Eur J Futures Res (2014) 15:27
DOI 10.1007/s40309-013-0027-0

ORIGINAL ARTICLE

Scenario development without probabilities — focusing on the most important scenario

Volker Grienitz · Michael Hausicke · André-Marcel Schmidt

Received: 9 July 2013 / Accepted: 17 October 2013 / Published online: 28 November 2013

Abstract Within foresight management in general and scenario development in particular, the question is often asked: "For what scenario do I have to be prepared?" Since there are manifold approaches of scenario technique, the ways to answer this question with the help of scenario technique are also manifold. Scenario approaches using probabilities, for example, would recommend emphasizing the most probabilistic scenario. However, the consideration of probabilities, in our opinion, is not always useful. From a combinatorial point of view, any given scenario has an infinitesimal probability of being right, since there are so many possible variations (Gee et al. in Deep News Glob Bus Netw 2(4):199, 1991). Additionally, when regarding all possible developments that may be relevant for a scenario, each development has only an infinitesimal probability of coming true. Following these thoughts, the consideration of probabilities often has no additional benefit and, therefore, is not necessarily needed within scenario development. In this paper, the use of probabilities in scenarios will be discussed. On the one hand, this includes a discussion about scenarios in which the considerations do not make sense. On the other hand, the paper will also show an approach of considering additional information within the scenario creation process to select the most important scenario.

Keywords Scenario process · Probability · Foresight · Trends

Preface

Having developed scenarios within foresight management, it is often unclear for what scenario a company has to be prepared. Different existing scenario approaches presumably also deliver different answers in this (decision-making) situation.

In this context, Bradfield et al. [2] provide a good overview of the existing schools of scenario technique using several criteria for classification. One classification criterion is the use of probabilities for the development of the scenarios. Probabilities within scenario technique are well discussed in literature – along with their advantages and disadvantages [1, 3, 4]. We will pick up these discussions and take a deeper look at probabilities in scenario development. We divide our consideration into three parts in order to do this: the use of probabilities within the scenario creation process; the attachment of probabilities to the developed scenarios; and probabilities in the scenario controlling process.

Since we see that the disadvantages dominate the advantages of using probabilities, the paper clearly takes a position against the use of probabilities. Hence, the paper constitutes more a position paper than a discussion paper. Nevertheless, it is naturally also our intent to foster discussion about the use of probabilities.

Foresight management with scenarios

Companies today find themselves in global competition with ever increasing dynamics and a complexity of framework requirements, processes and products. Apart from being internationally present, companies are also required to assure sustainable advantages in competition. Companies need to master the demands of markets (e.g. customer requirements, competition, reduce product lifecycles, etc.), as well as the demands of technologies (e.g. technological complexity, technological innovation barriers, etc.), among many other things (e.g. organizational behavior, processes, etc.), in order to succeed.

However, these demands, requirements, etc. are described mostly from today's point of view. Future topics also have to be regarded in order to achieve success. In this context,

V. Grienitz (✉) · M. Hausicke · A.-M. Schmidt
Industrial Engineering, University of Siegen, Paul-Bonatz-Str. 9-11, 57068 Siegen, Germany
e-mail: volker.grienitz@uni-siegen.de

foresight activities can assist the company within the process of preparing for and focusing on the right topics in the future. Foresight management can help to coordinate all the foresight activities within a company.

Foresight management, according to Ahuja et al. [5], can be described as the capability to generate competitive advantages. Salo, Könnöla and Hjelz [6] have a more detailed understanding and place emphasis on three objectives of foresight management. These are the elemental outcomes of the foresight activity: improved system understanding, enhanced networking and strengthened innovation activities. The success of foresight management itself depends on an adequate adoption and combination of analytical and communicative methods. Another and more likely description, from our point of view, is presented by Amsteus [7]. He sees foresight as a behavior that is limited by cognitive variables with the aim of pointing out possible futures and clarification of emerging situations; this is underlined by the following statement: "There is no need to know the future, but to be prepared for the future" [39].

In addition to this understanding, we emphasize the knowledge aspect that accompanies foresight management. In these terms, knowledge, for example, can be distinguished between one's own knowledge itself, and metaknowledge, i.e. the knowledge about one's own knowledge (cf. Fig. 1). Hence, it can be distinguished between known knowns (uncritical), unknown knowns ("forgotten" or hidden knowledge), known unknowns (white spots in knowledge), and unknown unknowns (so-called *black swans* [8]). Transferred to foresight management, the known unknowns are especially regarded – we know that there is a topic that we are unsure about and that this topic, therefore, has to be investigated.

In the context of foresight management, scenarios can be helpful when regarding (complex) future situations and problems. *Complex* means that the problem regarded is influenced by many factors, that these factors are interlinked in a manifold way and that there are a number of possible answers to the problem [9]. Research has shown that humans cannot be aware of and work with more than three pieces of information at the same time by reason of their limited working memory [10]. Hence, such problems should be supported by specific methods – such as scenario technique – when regarding complex future situations. The effectiveness of scenario technique, especially concerning increasing decision quality in strategy processes and improving performance, has just recently been empirically proven [11, 12].

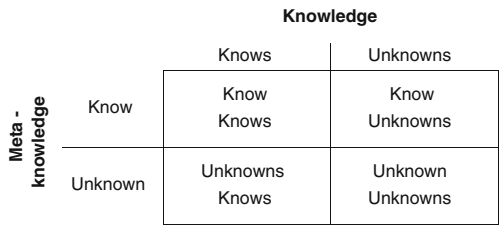


Fig. 1 Knowledge and Metaknowledge; according to Taleb [8]

However, recent research in this context at first calls for professionalization by higher quality standards, including, stronger scientific rigor and theoretical foundation [13, 14]. Wilkinson et al., for example, see the necessity to incorporate key insights from the theoretically grounded complexity science into the *pragmatic field* of scenario creation *grappling with theoretical grounding* – in order to engage the *upcoming complex, messy and puzzling situations* [14]. Secondly, recent research proposes cross-validation and multi-methodology (triangulation) [14–16], for instance, combinations of different scenario approaches may lead to more reasonable scenarios and a surplus. Thirdly, stronger integration of qualitative and quantitative data in foresight is also called for as different methods have their strengths and weaknesses in different areas [16–18].

