Master ICT in Business

Technology Trend Research & Forecasting

Using Text Mining as Input for Scenario Planning

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Abstract

As technologies emerge and develop in an accelerating pace, organisations affected by technological developments must keep up to stay relevant (Firat, Woon, & Madnick, 2008; Cooper, Schendel, et al., 1976; Drew, 2006). Technology forecasting (TF) allows organisations to anticipate rather than respond to these upcoming trends (Inman, 2004), and can also help identify potential new markets (Vanston, 1996). TF has proven its value over the years. However, there is still a need for a method that fits the pace of technological advancements in today's society.

In order to better understand technology forecasting and its methods, this research reviews existing technology forecasting methods and attempts to identify a more refined and up-to-date TF method that can be used to gather insights in emerging technological trends. This research developed, implemented, and validated a TF method that is not dependent on solely one technique, but combines the positive features of certain methods to eliminate bias where possible. First, text mining was used to identify technologically relevant trends. Second, scenario planning was applied in a workshop with experts to identify the barriers and benefits of scenario planning as TF method. This workshop was held in collaboration with management and technology consultancy firm BearingPoint. Before designing the workshop, interviews with experts were held to identify the problems in their current TF process. An observer was present at the workshop to observe the participants' behavior and attitude, as well as the facilitator, to assure the quality of the workshop. This research provides the template of a workshop design, and the barriers and benefits of its implementation that can be applied in organisations to assist in identifying and anticipating on emerging technologies.

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Contents

List of Tables

List of Figures

1 Introduction

In a world that becomes increasingly data oriented and where technologies emerge and develop rapidly, organisations are looking for ways to identify and assess opportunities and threats, and to gain a competitive advantage (Cho & Daim, 2013). Organisations have to be successful in anticipating and adapting to technological developments, to stay relevant (Firat et al., 2008; Cooper et al., 1976). This need to adapt creates the necessity to anticipate new upcoming technologies in an early stage (Day & Schoemaker, 2016). However, timing is a crucial concept in staying ahead of the curve, especially in a rapidly changing environment (Bush, 2012). Adopting a new technology before the market is ready can result in immense losses, where chasing a largely adopted technology can result in missed profits.

To remain relevant as an organisation it is not only important to know which technologies are relevant today, but also to know which technologies will be relevant in the future. Organisations need to "know when to act and, as importantly, when not to act" (Burt & van der Heijden, 2003, p.1022). This brings forward the challenge of making decisions for the future based on the knowledge of the past (Vanston, 1996). This concept is widely regarded as technology forecasting (Gnizy, 2020). There are several methods for technology forecasting such as trend monitoring, modelling, trend extrapolation, expert opinions, and scenario planning (Miller, Ph., & Swinehart, 2011). The aim of this research is to develop, implement, and validate an improved technology forecasting method by combining independent techniques.

1.1 Problem Statement

As technology advances in an accelerating pace, organisations affected by technological developments must keep up and exploit capabilities of new technologies (Drew, 2006). However, emerging technological trends can be hard to identify in advance, and its market growth can be difficult to predict (Christensen, 2013; Cooper et al., 1976). TF allows organisations to anticipate rather than respond to these upcoming trends (Inman, 2004), and can also help identify potential new markets (Vanston, 1996).

TF has proven its value over the years. However, there is still a need for a method that fits the pace of technological advancements in today's society. As mentioned, there are several methods for technology forecasting such as trend monitoring, modelling, trend extrapolation, expert opinions, and scenario planning (Miller et al., 2011). Most of these methods do not consider the accelerating pace of technological advancement and uncertain nature of external forces (Drew, 2006), and are either dependent on historical patterns (Eto, 2003) or prone to bias (Tran & Daim, 2008). This research attempts an improved technology forecasting method that is not dependent on solely one technique, but combines the positive features of certain methods to eliminate bias where possible.

1.2 Research Question

There are different technology forecasting methods. These methods require relevant data, which is collected through the use of extant literature, databases and experts among others.

New technologies can offer opportunities for more accurate technological trend analysis (Gordon, Glenn, & Jakil, 2005). Although not new in the technology forecasting literature (Firat et al., 2008), text mining is one of these technologies that can potentially enhance other existing technology forecasting methods (Kayser & Blind, 2017). Text mining is the process of extracting patterns or knowledge from textual documents (Tan et al., 1999). It is proposed that detecting patterns in published works can serve as a foundation that could then be examined using traditional technology forecasting methods, such as scenarios. Scenarios are descriptions of possible futures, including risks and opportunities. Szulanski and Amin (2001) advice organisations in a rapidly changing environment to balance discipline and imagination for strategy making. This research will study existing technology forecasting methods and attempt to identify a more refined and up-to-date TF method that can be used to gather insights in emerging technological trends. It aims to answer the following two research questions:

RQ 1: *What are barriers and benefits of applying scenario planning for technology forecasting methods?*

RQ 2: *What are barriers and benefits of applying text mining as input for scenario planning?*

Note:
The term technology forecasting used in this research does not refer to developing a highly accurate forecast. TF indicates the process of identifying and understanding upcoming trends and their potential direction, rate, and effect of technological change (Firat et al., 2008; Carlson, 2004).

1.3 Thesis Overview

To answer the research questions the first step is to discuss relevant literature. in section 2 existing technology forecasting methods will be reviewed and compared. The second step is to determine how this research will be approached and what methodology is used. The research approach and methodology will be described in section 3. The research itself, its results, and evaluation are covered in section 4, as well as limitations. Lastly, conclusions are made in section 5. References and Appendices are included at the end of the research.

2 Literature Review

The aim of this research is to develop, implement, and validate an improved technology forecasting method by combining independent techniques. In the literature review, extant literature is used to create a framework for this new method. The literature review of this study is composed of three sections. The first section consist of the history of TF, its applicability, and its definition. The second section consists of different TF methods and determines their advantages and disadvantages. The third section defines the research gap, and sets a framework that is used to develop a new method by combining TF methods relevant for this research.

2.1 Technology Forecasting

Although available since the 50's and 60's, technology forecasting was widely adopted by private sectors in the 1970's (Martino, 1993). Ever since problems in technology management started to occur, there has been need for a systematic approach of technology observation and assessment (Nosella, Petroni, & Salandra, 2008). These problems surfaced due to increasing complexity in interpreting and managing technologies as an asset (Twiss, 1974). With the rise of advanced computing and improved software, TF methods have become increasingly more advanced (Zhu & Porter, 2002).

Martino (1993) defines technology forecasting as a prediction of future characteristics of useful machines, procedures, or techniques. Coates et al. (2001) and Yoon and Park (2007) take a more complete and updated view and refer to TF as the process of anticipating and understanding the potential direction, development rate, characteristics, and effects of technological change. This research adopts the view of Coates et al. (2001) and Yoon and Park (2007) and refers to TF as the process of anticipating and understanding future technologies for both large organisations and smaller individual organisations that are dependent on technological trends and their ability to respond accordingly.

TF assists organisations by providing handles in the decision-making and analysis process when considering new technologies. Ultimately the aim of TF is to identify opportunities and threats for an organisation in its competitive business environment (Cho & Daim, 2013). Some reasons to engage in technological forecasting according to Martino (1993) are to maximize gain and minimize loss from environmental change, offset the actions of competitors, and forecast demands to regulate production, staffing, facilities, resources, etcetera. However, the need for technology forecasting varies from prioritizing R&D expenditure, to product development, and making strategic decisions (Firat et al., 2008; Haleem, Mannan, Luthra, Kumar, & Khurana, 2018).

2.2 Technology Forecasting Methods

Forecasting methods can be categorized as extrapolative or normative (A. L. Porter, Roper, Mason, Rossini, & Banks, 1991). This is based on whether they rely on the assumption that the past behavior will continue or looking back from a desired future. There are different technology forecasting methods, which can be divided into families (A. L. Porter, 2010). Table 2.1 shows various future-oriented technology analysis methods.

Methods families	*Sample methods*
Creativity approaches	TRIZ, future workshops, visioning
Monitoring and intelligence	Technology watch, tech mining
Descriptive	Bibliometrics, impact checklists, state of the future index, multiple perspectives assessment
Matrices	Analogies, morphological analysis, cross-impact analyses,
Statistical analyses	Risk analysis, correlations
Trend analyses	Growth curve modelling, leading indicators, envelope curves, long wave models
Expert opinion	Survey, delphi, focus groups, participatory approaches
Modelling and simulation	Innovation systems descriptions, complex adaptive systems modelling, chaotic regimes modelling, technology diffusion or substitution analyses, input-output modelling, agent-based modelling
Logical/Causal analyses	Requirements analysis, institutional analyses, stakeholder analyses, social impact assessment, mitigation strategising, sustainability analyses, action analyses (policy assessment), relevance trees, futures wheel
Roadmapping	Backcasting, technology/product roadmapping, science mapping
Scenarios	Scenario Management, Quantitatively based scenarios
Valuing/Decision-aiding/economic analyses	Cost-Benefit Analysis (CBA), Analytical Hierarchy Process (AHP), Data Envelopment Analysis (DEA), Multicriteria Decision Analyses
Combinations	Scenario-simulation (gaming), Trend impact analysis

Table 2.1: Future-oriented technology analysis methods (A. L. Porter, 2010)

In General, all methods can be divided in two main categories: quantitative and qualitative methods (Lee, Song, & Mjelde, 2008). Quantitative methods use quantifiable data applied on statistical tools. Qualitative methods do not rely on these tools and use non-numerical data such as text and images interpreted by experts (Haegeman, Marinelli, Scapolo, Ricci, & Sokolov, 2013).

A. L. Porter (2010) provides the Delphi method, participatory qualitative scenarios, and workshops as examples for qualitative TF methods. These methods include multiple views and threat/opportunity analysis, creating a substantially better forecast (A. L. Porter et al., 1991). However, required experts can be hard to identify and methods of qualitative TF are subject to scrutiny by many authors for both accuracy and reliability concerns (Firat et al., 2008) as they are criticised as lacking reproducibility and transferability of assumptions to quantitative models (Alcamo, 2008). Quantitative methods have become the most prominent group for TF (Bengisu & Nekhili, 2006; Sanders & Manrodt, 2003). "Quantitative TF is the process of projecting in time the intersections of human activity and technological capabilities using quantitative methods" (Walk, 2012, p.103). Important advantages of quantitative methods is that they are:

- Tested, scalable, and subjective.
- Generally applicable.
- Disambiguous.
- Open to independent scrutiny.

Additionally, quantitative methods for TF can be fully automated and often applied as a unifying conceptual framework (Walk, 2012). However, generally speaking, organisations' acceptance and adoption of quantitative TF methods is hindered by two main aspects:

- Resistance to new and less complex forecasting methods.
- Unavailability of (time-based) data sets (Watts, Porter, & Newman, 1998).

Although the role of quantitative methods has been conceptualized as the concrete predictive function in finding out technology potential (Lin, Tang, Shyu, & Li, 2010), a single use quantitative method does not create a full and reliable picture of dynamics in technology adoption (Walk, 2012). It is therefore hypothesized that a combination of methods eliminate the risk of faulty assumptions, bias, or faulty data (Lin et al., 2010). As insights gained from technology forecasting provides value, even when the predicted outcomes are not highly accurate (A. L. Porter et al., 1991), and integrating new technologies can improve and refine traditional TF methods (Gordon et al., 2005).

Firat et al. (2008) fitted all TF methods into nine families: Expert Opinion, Trend Analysis, Monitoring and Intelligence Methods, Statistical Methods, Modeling and Simulation, Scenarios, Decision/Economics Methods, Descriptive and Matrices Methods, and Creativity. However, some methods fit into more than one family. Therefore, this review dives into the following five main method families as identified by A. L. Porter (2010):

1. Monitoring and Intelligence Methods
2. Trend Analysis
3. Expert Opinion
4. Modeling and Simulation
5. Scenarios

The definition of these techniques and its challenges are elaborated below.

Monitoring and Intelligence Methods

A case study by Nosella et al. (2008) examined the process of technology monitoring and defines it as a process that provides information on a technology, predicts the direction of the technological change, or evaluates the potential of the technology for an organisation. Rossini (1987) states that the monitoring process itself is not a forecasting method. It observes the environment to gather information necessary to perform technology forecasting. Monitoring is useful to gain awareness of current technological trends and the direction of technological change (A. L. Porter et al., 1991; Firat et al., 2008).

Intelligence methods provide a lot of useful information from various sources. Therefore, this method can generally provide large amounts of data from various sources (A. L. Porter, 2010). However, this advantage comes with the the challenge of selecting, filtering, and structuring the huge amount of data. Additionally, the output of monitoring and intelligence TF methods are too general to support specific decisions (Madnick et al., 2008).

Trend Analysis
Trend analysis (TA) is a process that looks at current and historical trends in the market, and uses them to predict possible trends in the future (Harvey, 2014). TA offers a forecast that is based on (historical) data. "Trend analysis is the process of determining patterns over time of changes in technological variables and of developing forecasts on the assumption that these patterns will behave in the future as they have in the past." (Rossini, 1987, p. 28). Examples of a use case is the prediction of adoption rates over time (Firat et al., 2008).

"Trend analysis uses simple mathematical and statistical techniques to extend time series data into the future" (A. L. Porter, 2010, p. 34). It is based on the assumption that past trends will continue in to the future (Firat et al., 2008). TA is relatively simple and easy to use, and it ensures internal consistency because of its quantitative nature (Cho & Daim, 2013). However, TA is dependent on long past data for extrapolating trends, and Agami, Omran, Saleh, and El-Shishiny (2008) notes that TA is affected by unprecedented future events, should they occur.

Expert Opinion
The expert opinion method is the process of obtaining and analyzing experts' knowledge about forecasting technological development (Firat et al., 2008; Rossini, 1987). This can be used in early stages of technologies, when there is not yet a lot of data available. With this method, it is critical to find fitting experts. Therefore, it is often applied in a group setting. Multiple experts combined have greater knowledge than an individual, which results in a substantially better forecast (A. L. Porter et al., 1991; Inman, 2004). The Delphi method is the most popular method within the family of expert opinion, according to several surveys (Martino, 1980). Delphi is an interactive forecasting method that uses opinions of experts, and enables participants to reconsider their opinion based on an anonymous summary of the opinions (Linstone, Turoff, et al., 1975; Yoon & Park, 2007).

Expert opinion is dependent on the experts' ability to identify and select useful information (Nosella et al., 2008). Sudden technology breakthroughs are often overlooked by other TF methods (mainly quantitative TF methods). Expert opinion does allow for the identification and thus forecast of sudden technological breakthroughs (Lin et al., 2010). However, finding fitting experts is often a challenge which results in wrong forecasts. Additionally, the posed question can be unclear or ambiguous and in group settings the forecast can be affected by socio-psychological factors (A. L. Porter, 2010).

Modeling and simulation
Modeling constructs a simplified representation of a part of the real world, incorporating the most important relations and structures (Rossini, 1987; A. L. Porter et al., 1991). The models provide insights into complex system behavior by making approximations, which can be expanded to perform forecasts. Modeling and simulations methods are success driven, meaning that a model is created by successful iterations of the rules provided by its creator(Firat et al., 2008).

Modeling and simulation is dependent on the quality of the underlying assumptions (A. L. Porter, 2010). They efficiently incorporate the most critical relationships and dynamics of the parameters to be forecast (Rossini, 1987). It allows for the opportunity to solve complex problems without the risk of costly mistakes (Firat et al., 2008). With the advancements made in computing technologies, increasingly complex models are possible, increasing its potential (Coates et al., 2001). However, the adoption of modeling and simulations as a TF method is obstructed by the lack of transparency (Walk, 2012; A. L. Porter, 2010). Another limiting factor of modeling and simulation is that it is dependent on relatively large historical datasets (Yuskevich, Smirnova, Vingerhoeds, & Golkar, 2021).

Scenarios

Scenarios are descriptions of possible futures, including risks and opportunities. This method is useful in situations with variable degrees of complexity and certainty (Amer, Daim, & Jetter, 2013). Scenarios describe how different components might interact under hypothesized conditions (Schoemaker et al., 1995). Scenarios can include both qualitative and quantitative factors, which can result in diverse forecasts (Rossini, 1987). Scenarios stimulate strategic thinking and help organisations in their decision-making processes (Lindgren, Bandhold, et al., 2003; Amer et al., 2013; Gruetzemacher, 2019).

Like expert opinion, scenarios use experts' knowledge and experience to determine technological advancements. "Qualitative scenarios have the advantage of being able to represent the views of several different stakeholders and experts at the same time." (Alcamo, 2008, p.124). In comparison to most TF methods, scenarios takes uncertainties into consideration (Gordon et al., 2005). They provide a rich and complex image of multiple possible futures and require only a small amount of data (A. L. Porter, 2010). Additionally, scenarios allow for the creation of technology roadmaps (Rossini, 1987). However, like expert opinion, scenarios are dependent on the opinion and knowledge of experts, and thus prone to bias (A. L. Porter, 2010). Additionally, creating scenarios is time consuming (Rossini, 1987).

Family	Quantitative vs. Qualitative	Advantages	Disadvantages	Sources
Monitoring and Intelligence Methods	Quantitative	Useful information Not subject to bias	Dependent on dataset quality Too general	(A. L. Porter, 2010) (Madnick et al., 2008)
Trend Analysis	Quantitative	Relatively simple to use Ensure internal consistency	Dependent on historical data Affected by unprecedented events	(Cho & Daim, 2013) (Firat et al., 2008) (Agami et al., 2008)
Expert Opinion	Qualitative	Useful in sudden breakthroughs Does not need a lot of data	Limited to experts' knowledge Fitting experts hard to find Prone to bias	(Lin et al., 2010) (A. L. Porter, 2010)
Modeling and Simulation	Quantitative	Efficient Handles complex models	Dependent on underlying assumptions Dependent on historical data Dependent on dataset quality	(Firat et al., 2008) (Coates et al., 2001) (Walk, 2012) (Yuskevich et al., 2021)
Scenarios	Qualitative	Flexible Considers uncertainties	Resources needed Time consuming Prone to bias	(Gordon et al., 2005) (A. L. Porter, 2010) (Rossini, 1987)

Table 2.2: Characteristics TF method families

2.3 Research Gap

"The rate and direction of change are not consistent over time. Therefore, different forecasting methods may be needed." (Coates et al., 2001). In an attempt to develop a new and improved forecasting method, a combination of both quantitative and qualitative techniques has to be used. Quantitative methods because they tend to be disambiguous and open to scrutiny (Walk, 2012). Qualitative methods because they can provide substantially better forecasts (A. L. Porter et al., 1991).

