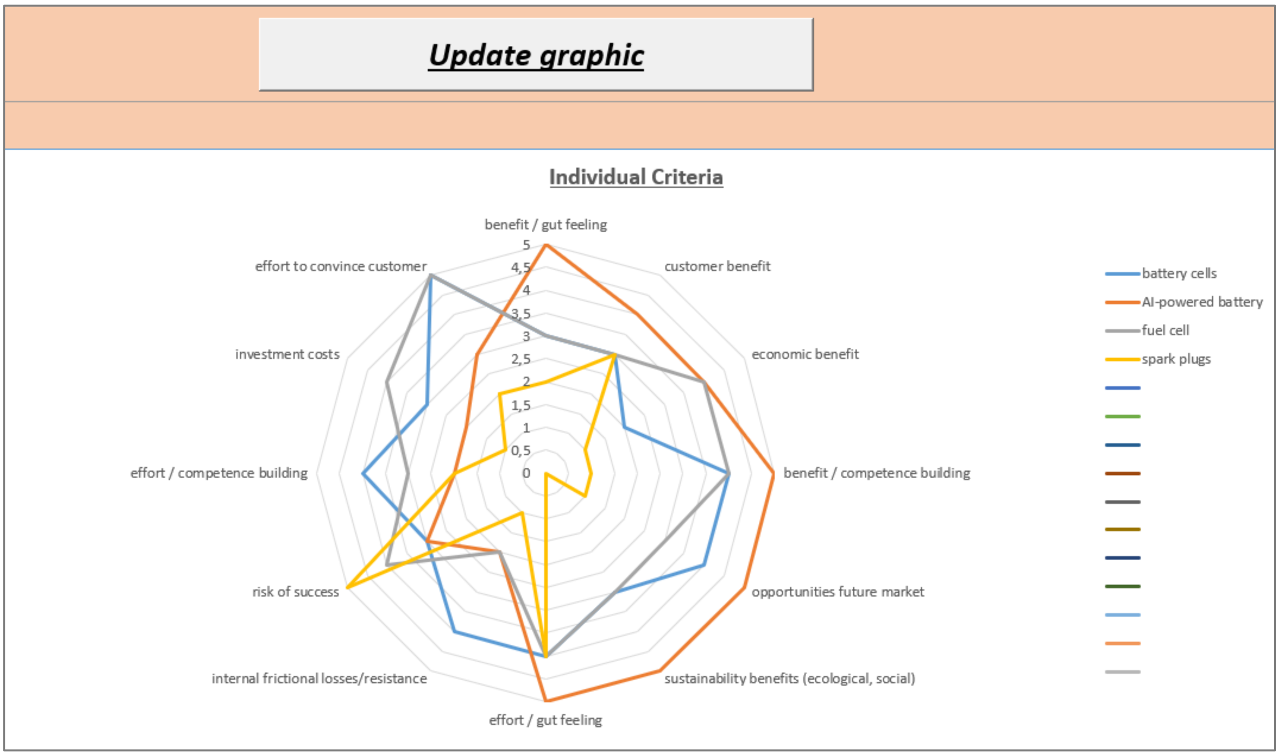

Figure 24: Network diagram.

7 Survey to evaluate methodology and instrument

As part of a survey, the methodology developed here was evaluated by 17 experts with many years of experience in the field of innovation. The methodology and the instrument were briefly introduced in a presentation and then evaluated with the help of a questionnaire. In addition to closed questions with a 5-point rating scale ranging from "strongly disagree" to "strongly agree", comments and suggestions could also be provided via various free text fields. The main aim of the survey was to check whether the fundamental requirements of the new methodology were met from the perspective of the experts in the field.

The survey took place on 19 September 2023 as part of an industry group that meets regularly to discuss the topics of innovation and innovation management. On average, the participating experts had around 12 years of professional experience in the field of innovation, with a range of at least 3 and up to 20 years. The current situation regarding the evaluation of innovation ideas in their own companies was given a grade of 3 (satisfactory), with the best grade being 2 (good) and the worst grade being 4 (sufficient).