Some scenario developers avoid assigning probabilities to the developed scenarios [19]. They argue that assigning probabilities to a scenario creates an expectation of predictability, which is not the aim of scenario planning [20]. Therefore, approaches, such as the one presented, do not use probabilities. In our opinion, there are considerable disadvantages that go along with probabilities; for example, probability ratings are often characterized as subjective [21]. Furthermore, when regarding all possible developments that may be relevant for a problem, each development only has an infinitesimal probability of coming true. When looking back at the concept of knowledge and metaknowledge (cf. Fig. 1), we think that it is also difficult to estimate probabilities of aspects that we do not know. In fact, there are also aspects, or rather events, and we do not even know that we do not know them, so-called *black swans* [8]. These events form the majority of all events [22] and often have a very high impact: For instance, even if a scenario is highly probable, there are many events about which we do not know and they can override the scenario – despite the scenario's high probability. Based on these thoughts, a great variety of thinkable and also (from today's point of view) unthinkable events should rather be used for developing scenarios, thus trying to cover a greater range of the unknowns – from both known and unknown unknowns (cf. Fig. 1).

However, there are also several advantages that go along with the use of probabilities, for example, the possibility of regarding development paths [23] or causal relationships of specific events [24]. In this context, Mahmoud et al. [25], for example, state that the question whether one uses consistency analysis or probabilities for the development of scenarios is so far unsolved. Therefore, some approaches propose combining the concepts of probability and consistency [26]. Heinecke [27], for example, concludes that the use of consistency analysis leads to very plausible scenarios, but not necessarily to very probable ones. As to this, a combination of both approaches is suggested: Calculating the most probable scenarios with a following consistency calculation for each probable

scenario. In this manner, very probable scenarios with high consistencies should be preferred.

Since we think that the disadvantages of the use of probabilities outweigh the respective advantages – and, therefore, that no probabilities should be used – we will present an alternative approach: focusing on the most relevant scenario(s). This concept combines the concept of consistency with the concepts of attributes and closeness. In this context, we use an inductive approach.

Scenario development omitting probabilities

Three major subjects where probabilities may actually be used can be identified when regarding the scenario development: the scenario creation process, the scenarios themselves and the scenario controlling. It will be argued in the following why the use of probabilities for each subject should be avoided.

Case 1: "the consideration of probabilities is not meaningful within the process of scenario creation"

Firstly, probabilities can be used within the process of scenario creation, i.e. probabilities are used for the calculation of the scenarios. In these terms, the rating of the probabilities themselves is the issue most discussed [28]. As has already been mentioned, these ratings are often characterized as subjective [21, 29], are based on the specific know-how of the people doing the evaluating [30] or are difficult to obtain [26]. These circumstances can be intensified by a growing complexity of the subject regarded [29]. Thereby, the number of ratings is twice as high compared to approaches that use consistencies. This requires scenario developers or experts with a high willingness and ability to estimate the probabilities [26]. Furthermore, the experts who perform the ratings are often unsure about the question behind the rating [31].

Mphahlele et al. [32] point out another problem that comes along with the revision of the marginal probabilities: the probability of the occurrence of the single events. They showed that the impact ranking that is generated by the marginal probabilities depends quite significantly on the revising method – thus leading to different outcomes. Jenkins highlights that estimates of conditional probabilities (cross-impacts) are, most of the time, not completely compatible with the estimates of the marginal probabilities [33].

Gausemeier, Fink and Schlake [34] also have concerns about the use of probabilities and refer to the so-called Linda test of Kahnemann and Tversky [24]. This test shows that humans tend to deduce the probability of an assumption from its consistency [24]. Jonda mentions, at this point, that normative and analytic aspects can be mixed and, therefore, that known and desired aspects are recognized as more probable and more impactful – fortified by the affectedness of the individual who does the evaluation of the rating [29].

Case 2: "assigning probabilities to the developed scenarios does not make sense"

Secondly, having calculated the scenarios, these could be described by a specific probability for each scenario. These probabilities, for example, can be calculated based upon the probability ratings of the events or are labeled to the scenarios in a qualitative process (e.g. most likely scenario) in a step that follows the scenario creation [35].

According to Reilja, a scenario is not a most likely forecast, but rather a more or less possible future development [36]. This is also the opinion of Gausemeier, Fink and Schlake. They point out that assigning probabilities to developed scenarios does not match the main aim: thinking ahead to a possible future and not predicting the future in a clear way [34]. The possible future consists neither of realities nor of wishes, but rather possibilities without probabilities [28, 29]. Furthermore, a scenario contains a combination of consistent events. The question about the likelihood of occurrence does not matter. The consistency of scenarios is sufficient and desirable in the majority of cases [34].

The possibility and desirability are two different kinds of rating dimension. Following Steinmüller, these two dimensions should not be mixed [37]. Mahmoud et al., furthermore, state that the effort significantly increases by adding probabilities to the scenarios [25].

Case 3: "working with probabilities within scenario controlling is not beneficial"

Thirdly, a controlling process should follow the scenario creation process – where probabilities could also be used. In our opinion, there are also considerable disadvantages that accompany the use of probabilities for the controlling process. Continuous and dynamic changes of market and technology developments, for example, complicate the prediction and assessment of probabilities. The number of relevant facts and variables of the business environment, as well as interdependencies, also increase the complexity [38].

Choosing and following the most probable scenario would also disagree with a basic idea of scenario technique. This basic idea aims at thinking in alternatives in order to cover a large area of possibilities [29]. By focusing on the most probable scenario, one limits the solution space. Furthermore, the inclusion of wild cards, for example, would not be possible – wild cards possess a relatively low probability of occurrence. This is critical, since wildcards by definition have a likely high impact on the conduct of business [39, 40]. Scenarios that have many wild cards, therefore, would have a smaller probability than other scenarios.

As to this, such wild card-dominated scenarios would not be considered.

Following Reibnitz, a consideration of probabilities is not beneficial [41]. This can be attributed to the subjective character of the assessment [30] and, furthermore, these assessments often represent only a snapshot of the current situation. The consideration of probabilities also depends heavily on the experience and knowledge of the risk perceptions of the scenario team [30]. On the one hand, relevant disruptive events for the company have a tendency to be underestimated by the scenario team [41]. On the other hand, it is observed that probabilities are often overestimated from a company's point of view.

The most important scenario

As the disadvantages that accompany the use of probabilities, in our opinion, dominate the respective advantages, in the following, an alternative course of action – focusing on the most important scenario – will be presented. Consequently, different sets of scenarios have to be regarded.

The cross-interpretation of the different sets finally allows for the identification of the most important scenario. The course of action will be shown by an application example: "future study of the automotive supplier industry in South Westphalia" [42]. In fact, the study was performed in 2009. It was initiated by the University of Siegen and tried to identify future needs for the local automotive supplier industry around the university. Since the time horizon back then was set to 2015, some scenario elements, of course, are prevalent today or have already appeared. In 2009, for example, we identified a differentiated scenario for the global development ("Crossroads") that could be more or less noticed after the economic crisis that started in 2008. In other words, in addition to the many successful companies that emerged stronger from the crisis, there were also a lot of companies that had to suffer. This differentiated development led especially to the establishment of a regional automotive center (as was proposed by the study) – accompanied by very strong political support.