Kayser and Blind (2017) propose multiple possible combined TF methods that have both a quantitative and qualitative approach. The article proposes different ways of accessing and aggregating today's volumes of data and how that can be used in foresight methods. Among the multiple proposed combined methods is the combination of text mining and scenario planning. Additionally, Walk (2012) talks about how quantitative methods can be used to increase both validity and reliability of expert- or probabilistic-based projections like scenario planning. However, The combined method of creating foresights from text mining data in combination with scenario planning is yet to be evaluated. This research attempts to "test the benefits and weigh the qualitative and quantitative methods" [p.7] of the combined method of text mining and scenario planning as proposed by Kayser and Blind (2017).

3 Methodology

To determine the research approach of this study, the research onion model of Saunders et al. (2007) is used. This model, shown in figure 1, explains the stages/layers of research, starting with the research philosophy.

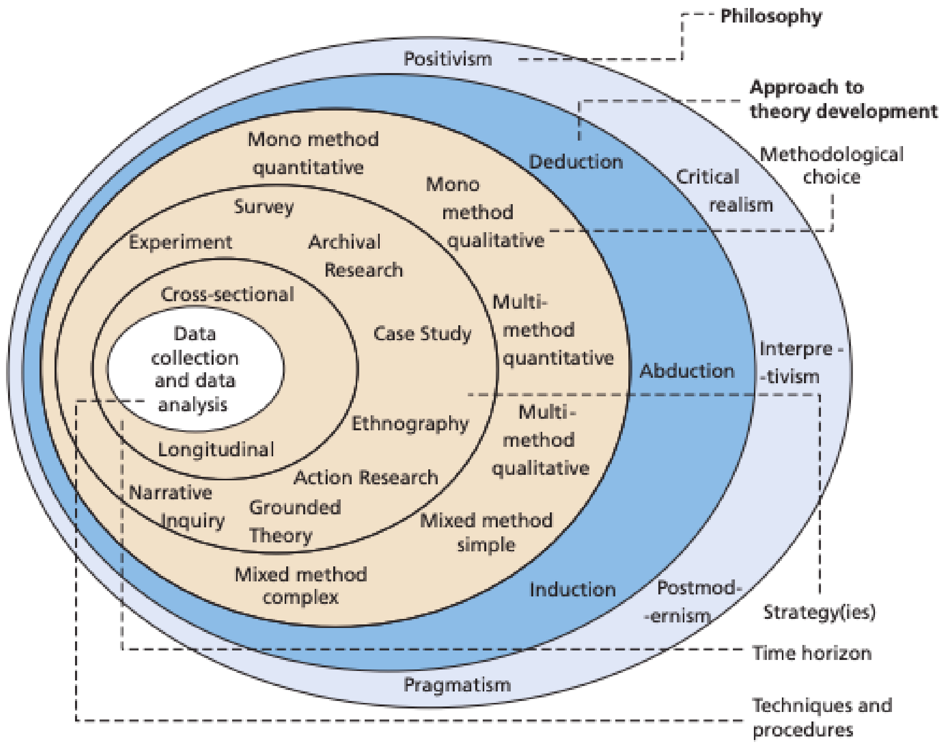


Figure 1: Research Onion (Saunders et al., 2007)

The research philosophy of this research is interpretivism. Interpretivism focuses on qualitative data, collected among individuals. Interpretivist research presents new and more in depth insights, contributing to new understandings (Saunders et al., 2007). The aim of this research is to develop, implement and validate an improved technology forecasting method, which uses text mining as input for scenario planning, applied in a workshop with experts. To do so, this research uses a deductive approach, which tests a theory in practice (Casula, Rangarajan, & Shields, 2021).

The scientific method that is used, is exploratory action research. Action research is a cycle, consisting of diagnosing, action planning, action taking, and reflecting/evaluating (Kemmis, McTaggart, & Nixon, 2014). Action research is concerned with creating practical knowledge by organisational change through a collaboration between researcher and practitioners (Reason & Bradbury, 2001). This is done by diagnosing the current situation, implementing changes, and create theory by interpreting and evaluating these results (Stettina & Smit, 2016; Reason & Bradbury, 2001). The two main reasons for doing action research, according to McNiff and Whitehead (2012), are to improve practices, and to generate new theory. Action research is used as research strategy to appropriately understand the barriers and benefits of the process of scenario planning conducted among a group of experts. Together with experts, this research will gather knowledge about technology forecasting, the TF methods, and interpret these results to improve the current situation.

To assure the credibility of the research, the five principles of canonical action research, proposed by Davison, Martinsons, and Kock (2004), are applied. The first principle is about the Researcher-Client agreement. The research is executed in collaboration with management and technology consulting firm BearingPoint. This offers the possibility of designing a systematic and repeatable approach to technology forecasting within their organisation. The second principle relates to the Cyclical Process Model of action research: diagnosing, action planning, action taking, and evaluating. These four stages have been followed throughout the study. Third is the principle of Theory. The aim of this research is to develop, implement, and validate an improved technology forecasting method by combining techniques, based on the knowledge gained from desk research, and experts' opinion. The improved method has been executed in practice through a workshop, in collaboration with experts employed at BearingPoint, and validated by these experts through questionnaires. The fourth principle relates to Change Through Action. At the end of the execution of the workshop participants completed a questionnaire to reflect on the TF methods that were used, and on the workshop structure itself. This is in line with the last principle: Learning Through Reflection.

This research uses a mixed methodology, which can be divided into two phases. The first phase exists of trend research that identifies new and upcoming technological trends in the market, using text mining. This is a quantitative method. The second phase is consulting and analyzing these results with experts through a workshop that uses scenario planning, which is a qualitative research method. Scenario planning can help organisations with their decision-making processes by creating descriptions of possible futures. The goal of the workshop is to test the proposed TF method, and to identify the advantages and disadvantages of this technology trend research and forecasting method.

3.1 Case Selection

This research was done in collaboration with BearingPoint, located in the Netherlands. BearingPoint is a management and technology consulting firm, focused on consulting, business services, and software solutions. In April 2022, an introduction call was held with the data management & information management director from BearingPoint. Two interviews were conducted with employees from BearingPoint, with a leading role, to gain insights into their organisation's current situation, regarding technology trend research & forecasting. When it comes to serving their clients, BearingPoint follows a systematic process. Their internal technology forecasting process is less systematic, although considered as an important process. "Consultants want to see the future rather than the past". (Interviewee A, personal communication, May 10, 2022).

3.2 Data Collection and Data Sources

This research uses different techniques to collect data. The data is collected from the following data sources: semi-structured interviews, questionnaires and observations during a workshop. Semi-structured interviews were conducted prior to the workshop to gain a better understanding of the current situation in consultancy firms, regarding technology trend research and technology forecasting. Experts employed at BearingPoint were interviewed (prior to the workshop) about their current forecasting methods and what they consider to be the advantages and disadvantages of these methods, and how this forecasting process could possibly be optimized.

A workshop was designed were the improved TF method was executed and validated. During the workshop, the experts were observed, by an observer, for their posture and behavior during the scenario planning steps. The observer took note how the experts engaged in the workshop and how actively they participated in it. Additionally, the facilitator was observed to assure the quality of the workshop and its results. At the end of the workshop the experts completed a questionnaire about the technology trend research and forecasting method of this research, and what they consider to be the advantages and disadvantages of this method, and how this compares to the method that they currently use in their organisation. The questionnaire exits of both open questions and questions to be answered on a 5 point Likert scale (Joshi, Kale, Chandel, & Pal, 2015). The open questions are designed to allow the experts to express their opinion as they see fit. The questions using Likert scale are intended to determine how accomplished the workshop and its structure were. Likert scale goes beyond a simple yes or no answer. Therefore, the results can provide a deeper understanding of the experts' experience during the workshop. For the data analysis, all interviews, questionnaires, and observation notes were fully transcribed and used in evaluation.

3.3 Research Design

Action research consists of four stages: diagnosing, action planning, action taking, and evaluating. Figure 2 shows these stages. They are elaborated on below.

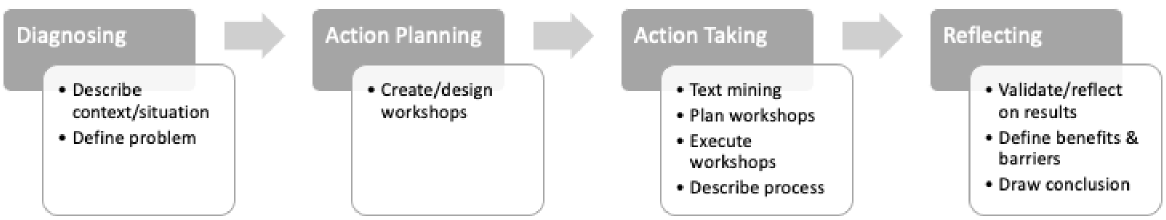


Figure 2: Action Research Design

Diagnosing
In the diagnosing phase, the current TF methods in BearingPoint were described, and problems were identified. To do so, interviews with experts were conducted, asking about their current forecasting methods and what they consider to be the advantages and disadvantages of these methods, and how this forecasting process could possibly be optimized.

Action Planning
This research developed an improved TF method and validated this in a workshop. This method uses text mining to find technologically relevant trends from multiple trend reports, published in the past two years. With advancements in technology and accessibility of data, text mining can become a vital part of a renewed technology forecasting method. A constraint of text mining is that it processes textual data and ignores figures and other meanings within a document (Kayser & Blind, 2017). Therefore, it is not used on its own (Grimmer & Stewart, 2013). The information drawn from documents (using text mining) can provide insights into trends in the technological field of interest, when provided to experts performing the technology forecast (Morris, DeYong, Wu, Salman, & Yemenu, 2002).

The consequences of upcoming technologies are hard to quantify, and come with an uncertainty that can never be completely eliminated. Therefore, Gordon et al. (2005) propose that uncertainty and assumptions should be made explicitly by technology forecasting methods. Contrary to most technology forecasting methods, scenario planning takes uncertainties into consideration. This research examines how scenario planning can be applied in a group setting to better predict and anticipate trends. A workshop with experts was held, were scenario planning was used as a tool. The text mining results were used as input for the scenario planning process. The goal of scenario planning is to make better decisions by considering scenarios about possible futures (Schoemaker et al., 1995). This method is especially useful for long term forecasts in uncertain situations. Scenario planning can be divided into the five steps of TAIDA (Lindgren et al., 2003): tracking, analysing, imaging, deciding, and acting. The workshop executed for this research focuses on analysing and imaging.

In the action planning phase, the workshop was created based on the results gained from literature study and the interviews with experts. The goal of the workshop is to explore the benefits and barriers of this improved technology forecasting method.

Action taking

In the action taking phase, the improved technology forecasting method was executed and validated in the workshop. The participants for the workshop are consultants, employed at BearingPoint. The participants and facilitator were observed during the workshop. The observer paid attention to the behavior and attitude of the participants. The facilitator was observed to determine whether the designed workshop was actually executed as proposed by the research. This is necessary to establish the reliability of the results.

At the end of the workshop the experts were asked to complete a questionnaire. The purpose of the questionnaire is to evaluate how the participants experienced the use of scenario planning in the workshop, based on the results from text mining. Additionally, they are asked for their opinion on their current methods, compared to the methods of the workshop. Lastly, they must answer whether they agree/disagree to certain statements about the quality of the workshop (structure). The goal is to explore the benefits and barriers of this technology trend research and forecasting method.

Evaluating

The final results are based on the text mining process, the interviews conducted prior to the workshop, the observations made during the workshop, the workshop itself, and the questionnaires completed at the end of the workshop. The transcribed data resulted in findings and conclusions. These results are reflected on and evaluated.

4 Action Research

The execution of the research followed the following timeline:

– February, 2022: Literature research

– February 21, 2022: Start text mining process and gather trend reports

– April 26, 2022: Introduction call BearingPoint

– April 29, 2022: Obtain text mining results

– May, 2022: Diagnosing: interviews with experts

– June 17, 2022: Action Planning: Finalize workshop design

– June 30, 2022: Action Taking: Execution workshop

– June 30, 2022: Evaluation of workshop

– July 1, 2022: End of Action Taking, beginning of evaluating

– July 15, 2022: Discuss findings and conclude

This study followed the stages from action research: diagnosis, action planning, action taking, and evaluating. These steps will be elaborated below.

4.1 Diagnosis

To diagnose the current situation in BearingPoint, regarding technology forecasting and identifying the problem of their methods, semi-structured interviews with experts were held, in the months May and June of 2022. Interviewee A is data management & information management director, interviewee B is advanced analytics expert and manager, both at BearingPoint. The interviewees were asked about their current forecasting methods and what they consider to be the advantages and disadvantages of these methods, and how this forecasting process could be optimized. The interview questions can be found in appendix A. Based on these interviews, the current situation in their consultancy firm, regarding technology trend research and technology forecasting, was described, and problems were identified. Currently, they do not have a systematic approach for technology forecasting. However, as a consultancy firm they value the insights resulting from technology forecasting and want to implement a TF method that is repeatable. Ultimately, a consultancy firm has to keep up with modern technologies to better serve their clients.

The approach that BearingPoint has towards its clients is in stark contrast with their internal approach when it comes to technology assessment. When it comes to serving their clients, BearingPoint has a structured process that follows certain steps. The first step is often for companies to indicate that they want to become data-driven. The next step is to establish the available data. This is mainly about the qualitative value of data: better decision-making and better insights. As this is where companies create value from data: "I think those companies will be more successful." (Interviewee A, personal communication, May 10, 2022). First, there must be a vision. From such a vision, a list of principles is established to determine the requirements. Therefore, the question is: what position do I want on data analytics in my company? "My approach is to embed it in the company culture and in the organisation of the company without putting down a lot of governance." (Interviewee A, personal communication, May 10, 2022). Just like the quality of consulting, you need to ensure the data quality. And tools can be helpful in making the work easier. Technology must facilitate this.

However, their internal technology forecasting process is less systematic. Certain valued sources outside the Netherlands, like academic researches and reports by large technology organisation are being monitored. This potentially leads to a trend that is already accessible to them and is hardly ever applied by Dutch companies. This can be used as a prediction for the coming years. Interviewee B indicated that this process is dependent on their availability (personal communication, June 9, 2022). Therefore, they hope that this workshop will contribute to a systematic and repeatable approach for technology forecasting, where they do not depend on one individual.

4.2 Action Planning

In this phase of the study, focus lies on designing the workshop. The workshop was created based on the results gained from literature study and the interviews conducted with experts. The workshop proposed and executed an improved technology forecasting method. The improved method uses text mining to find technologically relevant trends from multiple trend reports, and uses scenario planning, applied in a group setting, to better predict and anticipate trends.

To design the workshop, desk research was done to create a format to approach scenario planning, applicable in a group setting. The challenge was to create a method that combines the positive aspects of text mining as quantitative method and scenario planning as qualitative method to create: a repeatable, unbiased, and vivid description of possible futures, that allows for identification of possible next steps regarding the technology.

Text Mining

Text mining (TM) is a quantitative method that falls under the TF family of monitoring and intelligence methods. TM is the process of extracting patterns or knowledge from textual documents (Tan et al., 1999). It has been used as a technology forecasting method in the past, however with limited popularity (Firat et al., 2008). A constraint of text mining is that it processes textual data and ignores figures and other meanings within a document (Kayser & Blind, 2017). Therefore, text mining should not be used as a standalone TF method (Grimmer & Stewart, 2013). Text mining has the ability to process more data, in a shorter amount of time, than humanly possible and in comparison to many qualitative methods, it eliminates bias and is highly scalable (Walk, 2012).

With advancements in technology and accessibility of data, text mining can become a vital part of a renewed technology forecasting method. Roy, Gevry, and Pottenger (2002) propose an improvement on the performance of their existing fully automatic trend detection system that focuses on citation tracing. However, as for the use as technology forecasting method combined with the relative slow nature of academics compared to technologies, a more traditional method of text mining is more relevant to technology forecasting. The information drawn from documents (using text mining) can provide insights into trends in the technological field of interest, when provided to experts performing the technology forecast (Morris et al., 2002).

Scenario Planning
In comparison to most other methods, Scenario Planning (SP) is not about the accuracy of the forecast, but rather about creating a number of possible credible futures (Keough & Shanahan, 2008). SP is a method used to create different scenarios, which are internally consistent descriptions of possible futures (Bloom & Menefee, 1994; M. E. Porter & Advantage, 1985). "The overall purpose of scenario planning is to build a shared framework for strategic thinking that encourages diversity and sharper perceptions about external changes and opportunities" (Schoemaker et al., 1995, p.28). It is becoming increasingly challenging to keep track of new technologies, and to determine their impact on the organisation and its business model (Emrich, Klein, Frey, Fettke, & Loos, 2018). Therefore, Gordon et al. (2005) propose that uncertainty and assumptions should be made explicitly by technology forecasting methods. Contrary to most technology forecasting methods, scenario planning takes uncertainties into consideration, resulting in more in depth forecasts than other methods (A. L. Porter, 2010; Postma & Liebl, 2005).

