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INNOVATION FORMULA AND INNOVATION TEST BED

Development of an instrument to determine the Innovation status in the present

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CONTENT

1. INTRODUCTION AND OBJECTIVE

The discussion about the great importance and high effectiveness of innovation for the survival of companies (cf. Maaß/May-Strobl, 2016, p. 1), especially in the SME sector (cf. Kaschny, et.al., 2015, p. 15) and even for societies as a whole (cf. OECD, 2018, p.3) has been intensively debated both currently and for several decades. Despite this, or perhaps precisely because of this, there is still no generally valid concept of innovation in the literature (cf. Völker/Friesenhahn, 2018, p. 17; Vahs, 2013, p. 20), or at least none that has become established through a clear and simple approach and could provide orientation for practitioners in particular as to what is to be understood by innovation and what is not. For this reason, an attempt will be made here to contribute to a simple, clear and preferably unambiguous understanding of innovation. In addition, an attempt will be made to solve a dilemma that often arises in the application and discussion of innovation. This dilemma arises when the actors do not clearly distinguish the status quo of an innovation from its future potential, resulting in misunderstandings and wrong decisions. Therefore, it is of high importance for both science and business practice to develop a uniform understanding of innovation. This understanding is important in order to have a common idea of what is to be understood by innovation and what is not on the way to an innovation-oriented company. This then has far-reaching consequences for the design of organisation and processes in the company (cf. Hauschildt, 2007, pp. 6-7). Building on a clear definition of innovation, this work develops an instrument that is to be used both in practice and in teaching.

2. THE CONCEPT OF INNOVATION

2.1 The concept of innovation from Schumpeter to today

> *"Innovation is a dazzling, a fashionable term".*
> (Hauschildt, 2007, p. 3)

Since Schumpeter first dealt fundamentally with "innovations in the economy" for national economies and companies (cf. Schumpeter, 1939, p.87) and the innovation debate in economics and literature developed from this, the discussion about a delimitation, demarcation and definition has not ceased. While Schumpeter speaks of new combinations in the form of new products, new processes, new sources of supply, sales markets as well as forms of organisation and their implementation on the market (cf. Schumpeter, 1934, p.100 f.), a wide variety of explanatory models and definitions for innovation have been developed in the following decades up to the present day. Different approaches have been chosen, such as novelty as the decisive aspect (cf. Barnett, 1953, p. 7), the novel combination of ends and means (cf. Moore, 1982, p. 132) or innovation as a process (cf. Dosi, 1988, p. 222). A clustering of these different approaches can be found in Hauschildt et.al. where a total of seven focal aspects for innovation definitions are distinguished in the literature between 1953 and 1992 (cf. Hauschildt, et.al. 2016, p. 5):

1. "Innovation as novel products or processes according to the fact and extent of novelty
2. Innovation as novel products or processes of first...
3. Innovation as novel products or processes of perception according to
4. Innovation as a novel combination of ends and means...
5. Innovation as the exploitation of novel products or processes...
6. Innovation as a process
7. Innovation as novel services beyond industrial products and processes".

Mitterdorfer-Schaad presents a comparative overview of some of the authors, beginning with Schumpeter and including Vahs 1999. In this presentation, the development towards an increasingly comprehensive understanding of innovation is shown, starting from an understanding of innovation that was originally more focused on partial aspects (Mitterdorfer-Schaad, 2001, p. 14).

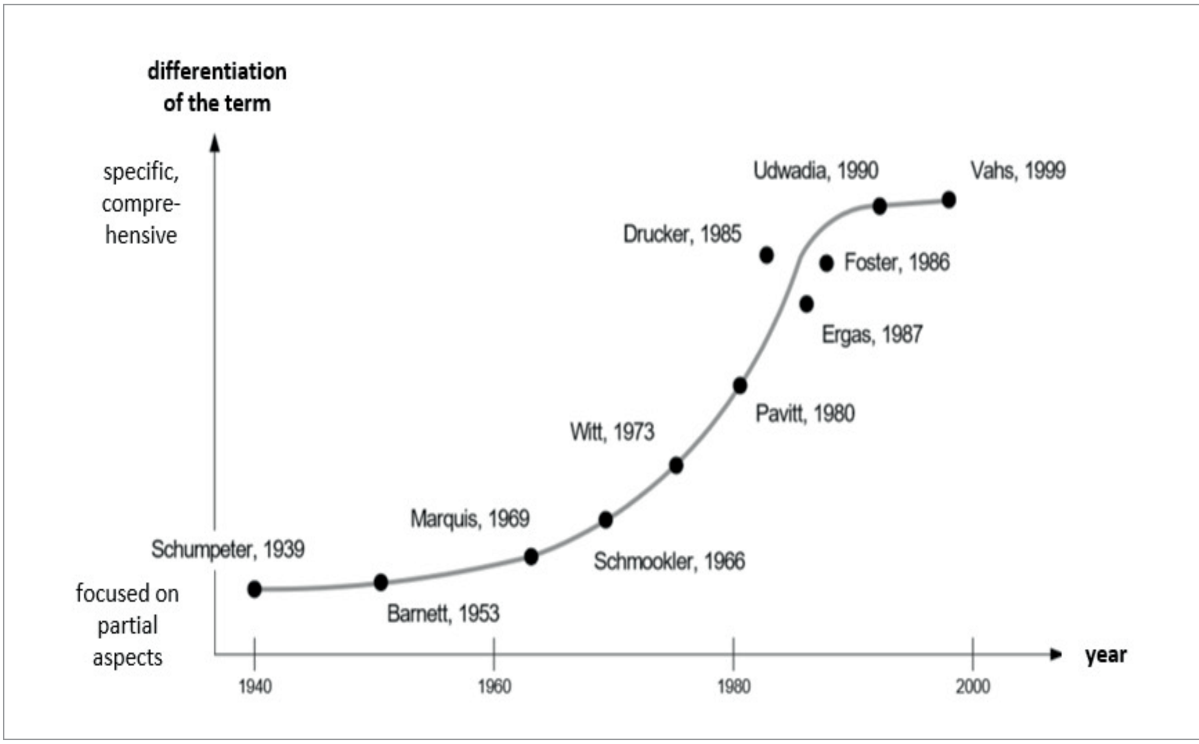

Figure 1: Evolution of the concept of innovation (Mitterdorfer-Schaad, 2001, p. 14)

Bullinger recognises a development in the understanding of innovation between the "old way" and the "new way". Whereas the earlier understanding of innovation tended to mean large dramatic steps, demolition and reconstruction by a few specialists in secret, it later developed into a more long-term, public and collaborative understanding (Bullinger, 1994, p. 37).

It becomes clear how diverse and numerous the authors are on this topic, without a generally valid definition having finally prevailed (cf. Vahs, Burmester, 2005, p. 43). In practice, too, there is usually no agreement on an understanding of innovation, which Goffin/Mitchel point out with a quote from an R&D manager: "If I ask five different people at our company what innovation is, I will get at least five different answers" (Goffin/Mitchel, 2017, p. 3). At this point, we will not go into the other numerous and different approaches to understanding innovation; comprehensive and structured works on this can be found in the literature (cf. Marcharzina, 2010, p. 744 ff.; Blättel-Mink, 2006, p. 29 ff.; Friedrich-Nishio, 2005, p. 40 ff.). However, there is agreement that this great semantic diversity means that the risk of misunderstandings is enormous and it should therefore not be left to chance (cf. Hauschildt, et.al. 2016, p. 4).