The Siegener approach of scenario technique that was used for the development of the scenario sets for the application example will be briefly presented. A detailed description of our approach and the methodology for the creation of the application example can be found in Grienitz and Schmidt [43].

Siegener approach of scenario technique

As mentioned previously, we omit probabilities within our scenario approach. Rather, our approach uses the concept of consistency evaluation for developing scenarios. This course of action originated in Europe and was first presented by Gausemeier, who established his "Scenario Management" methodology in Germany in the 1990s [34]. The following Table 1 tries to delineate our approach from the one of Gausemeier. Some criteria following the classification of Bradfield et al. [2] are used for this. Bradfield and colleagues classified the existing scenario approaches into "Three schools of Scenario Technique." The "Intuitive-Logics Models" School is also listed in Table 1 as it is the most similar to our approach and the approach of Gausemeier.

System analysis

In terms of a system analysis, the key factors are identified and described in a first step. In these terms, factors that have a strong influence on the whole system, that have a high significance and that play a special role in the whole system are chosen as key factors.

System design

Alternative characteristics for each key factor are worked out by means of a morphological analysis in a next step. The spectrum of characteristics should intentionally be stretched from today thinkable to provocative and also to improbable.

The calculation of the scenarios afterwards is performed with help of the consistency matrix. The characteristics identified in the consistency matrix are rated pairwise with regard to the consistence of their common appearance within the system regarded. The consistency evaluation ranges from "1" (inconsistent) to "5" (synergetic compatibility). Afterwards, consistent combinations of characteristics are calculated from the consistency matrix. These combinations consist of one characteristic per key factor and are referred to as raw scenarios.

Communication/transfer

In a next step, the raw scenarios identified are aggregated to a manageable number of scenarios by means of a cluster analysis. The cluster analysis provides the scenario-DNA in the form of a table that shows the percentage distribution of the characteristics per scenario for a better interpretation and communication of the scenarios. The scenario-DNA includes today's situation in addition to the scenarios. Graphic visualizations of the future scenarios are also created. This includes multidimensional scaling (MDS) or pictures of the future.

System controlling

Any assumptions that were made, the key factors, their characteristics, and the consistency evaluation may change over time. If there are changes, some single operations or evaluations may have to be redone.

Table 1 Overview of the Siegener approach, in comparison to the Intuitive-Logics Models and Scenario Management following Bradfield et al. [2]

	Intuitive-Logics Models	Siegener Approach Grienitz	Scenario Management Gausemeier
Purpose of the scenario work	Multiple, from a one-off activity making sense of situations and developing strategy, to an ongoing activity associated with anticipation and adaptive organizational learning [2].	The same as Intuitive-Logics Models. Additionally, we explicitly see scenario technique not only for future issues. In fact, we regard all problems that have a "native" morphological structure [44] and also consider systemic thinking.	The same as Intuitive-Logics Models – but mainly used in strategic management and restricted to future scenarios.
Scenario perspective	Descriptive or normative [2].	The same as Intuitive-Logics Models. Comprehensive description of complex contexts, thus following the Intuitive-Logics Model	The same as Intuitive-Logics Models.
Scope of the scenario exercise	Can be either broad or narrow scope ranging from global, regional, country industry to an issue-specific focus [2].	All problems that can be derived by a morphological structure (future, product [45], strategy [46], risk [47], production systems [48], etc.) Additionally, we also use sets of scenarios, i.e. combining different types of scenarios (e.g. future scenarios with product scenarios). See also 4.2.	The same as Intuitive-Logics Models.
Tools commonly used	Generic – brainstorming, STEEP analysis, clustering, matrices, system dynamics, and stakeholder analysis [2].	The same as Intuitive-Logics Models, but also intelligent morphological analysis using evolutionary strategies. Additionally, we integrated some other concepts, such as Social Network Analysis [49], LEGO® SERIOUS PLAY® [50], Attributes [48], "Blue ocean, Red Ocean" [46], and Delphi surveys.	The same as Intuitive-Logics Models, but also morphological analysis.
Scenario starting point	A particular management decision, issue or area of global concern [2].	The same as Intuitive-Logics Models.	The same as Intuitive-Logics Models.
Scenario exercise output	Qualitative – a set of equally plausible scenarios in discursive narrative form supported by graphics; some limited quantification. Implications, strategic options and early warning signals are increasingly a part of scenario output [2].	The same as Intuitive-Logics Models. However, not limited to future scenarios. We also use so-called "Landscapes of scenarios" (multidimensional scaling).	The same as Intuitive-Logics Models. Also: "Landscape of scenarios" (with multidimensional scaling).
Probabilities attached to scenarios	No; all scenarios must be equally probable [2].	No; the same as Intuitive-Logics Models.	No; the same as Intuitive-Logics Models.
Scenario evaluation criteria	Coherence, comprehensiveness, internal consistency, novelty – underpinned by rigorous structural analysis and logics. All scenarios equally plausible [41].	Basically the same as Intuitive-Logics Models. Additionally, we use Attributes to evaluate the characteristics, and hence, can add virtually any evaluation criteria; for example, for performing sensitivity analysis (closeness to today: close to today, trend, close to science fiction, etc.).	The same as Intuitive-Logics Models.

The course of action within the Siegener approach of scenario technique can be described by a phase-model, as shown in Fig. 2. The following paragraphs will briefly explain the essence of each phase

Application example "future study on the competitiveness of the automotive supplier industry in South Westphalia"

In the past, the business models had to change on both sides (automotive suppliers as well as original equipment manufacturers: OEMs) because of the increasing shift in value creation from the OEMs towards the automotive suppliers. In this context, the branch study assessed tried to assure the competitiveness of the local automotive supplier industry by thinking ahead for the future and generating promising future options for action. Figure 3 illustrates the method that was used to determine the prospective strategic positions [43]. In this way, the paper presented focuses on the phases "Social/global developments" and "Development of the automotive