4.2.1 Workshop Design

The goal of the workshop is to explore the advantages and disadvantages of the proposed technology forecasting method of this research. This method uses text mining as input for scenario planning to better anticipate trends. Scenario planning is used during the workshop and the behavior of the participants will be observed by an observer. During the interviews with experts, prior to the workshop, feedback was asked about the text mining process and scenario planning approach. This feedback was used for the final workshop design. At the end of the workshop, the participants are asked to complete a questionnaire about the technology forecasting method of this research, how this compares to the method they currently use in their organisations, and whether they would consider to run this workshop themselves in their organisation.

The first step in scenario planning is to formulate a question to determine the scope and ensure all participants are aligned. For this workshop, the question has already been prepared. The reason for that is to avoid a question being formulated that does not align with the remainder of the workshop. After presenting the key question, certain aspects must be identified, starting with the key business factors. These are the direct changes in an organisation that could impact the formulated question. Second, the external forces must be identified. The PEST-analysis is a strategic method that can help identify those external forces that could affect an organisation. PEST stands for the four sources of change: political, economic, social, and technological (Sammut-Bonnici & Galea, 2014). This process typically generates a list with a large number of factors, which will have to be reduced in order to be considered for scenarios (O'Brien, 2004). The reduced list of factors will be achieved by the experts, by ranking the factors in terms of their impact and uncertainty, in the impact-uncertainty matrix. This is the scenario matrix approach, which is designed to narrow the list of complex factors, and identify the two sources with high uncertainty and high importance, which are most relevant for scenarios (Maack, 2001). The impact and uncertainty of the factors will be determined by the experts through dot voting.

After dot voting, the facilitator plots the most relevant factors on two uncertainty axes. This pairing of two uncertainties is the deductive method to identify scenarios (Schwartz, 2012). Based on the extremes of these axes, four different scenarios must be created, and discussed by the experts. Schnaars (1987) gives advice to develop between two and four scenarios, to avoid confusion, but still be sufficient. This workshop will divide the group of experts in two subgroups. Both groups will create two scenarios, resulting in a total of four scenarios to discuss. The impact-likelihood matrix can help determine which developments need more research. After discussing these scenarios, the participants have the opportunity to share their opinion about potential next steps.

At the end of the workshop, participants are asked to complete a questionnaire. The purpose is to evaluate how the participants experienced the use of scenario planning in the workshop, based on the results from text mining. The participants are asked for their opinion on the methods they use themselves compared to the technology forecasting method of this research, and if they would consider executing the workshop regularly within their organisation.

The workshop is held physically, to encourage interaction among participants. It will not be recorded, due to the risk of influencing the experts' responses and participation in the session. To ensure the quality of results of the workshop, there will be an individual who observes the behavior and attitude of the participants and the facilitator. The observer received a briefing prior to the workshop, which can be found in Appendix E.1. An introduction meeting was held where the observer asked questions about the research and their tasks. Prior to this meeting, the observer received the workshop timeline. All observations and annotations are anonymous. The observation log can be found in Appendix E.2.

4.2.2 Workshop Agenda

The final workshop agenda is based on the following steps, on how to use scenario planning, proposed by the Centre for Innovation (Centre for Innovation, n.d.):

0. Invite experts.
1. Determine the scope (timeframe, market, products and stakeholders).
2. Describe current trends that could have an impact on the external and/or organisational environment.
3. Generate scenarios based on the trends.
4. Decide which trend developments need more research.
5. Generate decision scenarios based on previous scenarios.

The workshop goes through the stages shown in table 4.1. These are the main steps in a scenario planning workshop.

Stage	**Goal**
Introduction	Introduction of experts
Goal	Communicate the goal of the workshop
Question	Present key question
Trends	Describe current trends
Identify	Identify key internal business factors
	Identify external forces (PEST-analysis)
Prioritize	Prioritize factors (impact-uncertainty matrix)
Create	Give name to scenarios
Discuss	Discuss and plot scenarios (impact-likelihood matrix)
Answer	Answer key question

Table 4.1: Workshop agenda

The original workshop was supposed to follow the time schedule shown in table 4.2. Below the schedule, the playbook is elaborated in more detail. Due to certain constraints, the workshop that was executed for this research was shortened.

Time	**Activity**	**Duration**
12:30-12:35	Arrive at location	5 min
12:35-12:50	Preparation	15 min
12:50-13:00	Hand out writing materials, sticky notes and matrix template(s)	10 min
13:00-13:15	Walk-in & introduction of participants	15 min
13:15-13:25	Introduction workshop & agenda	10 min
13:25-13:30	Communicate the goal of the workshop	5 min
13:30-13:40	Present technologies	10 min
13:40-13:55	Discuss and decide on technology	15 min
13:55-14:10	Present key question	15 min
14:10-14:25	Identify key business factors	15 min
14:25-14:40	Identify external forces (PEST-analysis)	15 min
14:40-15:10	Describe key business factors	30 min
15:10-15:40	Describe external forces	30 min
15:40-15:55	Break	15 min
15:55-16:25	Prioritize factors in impact-uncertainty matrix	30 min
16:25-16:55	Give name to scenarios	30 min
16:55-17:30	Discuss scenarios (impact-likelihood matrix)	35 min
17:30-17:45	Answer key question	15 min
17:45-17:55	Complete individual questionnaires	10 min
17:55-18:00	Thank you & closing	5 min

Table 4.2: Workshop timeline

The timeline is elaborated below according to each activity. The following roles are retained:

- Facilitator. There is one individual presenting and guiding the workshop. The literal text of the facilitator is shown in *italics* in the activity descriptions below.
- Participants/experts. The participants are chosen based on their knowledge on data-driven consulting. They are the experts.
- Observer. There is one individual observing the participants during the workshop. The observer annotates the experts' behavior in the session. In addition, the observer annotates remarkable occurrences during the workshop.

Walk-in & introduction of participants — 15 min
In this workshop, the participants will most likely already know each other. However, this might not be the case in other situations. Therefore, there will be a short introduction round of all participants and the facilitator.

Introduction workshop & agenda — 10 min
The participants received an e-mail prior to the workshop, introducing the research and its methods: first, text mining to find technological relevant trends from multiple trend reports, second, scenario planning applied in a group setting to better predict and anticipate trends. Some participants were available for an individual call to explain the research and the expectations of the workshop. At the beginning of the workshop, this information will shortly be repeated and the agenda for the workshop will be presented.

Communicate goal of the workshop — 5 min
In this phase of the workshop, an explanation of the overall goal and the scope of the workshop is presented to the participants. *The goal of the workshop is to further explore a certain technology trend using scenario planning, determining whether to invest in this trend, the potential next steps for the organisation, and to determine the advantages and disadvantages of the proposed technology forecasting method.*

Present technologies — 10 min
A selection of the trend results from the text mining process are presented by the facilitator. This selection is based on experts' opinion given in the interviews prior to the workshop. The reason that this selection was made is to ensure all presented technologies are relevant for the participants. Examples of applications of these technologies were also presented to give an impression of the possibilities. These subtrends were identified by the facilitator through desk research.

Discuss and decide on technology — 15 min
The facilitator will ask the participants: *in which technology trend should BearingPoint invest, within the next 3 years, to better advise their customers?*
This technology will be chosen by the experts through dot voting.

- Decide which technology will be further elaborated in the workshop. — 10 min
  When all participants understand the presented technologies, they get some time to decide for themselves which technology they want to explore further in the workshop. The participants

come to the board, where they all have access to two dot stickers. A dot represents a vote. The participants then vote on the technology that they would like to explore in the workshop.

- The facilitator counts the technology that has the most votes. When there are multiple trends that received the most votes, the facilitator will do another voting round through raising hands. If this process takes too long, the facilitator has the overriding vote. — 5 min

Present key question — 15 min
To determine the scope of the scenario planning workshop, a question is defined. Instead of having the participants brainstorm and discuss the key question, the question has been formulated on forehand by the facilitator, based on desk research and consulting experts. The purpose of formulating the key question in advance, is to avoid the risk of devising and choosing a question on which the workshop cannot appropriately expand and to ensure the quality of the workshop. The question must be SMART: specific, measurable, acceptable, realistic, and timed.

The question that will be answered in this workshop is:
Should BearingPoint invest in this technology, within the next 3 years, to better advise their customers?

Identify key (internal) business factors — 15 min
The participants are going to identify a set of key internal business factors that could impact the technology and its adoption into the organisation. Examples of business factors are: customer experience, employee readiness, infrastructure change, supply chain changes, etcetera. Later in the process, the scenarios are based on the most critical factors.

What are the key internal business factors that could affect the technology and the decision whether to invest?

- The facilitator explains the assignment and gives examples of business factors. — 5 min
  Participants may have questions that will be answered by the facilitator.

- Participants individually write down one key business factor per sticky note. — 10 min
  The participants are given 10 minutes to brainstorm key business factors. For each factor they must use a different sticky note.

Identify external forces — 15 min
The participants are going to identify external forces that could impact the technology and its adoption into the organisation. The PEST-analysis is used as a tool to analyze the political, economic, social and technological factors. Examples of external forces are: social unrest, stay-at-home lockdowns, regulatory change, etcetera. Later in the process, the scenarios are based on the most critical factors.

What are the external forces that could affect the technology and the decision whether to invest?

- The facilitator explains the assignment and gives examples of external forces. — 5 min
  Participants may have questions that will be answered by the facilitator.

- Participants individually write down one external force per sticky note. — 10 min
  The participants are given 10 minutes to brainstorm external forces. For each force they must use a different sticky note. They do not have to identify a force for every category (political, economic, social, and technological).

Describe key (internal) business factors — 30 min

- In turn, the participants come forward with their sticky notes. They read them out loud to the group and stick them to the board one by one. Other participants have the opportunity to ask questions about factors that are unclear or need more explanation. — 25 min
- Duplicate sticky notes will be eliminated. — 5 min
  When a participant has the same factor written down that has already been placed on the board by the previous participant, they will not add that duplicate factor to the board.

Describe external forces — 30 min

- In turn, the participants come forward with their sticky notes. They read them out loud to the group and stick them to the board one by one. Other participants have the opportunity to ask questions about forces that are unclear or need more explanation. — 25 min
- Duplicate sticky notes will be eliminated. — 5 min
  When a participant has the same factor written down that has already been placed on the board by the previous participant, they will not add that duplicate factor to the board.

Prioritize factors in impact-uncertainty matrix — 30 min
The internal and external factors that have been identified will be prioritized in the impact-uncertainty matrix, as seen in figure 3. This matrix can identify the critical scenario drivers, which are factors and forces that are essential for success and highly unpredictable. These are the factors that are interesting to use when creating the different scenarios.

- Participants vote on the factors based on impact and uncertainty. — 10 min
  The participants come forward and get access to ∼10 dot stickers per person, representing their vote. The number of votes that they each get depend on the number of factors that must be ranked. They get more or less half the number of votes of the total number of factors. Half of these dots are blue, the other half is red. In the example of 10 dots total, there would have been 20 factors, and they will get 5 blue and 5 red stickers. Blue represents the uncertainty of a factor and red represents the impact of a factor. The participants can vote on the factors that they consider high in impact or uncertainty.
- Facilitator creates final impact-uncertainty matrix on the board. — 5 min
  Based on this dot voting system, the facilitator creates the final impact-uncertainty matrix on the board. This matrix can identify the critical scenario drivers, which are factors and forces that are essential for success and highly unpredictable. These are the factors that should be used to create the different scenarios. Contrary to the impact-uncertainty matrix in figure 3, the matrix in the workshop will be empty, and solely contain the axes impact (low to high) and uncertainty (low to high).

- Determine two most relevant factors — 10 min
  Based on the plot, the group decides which two factors are the most relevant. These are initially the factors that have a high impact and high uncertainty (critical scenario drivers). If the situation occurs that more than two factors are in the right top corner of the matrix (critical scenario drivers), the participants will vote, by raising hands, on the two drivers that they want to further explore. If the situation occurs that there are less than two factors in the right top corner of the matrix, factors from the left top corner (critical planning issues) will be chosen.

- The facilitator plots the two factors on the board. — 5 min
  The facilitator plots the two chosen factors on two uncertainty axes on the board. This creates a matrix. In the following stage, the scenarios will be based on the extremes of these uncertainty axes.

Degree of uncertainty

Level of impact	**Low**	**Medium**	**High**
High	**Critical planning issues** Highly relevant and fairly predictable (can often be based on existing projections). Should be taken into account in *all* scenarios.	**Important scenario drivers** Extremely important and fairly certain. Should be used to differentiate scenarios. Should be based on projections but potential discon-tinuities also should be investigated.	**Critical scenario drivers** Factors and forces essential for success and highly unpredictable. Should be used to differentiate scenario plots and trigger exit strategies.
Med	**Important planning issues** Relevant and very predictable. Should be figured into most scenarios.	**Important planning issues** Relevant and somewhat predictable. Should be present in most scenarios.	**Important scenario drivers** Relevant issues that are highly uncertain. Plausible, significant shifts in these forces should be used to differentiate scenario plots.
Low	**Monitorable issues** Related to the decision focus but not critical. Should be compared to projections as scenario is implemented.	**Monitorable issues** Related but not crucial to the decision focus. Should be monitored for unexpected changes.	**Issues to monitor and reassess impact** Highly unpredictable forces that do not have an immediate impact on the decision focus. Should be closely monitored.

Figure 3: Impact-Uncertainty matrix (Maack, 2001)

Give name to scenarios — 30 min
Based on the two chosen factors, the participants are asked to create four plausible scenarios. These scenarios must be a vivid image of possible futures, that show how different elements might interact under certain conditions (Schoemaker et al., 1995). This part of the workshop is conducted in two groups, as this can stimulate a critical voice.

The scenarios must contain certain aspects:

1. Key issue to be addressed.
2. Stakeholders. Stakeholders are interested in the issues. They can be affected by the issues. Or they can influence them. Stakeholders can be shareholders, customers, suppliers, competitors, etcetera.
3. Critical scenario drivers. These are already defined in a previous stage.
4. Other factors that need to be addressed, and their relationship.
5. Assumptions that are being made.
6. Risks to the scenario.
7. Consequences of the scenario.

- The facilitator will number and divide the four scenarios. — 5 min
  The four scenarios are based on the extremes of the two most relevant factors that were chosen earlier in the workshop. The facilitator maps the four scenarios into the plot of the two critical scenario drivers, that they made in the previous stage. The key issue of each scenario is already known, based on their position in the plot.
- The group is divided in half by the facilitator. — 5 min
  An attempt is made to create two equally diverse groups. The facilitator distributes the four scenarios among the subgroups.
- The subgroups are both asked to create two scenarios, which leaves four in total. — 20 min
  Make sure to define the key issue, and the assumptions that you make. The scenarios should also contain elements such as: risks and opportunities, stakeholders, triggers, and consequences.
  Each scenario is oriented in one of the extreme corners of critical scenario drivers' plot. The scenarios do not have to be perfect. They are to be drawn using outlines and bullet points. The participants received a template, which can be found in Appendix B.1.

  The workshop aims for at least four experts. If there are less than four experts present, the participants give name to the first scenario together and then each of them works out one scenario individually.

Discuss scenarios — 35 min
The experts are asked to reflect upon the four created scenarios in the previous stage. The participants will individually fill in the four scenarios in the impact-likelihood matrix. This matrix compares possible scenarios on two axes: impact (what is the effect of a scenario on the organisation), and likelihood (what is the chance that a certain scenario will unfold). After that, the facilitator will guide the participants in the process of plotting the scenarios on the final impact-likelihood matrix on the structure board, aiming for consensus among the participants.

- The groups shortly describe their scenarios to each other. — 20 min
  The facilitator writes down the headlines of each scenario on the board. This serves as memory support for the following activity.

- Participants individually rank the four scenarios in the impact-likelihood matrix. — 5 min
  At the beginning of the workshop the participants received various materials. One of which a template of the impact-likelihood matrix. The template can be found in Appendix B.2. The participants are given five minutes to rank the earlier created and explained scenarios in the matrix based on impact and likelihood.

- The facilitator guides the participants in the process of plotting the scenarios on the final impact-likelihood matrix on the structure board, aiming for as close to consensus as possible among the participants. — 10 min
  The facilitator asks any expert were they plotted the first scenario. The facilitator then asks the other participants if they agree, or if someone has another thought on where the scenario should be plotted. If the participants do not agree on the position of the scenario, a voting is performed by a raise of hands, where most votes prevail. Based on this voting process, the number of the scenario will be written into the impact-likelihood matrix on the board, by the facilitator. From there on, the other scenarios will also be placed in the impact-likelihood matrix.

Answer key question — 15 min
The experts are given the opportunity to brainstorm and discuss potential next steps for them and their organisation. *What are potential next steps? What would you like to do based on the final impact-likelihood matrix?*

- The experts form duos where they discuss potential next steps. — 10 min

- The duos get the chance to share their opinion with the rest of the group. — 5 min

Questionnaire — 10 min
Before closing the session, the participants are asked to complete a questionnaire. The purpose is to evaluate how they experienced the use of scenario planning in the workshop, and what they think are the advantages and disadvantages of using text mining as input for scenario planning. The participants were asked for their opinion on the methods they use themselves compared to the technology forecasting method of this research, and if they would consider executing the workshop regularly within their organisation.

- The facilitator hands out the questionnaires to the participants. — 1 min

- Participants individually complete the questionnaire. — 9 min
  Their answers are completely anonymous, to assure the quality of the results.

Thank you & closing — 5 min

- Thank all the experts for their participation. Thank other individuals for their efforts in making this workshop possible. — 5 min

4.2.3 Workshop Structure

For the workshop, a board was constructed to fill in the different stages: formulate key question, identify internal and external factors, prioritize the factors based in impact and uncertainty, and create and discuss scenarios. In figure 4, an outline of this structure is shown. The structure board was drawn on different pages of a flip chart in advance, by the facilitator. Due to certain constraints, the workshop that was executed did not use the section intended for internal factors.