2.2 The dilemma with the concept of innovation

One of the reasons for the different understanding of innovation seems to be the synonymous use of the terms "invention" and innovation, especially in everyday language (cf. Albach, 1991, p. 46; Schaudel, 1993, p. 46; Strebel, 2007, p. 20 f.). However, the invention is only the necessary preliminary stage of an innovation and describes the result of a planned or unplanned generation of ideas, i.e. it is time-related, whereas the innovation always represents the result of an innovation process or the innovation process itself (cf. Vahs/Brem, 2013, p. 21). However, the concept of innovation is not clearly anchored in time, but is subdivided between different temporal perspectives. In the literature, a distinction is made between a results-oriented or object-oriented view and a process-oriented view (cf. Gerpott, 2005, p. 37; Corsten et. L., 2016, p. 6). If these two perspectives are not clearly defined and separated in corporate practice, far-reaching misunderstandings can arise. In practical application, the definitional approaches from the literature therefore only appear to make sense if a clear distinction is made in the discussion between the different perspectives, i.e. whether it is a question of describing the state of innovation or whether the future potential is to be analysed and evaluated. The concept of innovation thus seems to include both the present and the future at the same time. Figure 2 illustrates this fundamental dilemma of understanding innovation. While one person focuses on the actual status and cannot see any novelty, the other person is already in a mental development and sees the great potentials and opportunities that could arise.

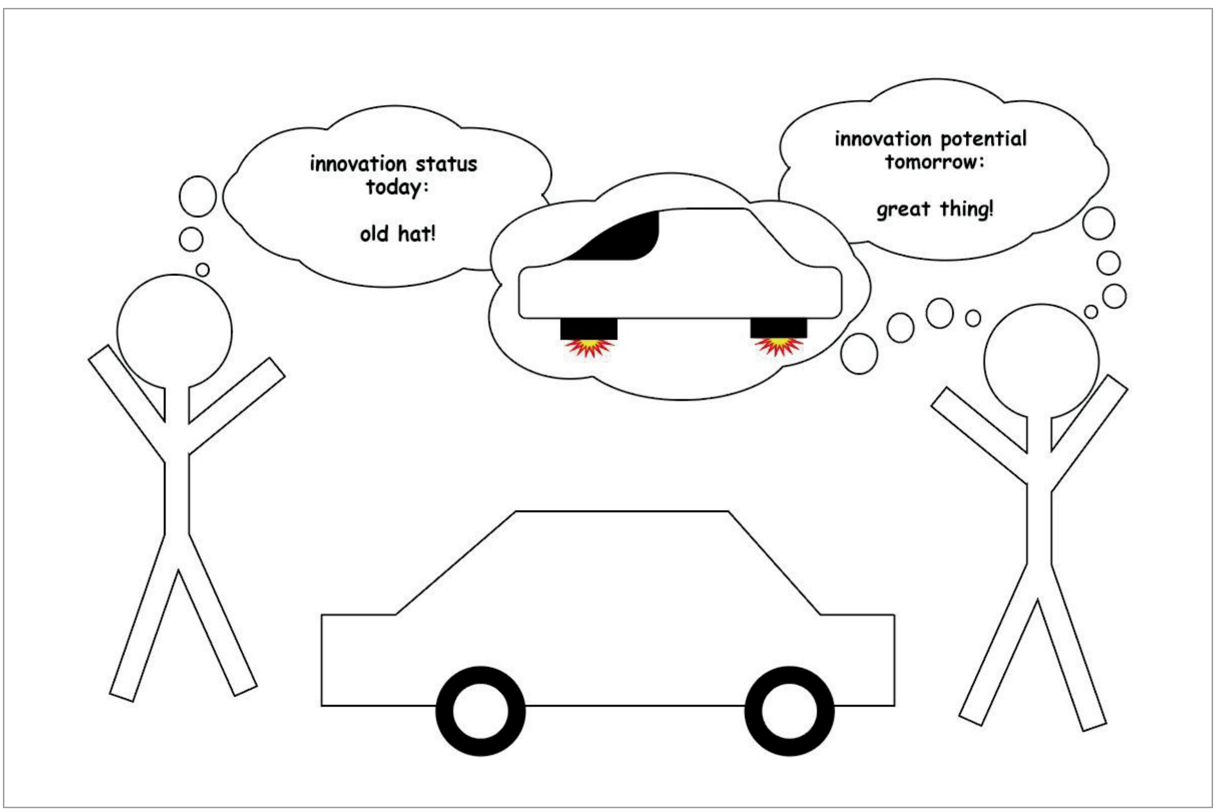

Figure 2: Dilemma of understanding innovation (Own representation)

In the following chapters, a proposal will be developed to make the understanding of innovation understandable and applicable to the status quo in the present. It is based on a result-oriented view of innovation, since from a business perspective innovation is intended as the result of multiple efforts (cf. Gerpott, 2005, p. 37). An attempt is made to clarify and illustrate this understanding in the form of a formula.

3. INNOVATION FORMULA FOR DETERMINING THE INNOVATION STATUS IN THE PRESENT DAY

3.1 Previous approaches to innovation formulas

There are already some proposals in the literature to express the concept of innovation in a formula. Roberts, for example, defines innovation as the sum of "invention" and "exploitation":

$$\textit{innovation} = \textit{invention} + \textit{exploitation}$$

Figure 3: Own representation after Roberts, 1987, p. 3.

Roberts thus emphasises the prerequisite of market success for innovations, i.e. in particular financial success. Similarly, Müller Prothmann/Dörr add the idea as a preliminary stage to invention:

$$\textit{innovation} = \textit{idea} + \textit{invention} + \textit{diffusion}$$

Figure 4: Own illustration based on Müller Prothmann/Dörr, 2009, p. 7.

Here, too, diffusion as successful economic dissemination and market penetration is indispensable for innovations. Müller-Roterberg's proposal is even more comprehensive, with its formula innovation consisting of knowing, being able, wanting, being allowed and doing (Müller-Roterberg, 2018, p. 651):

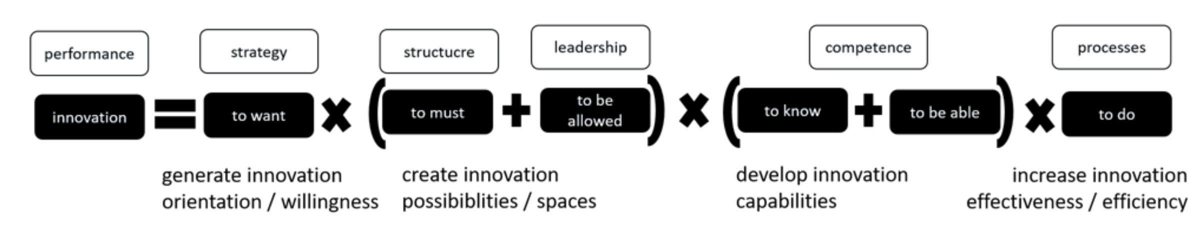

Figure 5: Innovation formula (Müller-Roterberg, 2018, p. 651)

The multipliers are intended to express that the individual elements must not be missing or zero in order to obtain an innovation, following North et. al. who proposed the following “rule of thumb” for value creation:

added value = be able x want x be allowed

Figure 6: Own illustration based on North et.al., 2018, p. 35.