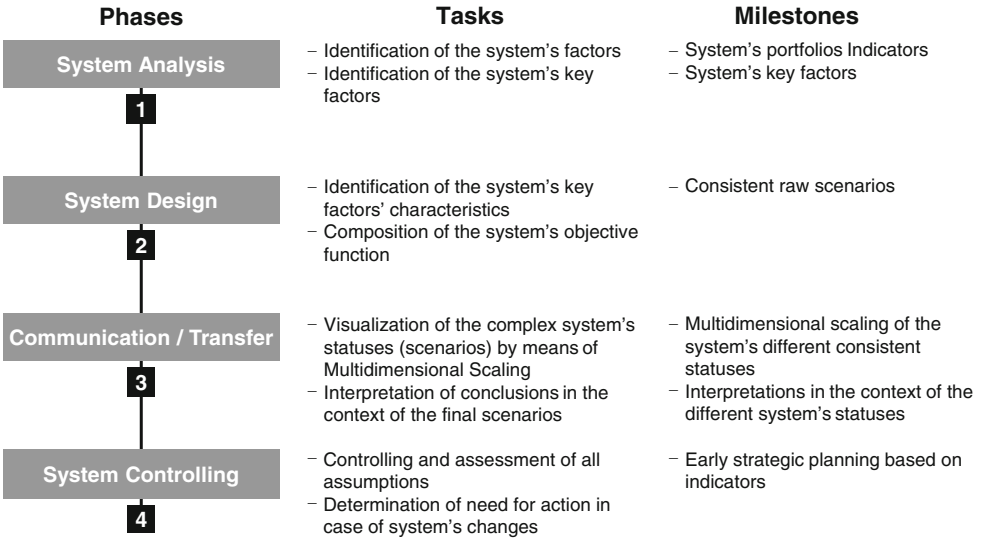


Fig. 2 Phase model of the Siegener scenario approach

industry," since these phases used the Siegener approach provided for the scenarios developed.

A wide range of different enterprise sizes and fields of activity could be covered within the survey of 71 companies.

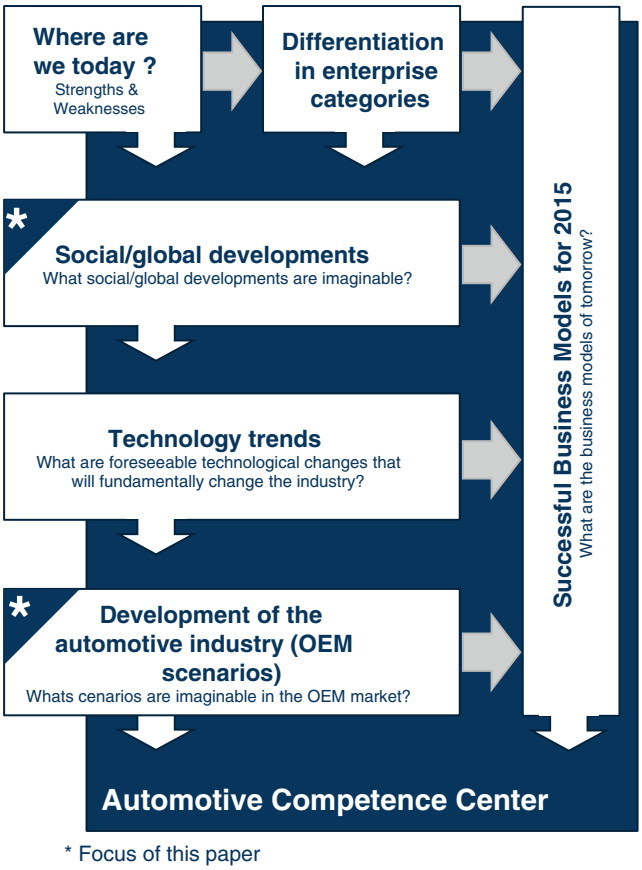


Fig. 3 The process model of the industry study "Future-study on the competitiveness of the automotive supply industry in South Westphalia in 2015"

The companies questioned generate 67 % of the turnover of all economic power in the region located. Thus, the study is based on a strong foundation.

Global scenarios

Global developments in ecology and technologies, as well as in politics, society and economics, have a significant impact on the development of the OEMs and suppliers. Hence, global scenarios can describe the major basic conditions for all participants in the automotive sector. Three global scenarios: "Low road," "High Road" and "Crossroads," have been developed in this context during the scenario process. These scenarios were explicitly described (cf. Fig. 4) and supplemented by short management summaries (cf. Table 1).

OEM scenarios

As has already been mentioned, scenarios for the OEM market were also generated because the OEMs essentially affect the whole structure of the industry sector and, thus, the automotive sector's drivers and "internal clock." Thereby, an automobile is and remains an emotional product. However, the focus from today's possession and individual claims, e.g. in the case of equipment, will change. There will be a shift to the real value of mobility, availability and its price. Comparable to the telephone market, the product will be pushed into the background. Moreover, there will also be product innovations that involve new business models. The following Table 2 presents the four developed and thinkable environment developments from the automobile manufacturer's perspective. It seems clear that the descriptions pointed out will not occur singularly and selectively. Nevertheless, the statements should be used as a fundamental framework by the supplier industry. In detail, the study identified four consistent OEM scenarios.

Compared to Europe, the high growth rate of emerging nations, especially in the Asian and the Latin American regions, continues. Even though the growth rate of the "old" Europe is far behind the rate of the emerging nations, the economic trend of Germany has sustainably recovered from the impacts of the financial and economic crisis. The low geographical distance and the economic interlinkage with the eastern European countries is a specially important economic success factor for Germany. The power of innovation of some key industries has set international standards and secured jobs.

Subsidies and tax benefits were drastically deleted: Only the regional support of innovation and technology are specifically perceived. Decision-making channels are transparent, because bureaucracy has been reduced. The state ensures a basic education. Furthermore, there is a real education industry. Some excellently equipped research institutions were founded. A major part of the knowledge-based manpower will come from the non-European regions to equalize the German educational deficits. Media and press freedom is given, but, if the individual wants to be well-informed, he has to take care of the information gathering by himself.

The income gap is widening more and more – the development of a two-tier society is noticeable and induces more social tensions. Ethical and religious values play an important role externally, but the expression of individuality caused by the consumer behavior is decisive for the social status. The family has a great significance, but the number of one- and two-person households is increasing. People mainly live in conurbations with very good infrastructure.

Access to new technologies is only available to the well-educated and well-paid people. People are less mobile in both their working and private life. Health awareness depends strongly on social background.

German companies have a competitive advantage compared with their international competitors caused by a low corporation tax. Liquidity has a higher importance for most companies than profitability. The power of individual choice is greater than ever, but it can only be used by the wealthy part of society. The character and communication of companies with micro consumer groups plays a central role in the field of sales distribution and marketing. New distribution channels enable a more profitable but, simultaneously, wider variation of highly individualized products and mass products.

Fig. 4 Detailed prose description of the global scenario "Crossroads"

These scenarios are: "Cheaper than four tires, better than two feet," "Ecological renaissance and sustainable mobility," "Digital mobility and information concept," and "Darwinism in the OEM market" (cf. Table 2).

Scenario selection – relevance evaluation

The global scenarios established represent polarized future descriptions. A regular monitoring of all relevant trends, developments and all positioned premises is needed to point out realistic statements in order to place the right scenario in focus. In this case, the evaluation of the today's DNA is necessary. This can be performed by workshops and discussions with experts of the industry. Furthermore, this will be supported by observation of the economic indicators and/or by regular and extensive scanning and monitoring of numerous sources, e.g. the literature and internet.