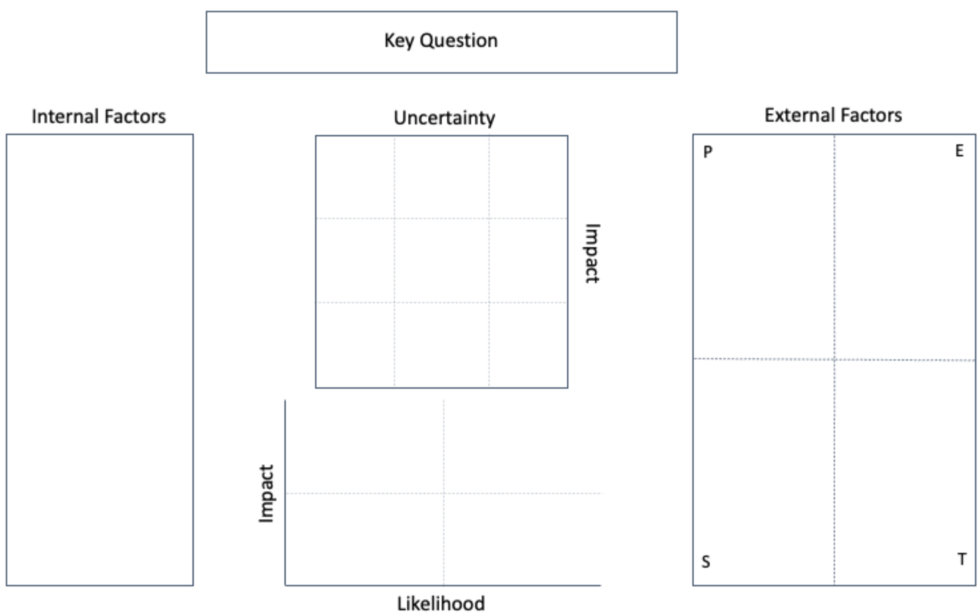


Figure 4: Workshop board structure

4.3 Action Taking

In the action taking phase, trend research was done using text mining, and the workshop was executed. The technology trends that resulted from the text mining process were shown to the experts in their individual interview. Based on their feedback, one trend was chosen to elaborate on in the workshop, using scenario planning to determine the potential of that technology. The experts' behavior was observed during the workshop by an observer. At the end of the workshop, individual questionnaires were conducted among the participants, to evaluate how they experienced the use of scenario planning in the workshop, and what their opinion on using text mining as input for scenario planning as method for technology forecasting. The text mining process and workshop execution, and results are described in this section.

4.3.1 Text Mining Process and Results

This research used text mining to find (emerging) technology trends, which can be presented in the workshop with experts. The text mining process serves as input for scenario planning. The tool that is used for text mining is KNIME. This is an open source platform for data analysis, manipulation and visualization.

Kayser and Blind (2017) summarizes text mining into three steps. The first step is selecting a data source to collect the data, and summarize it to get an overview. Second, is preprocessing of the data. Lastly, the results will be interpreted.

Data Collection

There is a lot of data available on the internet. First, trend reports were selected as input for text mining. It is important to identify the right data sources among the large amount of information. The data was collected from technology trend reports of the last two years, published by large organisations and consultancy firms, as seen in table 4.3. This selection is based on its relevance for trend research, as these reports are likely to contain information about emerging technologies. This selection is made based on personal knowledge and experts' advice.

Company/Publisher	Report name
Accenture	Technology Vision 2021
Accenture	Technology Vision 2022
Deloitte	Tech Trends 2021
Deloitte	Tech Trends 2022
Future Today Institute	2022 Tech Trends Report - 00 Methodology & Frameworks
Future Today Institute	2022 Tech Trends Report - 01 Artificial Intelligence
Future Today Institute	2022 Tech Trends Report - 02 Recognition, Scoring & Privacy
Future Today Institute	2022 Tech Trends Report - 03 Metaverse, AR/VR & Synthetic Media
Future Today Institute	2022 Tech Trends Report - 10 Decentralization & Blockchain
Future Today Institute	2022 Tech Trends Report - 11 Telecommunications & Computing
Gartner	Gartner Top Strategic Technology Trends for 2022
Info-Tech	Tech Trends 2021
Info-Tech	Tech Trends 2022
Kearny	The technology trends set to transform 2022
KPMG	The top 10 tech trends of 2022
KPMG	The top 20 technology sourcing trends of 2021
McKinsey	The top trends in tech
Mediahuis nv.	Journalism, Media, and Technology Trends and Predictions 2022
PWC	The Essential Eight Technologies
Rabobank	Technology Trend Report 2021

Table 4.3: Selected trend reports

Data Preprocessing

Starting of, the trend reports were loaded into KNIME. Tika parser was used to detect the document types and extract the textual data. The strings were then converted to documents and tags were added using the POS Tagger, which assigns a part of speech to each term. After that, the following preprocessing steps were taken:

- Case Converter. The case converter converts all alphanumeric characters to the same format, in this case to lowercase.
- Punctuation Erasure. Punctuation erasure erases punctuation characters of terms.
- Number Filter. The number filter removes all terms that exist of numbers.
- Stop Word Filter. This filter is used to filter all terms, which are contained in the specified stop word list.
- Bag Of Words Creator. All documents are divided into individual terms (tokenization). Before splitting the documents into separate words, a dictionary filter was added. This filters out all terms of the input file. This list of excluded words has bees assembled based on older trend reports that were not used as input for this research. This file contains words such as: page, help, button, next etc.

Frequencies

Text mining brings the challenge of quantifying the importance of terms. After preprocessing of the data, the remaining terms were quantified and interpreted. There are different methods to determine the 'importance' of terms in a document. This research used two different frequency measures explained below:

- TF-IDF. One of the most commonly used technique to give a weight to terms is "term frequency–inverse document frequency" (TF-IDF) (Aizawa, 2003). TF-IDF is a combination of the measures term frequency and inverse document frequency.

  Term frequency measures the number of occurrences of a certain word in a document, to show the importance of a word in that document. Term frequency is calculated by dividing the number of occurrences of a term by the total number of terms in that document. Inverse document frequency measures how rare a term is. This measure takes into account the stop words in a document, by assigning lower weight to frequent words and greater weight for rare words (Qaiser & Ali, 2018). TF-IDF quantifies the significance of a word towards a document in a collection of documents, using the following formula:

  $$W_{i,j} = tf_{i,j} \times \log\left(\frac{N}{df_i}\right)$$

  $tf_{i,j}$ = number of occurrences of i in j
  df_i = number of documents containing i
  N = total number of documents

- Term co-occurence. Term co-occurrence is a frequency measure that counts the number of co-ocurrences of terms. In this case, the neighbor co-ocurrence level was used, which counts the number of times that one term is directly in front or behind another term. It does not matter in what order they occur.

Text Mining Results

After preprocessing the trend report data and quantifying the terms in KNIME, the results were transformed to excel files. These files were loaded into Microsoft Power BI, an interactive tool to analyse and visualize data. This platform was used to visualize the extracted terms so that the results can be clearly presented in the workshop. Terms that are unrelated to technologies were filtered out to get a clearer image.

TF-IDF.

Visualizing the top 80 terms based on on highest Term Frequency-Inverse Document Frequency, resulted in the following word cloud:

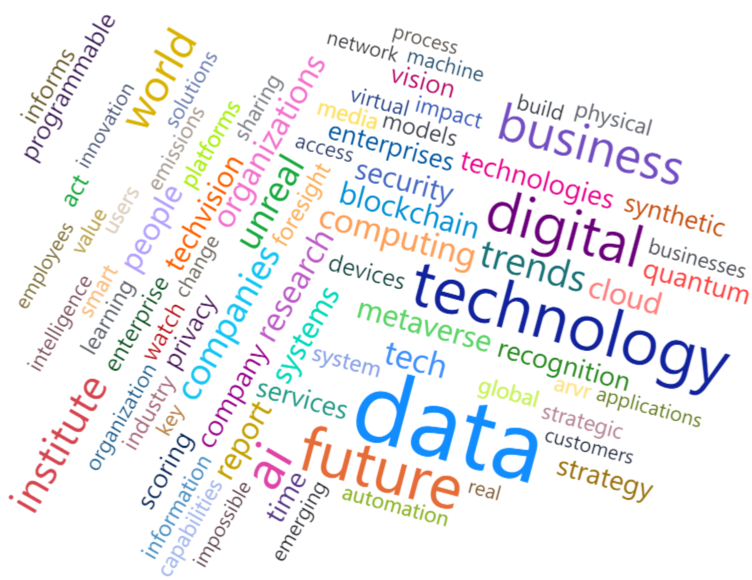


Figure 5: Top 80 TF-IDF wordcloud

The exact term frequencies and term frequency-inverse document frequencies are shown in table 4.4. The terms are sorted in descending order, based on TF-IDF.

Term	**TF absolute**	**TF-IDF**	**Term**	**TF absolute**	**TF-IDF**	**Term**	**TF absolute**	**TF-IDF**
data	1294	389,53	quantum	269	96,58	data-sharing	55	70,33
technology	963	289,89	services	303	95,03	capabilities	203	69,51
future	874	274,1	recognition	210	93,9	arvr	54	69,05
digital	828	249,25	enterprises	193	92,08	strategic	192	68,93
ai	779	234,5	scoring	163	90,11	virtual	201	68,83
business	707	212,83	synthetic	200	89,43	emissions	91	67,37
world	561	175,94	privacy	247	88,68	organisation	214	67,11
institute	475	170,54	vision	222	88,34	build	193	66,09
trends	493	154,61	programmable	154	85,14	key	192	65,75
unreal	144	144	informs	149	82,37	automation	174	65,67
companies	447	140,19	act	204	81,18	businesses	200	65,47
tech	409	128,27	watch	180	80,49	solutions	199	65,14
computing	388	127,02	devices	223	80,06	value	207	64,92
research	404	126,7	enterprise	198	78,79	intelligence	198	64,82
organisations	406	122,22	models	258	77,67	access	198	64,82
people	349	114,25	foresight	137	75,74	change	206	64,61
report	318	114,17	platforms	206	73,96	machine	197	64,49
cloud	357	111,96	learning	225	73,66	emerging	205	64,29
systems	356	111,65	system	215	73,62	real	162	61,14
metaverse	265	111,57	media	194	73,22	applications	194	60,84
blockchain	310	111,3	industry	223	73	network	177	60,61
security	355	106,87	impact	232	72,76	innovation	200	60,21
techvision	82	104,86	users	199	71,45	employees	167	59,96
company	294	100,67	information	226	70,88	impossible	125	59,64
technologies	315	98,79	physical	216	70,71	customers	165	59,24
time	327	98,44	smart	206	70,54	process	186	58,33
strategy	309	96,91	global	215	70,38			

Table 4.4: Terms with the highest term TF-IDF

Term co-occurrence.
Visualizing the top 80 terms based on on highest neighbor co-occurrence, resulted in the following word cloud:

Figure 6: Top 80 neighbor co-occurrence wordcloud

A wordcloud can only show single terms. Table 4.5 shows the top 80 (based on descending neighbor count) combination terms with their neighbor co-occurrence count (NC) and document frequency (DF). Note that the neighbor co-ocurrence level counts the number of times that one term is directly in front or behind another term. It does not matter in what order they occur. The document frequency shows the number of documents that contain the combined terms.

Terms combined	NC	DF	Terms combined	NC	DF	Terms combined	NC	DF
tech trends	185	3	intelligence watch	39	1	digital world	25	4
act strategy	141	1	ai cyber	37	1	metaverse techvision	25	1
technology vision	132	2	mirrored world	36	1	physical world	25	2
learning machine	121	3	stack tech	35	1	action trends	24	1
artificial intelligence	120	4	facial recognition	34	2	blockchain business	24	1
media synthetic	105	1	computing telecommunications	33	1	digital sourcing	24	1
unreal world	102	1	frameworks methodology	33	1	media watch	24	1
computing unreal	85	1	institute metaverse	33	1	physical stack	24	1
report research	81	1	media social	31	3	ai real	23	1
foresight strategic	80	2	privacy watch	31	1	computers quantum	23	3
trust zero	80	2	blockchain watch	30	1	institute methodology	23	1
disruptive impact	65	1	scoring systems	30	1	institute telecommunications	23	1
emerging players	64	1	technology trend	30	1	language natural	23	4
digital twins	60	4	products services	29	4	multiparty systems	23	1
privacy scoring	60	1	report trend	29	1	cloud vertical	22	1
recognition scoring	60	1	emerging trends	28	2	deep learning	22	2
artificial institute	59	1	financial services	28	3	estate real	22	2
computing quantum	59	5	meet metaverse	28	1	augmented reality	21	4
blockchain decentralization	58	1	privacy security	28	3	business technology	21	3
emerging impact	55	1	real time	28	3	data synthetic	21	3
act list	52	1	ai systems	27	1	networks neural	21	3
arvr metaverse	52	1	care health	27	2	ai future	20	3
arvr synthetic	52	1	data privacy	27	3	associate foresight	20	1
decentralization institute	48	1	computer vision	26	3	business processes	20	3
digital transformation	44	4	key questions	26	2	enforcement law	20	1
institute recognition	43	1	recognition systems	26	1	forces macro	20	1
computing edge	41	4	defense real	25	1	science technology	20	1
chain supply	39	4	digital twin	25	3			

Table 4.5: Terms with the highest neighbor count

Based on the document frequency, certain combined terms were excluded from the list proposed in the workshop. The remaining trends have a DF greater than one, with some exemptions. There are results with alternative names. Examples are Artificial Intelligence, Augmented Reality, and Virtual Reality. Some documents use the abbreviations: AI, AR, and VR. These exceptions were examined separately to verify whether the trend itself is mentioned in multiple documents. Besides abbreviations, certain technologies are described in one word, like metaverse. This term is combined with various terms like institute, meet, and techvision. If this was found to be the case then the modified document frequency was used to include or exclude the trend from the final list of (emerging) technology trends. The following table 4.6 contains the resulting technology trends with their modified document frequency, sorted in descending order. Combined terms that do not refer to a technology are excluded (supply chain, social media, products services, financial services, etc.).

Terms combined	DF
artificial intelligence	5
quantum computing	5
augmented reality	4
digital twins	4
digital world	4
edge computing	4
business technology	3
computer vision	3
machine learning	3
neural networks	3
synthetic data	3
tech trends	3
deep learning	2
facial recognition	2
metaverse	2
physical world	2
strategic foresight	2
technology vision	2

Table 4.6: Technology trend results

These results were discussed in the two interviews with consultants of BearingPoint to decide on the technologies that are relevant for their organisation. They both identified a few technologies that stood out above the rest in terms of their interest. These are Artificial Intelligence (AI), with subtrends Machine Learning (ML), Deep Learning (DL) and Neural Networks (NN), and Augmented Reality (AR). For this workshop, the technology trend was chosen in advance, rather than during the workshop. AR was chosen to elaborate on in the workshop using scenario planning. "AR could provide an extra layer of insights, and I think we should do significantly more with that from a consulting perspective". (Participant A, personal communication, May 10, 2022).

4.3.2 Workshop Execution and Results

The workshop was executed June 30, 2022, at the office of management and technology consulting firm BearingPoint. The participants of the workshop are experts working at BearingPoint. There were four participants present at the workshop. The four participants are referred to as participant 1,2,3, and 4.

The executed workshop followed a different timeline than the original drafted outline in section 4.2 Action Planning, due to case constraints. The first change is the duration of the walk-in and introduction of the participants. Since the venue was available earlier, a buffer for attendance was not necessary. The participants, facilitator and observer were present before the starting time. The participants work with each other in the same team, therefore the introduction was kept short.

The second change is the discussion and joint selection of the technological trend. Instead of the participants deciding on the technology trend during the workshop, there was already a trend chosen by experts to further explore during the workshop, using scenario planning. The experts still had input in this decision. However, this had been communicated prior to the workshop through e-mail.

Third, identification of key internal business factors and external forces has been merged into one activity: identify key driving forces. The participants identified a set of key drivers that have an impact on Augmented Reality and the decision whether to invest. The PEST-analysis was used as a guide and direction for the participants. The interpretation of the activity (identify key driving forces) stayed the same.

Lastly, answering the key question was optional. The facilitator asked the participants about potential next steps and what they would like to do based on the resulted scenarios. The question was answered when it appeared that other activities had been run through more quickly. There was no time exclusively scheduled for it. Ten minutes were devoted to talk about potential next steps as there was time for this activity.

Below the workshop is described in three parts. First, the workshop execution is described in detail. Second, The workshop results and observations are described. Last, the questionnaire results are provided.

Workshop Execution

This section gives a detailed description of the workshop executed at BearingPoint, and how it went. Table 4.7 shows the workshop activities with their timeslots.

Time	Activity	Duration
14:00-14:30	Preparations	30 min
14:30-14:35	Walk-in & introduction of participants	5 min
14:35-14:40	Communicate the goal of the workshop & present technology trend	5 min
14:40-14:45	Present key question	5 min
14:45-14:55	Identify key driving forces (PEST-analysis)	10 min
14:55-15:05	Describe external forces	10 min
15:05-15:15	Prioritize factors in impact-uncertainty matrix	10 min
15:15-15:25	Break	10 min
15:25-15:35	Decide two uncertainty axes	10 min
15:35-16:00	Give name to scenarios	25 min
16:00-16:40	Discuss scenarios (impact-likelihood matrix)	40 min
16:00-16:25	Describe scenarios to other participants and facilitator	
16:25-16:30	Individually rank four scenarios in impact-likelihood matrix	
16:30-16:40	Create final impact-likelihood matrix on the board	
16:40-16:50	Answer key question	10 min
16:50-17:00	Complete individual questionnaires	10 min
17:00-18:05	Thank you & closing	5 min

Table 4.7: Executed workshop timeline

All activities, including their actual timeslot, are elaborated below.