If one of the multipliers is missing, e.g. “may” in the case of North et al. or “do” in the case of Müller-Roterberg is not present or zero, value creation or innovation performance cannot occur. Krauert provides a competence-oriented approach with the following innovation formula:

$$i = ((cc + ds + uc) \times a)^{f+m}$$

i: innovation, cc: core competency, ds: diversity of skills,
uc: user centration, A: activity, f+m: framework and courage

Figure 7: Own illustration according to Kranert, 2021, p. 16.

In his five elements, Kranert particularly emphasises competence as well as customer orientation for successful innovation. He also uses both sum elements and multipliers. If, for example, the activity is missing in this formula or if it is 0, the innovation would also be zero in the result.

Sometimes the term innovation formula is used without explicitly defining a formula, but rather to name the most important and relevant elements, such as Löhr in the sense of a “recipe” and the components invention, project, marketing and scientific approach (Löhr, 2013, p. 235).

3.2 Critical evaluation of the previous innovation formulas

With the two approaches of Roberts and Müller Prothmann/Dörr, the basic components of a new idea and its implementation are pointedly presented. However, the unambiguousness is limited by the summation, because even if one of the variables is zero, the result remains positive and thus confirms the existence of an innovation. However, as explained in the previous chapters, this is precisely what should be avoided in order to clarify the difference between innovation and non-innovation. Furthermore, both approaches restrict the implementation of the invention to an economically successful exploitation in the market. This does not appear to be sufficient against the background of numerous other internal and external benefit aspects of innovations, as will be explained further in Chapter 4.

The two formulas by Müller-Roterberg and Kranert not only describe a definition of the term, but also address the prerequisites and success criteria for successfully achieving innovation. In this way, they create a concise picture of what companies must consider on the path to innovation and which elements such as “strategy”, “leadership” or “competence” and framework conditions such as “structure” or even values such as “courage” are important for achieving innovation. For the objective of this thesis to find a definition of innovation that is as simple and clear as possible, they are not, however, related to the present, but are already a step ahead in terms of thought. The following chapter will therefore attempt to define a formula according to the requirements of simplicity, clarity and relevance to the present.

3.3 The innovation (status) formula I=NxU

If we go back to Schumpeter's original approach as already presented in chapter 1, the two essential elements of the concept of innovation become clear. First, there is the element of the "new" combinations, i.e. the invention, the idea, the novelty as such. The second element is the utilisation, the market success of the innovation and thus, in the best case, a commercial success on the market. In the sense of such a reconsideration, innovation only exists if there is a novel purpose-means relationship (cf. Baker et. al., p. 160), an understanding that is also confirmed in the basic meaning and origin of the word: "introduction of something new; innovation; reform" (Duden online, 2022, n.d.). At this point, we will not go into the discussion of whether a "broad" understanding of innovation also includes diffusion on the market, i.e. broad market penetration, or whether a narrow definition is more appropriate (cf. Vahs, 2013, p. 21). Although this aspect is important for differentiating between innovation and non-innovation, it will only be taken up again in Chapter 4. Here we will first deal with the two basic elements. If we reduce it to these two aspects, we are only dealing with the "new" and the implementation, i.e. the creation of a "benefit". However, it is important to note that innovation must always consist of both aspects, i.e. a new idea without a beneficial implementation is not an innovation and vice versa. If this insight is summarised in a short formula, it can be deduced that innovation is therefore a product of a new idea with a beneficial implementation:

$$I = N \times U$$

Innovation (I) =

New idea (N) × Useful implementation (U)

Figure 8: Innovation (status) formula (Own representation)

If it is determined that the idea is not actually new, this value would be zero and thus the result would be zero, even if the implementation is extremely beneficial, and it would not be possible to speak of an innovation. Likewise, the result is zero if the idea is defined as new, but no beneficial implementation can yet be determined. Thus this approach with the two elements is close to Roberts' formula (see Chapter 3.1), but on the one hand, following the two formulas of Müller-Roterberg and Kranert (Chapter 3.1), the multiplication is chosen and the implementation is not only reduced to a commercially successful marketing, but extended to a generally ascertainable benefit creation, as will be explained in Chapter 4. It should be emphasised once again that the aim is to carry out the assessment at the present time in order to evaluate the actual state, similar to an MOT, and not the possible potential in the future.

At the level of this formula, no further differentiation is made, e.g. what does "new" mean or how is a benefit expressed more precisely? The focus is on clarifying the mandatory two-sidedness of an innovation in order to create a common understanding. Even at this very aggregated level, it should be possible to make an assessment of innovation and non-innovation as quickly and easily as possible.

For example, the idea of a dental mobile phone, in which a miniaturised mobile phone implanted in a dental implant would make it possible to make phone calls in the mouth, is so far only an idea in the form of a Plexiglas demonstrator (cf. Albrecht, 2002, n.d.). Neither an implementation or the construction of a prototype, nor further feasibility studies or tests, nor marketing have ever taken place, which is why we cannot speak here of an innovation, but only of a new idea. On the other hand, the smartphone, for example, is not (any longer) an innovation, although it is of great financial benefit, but as an idea it is no longer new in its basic nature, but has been available on the market for many years. If the innovation (status) formula had been applied in 2008, Apple's iPhone would indeed have been an innovation, because its form and range of applications were new and it brought both financial success and many benefits for users.

Even if the application of the innovation (status) formula appears simple and purposeful, it must be taken a step further for a meaningful application in practice. At this level, it is possible to distinguish between innovation and non-innovation in an initial assessment, albeit subjectively, but no further qualitative statement can be made. However, this is usually the case in situations where several projects or ideas have to be analysed and evaluated for a decision. Therefore, building on this formula with the two components "new idea" and "beneficial implementation", a further analysis and evaluation procedure is to be developed.

4. INNOVATION TEST BENCH TO DETERMINE THE INNOVATION STATUS IN THE PRESENT DAY

With the help of the short innovation formula, a distinction can be made between innovation and non-innovation in a first step. This is intended to create an understanding of innovation that is as simple and memorable as possible. However, this is not sufficient for a more in-depth and possibly also comparative analysis, which is why the two variables of the innovation formula are considered in a more differentiated way in a second step. For this purpose, corresponding approaches are first presented in Chapter 4.1 and then concretised and defined in Chapter 4.2 for the novelty and in Chapter 4.3 for the benefit.

4.1 Innovation dimensions and characteristics

Chapter 2 explained the great diversity and the different understandings of the concept of innovation. In the further description and definition of different innovation dimensions, there are also numerous approaches that sometimes also speak of innovation characteristics (cf. Rath, 2008, p. 217). Some authors take up the characteristic of complexity in their approaches (cf. Eigenmann-Wunderli, 1994, p. 55 ff.; cf. Vahs, 2013, pp. 31-35) to describe the multiple connections within companies and the unclear problem structure. The OECD defines the four dimensions "Knowledge", "Novelty with respect to potential uses", "Implementation and actual use" and "Value creation" (OECD, 2018, pp. 46-48). These dimensions are intended to support the measurability of innovation in particular. Hauschildt et al. propose the following multidimensional approach to the concept of innovation for a better understanding of "what is or should be innovative" (Hauschildt et al. 2016, pp. 5-6):

1. Content dimension (what is new?)
2. Intensity dimension (how new?)
3. Subjective dimension (new for whom?)
4. Actor dimension (new by whom?)
5. Processual dimension (beginning and end of the innovation?)
6. Normative dimension (success in what respect?)