The noticeable developments in focus are located close to the global scenario III "Crossroads" due to consideration of the current framework. Some ways to use the opportunities of scenario II and some ways to prepare for dangers of scenario I will also be mentioned within the future study developed.

Scenario compatibility

The OEM scenarios were then rated in the light of the global scenarios (Table 3); in other words, those combinations which are most plausible and worth looking at were analyzed.

As mentioned above, all current signs and developments point to the global scenario "Crossroads," so that after the rating, the scenario "Darwinism in the OEM market" followed by the scenarios "Cheaper than four tires, better than two feet" and "Ecological renaissance and sustainable mobility" are the industry scenarios in focus.

The global scenarios contain only a few statements regarding technological developments. Nevertheless, technological trends should be taken into consideration for the strategic calculus. This can also be confirmed by the fact that the analysis of the current situation neglected these trends.

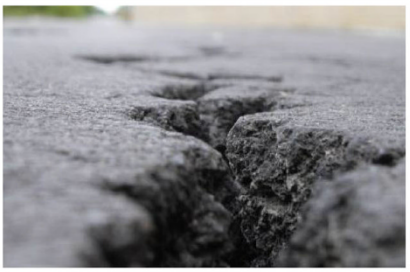
In addition to the description and classification of the business models compared with each other, a rating with regard to the scenario compatibility was made as a part of the study. The description of the scenario compatibility was followed by a rating of the business models with regard to their relevance in the light of the global scenarios, the OEM scenarios and company classes. In other words: "How relevant are the different environments for this specific business model?"

In addition to the compatibility of the "OEM scenario" – "business model," all combinations of scenarios were rated with regard to their compatibility in a workshop. The following Table 4 shows the results. The business models regarded, thus, have a differentiated relevance according to the global and OEM scenarios, as well as to the company classes observed.

Discussion

In the following chapters, the three cases from chapter two are discussed in the context of the Siegener scenario technique approach.

Table 2 Global scenarios – a brief overview

Global Scenario I "High Road" – The "country of knowledge" becomes reality	**Global Scenario II** "Low Road" – Tangibles characterize the low-tier society	**Global Scenario III** "Crossroads" – Liberalization of all economic and socio-political structures
		
Quintessence		
• Convergence of the markets in the Euro zone induces a strong economic growth • Media democracy encourages the independent formation of opinion • Social pluralism and environmental awareness have a high importance • Efficient research facilities help to open new niche markets	• International terrorism and a shortage of resources lead to new stress ratios of the community of states • Weak economic growth and trade barriers bate foreign investments • There is a high regulation density and a polarized political party landscape • The label "Made in Germany" has worn out	• The economic situation is stable – German key industries are staying competitive • The social market economy has worn out – Americanization is ubiquitous • Traditional social values are accompanied by status-oriented individualism and fragmented consumer behavior • Egocentrism supports the political apathy

Case 1: "the consideration of probabilities is not meaningful within the process of scenario creation"

As we look at the idea behind the scenario technique, we see that it is necessary to think of alternatives to cover a large area of developments. Thereby, it is valid to think in extremes; that means, "What might happen, what is thinkable?"

In this context, a wide search and the consideration of characteristics in the phase of system design is necessary. Not only probable and thinkable developments should be taken into account, but also, in particular, improbable and thinkable developments. The past has already demonstrated that even experts can err. Karl Benz once said in 1920, "The car is completely developed. What is next?" In his opinion, it was impossible and unthinkable that the automobile was at the beginning of its development at that time.

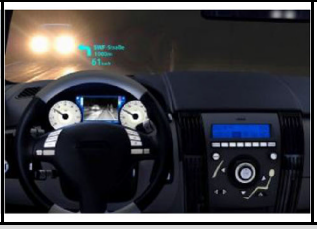
The range of alternative solutions would already be restricted at the beginning of the scenario process if one only concentrated on the probable developments. That means, from the present vantage point, improbable characteristics would not be followed up. As a consequence of this, the whole concept of wild cards would also not be considered in the scenario process. Characteristics which are thinkable and have a high influence from today's point of view, but have a probability of occurrence close to zero, would not appear in scenarios calculated later. According to Steinmüller [39], an example of this is the wild card, which describes that biological sexual dimorphisms disappear as a result of a lifestyle revolution. Its probability of occurrence is very low, but, in the case of occurrence, its impact would be high.

In further steps, a very important question arises in the context of scenarios: How are the individual probabilities handled to get a scenario overall probability? It consists of a certain uncertainty in the case of the allocation of the probabilities. Should they to be summed up, multiplied or should the arithmetic mean be determined?

The Siegener approach of scenario technique avoids this difficulty by calculating scenarios based on a consistency analysis (cf. Fig. 5). The question, thereby, is not how high the probability of occurrence is, but rather, if it is thinkable that both characteristics considered will appear pairwise in the future.

After the consistence evaluation, the future scenarios are calculated in a consistent way by the use of natural analogue algorithms. These future scenarios only contain bundles of characteristics that are able to appear in common in the future from the vantage point of the present; for this reason, they are consistent. A major advantage is that the whole solution space becomes better illuminated. No possible solution is eliminated in advance. Another advantage is that our brain builds so-called trails by repeated consideration and evaluation of all future developments. In other words, we are "thinking in

Table 3 OEM scenarios – a brief overview

OEM Scenario I "Cheaper than four tires, better than two feet"	**OEM Scenario II** "Ecological renaissance and sustainable mobility"	**OEM Scenario III** "Digital mobility and information concept"	**OEM Scenario IV** "Darwinism in the OEM market"
			
Quintessence			
• Classification of the market in cheap and individualized premium products • Automotive market in focus shaped by minimal concepts • Increasing competition from emerging countries • Unchanged supplier structure	• Ecologically ambitious mobility instead of one's own car • Mass production vehicle with intelligent user-models and sustainable resource usage • Threat for suppliers from traditional machine building industry • New suppliers with intelligent service	• Functional and intelligent mobility instead of one's own car • Mass production vehicle with intelligent user-models • Threat for suppliers from traditional machine building industry • New suppliers with intelligent service	• Environmentally-friendly high-tech and cheap products • Eco-friendly high-tech and low-cost products • Companies from emerging countries take over traditional brands • Company concentration over all steps of value creation • High innovation pressure for suppliers

stock" and immunize ourselves against undesirable surprises. As soon as a combination of characteristics (scenarios) arises, we already know intuitively what the consequences are and which countermeasures we have to initiate.