- 14:00-14:30 Preparations
  For the workshop, a framework was constructed that could be filled in the different stages: present key question, identify key driving forces, prioritize driving forces in impact-uncertainty matrix, plot two uncertainty axes, generate scenarios, and plot scenarios in impact-likelihood matrix. The outlines of the framework were created prior to the workshop on flipover paper, by the facilitator. At the start of the workshop, the participants received sticky notes and writing materials for the first part of the workshop.

- 14:30-14:35 Walk-in & introduction participants
  The workshop started at 14:30. Participants were all seated by then, and the facilitator and observer got the chance to shake hands with participants and introduce themselves. This led to the introduction of the workshop and the agenda.

- 14:35-14:40 Communicate goal of the workshop
  The walk-in and introduction went quite fast. This allowed for an explanation of the goal of the workshop starting at 14:35. The goal of the workshop was to further explore Augmented Reality (AR) through scenario planning, determining the advantages and disadvantages of the proposed technology forecasting method.

For this workshop, the trend Augmented Reality was elaborated. After communicating the goal, AR was explained, and some practical examples were mentioned by the facilitator and the participants to stimulate the thought process.

- 14:40-14:45 Present key question
  To determine the scope of the scenario planning workshop, a question was defined. Instead of having the participants brainstorm and discuss the key question, the question was formulated on forehand by the facilitator, based on desk research and discussion with experts. The purpose of formulating the key question in advance, is to avoid the risk of devising and choosing a question on which the workshop cannot appropriately expand, and to ensure the quality of the workshop. The key question of the workshop was: *should BearingPoint invest, within the next 3 years, in Augmented Reality to better advise their customers?*

- 14:45-14:55 Identify key driving forces
  This activity started at 14:45, five minutes earlier than planned.

  The participants identified a set of key drivers that have an impact on Augmented Reality and the decision whether to invest. The PEST-analysis (Political, Economic, Social, Technological) was used as a guide and direction for the participants. The facilitator explained the assignment, and asked the participants: *what are the key drivers that could affect Augmented Reality and the decision whether to invest?* The timer was set on the board to 15 minutes, by the facilitator. The original timeline scheduled five minutes for explanation of the activity and ten minutes for the participants to individually brainstorm and identify key driving forces. As the workshop was moving faster than planned, there was confusion about this on the facilitators' part. After ten minutes, all participants indicated they had finished writing down relevant factors, and the facilitator stopped the timer.

- 14:55-15:05 Describe driving forces
  In turn, the participants came forward with their sticky notes (participant 3,2,4,1). They read the factors and explained them in one sentence, and sticked them to the board. The factors were categorized by political, economic, social, and technological factors. There were similar factors, but no matching sticky notes.

  There was a consensus among the participants. Therefore, the activity moved at a higher pace than originally planned.

- 15:05-15:15 Prioritize driving forces
  The beginning activities moved faster than planned. The break was therefore pushed back 20 minutes. Instead, participants first voted on the identified factors based on their impact and uncertainty.

  The participants came forward and got access to 10 dot stickers per person. These contained 5 blue dot stickers and 5 red dot stickers, which represented their vote. Blue represents the uncertainty of a factor and red represents the impact of a factor. The participants were able to vote on the factors that they consider high in impact or uncertainty, by putting a dot sticker on that sticky note. After voting, these factors were plotted in the impact-uncertainty matrix on the board. The voting process took longer than anticipated. Since other activities were more time consuming, this transitioned well.

- 15:15-15:25 Break
  During the ten minutes break, the facilitator filled in the impact-uncertainty matrix on the board, based on the participants' votes. This matrix can identify the critical scenario drivers, which are factors and forces that are essential for success and highly unpredictable.

  Before continuing the workshop, the participants all received a template to write their scenarios and a template of the impact-likelihood matrix. These materials were necessary for the second part of the workshop.

- 15:25-15:35 Decide two uncertainty axes
  As soon as the participants were back in their seats, they asked the facilitator how the matrix was completed. The matrix was filled in by placing the factors in area 'low', 'medium' or 'high' impact/uncertainty. A factor is placed low when there are zero votes, medium when there were one or two votes, and high when there were three or four votes. Due to time, not all factors were placed in the matrix during the workshop. The factors that received enough votes to be considered relevant were plotted in the matrix.

  After dot voting, there were no factors with high impact and high uncertainty, and no factors with high impact and low uncertainty. Therefore, two important scenario drivers were chosen, which can have medium impact and high uncertainty, or high impact and medium uncertainty. This was done through voting by raising hands. The facilitator asked the participants to think briefly about the two factors that they considered most relevant. Then the participants were able to vote for the two uncertainties they preferred to use as foundation for the scenarios, by raising their hand. Most votes prevailed. This resulted in axes of: digital world versus physical world and reinforced privacy regulations versus no reinforced privacy regulations.

  The facilitator wrote down these two uncertainties on the axes and wrote down the numbers one to four, representing the four scenarios. Before starting the next activity, the facilitator explained the uncertainty axes and how they form the basis of the scenarios.

- 15:35-16:00 Give name to scenarios
  This activity started ten minutes earlier than planned at 15:35.

  The group was divided in duos by the facilitator, both duos were assigned two scenarios to write out in more detail. Participant 1 and 2 worked on scenario 2 and 3, participant 3 and 4 worked on scenario 1 and 4. The participants were told that a scenario must be a vivid image of the future, written in outlines and bullet points. The scenarios must contain the key issue, assumptions that they made and elements such as: other relevant factors, stakeholders, triggers, and consequences.

The facilitator started the 20 minute timer on the board and both duos start discussing the uncertainties and their impact. They both ask their partner questions to get a clear image. After a few minutes participant 1 wonders if their scenario is realistic, or if they should think less outside the box. They start making assumptions. The facilitator then notices that the axis (no) reinforced privacy regulations is not clear to everyone, and explains to make sure all experts understand the scope of the scenarios.

- 16:00-16:40 Discuss scenarios
  This activity started at 16:00, ten minutes earlier than planned and lasted till 16:40, five minutes longer than planned. The discussion of the scenarios existed of the following three activities:
  16:00-16:25 Describe scenarios to other participants and facilitator.
  16:25-16:30 Individually rank four scenarios in impact-likelihood matrix.
  16:30-16:40 Facilitator guides participant to create the final impact-likelihood matrix on the board.

  One by one the participants explained their scenarios to the rest of the group. This led to discussion, additions, and clarification of all four scenarios. After the participants all understood the scenarios, they were given five minutes to individually rank the four scenarios in the impact-likelihood matrix template they received earlier.

  Before discussing the ranking of the scenarios and the impact-likelihood matrix with the group, one of the participants had to leave a few minutes early. The facilitator thanked the expert for their participation and continued the workshop with the other three participants. The facilitator asked one of the participants where they ranked the first scenario, and asked the other participants whether they agree or if someone has another thought on where the scenario should be plotted. All participants got the opportunity to share their opinion. This was repeated for the other three scenarios. The facilitator guided the participants to come to a consensus, or as close to consensus as possible.

- 16:40-16:50 Answer key question
  The final impact-likelihood matrix was discussed in the group, and potential next steps were considered. While presenting the scenarios to each other, in the previous activity, participants were already addressing how scenarios could be relevant within their organisation and how to implement this in practice. The participants discussed next step, now that possible scenarios are defined, and their impact and the chance that they will occur are determined.

- 16:50-17:00 Questionnaire
  The questionnaires were handed out by the facilitator and participants began to write down their reflections.

- 17:00-17:05 Closing
  The facilitator thanked the participants for their time and active participation in the workshop. There was still a conversation going about the usefulness of the workshop and how the experts can repeat the process in their organisation and with their clients.

Workshop Results

During the workshop, an observer was present. The role of the observer was to annotate events and behavior of the participants and the facilitator. The observer received a detailed briefing and an Excel template to fill in their observations. This briefing is included in Appendix E.1. The original file containing observations can be found in Appendix E.2.

This section show the results/outcome of the workshop per activity. For each activity with an explicit goal, the results are examined. These are interpreted and compared to each other. In addition, the observer's and facilitator's observations are linked to this information.

- 14:35-14:40 Communicate goal of the workshop
  The participants had a lot of questions about the goal of the workshop. Most of them had not worked with scenario planning before and found the concept hard to grasp.

- 14:40-14:45 Present key question
  The key question was: *should BearingPoint invest in Augmented Reality, within the next 3 years, to better advise their customers?*. Clarification of the question was required by two participants. They wondered if the question is about investing in the adoption of AR or bringing the knowledge in-house. The answer is that it could be both. They do not have to have a yes or no answer at the end of the workshop. The goal was to create scenarios and discuss potential next steps for BearingPoint from there on. "I am excited to see the outcome". (Participant 1).

- 14:45-14:55 Identify key driving forces
  The participants identified a set of key drivers that have an impact on Augmented Reality and the decision whether BearingPoint should invest in this technology. The PEST-analysis (Political, Economic, Social, Technological) was used as a guide and direction for the participants.

  Participant 1 immediately started writing down multiple factors. Participant 4 seemed distracted by this and expressed difficulty in retrieving knowledge about the PEST-analysis and how it should be used. The facilitator briefly explained and reassured them that it is not about the amount of factors and that there is plenty of time to brainstorm. The other participants added to the clarification of the PEST-analysis. All participants then understood how to approach the assignment and started brainstorming important driving forces. Their tables started filling up with sticky notes containing the different factors. They ended up with a total of 23 sticky notes.

- 14:55-15:05 Describe driving forces
  In turn, the facilitator pointed out one participant to come forward with their sticky notes. They read them out loud to the group, explained the driving force in one sentence, and stuck the sticky notes to the board one by one. This resulted in the scheme in figure 7. In this figure, not all factors are plotted. Factors with the same intention are merged into one sticky note to give a clear overview of the results. The original scheme was photographed and can be found in Appendix D.1.

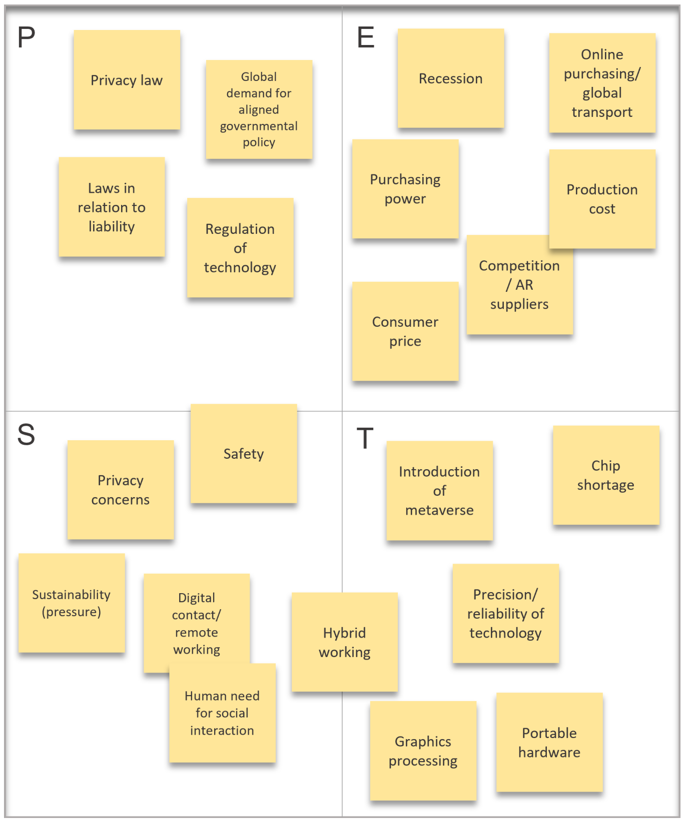
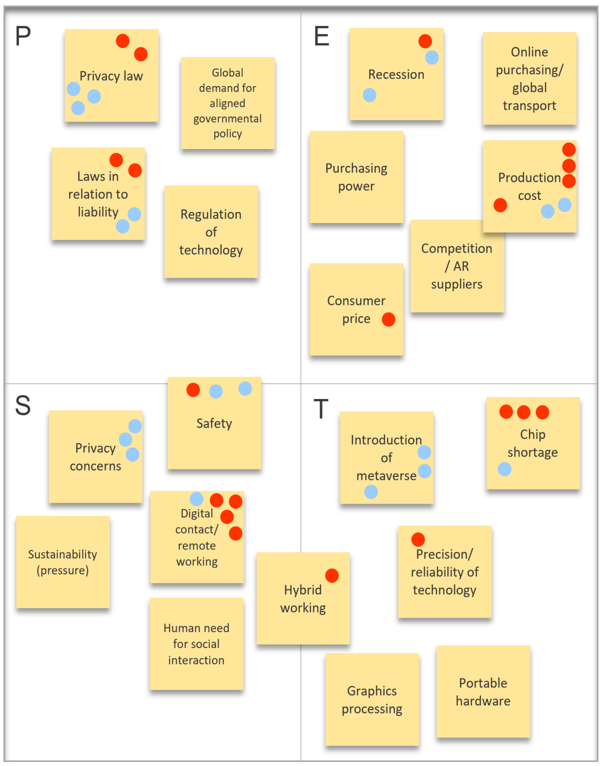


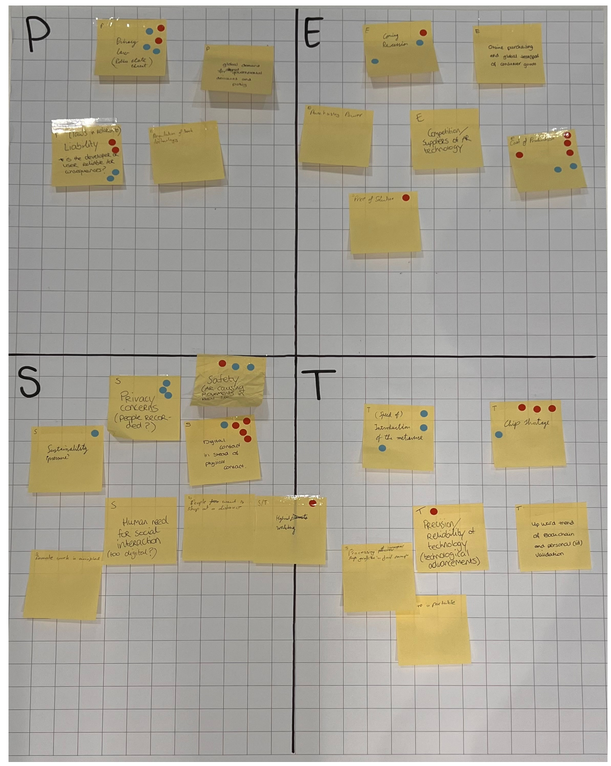
Figure 7: Identify driving forces

The participants came up with 23 sticky notes containing different factors. No significant unclarities or observations were noted during this activity.

- 15:05-15:15 Prioritize driving forces
  The facilitator explained the dot voting process and handed the participants five blue dot stickers and five red dot stickers, which represent their votes. Blue represents the uncertainty of a factor and red represents the impact of a factor. The participants were able to vote on the factors that they consider high in impact or uncertainty. This resulted in the scheme in figure 8a. In this figure, not all factors are plotted. Factors with the same intention are merged into one sticky note to give a clear overview of the results. The original scheme is added in figure 8b.



(a) Prioritized driving forces



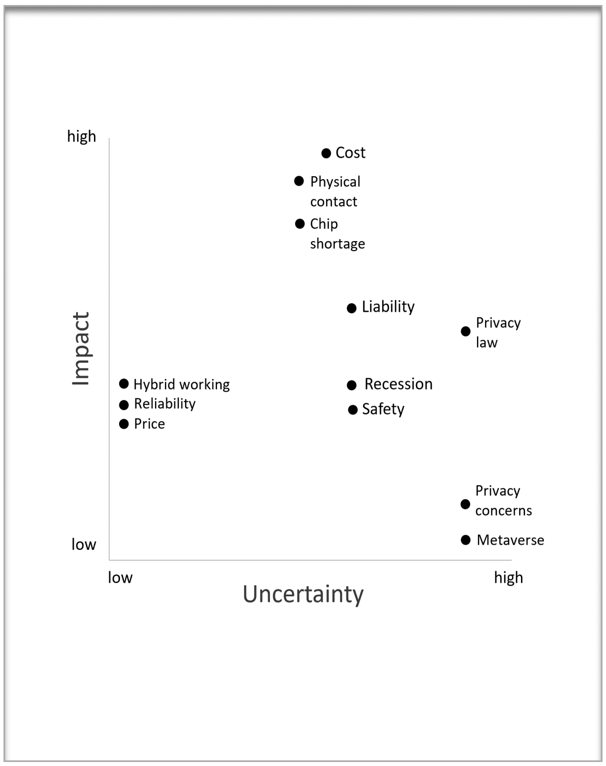
(b) Original prioritized driving forces

Figure 8: prioritize driving forces

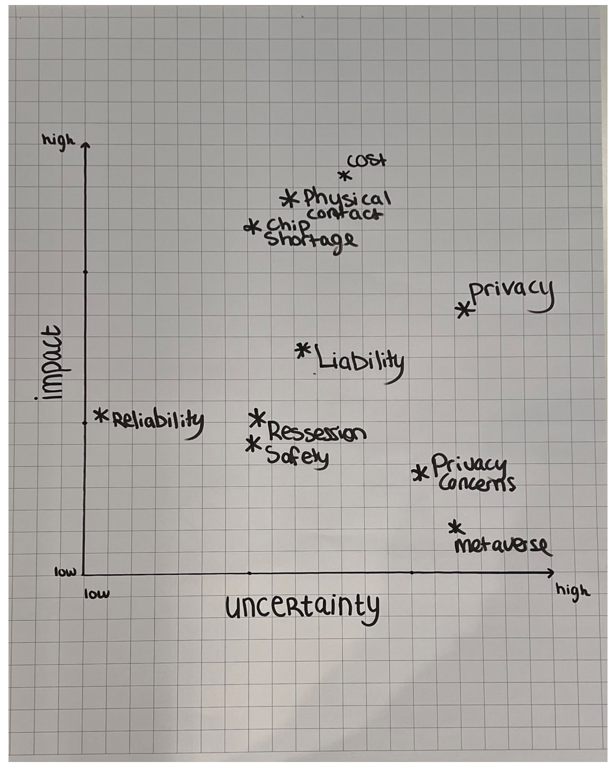
All participants were standing in front of the board to vote at the same time. The participants started with the red dots to determine the factors with high impact. They had more difficulty determining the uncertainty than the impact. After a few minutes, participant 2 remarks that none of them thought about safety, even though they found it to be an important factor. Participant 4 pulled out a crumpled sticky note with the word 'safety'. They asked the facilitator if they could still add this note to the board, to which the answer was yes, leaving a total of 24 sticky notes on the board.