In the evaluation of the methodology, it became clear that the inclusion of intuition as an evaluation criterion met with a very high level of approval. At 4.4 out of a maximum of 5, the average value is the highest, followed by a value of 4.2 for the overall use of the methodology in innovation. The assessment of the broad applicability of the methodology during the innovation process also received a very high approval rating of 4.1. This confirms some important requirements for the new methodology. The intended simple application, which requires little time and effort, was also rated very positively at 3.9. In the assessment of the completeness of the criteria, there was a predominantly favourable but mixed assessment between benefits & opportunities and costs & risks and a few additional comments in the text fields. For example, it was suggested several times that the motivation and expertise of the team should be considered in the criteria. The USP (Unique Selling Point) and alignment with the company's objectives were also added several times. In the assessment of the informative value of the new KPI, most respondents agreed, but there were also a few critical assessments. The question on the use of the tool in one's own company received the lowest level of approval with an average score of 3.5. However, this is also where the greatest spread of individual responses between the various answer options can be found. This could be due to the very different situations in the companies of the participants surveyed. The following figure shows the results of the survey according to the average values of the questions.

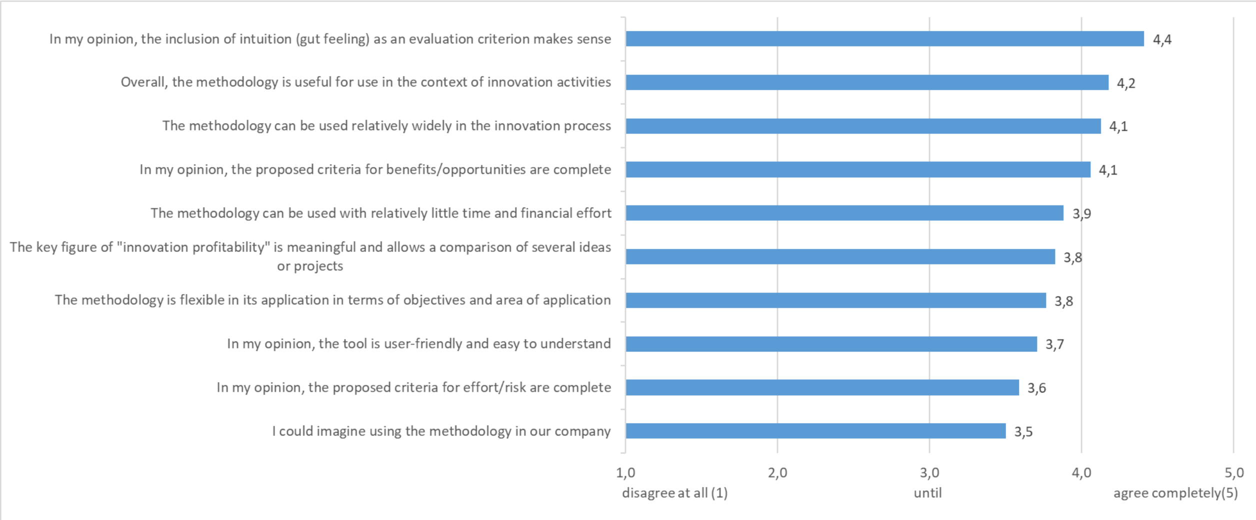

Figure 25: Average values for the assessment of the methodology by experts.

8 Conclusion and outlook

The aim of this work is to contribute to an improved evaluation of innovation ideas and projects in order to increase the success rate of innovations on the way from the idea to market success in the best case. This work is thus directly linked to the considerations and proposed solutions for better assessment and differentiation of innovations in the actual state (Hube, 2022). Once there is clarity about the status of innovation ideas and projects in the company with the help of the innovation status formula and the innovation test bench, these ideas and projects can be assessed for their return in the future with the help of the innovation return formula developed in this thesis and the innovation return calculator. This is intended to help in selecting the ideas and projects with the best cost-benefit ratio. **Figure 26** shows the underlying categorisation of innovation into the three "aggregate states of what is and will be" and the formulas and tools for analysing and assessing them. Following on from the explanation in Chapter 1, Apple could attempt to determine a return on investment for the "Vision pro" as a product in the area of VR, as the smartphone is no longer an innovation according to the innovation status formula from today's perspective.