Case 2: "assigning probabilities to the developed scenarios does not make sense"

The selection of the most probable occurring scenario does not make sense in the respect that it does not allow a statement on the topic if it is also the most relevant scenario for us. The determination of the most relevant seeming scenario for us is, in fact, a multidimensional optimization problem that cannot be solved by the calculation of the overall probability. The multidimensionality is directly dependent on the number of key factors. Each key factor builds a dimension.

The selection process of the most relevant scenario(s) is as follows. After the calculation of the raw scenarios by the natural analogue algorithms already mentioned, a clustering of the raw scenarios takes place on the basis of their similarity regarding content. That means that the high number of raw scenarios calculated becomes summarized to a manageable number of scenarios. The clustering is made by the use of multivariate methods. Which raw scenario belongs to which scenario is calculated, depending on the content of each raw scenario. It is possible to derive a so-called scenario-DNA for each scenario. On the one hand, this scenario-DNA shows the percentage distribution of characteristics per cluster. On the other hand, this structure, to the same extent, provides the possibility of determining today's situation ("present-DNA").

The landscape of scenarios is built by the use of a distance calculation of the content similarity of scenarios and the help of multidimensional scaling (MDS) (cf. Fig. 6). This map consists of the present situation in addition to the scenarios. Using this graphic, the relevant scenarios can be determined by checking which scenario(s) is (are) closer to the present situation. In the application example, we did this interpretation with the group of experts that helped to develop the scenarios. The attributes could also be used for a more detailed analysis of the closeness.

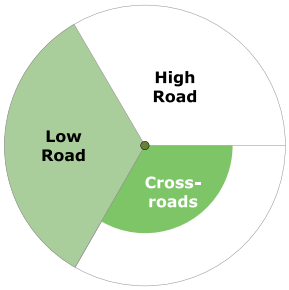
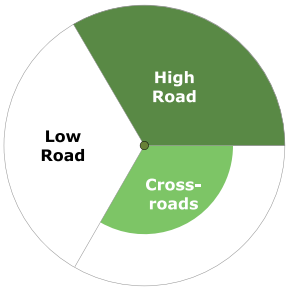
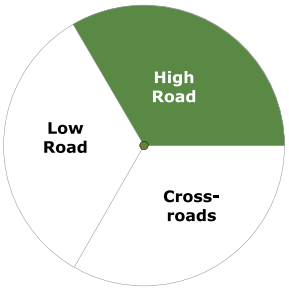
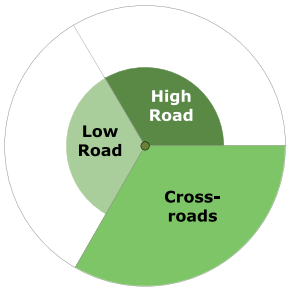
This shows that the identification of the most relevant scenario by the (graphical) spatial closeness is more effective and easier to communicate than by the consideration of probabilities. Moreover, a certain uncertainty of the allocation of probabilities exists. Should they be summed up, multiplied or should the arithmetic mean be determined?

The Siegener approach of scenario technique is able to calculate scenarios under different aspects by means of the consideration of further attributes of the characteristics. As an example, the calculation of high impact or volatile scenarios is

Table 4 Compatibility of the OEMs and global scenarios

Compatibility of the OEMs and global scenarios

Reading support: The OEM Scenario I "Cheaper than four tires, better than two feet" has a high compatibility to the global scenario "Low Road." The global scenario "Crossroads" plays a certain role for the OEM scenario I; the global scenario "High Road" has no importance for OEM scenario I.

OEM scenario I "Cheaper than 4 tires, better than 2 feet"	**OEM scenario II** "Ecological renaissance and sustainable mobility"	**OEM scenario III** "Digital mobility and information concept"	**OEM scenario IV** "Darwinism in the OEM market"
			

The segments show the single global scenarios. The filling level of the segments increases with the compatibility.

The segments show the single global scenarios. The filling level of the segments increases with the compatibility

also possible. By the calculation of scenarios under the consideration of volatility, which combination of characteristics provides wild fluctuations of the future or which provides a pole of tranquility can be spotted. The evaluation of the attributes can, for example, take place by a Delphi survey while collecting the uncertainty of the experts in the form of a standard deviation additional to the attributes themselves. The standard deviation builds areas of uncertainty of the characteristics for later checking.

Case 3: "working with probabilities within scenario controlling is not beneficial"

Since attributes such as the time horizon or impact can be considered, it is possible to automatically derive roadmaps from the scenarios calculated and some characteristics can be prioritized. The combination of scenario-DNA and roadmaps (cf. Fig. 7) induces an initialization of a foresight system in terms of the concept of weak signals according to Ansoff [51].

Fig. 5 Example of consistency matrix

Consistency matrix

Crucial Question: "How does characteristic A (row) get along with characteristic B (column)?"

Rating of consistency
1 = not conceivable/total inconsistency
2 = conceivable with restrictions
3 = neutral or stand-alone
4 = good combination/fits well
5 = lock and key/perfect match

Key factor	Characteristic	No.	1A	1B	1C	1D	2A	2B	2C	2D	3A	3B	3C	3D
		Characteristic	Characteristic 1A	Characteristic 1B	Characteristic 1C	Characteristic 1D	Characteristic 2A	Characteristic 2B	Characteristic 2C	Characteristic 2D	Characteristic 3A	Characteristic 3B	Characteristic 3C	Characteristic 3D
Key factor 1	Characteristic 1A	1A												
	Characteristic 1B	1B												
	Characteristic 1C	1C												
	Characteristic 1D	1D												
Key factor 2	Characteristic 2A	2A	5	3	3	3								
	Characteristic 2B	2B	1	3	2	3								
	Characteristic 2C	2C	2	4	3	3								
	Characteristic 2D	2D	4	4	4	5								
Key factor 3	Characteristic 3A	3A	4	3	3	3	4	4	4	4				
	Characteristic 3B	3B	4	3	5	3	4	4	4	3				
	Characteristic 3C	3C	2	3	1	3	4	3	2	3				
	Characteristic 3D	3D	1	3	2	3	1	2	1	3				