Eventually, the participants resolved their difficulty of determining the uncertainty of factors by discussing this with each other.

- 15:25-15:35 Decide two uncertainty axes
  After dot voting, there was a 10-minute break. During the break the facilitator completed the impact-uncertainty matrix on the board, based on the participants' votes. A factor was placed low when there were zero votes, medium for one or two votes, and high for three or four votes. Due to time, not all factors were placed in the matrix during the workshop, which can be seen in figure 9b. On the matrix in figure 9a, all factors that were voted on are included to give a more complete picture. The remaining factors did not receive any votes, and belong in the lower left corner with low impact and low uncertainty. Factors with the same number of votes are clustered in the same area: low, medium or high.



(a) Impact-uncertainty matrix



(b) Original impact-uncertainty matrix

Figure 9: Impact-uncertainty matrix

In the final impact-uncertainty matrix there were no factors with high impact and high uncertainty, and no factors with high impact and low uncertainty. Which means, there were no factors located in critical scenario drivers or critical planning issues, as shown in figure 3. Therefore, two important scenario drivers were chosen, which can have medium impact and high uncertainty, or high impact and medium uncertainty. Voting was done by a raise of hands. The facilitator asked the participants to think briefly about the two factors that they considered most relevant. Then the participants were able to vote to the two uncertainties they preferred to use as foundation for the scenarios, by raising their hand. Most votes prevailed. This resulted in axes of: digital contact versus physical contact and reinforced privacy regulations versus no reinforced privacy regulations, as seen in figure 10. The original uncertainty axes are included in Appendix D.3

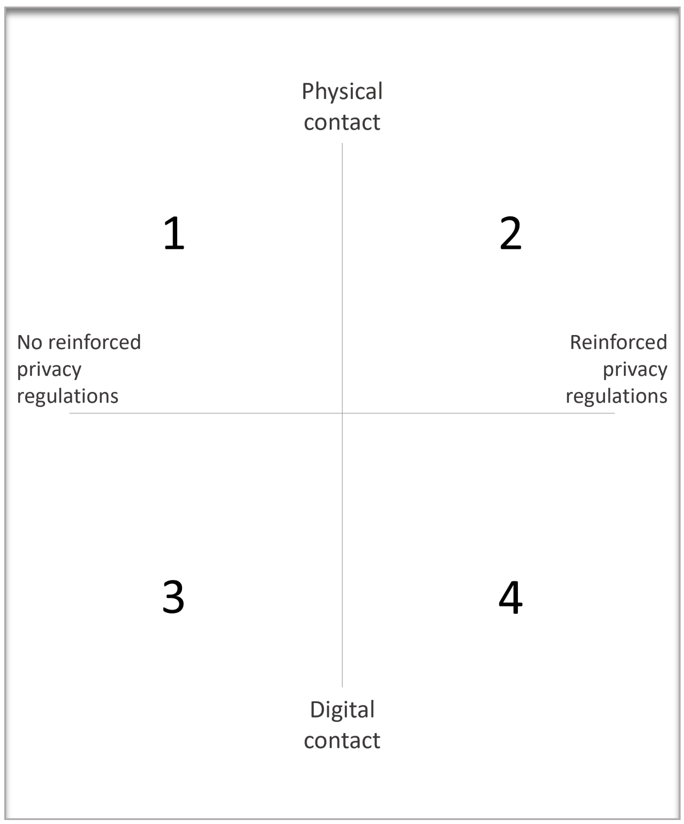


Figure 10: Scenarios based on uncertainty axes

- 15:35-16:00 Give name to scenarios
  When the participants heard about the scenarios they were going to create, they expressed concerns about their approach. The further along in the process, the more confident they became and the better it went. Filling out the scenarios went pretty smoothly. Some participants indicated that the scenarios occurred naturally as the two axes of uncertainty were completed. This provided guidance.

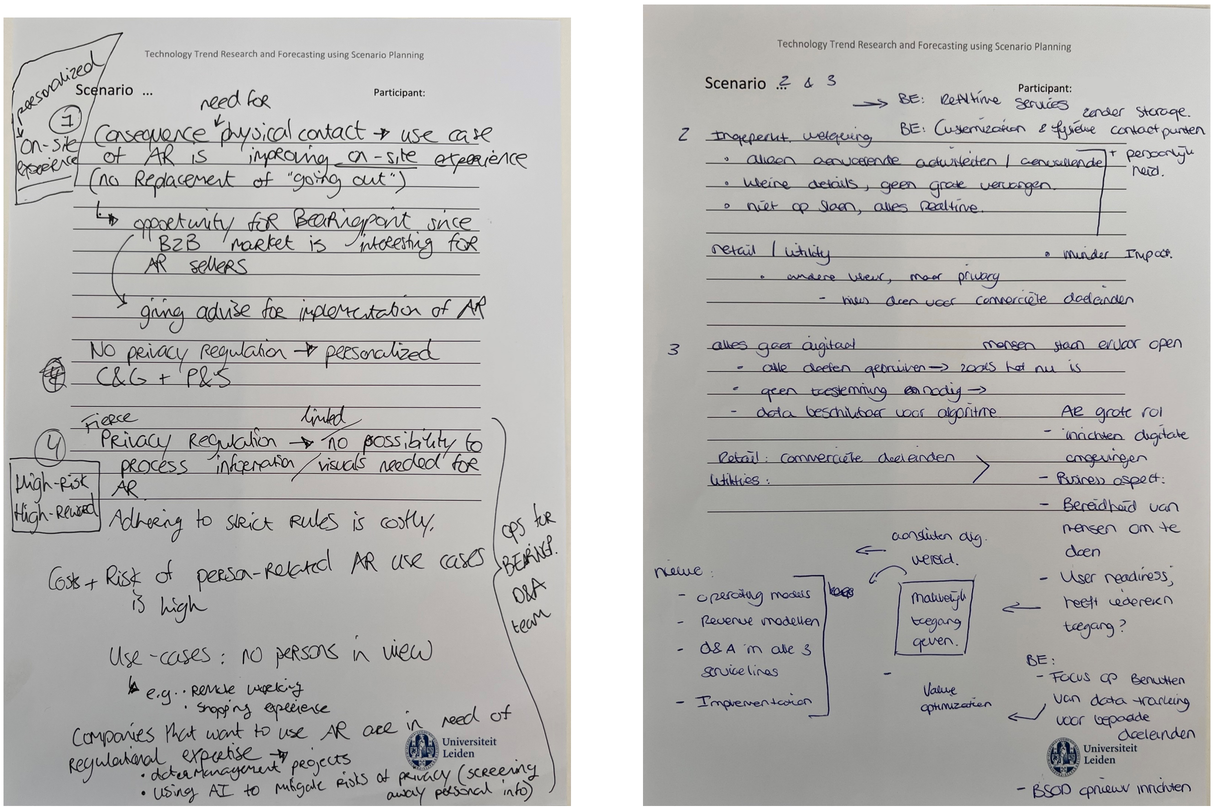


Figure 11: Scenarios created in workshop

There was confusion about the axis (no) reinforced privacy regulations. This was written down on the board, by the facilitator, as (no) privacy regulations. One participant thought that this meant that there were no guidelines concerning civilians' privacy at all. In figure 10 this axis was redefined to avoid confusion. The original axes are included in Appendix D.3.

Participant 1 indicated at the start of the workshop that they had to leave for half an hour at 15:45. They came back after three minutes due to cancellation of the meeting.

- 16:00-16:40 Discuss scenarios
  This activity started with the participants describing their scenarios to each other. Participant 1 and 2 formed a duo, working on scenario 2 and 3. Participant 3 and 4 formed a duo, working on scenario 1 and 4.

The discussion of the scenarios existed of the following three activities:
16:00-16:25 Describe scenarios to other participants and facilitator.
16:25-16:30 Individually rank four scenarios in impact-likelihood matrix.
16:30-16:40 Create the final impact-likelihood matrix on the board.

16:00-16:25 Describe scenarios to other participants and facilitator.
Participant 3 leaves the room for a minute to answer a call. Their partner (participant 4) starts explaining their first scenario (scenario 1) to the others. The duos take turns elaborating their scenarios. They comment on each other, ask questions, and complement each others descriptions. It turns into an open conversation among all participants, and they seem to be on the same page in terms of possibilities for their organisation.

Along the way, the experts thought of the following headlines/titles for the scenarios, which were written down by the facilitator. The scenarios and their titles are shown in table 4.8.

Scenario	**Title**	**Participants**	**x-axis**	**y-axis**
1	Personalized onsight experience.	3 & 4	No reinforced privacy regulations	Physical contact
2	Addition instead of replacement.	1 & 2	Reinforced privacy regulations	Physical contact
3	Unlimited possibilities.	1 & 2	No reinforced privacy regulations	Digital contact
4	High risk. High reward.	3 & 4	Reinforced privacy regulations	Digital contact

Table 4.8: Scenarios created in workshop with headlines

It is being noted that the experts are quite positive about the possibilities that Augmented Reality offers for BearingPoint and their customers.

16:25-16:30 Individually rank four scenarios in impact-likelihood matrix.
During the break, the participants all received a template of the impact-likelihood matrix. The experts were given five minutes to individually rank the four scenarios. Participant 3 asked clarification of the matrix, and what impact is being referred to. The matrix refers to the impact of the issue and the likelihood of investing in the trend.

16:30-16:40 Create the final impact-likelihood matrix on the board.
Participant 3 had to leave the workshop at this point. The others continued the activity. The facilitator guides the participants to fill in the final impact-likelihood matrix on the board. The confusion about (no) reinforced privacy regulations was addressed by the facilitator to make sure all participants fully understood the scenarios.

An open discussion began among the participants, guided by the facilitator. This resulted in a matrix where the scenarios are plotted relatively to each other. This process resulted in the matrix in figure 12. The photographed matrix is added in Appendix D.4. The dotted arrow from scenario 4 suggests that this scenario will probably be more likely to happen in the nearby future.

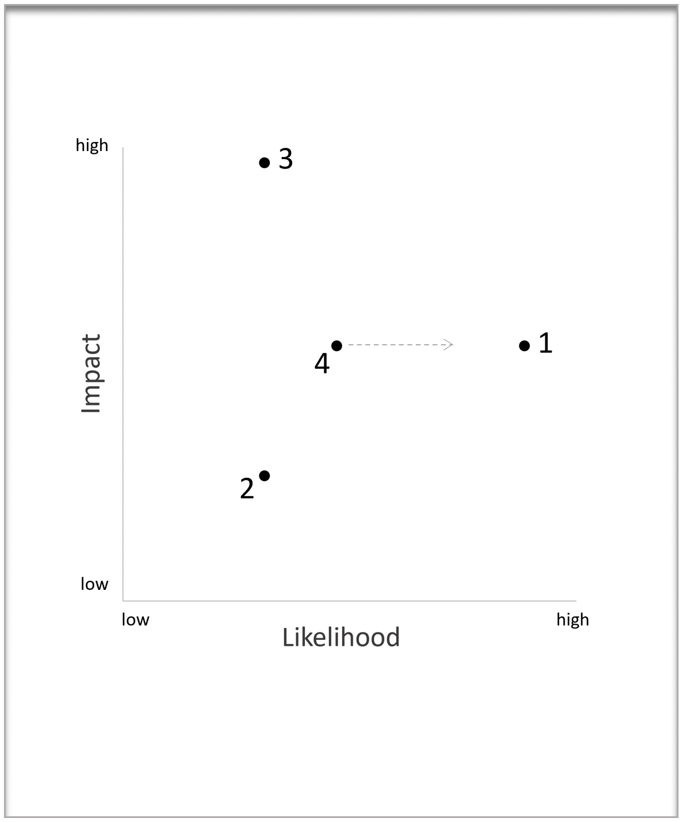


Figure 12: Impact-likelihood matrix

- 16:40-16:50 Answer key question
  The experts discussed the scenarios and the final plot. They thought of practical implementations for BearingPoint and came to consensus on the next steps: invest on user behavior and relate different scenarios at different customers.

- 16:50-17:00 Questionnaire
  The questionnaires were handed out by the facilitator and participants began to write down their reflections. During this activity, participants give their compliments to the facilitator. Two participants asked more information about the text mining process of the research. The facilitator explains more about the research, while the others continued completing the questionnaire.

Questionnaire Results
This section provides the questionnaire results. The questionnaire itself is included in Appendix C. All four experts that participated in the workshop completed the questionnaire.

Workshop Experience
Overall the participants had a positive experience of the workshop. They found the systematic approach of scenario planning useful and effective. Starting of, they had some difficulty diving into the topic Augmented Reality, but the scenario planning process proved useful and effective: "at first it it was difficult to dive into this topic, but along the way the ideas started flowing thanks to this method" (Participant, questionnaire, June 30, 2022). All participants answered yes to the question whether they would organize this workshop themselves.

Method
Not all participants were available for interviews prior to the workshop. They received information through e-mail about the workshop, shortly explaining the role of text mining and scenario planning. Most participants did not know enough about the text mining process of this research to form an opinion on the method. One of the experts thought text mining to be a decent method for initial exploration of trends, but would augment it with human research. They found a disadvantage of text mining that it is typically best at recognizing single words, which means trends that are not captured in a single term might be missed.

The workshop used scenario planning as a method for predicting and anticipating trends. The scenario planning process was experienced positively. The experts found the structure to be clear, having a step-by-step process. These steps force a critical analysis of possible futures. They refer to the workshop method as: "straight forward, easy to use, with great impact/result in a short amount of time" (Participant, questionnaire, June 30, 2022).

The experts identified the following improvements of the workshop method. First, when important key driving forces are not identified in the first part of the workshop, other important factors may be overlooked/forgotten. Second, based on the key driving forces, two critical scenario drivers are identified. These factors are plotted on two uncertainty axes, on which the scenarios are based. Using only two factors may cause other relevant factors to be missed in the scenarios. Last, the scenario planning process guides in structuring thoughts, but it does not contain a structure on how to approach the different scenarios after they are created.

Not all participants were aware of their current technology forecasting methods. Others said their current methods consists of reading up on trends by keeping track of online sources such as Gartner, HBR, and Scientific American. The participants found the method of the workshop much more structured and insightful, thus very helpful. They also referred to the scenario planning process in a group setting as more applicable and effective, setting the scene for an adoption or adjustment of actual practices.

4.4 Evaluating

This section reflects upon the research processes and results. Focus lies on areas of improvement concerning the text mining process and the scenario planning workshop. The evaluation is based on observations and experts' feedback provided in the questionnaire, linked to existing literature. This sections reflects upon the research questions in order to evaluate the action research.

4.4.1 Text Mining as Input for Scenario Planning Workshop as TF Method

The barriers and benefits of applying text mining as input for scenario planning are discussed below.

Barriers to applying text mining as input for scenario planning
Data validity: Although the number of technology trend reports collected in this research was deemed appropriate, a larger dataset could have positive effects on the accuracy of the text mining process. Additionally, These datasets can have different sources than solely trend reports. For example: (white) papers, social media, fora. An important factor of using open platform data is determining the validity of the information. Therefore, a strict selection process has to be implemented when using these different data sources. The challenge in this research was selecting the trend reports through desk research, resulting in a non-repeatable process. The text mining model could be improved by automatically selecting the sources of data, making the process repeatable and testable (Walk, 2012).

Depth of data: The collected trend reports used in this research identified trends on different levels: global trends and subtrends. An example is that Artificial Intelligence can be seen as the umbrella term for other technologies like Machine Learning, Deep Learning, and Neural Networks. "They are not complete subsets of one another, but there is a lot of coherence." (Interviewee B, personal communication, June 9,2022). The results gained from the text mining process were therefore not in the desired format to use as input for the scenario planning workshop. In this case, additional desk research was done to identify subtrends of the technology trend presented in the workshop.

Availability of data: Many of the activities in technological development are not recorded in journals, conferences or papers in a timely manner (Watts et al., 1998) resulting in a gap between technological developments and identifying developments as an upcoming trend. Although there was no notable effect in this research of the gap between development and identification, this method of data collection and analysis makes it difficult for early adopters to identify trends in its infancy. The development of a new technology goes through several stages, shown in Gartner's Hype Cycle. The Hype Cycle is a representation of the progression of an emerging technology based on visibility (hype) and maturity (Linden & Fenn, 2003; Blosch & Fenn, 2018), as seen in figure 13. This research did not take into account the position of a technology on the Hype Cycle of Gartner.

Figure 13: Gartner's Hype Cycle (Linden & Fenn, 2003)

Trend interpretation: A constraint of text mining in this research is that it processes textual data and ignores figures and other meaning within a document (Kayser & Blind, 2017). By solely measuring the frequency of trends in trend reports, the context cannot be determined. Additionally, the frequent technology trends were interpreted by the researcher and the experts during the interview, which makes it prone to bias.