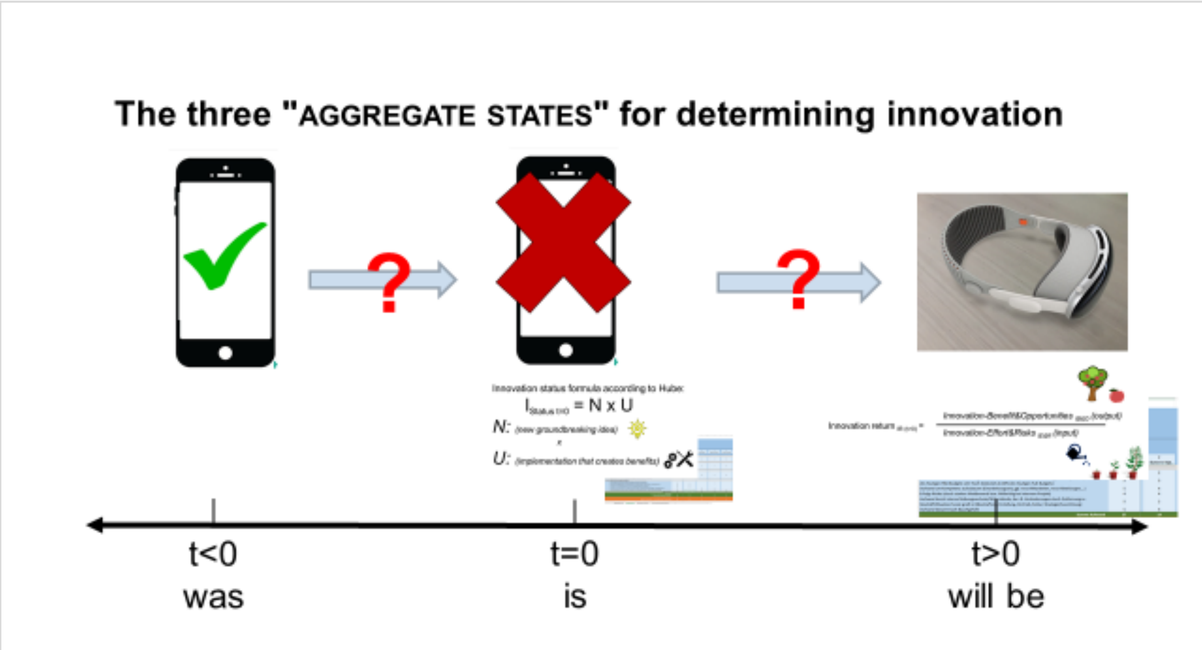

Figure 26: Innovation status and return on innovation.

Outlook and ideas for use and further development

As the methodology does not contain any KO criteria, it should be considered whether a KO criteria check should be carried out before using the innovation return calculator to rule out the possibility of ideas being included in the evaluation that do not fit the corporate strategy, violate legislation or contravene the company's guiding principles, for example. However, criteria should not be used that can only be clarified later in the valuation process, such as minimum turnover or return on sales (Kerka et. al., 2007, p. 288).

In order to do justice to the initially uncertain data situation, which will presumably improve as the innovation progresses, the determination of the financial criteria could possibly be calculated rather roughly at first and then more and more finely, e.g. initially using static methods and later using dynamic methods. However, this would also require the methodology to be applied regularly over the course of the innovation process, which would certainly lead to an increasingly better assessment of the return on investment or enable corrections to be made. An interesting suggestion was made during the survey in Chapter 7, which envisages a "basic" variant for pre-selection in the early phase, switching to an "advanced" variant as the process progresses and working with a "professional" variant in the final third, which would almost represent a business case.

Further possibilities for the further development of the methodology could be the systematic review of the use of artificial intelligence (AI). It would be interesting to determine which AI tools could be used to process the various proposed criteria. The pilot practical use of the tool in the innovation area of a company could also provide further insights for improvement and further development. In the context of teaching, the tool should be used to convey the importance and some of the fundamental characteristics of innovation.

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