This already enables a much more specific discussion of innovation and shows the complexity of the term. For example, the dimension of subjectivity shows that novelty is always a question of perspective, i.e. innovation is "inherently subjective" (OECD, 2018, p. 20). Zillner/Krusche divide into a factual dimension for describing innovation drivers, a gradual dimension for the degree of novelty, and a content dimension for describing different types of innovation (cf. Zillner/Krusche, 2012, pp. 28-42). Even if many of the approaches differ in the characteristics or dimensions, they all include the dimension of novelty and the dimension of a beneficial result, consisting of a product, process or organisational innovation. These two aspects are also central components of the innovation formula and will now be defined in more detail in the following on the basis of the considerations presented and in preparation for the instrument to be developed.

4.2 The N of the formula for evaluating the new idea

As explained at the beginning, innovation is something that must be new compared to a previous product, process or condition. However, this is precisely where a major challenge lies, because the possibility of objectively assessing the degree of such an innovation according to the facts is only possible to a limited extent (cf. Hauschildt, et.al., 2016, p. 13). This difficulty has led to the development of a variety of approaches to classify the degree of novelty of innovations. In many cases, a distinction is made between incremental, radical and disruptive innovations (cf. Zillner/Krusche, 2012, p. 32 ff.; Goffin/Mitchel, 2018, p. 13; Knappe, 2015, p. 27) Incremental innovations tend to be evolutionary, occur gradually (cf. Dahl, 2011, p. 298, Zollenkop, 2006, p.109) and are responsible for efficiency improvements and product differentiation (cf. Kline/Rosenberg, 1986, p. 304). Radical innovations describe rather erratic completely new developments (cf. Reid/De Bretani, 2005, p. 106, Leifer, 2000, p. 5) and disruptive innovations are able to create completely new markets (cf. Zillner/Krusche, 2012, p. 37). Other authors use the distinction between basic innovations and follow-on innovations, whereby follow-on innovations are further subdivided into improvement, adaptation and sham innovations (cf. Kaschny et.al., 2015, pp. 24-25). In addition to these subdivisions, scale classifications can also be found, e.g. from totally new or changed product to significantly changed product, a new or improved additional facility or service to product or service differentiation (Kleinknecht, et.al., 1993, p.44f. Kleinschmidt/Cooper, 1991). Furthermore, in addition to various scoring models for the assessment of concrete technological criteria such as speed, size or temperature resistance (cf. Hauschildt, et.al. 2016, p. 14), comprehensive multidimensional approaches have been developed to measure the degree of innovation. Schlaak proposes a multi-level model of the degree of innovation in which 24 indicators are condensed into the degree of innovation via the three levels; factors, dimensions and the highest construct level (cf. Schlaak, et al. p. 194). Schultz et al. developed a measuring instrument with the 4 categories: technology innovation level, market innovation level, organisational innovation level and environment innovation level, each with 3 sub-criteria (cf. Schultz et al., 2013, p. 93 ff.).

For the test bench to be developed in this work, a qualitative approach should be used that allows for the simplest and quickest possible assessment. In order to capture the basic definition of innovation as a novel purpose-means combination (cf. McNally et al., 2010), it therefore appears sufficient for an initial assessment to ask the questions about the novelty of the technology or solution and the novelty for the market, as can also be determined as the intersection of most proposals for capturing the degree of novelty (cf. Corsten et al., 2016, p. 12). For the categorisation of the degree of novelty, four degrees of innovation are to be defined in this sense and following Reichwald/Piller (Reichwald/Piller, 2009, p. 122):

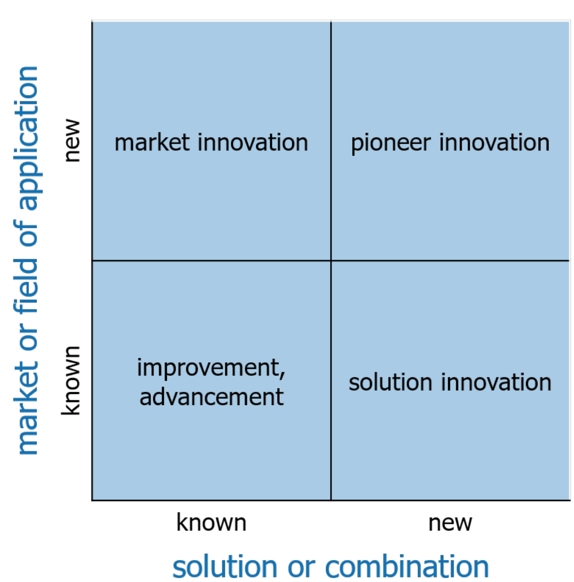

Figure 9: The four degrees of novelty of innovation

The use of the terms incremental, disruptive or radical innovation will be deliberately avoided here. On the one hand, an improvement or further development should explicitly not be called an "incremental innovation" in order to emphasise the concept of the innovation status formula. For another, the scope and meaning of the terms radical and disruptive innovation is much broader in innovation research and is also associated with a destructive impact on the market environment (cf. Schimpf 2019, pp. 5-8; cf. Christensen 1997,). However, the focus of this approach is initially on dealing with the new from the company's point of view and the situation in the present, irrespective of the degree to which the innovation increases performance or has an impact on the market environment.

4.3 The U in the formula for beneficial implementation

The second important building block for assessing the innovation is the benefit- generating implementation, which must be fulfilled in order to be considered an innovation. For this purpose, the innovation dimensions of maturity and actual benefits are used in accordance with the explanations in chapter 4.1.

4.3.1 Maturity level in the innovation process

Many good ideas do not get beyond the prototype or demonstrator status, see also the example with the idea of a tooth mobile phone in Chap.1. Therefore, the assessment of the maturity level is essential to judge the status of a (supposed) innovation. A large number of process and phase models are available for describing the degree of maturity. The number and divergence appears to be almost greater than for the concept of innovation, since the innovation process in part already addresses specific requirements and conditions of various fields of application. McGrath already sees a first generation of product development processes in Thomas Edison's development centre (cf. McGrath, 2004, p 5 ff.) and Bayazit recognises methodological foundations for product and design development in Walter Gropius and the Bauhaus (cf. Bayazit, 2004, o.p.). The first generation of a process model for product development is the "Phased Project Planning" concept developed by NASA in the 1960s for large and multi-year projects, which was taken up by Cooper for his first Stage Gate model. This stage gate model was divided into seven sub-steps (stages) and the resulting decision points (gates) in order to control the course of a project and ensure the achievement of milestones (cf. Cooper, 1983, p. 7).

In parallel, Thom developed a three-phase model in 1980 that divides the innovation process into 1. idea generation, 2. idea acceptance and 3. idea realisation and thus places the idea process at the centre (cf. Thom, 1980, p.45 ff.).