Self fulfilling prophecy: This research collected data from trend reports published by large organisations and consulting firms. There is a possibility that these technologies are becoming trends solely because these organisations are talking about them, instead of emerging trends being identified. A so called self fulfilling prophecy. One of the participants found text mining to be a decent method for initial exploration of trends, but that it should be augmented with expert opinion(s) (Participant, questionnaire, June 30, 2022).

Synonyms: When designing the text mining model in KNIME abbreviations and synonyms for trends were not considered. For example: AI, AR, and VR were changed to Artificial Intelligence, Augmented Reality, and Virtual Reality respectively. Only after executing the text mining process, the results were analysed by hand by the researcher and connections between abbreviations and full terms were made. To increase validity of the text mining process, a dataset of full terms and abbreviations should be used to eliminate manual work and possible human errors. This is especially true for a text mining process with a larger dataset than 20 technology trend reports. If this research were to be repeated, synonyms should be considered at forehand to eliminate researcher bias.

Benefits to applying text mining as input for scenario planning

Term co-occurrence: One of the participants noted that text mining typically prevails in identifying single terms: "Text mining is typically best at recognizing single words/small collections of words so trends that are not captured in a single term might be missed." (Participant, questionnaire, June 30, 2022). For this reason, term co-occurrence was used as a frequency measure in the text mining process. Contrary to single term frequency measures, term co-occurrence considers term dependencies. The advantage of term co-occurrence analysis is that the information is all derived from the documents without the need for human intervention (Buzydlowski, White, & Lin, 2002), which makes it scalable and less prone to human bias. The text mining results of this research were therefore viewed by the experts as appropriate input for the qualitative scenario planning workshop.

Fast trend identification: As mentioned by Walk (2012), quantitative TF methods such as text mining can be automated and scaled. Therefore, this method allows for a systematic and repeatable process that: "Reduces the time needed for trend identification to the time needed to collect articles". (Participant, questionnaire, June 30, 2022).

Less biased: Although a text mining process is as reliable and valid as the designer of the model, it is fully transparent as the process can be repeated and tested. As stated by Rossini (1987), text mining is not a forecasting method on its own. However, due to its unbiased nature it does provide a grounded input for a qualitative TF method like scenario planning. "It is a decent way to get some initial thoughts on what to look for..." (Participant, questionnaire, June 30, 2022).

4.4.2 Scenario Planning Workshop as TF Method

The barriers and benefits of applying scenario planning for technology forecasting methods are discussed below.

Barriers to applying scenario planning for TF
Dependent on experience of participants: In this case, the participants of the workshop consisted of four consultants with a varying degree of experience. For future scenario planning workshops it can prove useful if all participants have a predefined minimum degree of experience. More experienced participants could have contributed to a smoother process. In the case of the executed workshop, the observer noted that the basic knowledge provided by the facilitator has proven helpful in guiding the participants through the scenario planning process. In the beginning of the workshop, participants were looking for reassurance. As the workshop progressed, the process of scenario planning and the aim of the workshop became more clear.

Iterative process: A Scenario planning process contains various steps. One of the first stages in this process is identifying key driving forces. A barrier of this process is when certain relevant factors are not addressed during this stage, they may be overlooked in a later stage of the scenario planning process. A solution is to add an iterative approach. The iterative approach allows the participants to add key driving forces that are identified in a later stage. However, adding key driving forces is limited to the stage where scenarios are named.

Opinions may be influenced: One of the participant suggested in their questionnaire to anonymize the voting activities in the workshop: "first anonymously vote, then discuss and give people the opportunity to change their vote." (Participant, questionnaire, June 30, 2022), as done with the Delphi method. The Delphi method is commonly used for technological surveys (Martino, 1980). Delphi uses opinions of experts anonymously, discusses this in the group, and enables participants to reconsider their earlier opinion (Linstone et al., 1975; Yoon & Park, 2007). For this workshop an explicit choice has been made to open the discussion among the participants. The strength of scenario planning in a group setting lies in combining the expertise of multiple individuals, resulting in various scenarios, and implications and potential next steps for their organisation. A barrier is that the experts' opinions can be influenced by others. To limit this barrier, the activities start with an individual assignment, before discussing with the group.

Benefits to applying scenario planning for TF

More specific forecasts. Scenarios go further than most TF methods, due to its qualitative nature. Contrary to most technology forecasting methods, scenario planning takes uncertainties into consideration, resulting in more specific and in depth forecasts (A. L. Porter, 2010; Postma & Liebl, 2005). Scenarios have the ability to represent the perspective of different stakeholders and experts (Alcamo, 2008).

Structured approach: The goal of this research was to develop, implement and validate an improved technology forecasting method that provides a systematic and repeatable approach. The participants found the process of scenario planning to have a clear structure due to the step-by-step process: "these steps force a critical analysis of possible futures." (Participant, questionnaire, June 30, 2022).

Fast results. The participants indicated that they found the workshop useful, in terms of impact, effectiveness, insights, and results. The scenario planning workshop offers an immediate outcome that can help an organisation decide on their next potential steps. "It has a great impact and result in a short amount of time." (Participant, questionnaire, June 30, 2022).

Repeatable process: One of the participants commented that the number of created scenarios in the workshop was limited by two uncertainty axes. They asked if this approach was a simplified version of a scenario planning method. However, earlier research recommends restricting the number of scenarios because of cognitive limits (Drew, 2006). A maximum of four is suggested to avoid confusion, but still be sufficient (Schnaars, 1987). As the reality is more complex than a two axes model, the workshop should be repeated regularly over a longer time span (every few months). This approach is aligned with the goal of this research to develop a systematic approach with concrete steps that could easily be repeated within the organisation.

Improved TF method: Most participants thought the scenario planning workshop to be more applicable and effective than their current TF method. "It sets the scene for an adoption or adjustment of actual practices." (Participant, questionnaire, June 30, 2022). More specifically, they found the insights "more grounded, and less based on random assumptions." (Participant, questionnaire, June 30, 2022). "The used methodology proved to be effective for creating and assessing scenarios." (Participant, questionnaire, June 30, 2022).

4.4.3 Specifying Learning

The observations during the workshop and the questionnaire results showed that there were some unclarities about the individual workshop activities among the participants. The questionnaire contained eight statements on the workshop structure, to be answered on a 5-point Likert scale of strongly disagree to strongly agree. Figure 14 shows the results of these statements regarding the structure of the workshop. The horizontal axes shows the number of experts that voted for a certain category.

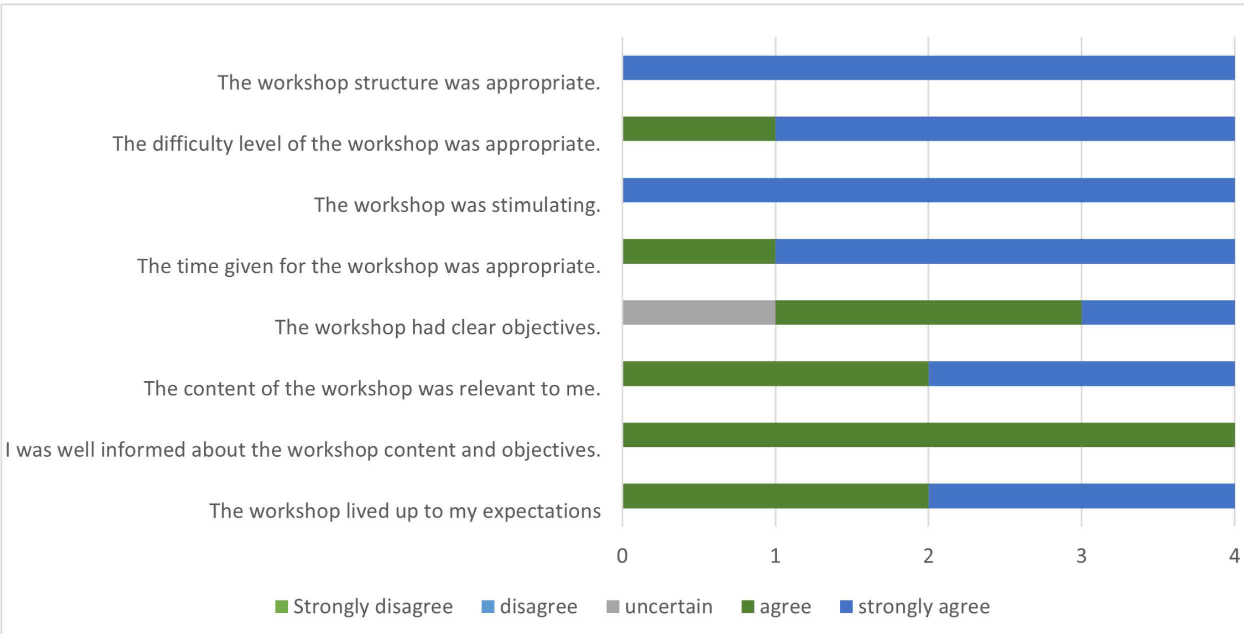


Figure 14: Workshop structure - questionnaire results

One of the participants indicated, based on statement 5 'the workshop had clear objectives', that sometimes there was lack of clarity. They suggested to, occasionally, remind the audience of the scope of the exercise to work towards a goal. Others indicated that there was confusion at certain steps in the process, but that it all came together eventually. "Ideas started flowing, thanks to this method". (Participant, questionnaire, June 30, 2022). For future workshops the facilitator must make sure all participants completely understand the process before starting the scenario planning process. This could improve the results of the workshop. Additionally, it could be useful to add a roadmap of the workshop process on the provided slides. This allows for the participants to see the bigger picture, which step of the process they are currently working on, and what they are working towards.

Figure 15 shows results of statements regarding the insights gained from the workshop, to be answered on a scale of strongly disagree to strongly agree. The horizontal axes shows the number of experts that voted for a certain category.

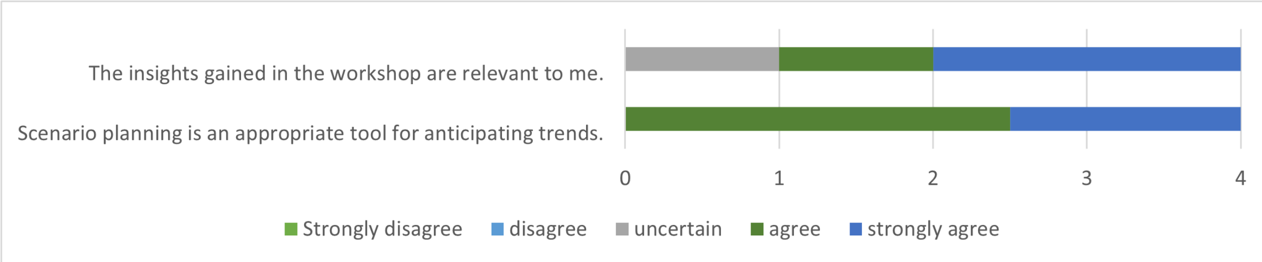


Figure 15: Workshop insights - questionnaire results

The participants indicated that the discussions were interesting and useful. Especially the discussion towards the end of the workshop, on what to do next based on the outcome of the scenario planning process. Initially there was no time planned to answer the key question and brainstorm on next steps, due to time constraints. However, this turned out to be a crucial step in the scenario planning process. For future workshops more time should be spent on discussing potential next steps for the organisation.

This workshop consisted of four participants. This is the minimal number of participants needed to execute the workshop as designed in this research. The ideal number of participants would be around six experts, to have a wider range of opinions. To make sure there were enough participants, multiple experts were asked to join the workshop. This is recommended to assure the minimal required number of participants.

An important factor in the success of the workshop were the preparations. A lot of time went into the designing process of the workshop, outlining the structure board and templates, creating simple and effective presentation slides, facilitating all materials needed for execution, and informing the participants about the research and the workshop. The facilitator has a big influence on the workshop, and how the participants were guided through the scenario planning process. All participants were positive about the workshop experience, the set-up and preparations of the workshop, and how it was facilitated: "in a very calm and professional manner." (Participant, questionnaire, June 30, 2022).

4.4.4 Limitations

This research has four limitations concerning the text mining process, the workshop execution, and overall TF method of this research.

The first limitation of this research is how text mining was used, as it only measured the frequency of technology trends and did not interpret the context within the documents. Future research could use additional measures like a sentiment analysis (SA). "Document-level SA aims to classify an opinion document as expressing a positive or negative opinion or sentiment." (Medhat, Hassan, & Korashy, 2014, p.1093). Sentiment analysis looks beyond the text and can interpret whether the information is positive, negative, or neutral. Additionally, the trend reports used for text mining were manually selected through desk research. The limitation is that this is a non-repeatable process that is prone to bias. Automating this process could eliminate researcher bias.

The second limitation is that the workshop was executed only once. Research has shown that technology forecasting is most effective when conducted on a regular basis, rather than on a one-time basis (Vanston, 1996). The TF method of this research follows a systematic process that can be repeated regularly within the organisation.

Third, the available time was limited to 2,5 hours. The original workshop design takes 5 hours. Therefore, the executed workshop had to be shortened by limiting some of the activities. This did not seem to take away from the quality of the workshop, based on the experts' feedback, the observers annotations and the facilitators' experience. However, this must be validated by conducting the 5 hour workshop and comparing the results.

Lastly, the experience and results of the workshop were not compared to the experience and results of any other combined TF method. Since the organisation did not have a technology forecasting process that involves their employees, the participants had no reference to compare the TF method of this research. Although the questionnaires showed positive results about the TF method of this research, future research on combined TF techniques could provide a more valid comparison of methods. This could be done by executing two different workshops with the same experts, using different TF methods.

5 Conclusion

For organisations that utilize the capabilities of technologies to gain a competitive advantage it can be hard to keep up with the rapid pace of technological development. The goal of this research was to develop, implement, and validate an improved technology forecasting method by combining quantitative and qualitative techniques. First, text mining was used to identify technologically relevant trends. Second, scenario planning was applied in a workshop with experts to identify the barriers and benefits of scenario planning as TF method. Before designing the workshop, interviews with experts were held to identify the problems in their current TF process. An observer was present at the workshop to observe the participants' behavior and attitude, as well as the facilitator, to assure the quality of the workshop. This research provides the template of a workshop design, and the barriers and benefits of its implementation that can be applied in these organisations to assist in identifying and anticipating on emerging technologies.

The main findings of this research are:
First, shortening the 5 hour workshop to 2,5 hours did not seem to take away from the quality of the workshop. If anything, it seemed to help the participants to stay committed throughout the process, providing more qualitative results. Second, combining quantitative and qualitative techniques for TF provides a good base method. The shortcomings of text mining were complemented by the strengths of scenario planning, and vice versa. The final method resulted in a repeatable and scalable technology forecasting method. Third, the workshop design left little room for discussion on potential next steps after discussing the scenarios. The participants considered the ten minute discussion on what to do next most valuable and would have liked to spent more time on this activity.

Technology forecasting has proven its value over the years. However, this research attempted to fill the need for a method that fits the pace of technological advancements in today's society. The technology forecasting method proposed in this research is a proper method to identify possible futures of emerging technological trends and start discussions about potential next steps for an organisation. Despite the fact that the executed workshop was shorter than initially proposed, the scenario planning workshop has proven to be an "effective methodology for creating and assessing scenarios" (Participant, questionnaire, June 30, 2022). The participants found the systematic approach useful and the discussions valuable. The practical contribution of this research is that it provides a framework for future identification and assessment of upcoming technologies. The academic contribution of this research is an expanded understanding of the combination of text mining and scenario planning applied in a group setting as technology forecasting method.

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Appendices

A Diagnosis interview questions

Technology Forecasting: what does that mean according to you?

Personal
Introduction
Could you tell me about your professional background?
How is your function related to technology trend research?

Current Situation (AS-IS)

1. How do you, as an organisation, look into the future?
2. What trend reports do you currently use?
3. If you have to make a prediction on the development of technologies, how do you proceed?
   (a) Step by step (at least 5-10 steps)
   (b) What part of the organisation is responsible?
   (c) What is your role in this process?
4. What would you rate this process, based on how satisfied you are (on a scale of 1 to 10)?
   (a) What works well?
   (b) What are the challenges?
5. How important do you think this process will be in the future (on a scale of 1 to 10)?
6. What could improve/optimize the current process (to predict technological trends)?
7. What additional tools do you use?
8. Have you ever used scenario planning as a tool for the decision-making process?
   (a) What input is needed for this?
   (b) What are the advantages and disadvantages of scenario planning?
   (c) What could improve/optimize the current decision-making process?

Workshop

1. What trends are useful within data-driven consulting?
   Show text mining results.
2. What are your wishes for the content and structure of the workshop?

Do you have any questions/remarks?