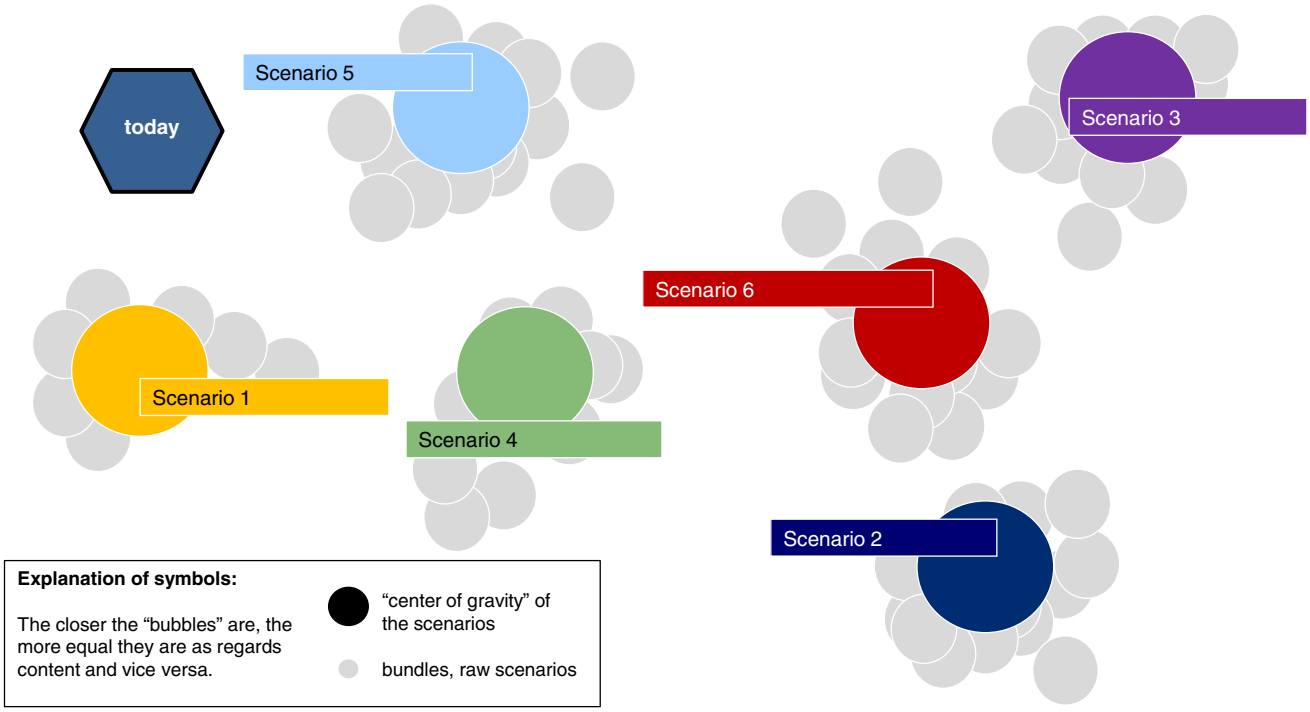


Fig. 6 Example landscape of scenarios

Firstly, it becomes clear when, in theory, the first characteristic arises, and secondly, if our assumptions were right and are still valid. If a characteristic does not occur at the expected date, this is a first indication to verify the assumptions of the scenario development process. When the first characteristics occur, the process of action should slowly start, depending on the priority of the characteristics. At the point when the last characteristic of a scenario occurs, it is absolutely necessary to act. With this in mind, it is obvious that dealing with probabilities cannot achieve a foresight system in this way.

As described at the beginning, the market and its developments are underpinned by continuous changes. This requires an inspection and adaptation of the scenarios and of the present situation if necessary. The inspection and adaptation focuses for this purpose on every underlying assumption, the influential factors, their characteristics, and the influence, weighting and consistence evaluations. Because the scenario development process is already free of probabilities, a consideration of probabilities at this point would also not provide additional value.

Scenario DNA				Scenario Roadmap											
		Scenario		2013		2014				2015					
Key factor	Characteristic	No.	I	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4		
Key factor 1	Characteristic 1A	1A	100												
	Characteristic 1B	1B	0												
	Characteristic 1C	1C	0												
	Characteristic 1D	1D	0												
Key factor 2	Characteristic 2A	2A	100												
	Characteristic 2B	2B	0												
	Characteristic 2C	2C													
	Characteristic 2D	2D	0												
Key factor 3	Characteristic 3A	3A													
	Characteristic 3B	3B	0												
	Characteristic 3C	3C	0												
	Characteristic 3D	3D	100												

expected time of occurrence with its impact
low middle high

Fig. 7 Example for scenario-DNA including Roadmap

Limitations and future work

The process of scenario development has indeed been well investigated, nevertheless, there are a number of outstanding points which should be further researched. These include, for example, the choice of characteristics and their attributes. At this point, the following questions arise: "When do I have the right and the right number of characteristics?" and "Are all thinkable developments of attributes considered?"

A further outstanding point is the evaluation of the matrices by the scenario team. Everyone who takes part in the evaluation process holds another position or perspective to the respective topic. This often causes the evaluation to be subjective. At this point, the following questions arise: "How can the subjective character be invalidated?" and "How can the uncertainty in the evaluation process be handled?"

Future research will have to deal with the points listed among other things.