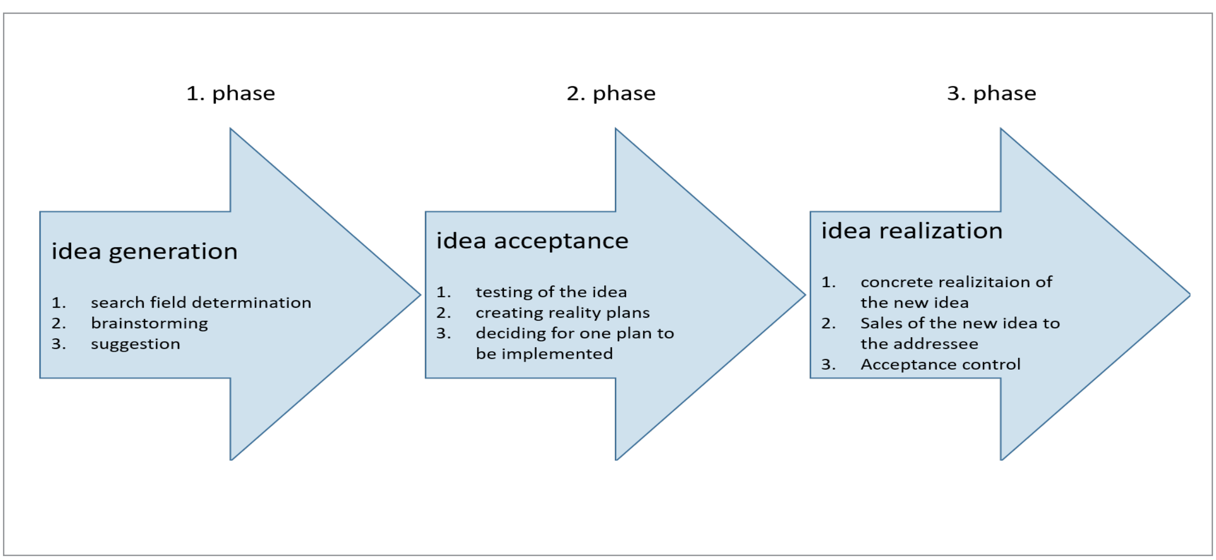

Figure 10: Thom three-phase model

In the following decades, the models and approaches became more and more flexible and comprehensive in order to do better justice to the dynamic environment of innovations. Cooper's stage gate approach, for example, was further developed to allow for loopbacks and overlaps between the steps (cf. Cooper, 1994, p.9). Other approaches emerged, such as the Value Proposition Cycle, which regularly runs through loops in four defined process steps and questions customer relevance, business relevance, competitiveness and implementation competence (cf. Hughes/Chafin, 1996, p. 91f.). This is to ensure that the innovation project is still profitable and attractive for the customers even after a possible longer term. The complexity of the ever new and different approaches varies greatly in terms of the number, scope and delimitation of individual steps or phases. Gerpott, for example, following Thom, limits himself to the three phases of "idea generation", "idea concretisation" and "idea commercialisation" (Gerpott, 2005, pp. 51-53) while other authors have developed models with up to 10 phases (cf. Kuczmarski, 2000, p. 150). Overall, many of the approaches differ in their view of the beginning and end of the innovation process, which is also intensively discussed (cf. Thom, 1980, p. 45 ff; Ernst, 2001, p. 19 ff.). There is also justified criticism of phase models in general, in terms of practicality (cf. Moore, 1984, p. 5 ff; Hauschildt/Petersen (1987), p. 1043 ff) or the dependence of the process on the degree of innovation (cf. Billing, 2003, p. 39 f). Nevertheless, phase models are certainly useful to provide an orientation framework for the process and the developing maturity level of an innovation (cf. Ernst, 2019, p. 19). Sammerl proposes such a solution approach in her phase model, which contains phases that are as simple and abstract as possible and should therefore have a high degree of general validity (cf. Sammerl, 2006, p. 30).

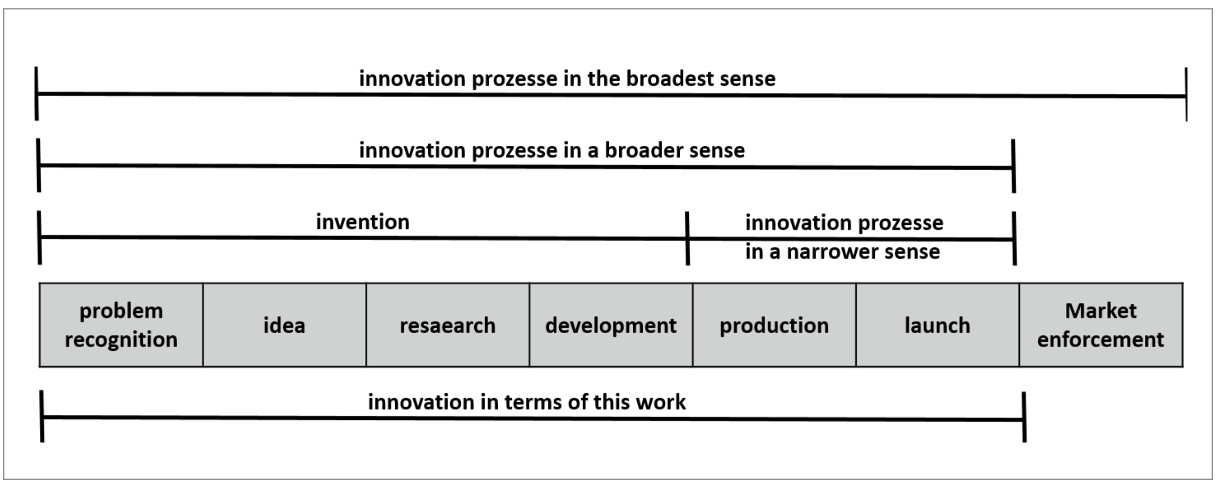

Figure 11: Phase model of an ideal-typical innovation process (Sammerl, 2006, p. 30)

In this phase description, Sammerl describes the different perceptions of the beginning and end of an innovation process from a narrower to a broader sense and defines innovation for your work from problem recognition to market introduction without market penetration.

For the present work, the decisive point for implementing the innovation formula is when the innovation process leaves the idea status and changes to a benefit-generating type of implementation. On the other hand, it is important to distinguish the innovation process in market implementation from routine processes, which should be robust and reliable after a certain degree (cf. Hauschildt, et. al., 2016, p. 22). Based on these considerations, the maturity level of an innovation is to be divided into 5 phases for the test bench to be developed. Following the innovation processes according to Pleschak/Sabisch and Witt, the market phase is to be further subdivided in order to make it clear that a pilot and successful achievement of stable processes and routines are still necessary before successful diffusion and market penetration (cf. Pleschak/Sabisch, 1996, p. 24; cf. Witt, 1996, p. 10).

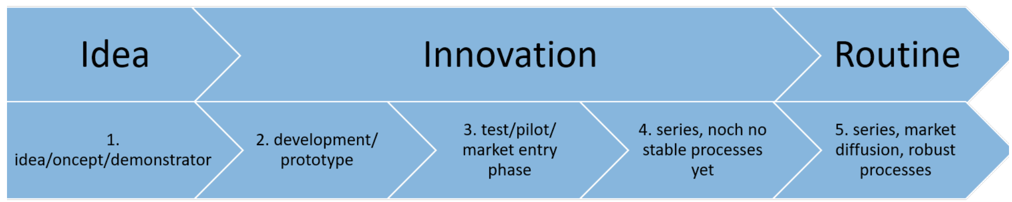

Figure 12: The 5 phases from idea to routine of an innovation

In the sense of the innovation status formula, one should only speak of an innovation when an initial benefit is recognisable, i.e. from phase 2 onwards, and not as soon as robust and stable processes in market penetration have been achieved, i.e. phase 5.

4.3.2 Actual benefit of the innovation

Innovation activities are not an end in themselves, but are specifically activated to achieve certain objectives (cf. Vahs, 2013, p. 40). Technical and economic content are listed as the most important objectives (cf. Hauschildt et.al., 2016, p. 322), whereby numerous authors place the economic objective of innovations in the foreground (cf. Vahs, 2013, p. 21; Roberts, 1987, p. 3; Gerpott, 2005, p. 37; Fagerberg, 2003, p. 131; Corsten, 2016, p. 6). The technical target variables are also referred to as performance or material targets and refer to the characteristics and use aspects of the innovation (cf. Hauschildt, et.al.2016 p. 322). In addition to these two objectives, innovations can also generate benefits in social or ecological terms, aspects that are becoming increasingly important (cf. Vahs, 2013, p.38). For this approach, we should therefore speak of a benefit-generating implementation of an innovation, taking into account not only the economic and technical perspectives but also other benefit aspects. The benefit formulation should be used deliberately, as complex and conflicting target systems often arise for innovations and these can be more easily resolved with the benefit formulation as an overarching target property (cf. Hauschildt, et.al., 2016, p. 332). Thus, in addition to a direct technical benefit such as running time or heat resistance, indirect benefits such as learning effects, experience and knowledge or higher employee satisfaction can also result from innovation, which can often be more significant than the direct effects (cf. Keil, et.al., 2009, p. 620). Even if an innovation is not successful on the market, internal effects such as gains in experience and competence within the framework of an innovation project can contribute to the success of future innovations (cf. Billing, 2003, p. 177).

The numerous and differentiated considerations on the measurement of innovation success (cf. Kaschny, et.al. 2015, pp. 7-9; Corsten et.al., 2016, pp. 17-20; Hauschildt et.al., 2016, p. 397 ff.), will not be discussed further here, nor will the numerous indicator models for measuring the success of innovation activities (cf. e.g. Pillai, et. al., 2002, pp. 166-176; Bürgel, et.al., 1996, pp. 290-332; Werner, 2002, pp. 56-235). This paper is about a status quo analysis of innovation activities in order to subsequently intervene and prepare decisions. Therefore, it does not seem sensible to choose detailed, isolated criteria, but rather to find qualitative measures that are as easy to assess as possible (cf. Gerpott, 2005, p. 70). Against the background of these findings, the following 5 benefit criteria are to be used for this approach.

1. economic benefit
2. benefit through know-how growth, experience or knowledge
3. benefits for employees in the company
4. benefit for society
5. environmental benefits

Figure 13: The 5 benefit criteria (Own representation)

With the two criteria now defined for the degree of maturity (Chapter 4.3.1) and for the benefits in this chapter, an assessment can be made for the innovation project that goes beyond the idea. In the following chapter, the considerations of the innovation (status) formula can be translated into an instrument.

4.4 Excel tool for determining the innovation status

This chapter presents the implementation of the considerations from chapters 4.1 and 4.2 in a tool that is as easy to use as possible. For a first draft, a tool based on Excel was developed, which will be briefly presented in the next chapter. For this purpose, the requirements for the tool are explained in chapter 4.4.1 before the implementation is presented in chapter 4.4.2.

4.4.1 Requirements and prerequisites

The tool for assessing the status quo of a (supposed) innovation on the basis of the innovation formula is intended to help companies better assess the current status of their innovation activities. In particular, it should become clear after the assessment whether it is actually an innovation and how it should be evaluated. In addition to the content, the tool should also fulfil a number of other requirements, which are listed below:

- Simple software environment without access barriers if possible
- Complete content mapping of the basic considerations and criteria
- Brief explanatory notes on use
- Intuitive operation as simple as possible
- Possibility of comparative evaluation of several innovation activities
- Possibility for comparative assessment of different assessors
- First graphic evaluations for interpretation and decision support

To meet the first requirement, Excel was chosen as the software for a first version, as it is very widespread and frequently used. In the following chapters, the different elements of the tool are explained.

4.4.2 Initial dialogue

The first dialogue serves as a welcome and explanation of the instrument. After a short introduction to the background and the innovation formula, you can choose whether the instrument should be used in multi-project or multi-assessor mode and how the project to be assessed should be named. The number of projects or assessors to be assessed can be defined up to 100.