References

1. Gee K, Greenwood K, Ogilvy J, Schwartz P (1991) Probabilities: Help or Hindrance in Scenario Planning? Deep News Glob Bus Netw 2(4):199
2. Bradfield R, Wright G, Burt G, Cairns G, van der Heijden K (2005) The origins and evolution of scenario techniques in long range business planning. Futures 37(2005):795–812
3. Ha-Duong M (2006) Scenarios, probability and possible futures. Working Paper. http://halshs.archives-ouvertes.fr/halshs-00003925/en/. Accessed 3 Sep 2013
4. Millet SM (2009) Should probabilities be used with scenarios? J Future Stud 13(4):61–68
5. Ahuja G, Coff RW, Lee PM (2005) Managerial foresight and attempted rent appropriation: insider trading on knowledge of imminent breakthroughs. Strat Manag J 26(9):791–808
6. Salo A, Könnölä T, Hjelt M (2004) Responsiveness in foresight management: reflections from the Finnish food and drink industry. Int J Foresight Innov Pol 1(1–2):70–88
7. Amsteus M (2008) Managerial foresight: concept and measurement. Foresight 10(1):53–66
8. Taleb NN (2010) Black swan. Random House Trade Paperback, New York
9. Ulrich H, Probst GJB (1988) Anleitung zum ganzheitlichen Denken und Handeln. Haupt, Bern/Stuttgart
10. Rouder JN, Morey RD, Cowan N, Zwilling CE, Morey CC, Pratte MS (2008) An assessment of fixed-capacity models of visual working memory. Proc Natl Acad Sci U S A 15(16):5975–7979
11. Meissner P, Wulf T (2013) Cognitive benefits of scenario planning: its impact on biases and decision quality. Technol Forecast Soc Chang 80(4):801–814
12. Phelps R, Chan C, Kapsalis SC (1998) Does scenario planning affect performance? Two explorative studies. J Bus Res 51(2001):223–232
13. Godet M (1990) Integration of scenarios and strategic management: using relevant, consistent and likely scenarios. Futures 22(7):730–739
14. Wilkinson A, Kupers R et al (2013) How plausibility-based scenario practices are grappling with complexity to appreciate and address 21st century challenges. Technol Forecast Soc Chang 80(4):699–710
15. Bishop P, Hines A et al (2007) The current state of scenario development: an overview of techniques. Foresight 9(1):5–25
16. Varum CA, Melo C (2010) Directions in scenario planning literature – a review of the past decades. Futures 42(4):355–369
17. Armbruster H, Kinkel S et al (2008) Kombination von Szenarien und Delphi-Methodik: Potenziale und zukünftige Herausforderungen. In: Gausemeier J, Kinkel S (eds) Strategische Technologieplanung mit Zukunfts-Szenarien. VDMA, Frankfurt am Main, pp 83–98
18. Tapio P, Paloniemi R et al (2011) The unholy marriage? Integrating qualitative and quantitative information in Delphi processes. Technol Forecast Soc Chang 78(9):1616–1628
19. Goodwin P, Wright G (2001) Enhancing strategy evaluation in scenario planning: a role for decision analysis. J Manag Stud 38(1):1–16
20. Wilson I (2000) From scenario thinking to strategic action. Technol Forecast Soc Chang 65(1):23–29
21. Oehler A, Unser M (2002) Finanzwirtschaftliches Risikomanagement, 2nd edn. Springer Verlag, Berlin
22. Burmann C, Freiling J, Hülsmann M (2005) Management von Adhoc-Krisen: Grundlagen – Strategien – Erfolgsfaktoren. GWV Fachverlage, Wiesbaden
23. Duperrin JC, Godet M (1975) SMIC 74 – a method for constructing and ranking scenarios. Futures 7(4):302–312
24. Kosow H, Gaßner R (2008) Methods of future and scenario analysis – overview, assessment, and selection criteria. German Development Institute, Bonn
25. Mahmoud M, Liu Y, Hartmann H et al (2008) A formal framework for scenario development in support of environmental decision-making. Environ Model Softw 24:798–808
26. Dönitz EJ (2009) Effiziente Szenariotechnik durch teilautomatisierte Generierung von Konsistenzmatrizen. Gabler, Wiesbaden
27. Heinecke A (2003) Die Szenario-Technik als entscheidungsunterstützendes Instrument. In: Biethan J, Kuhl J, Lackner A (eds) Soft-Computing in Wissenschaft und Wirtschaft. Conference paper, University of Göttingen, pp 41–52
28. Schoemaker PJH (1993) Multiple scenario development: its conceptual and behavioral foundation. Strat Manag J 14:193–213
29. Jonda M (2004) Szenario-Management digitaler Geschäftsmodelle – Skizze einer Geschäftsmodellierung am Beispiel von Mobile-Health-Dienstleistungen. Dissertation, University of Oldenburg
30. Winter DH (2011) Simultane strategische Produktionsplanung beim Vorliegen unvollständiger Informationen: Vorstellung eines risikobasierten Entscheidungsunterstützungssystem unter Verwendung der unscharfen, stochastischen Programmierung. Logos, Berlin
31. Mitchell RB, Tydeman J (1978) Subjective conditional probability modelling. Technol Forecast Soc Chang 11:133–152
32. Mphahlele M, Olugbara O, Ojo S, Kourie D (2011) Cross-impact analysis experimentation using two techniques to revise marginal probabilities of interdependent events. ORiON 27(1):1–15
33. Jenkins L (1997) Selecting a variety of futures for scenario development. Technol Forecast Soc Chang 55:15–20
34. Gausemeier J, Fink A, Schlake O (1996) Szenario-management – planen und führen mit szenarien, 2nd edn. Carl Hanser, München Wien
35. Schnaars SP (1987) How to develop and use scenarios. Long Range Plan 20(1):105–114
36. Reiljan J (2008) Die Probleme der Szenarioerstellung für die Wirtschaftsentwicklung Estlands. Discuss Estonian Pol 16:163–180
37. Steinmüller K (2003) Szenarien Instrumente für Innovation und Strategiebildung. Z_punkt, Essen
38. Fichter K, Kiehne DO (2004) Trendmonitoring im Szenario-Management. nova-net, Stuttgart

39. Cornish ES (2003) The wild cards in our future. Futurist 37(4):18–22
40. Petersen JL (2000) Out of the blue: how to anticipate big future surprises, 2nd edn. Madison Books, Lanham
41. Uv R (1991) Szenario-Technik – Instrument für die unternehmerische und persönliche Erfolgsplanung. Gabler, Wiesbaden
42. Grienitz V, Ley S, Schmidt AM (2009) Zukunftsstudie zur Wettbewerbsfähigkeit der Automobilzulieferindustrie in Südwestfalen 2015. Universität Siegen, Siegen
43. Grienitz V, Schmidt AM (2012) Anticipation of developments in industry sectors with future scenarios and creation of business models using a multi-stakeholder approach. Int J Foresight Innov Pol 8(4): 335–353
44. Ritchey T (2012) On the formal properties of morphological models. Acta Morphol Gen 1(2):1–15
45. Grienitz V, Blume V (2008) Strategic Planning of Future Products with Product Scenarios. Proceedings of 4th IEEE International Conference on Management of Innovation and Technology, 21–24 Sept 2008, Bangkok, Thailand, pp 374–379
46. Grienitz V, Schmidt AM (2012) Taxonomy for generation of Blue Ocean Business Model with Scenario Technique. Proceedings of the 2012 Industrial and Systems Engineering Research Conference (ISERC), Orlando, Florida
47. Grienitz V, Schmidt AM (2011) Development and Assessment of future scenarios in the context of the Security Environment. Systems Analysis and Studies (SAS) Panel, Specialists Meeting SAS – 088 on long range forecasting of the future security environment, Stockholm, pp 5–1 to 5–12
48. Grienitz V, Schmidt AM (2011) Entwurf von nachhaltigen Produktionssystemen mit Hilfe der Szenariotechnik. Nachhaltigkeit in Fabrikplanung und Fabrikbetrieb. TBI'11 - 14. Tage des Betriebs- und Systemingenieurs. TU Chemnitz, Chemnitz, S. 383–392
49. Grienitz V, Schmidt AM (2010) Scenariobased Complexity Management by adapting the Methods of Social Network Analysis. Proceedings of The International Multi-Conference on Complexity, Informatics and Cybernetics: IMCIC 2010, Orlando, Florida, pp 61–66
50. Grienitz V, Schmidt AM (2012) Scenario workshops for strategic management with Lego® serious play®. Probl Manag 21st Century 3(2012):26–36
51. Ansoff HI (1975) Managing strategic surprise by response to weak signals. Calif Manag Rev 18(2):21–33