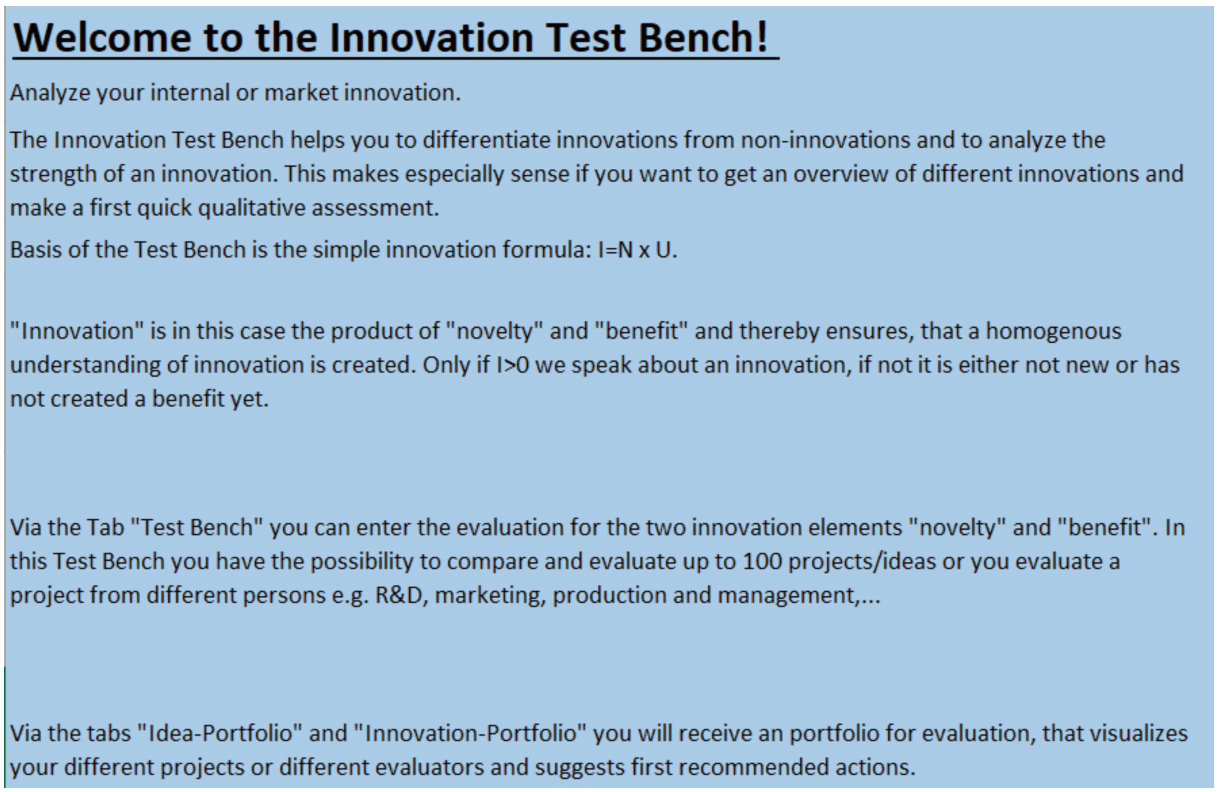

Figure 14: Assessment Mode Welcome Dialogue

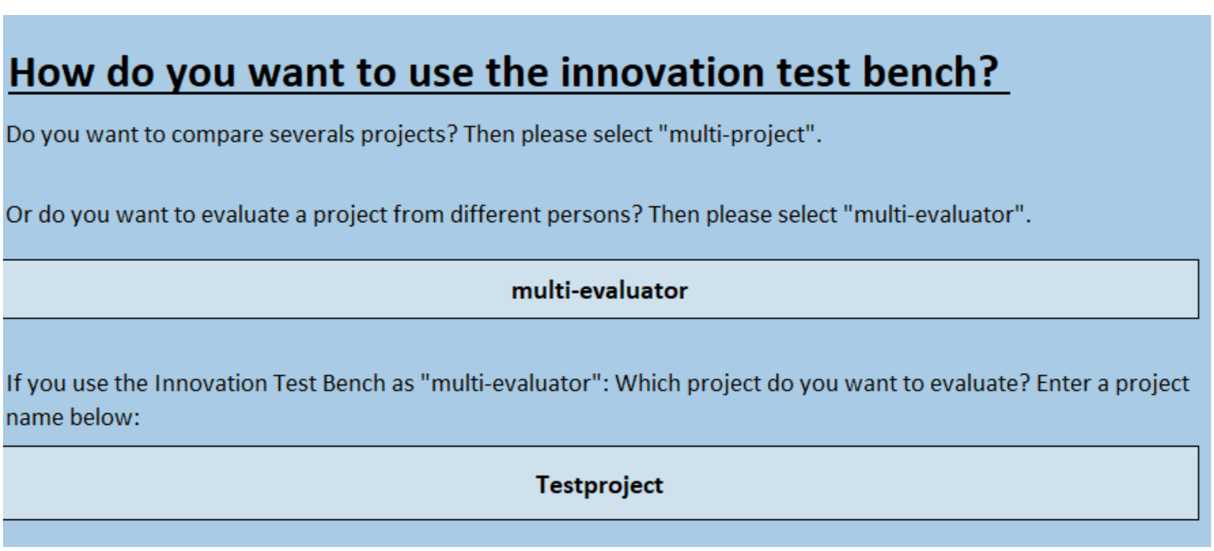

Figure 15: Assessment mode selection options

In multi-project mode, different projects can be assessed comparatively, while in multi- assessor mode, a project is assessed from different perspectives in order to capture the different assessments.

Use as:	**multi-project**		
Project number:	1	2	3
Please enter a project name.	3D print prototyp	online configurator	digital twin
Use as:	**multi-evaluator**		
the following project is evaluated:	**3d print prototyp**		
Evaluator number:	1	2	3
unction or something similar of the evaluators	head R6D	head production	head sales

Figure 16: Multi-project and multi-assessor mode

4.4.3 Evaluation dialogue

The core of the instrument is the evaluation with the help of the criteria developed in the previous chapters. For the assessment of novelty, i.e. the "N" in the formula "I=N*U", the two questions "new for whom?" and "how new?" are asked, as shown in the example in the following figure. If there is no recognisable novelty or it is merely an adaptation, the criterion is assessed as 0 and already leads to a 0 in the overall result, i.e. the result that it is not an innovation.

Use as:	**multi-project**		
Project number:	1	2	3
Please enter a project name.	3D print prototyp	online configurator	digital twin
New for whom? (single response)			
0: nothing new 2: only for the company 4: for the whole industry	2	0	4
How new? (single response)			
0: only adaption/enhancement, that means known market and solution 2: new solution/combination in a known market/application 2: known solution/combination in a new market/application 4: both, solution and market/application are new	2	0	2

Figure 17: Assessment of novelty

In the next part of the assessment, the degree of maturity and the benefits of the innovation project are evaluated. If it is only an idea or concept so far or has already been in series production for years, i.e. in the case of completed robust processes, this is assessed with a 0. The same applies if there is no discernible benefit. This ensures that, in the sense of the innovation formula "I=N*U", we only speak of innovations if both novelty and a beneficial implementation are present. For the benefit aspects, multiple selection is possible in order to map the different benefit elements as developed in Chapter 4.3.2.

	Use as:	multi-project		
	Project number:	1	2	3
	Please enter a project name.	3D print prototyp	online configurator	digital twin
Level of maturity? (single response)				
	0: so far just an idea/concept 1: prototypical implementation 2: market entry phase/testing phase in company/pilot 3: in series respectively in use, but no completed robust processes yet 0: for years in series respectively in use (completed robust processes)	1	0	2
Benefit? (multiple answers possible)				
	Yes/No: Is there a regonizable benefit? (internal or external benefit)	Yes	No	Yes
	1: valuable increase in know-how/learning effect for the company	1		1
	1: benefit for employees in the company (e.g. ergonomics, health, satisfaction, ...)	1		1
	1: benefit for society (e.g. fair trade, education, charitable, ...)	1		1
	1: benefit for environment (e.g. saving resources, renewable resources, environmental protection, ...)	1		1
	2: economical benefit (first turnover or subsidies, respectively cost-efficency benefits)	0		0
	Total Benefit	**4**	**0**	**4**

Figure 18: Assessment of maturity and benefits

In order to arrive at an overall result in the logic of the innovation formula after the assessment of the individual aspects, the products are now formed from the various elements. This produces a result for the novelty, a result from the degree of maturity and benefit as well as the overall result for the assessment. The multiplication between the sub-aspects ensures that the basic idea of the innovation formula is represented in the result. This means that only if there is an existing novelty and an ascertainable benefit is the result greater than 0 and thus also an innovation. If not, it is only an idea so far or the project shows no benefit or is actually already in series production and should no longer be treated as an innovation project.

Use as:	multi-project		
Project number:	1	2	3
Please enter a project name.	3D print prototyp	online configurator	digital twin
New idea: new for whom x how new?	4	0	8
utilization: level of maturity x Benefit	4	0	8
Result: Innovation = N x U (new idea x utilization)	16	0	64

Figure 19: Intermediate results and final results from the multiplications

4.4.4 Evaluations

Two portfolio representations are used for an initial evaluation of the innovation test bed. Portfolio representations allow for a simple and easily understandable visualisation; in addition, initial recommendations for action can already be given for each result field.

In the first portfolio, only the idea should be evaluated, in the two categories “New for whom?” and “How new?”. In this way, the idea can be assessed independently of its implementation and, if necessary, help in the selection of different ideas. Suggestions for an initial interpretation are prepared in the individual fields.

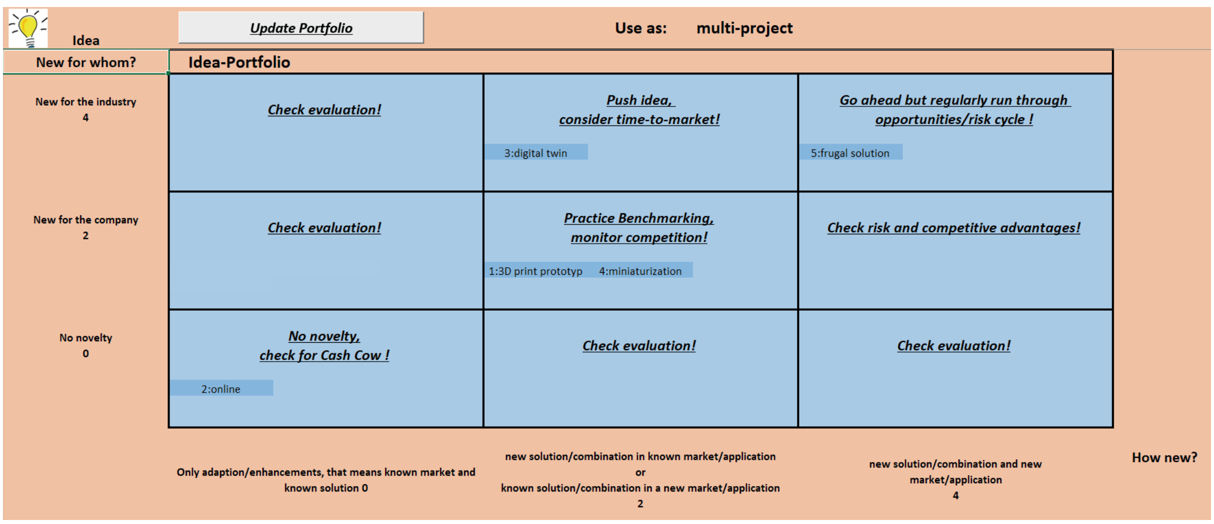

Figure 20: Ideas portfolio

The innovation portfolio is intended to present the overall result of the innovation review. In the nine fields, as in the idea portfolio, an initial recommendation for action is proposed.

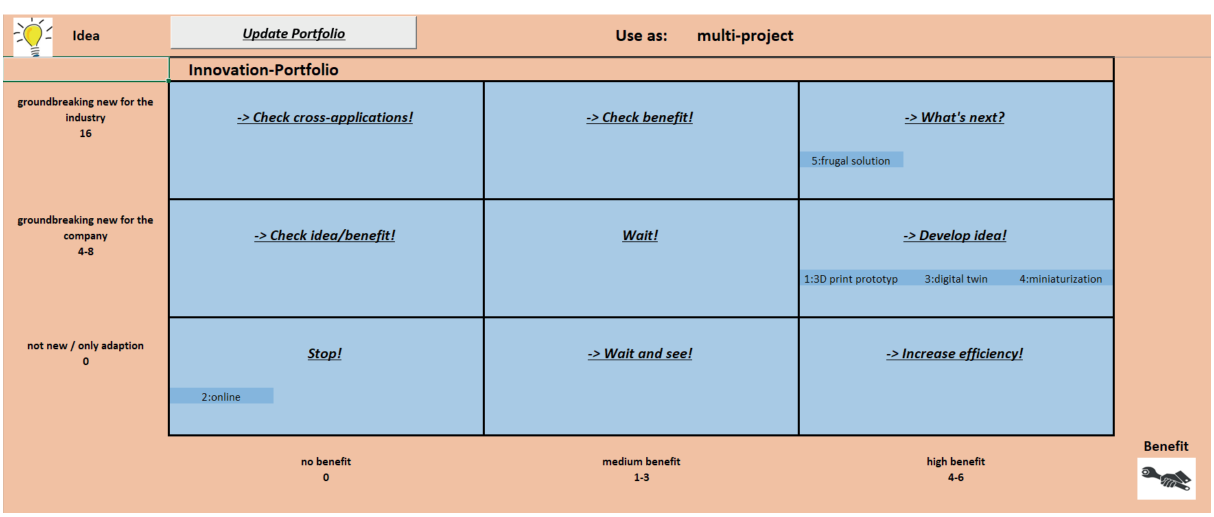

Figure 21: Innovation portfolio

If, after this assessment, which may have been carried out by the R&D department, the assessments are also to be obtained from other company divisions, this could now be implemented for selected projects in multi-assessor mode. In this way, the different assessments would become apparent and could be taken into account in further decision- making or in the course of the project.

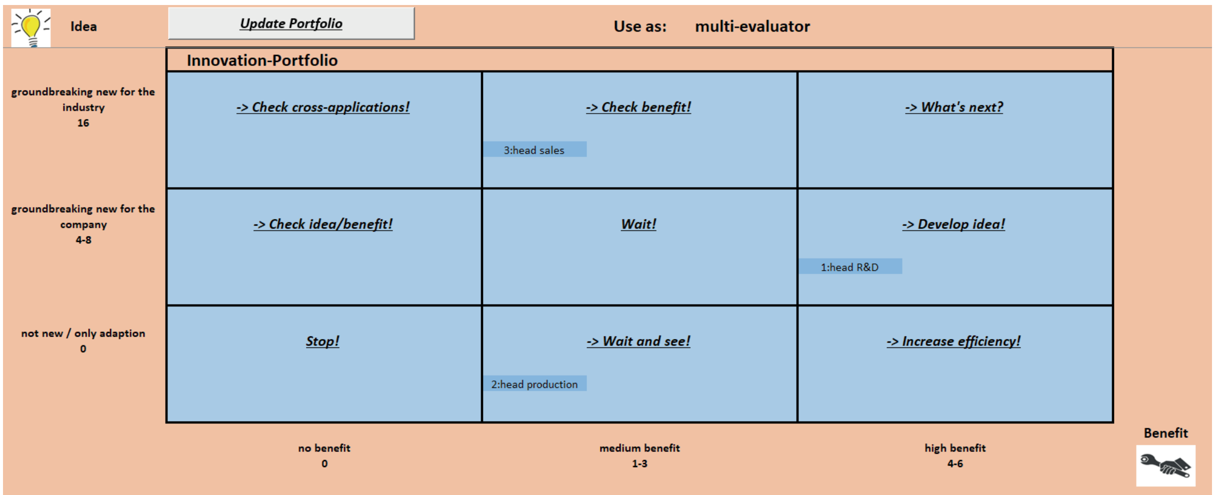

Figure 22: Exemplary representation for the multi-judge mode

5. CONCLUSION AND OUTLOOK

The innovation (status) formula approach presented here has already been used in teaching, both in Bachelor's degree courses and in courses of a Master's degree programme. The teaching of the basic ideas and characteristics of innovation, as well as the use of the innovation test bench as a practical application could be used well and effectively in teaching. In addition to teaching, the approach was also evaluated through expert interviews and has already been applied in several projects with commercial enterprises. The experience gained from this could be successfully used in the revision, especially of the instrument. For example, the addition of the multi-assessor mode is a wish of business practice. Based on the good experiences with this approach, a further formula is to be developed subsequently, which, following on from the analysis of the innovation status, develops an approach that enables the assessment of the potential of (future) innovations. Similar to the innovation (status) formula, this should be as simple and easy to remember as possible and make clear that special expenditures and activities are necessary before a potential innovation success and that certain risks can occur.

6. LIST OF FIGURES

7. LITERATURE

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