B Templates

B.1 Scenario Template

Technology Trend Research and Forecasting using Scenario Planning

Scenario …

Participant:

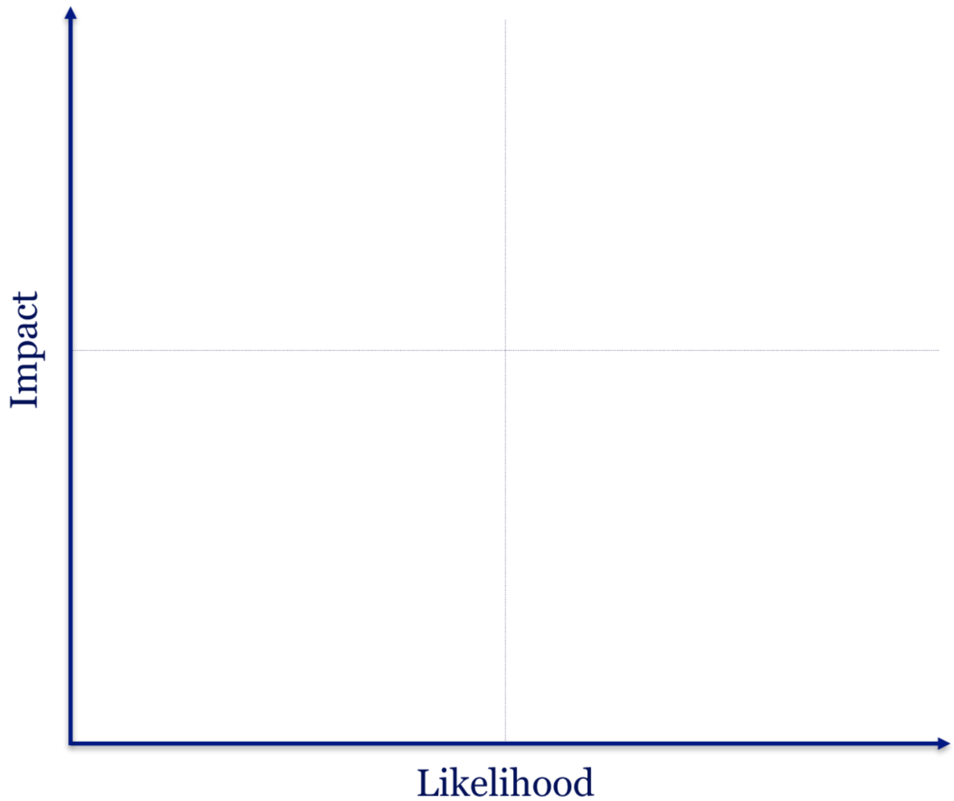
Universiteit Leiden

B.2 Impact-likelihood matrix Template

Technology Trend Research and Forecasting using Scenario Planning

Impact-likelihood matrix

Participant:



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C Questionnaire

Questionnaire

30-06-2022

The purpose of this questionnaire is to evaluate the workshop and its methods. The questions are about the advantages and disadvantages of the technology trend research and forecasting method of this research. The results are compared to your current methods for identifying and anticipate technology trends. Besides, feedback on the workshop structure is asked, to be able to optimize this method in the future.

This questionnaire consists of both open questions and 5-point Likert scale statements, that are answered on a scale of strongly agree to strongly disagree. Your answers are completely anonymous.

1. How did you experience the workshop?

2. What did you experience to be the advantages and disadvantages of using scenario planning in this workshop as a method for predicting and anticipating trends?

Advantage:

Disadvantage:

3. What do you consider to be the advantages and disadvantages of using text mining to identify relevant trends? (This question is optional)

Advantage:

Disadvantage:

4. What is your opinion on using text mining as input for scenario planning?

6. What method do you currently use for technology forecasting?

7. How does the method of this workshop compare to the methods you currently use?

8. How do the insights resulted from the workshop compare to the insights you get from your current methods?

	strongly disagree	disagree	uncertain/ not applicable	agree	strongly agree
1. The insights gained in the workshop are relevant to me.					
2. Scenario planning is an appropriate tool for anticipating trends.					

Workshop

Rate the following statements on a scale from strongly disagree to strongly agree

	strongly disagree	disagree	uncertain/ not applicable	agree	strongly agree
1. The workshop structure was appropriate.					
2. The difficulty level of the workshop was appropriate.					
3. The workshop was stimulating.					
4. The time given for the workshop was appropriate.					
5. The workshop had clear objectives.					
6. The content of the workshop was relevant to me.					
7. I was well informed about the workshop content and objectives.					
8. The workshop lived up to my expectations					

Other

1. Would you run this workshop yourself? Please elaborate your answer.

2. Do you have any remarks about the methods and/or the workshop structure?

D Workshop Results

D.1 Driving Forces

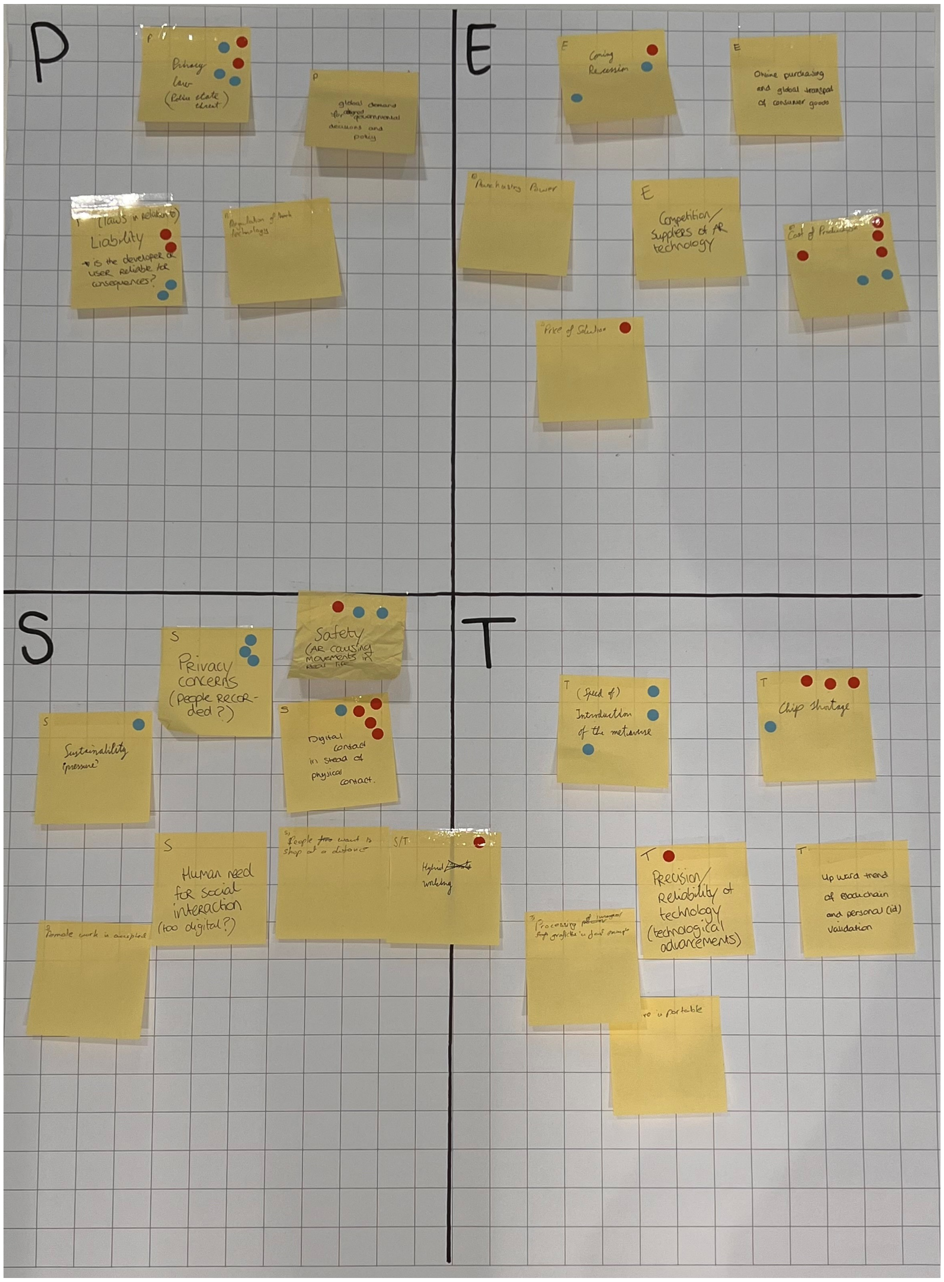

Figure 16: Prioritized driving forces

D.2 Impact-Uncertainty Matrix

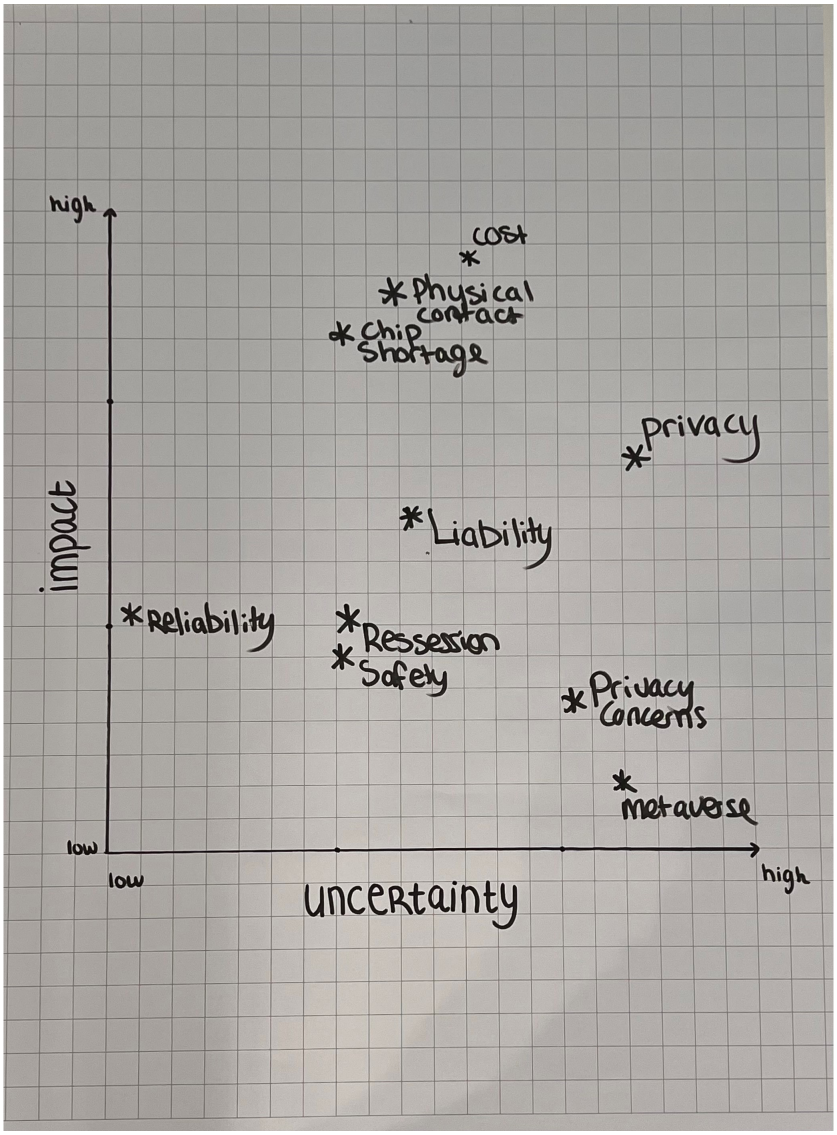

Figure 17: Impact-uncertainty matrix

D.3 Uncertainty Axes

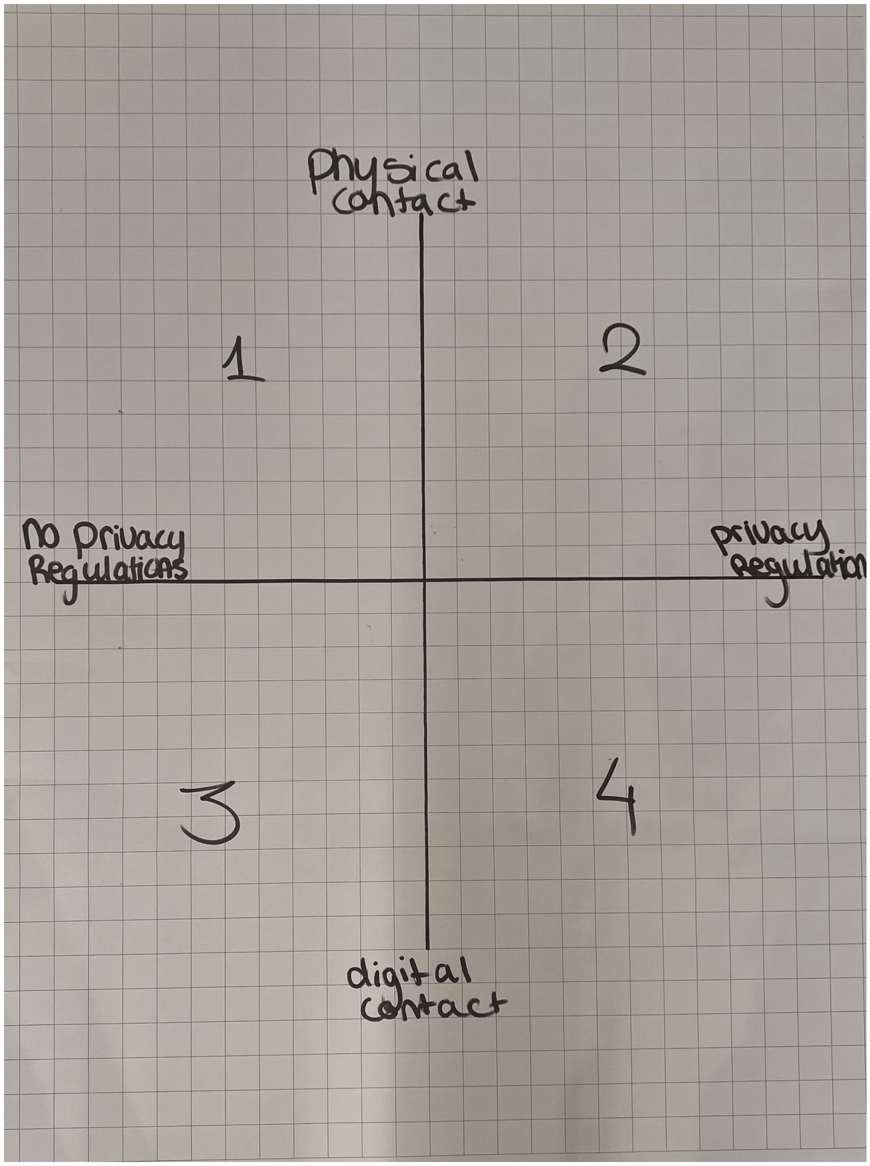

Figure 18: Scenarios based on uncertainty axes

D.4 Impact-Likelihood Matrix

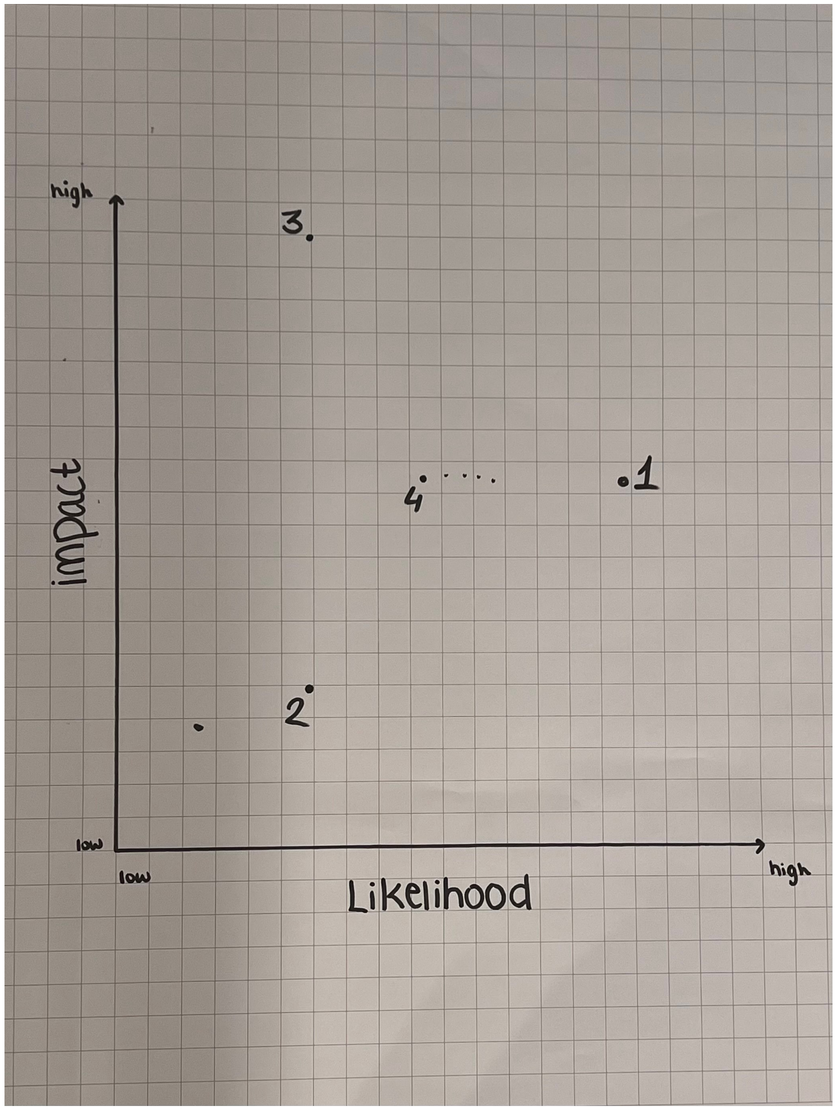

Figure 19: Impact-likelihood matrix

E Observation

E.1 Observation Briefing

The goal of the workshop is to further explore a technology trend using scenario planning, determining whether to invest in this trend, and to determine the advantages and disadvantages of this technology forecasting method.

Observing the participants and the facilitator is part of the results of this research. This is in addition to questionnaires that the participants fill out at the end of the workshop. Unconsciously, they may experience the workshop differently than they indicate in the questionnaire. The purpose of the questionnaire is to evaluate how the participants experienced the use of scenario planning in the workshop, based on the results from text mining. Besides, they are asked about their opinion on their current methods, compared to the methods in this workshop. Lastly, they must answer whether they agree/disagree to certain statements about the quality of the workshop (structure).

There are a few guidelines for the observations (the participants as well as the facilitator must be observed):

For observing the participants, specifically:

- The behavior and attitude of the participants must be observed, to not only assume their answers in the questionnaire, but also their 'unconscious' attitudes.
- Do the participants have a lot of questions about the tasks? This could indicate that the explanation was not clear and/or the difficulty level was not appropriate.
- Are participants distracted during certain activities, for example, by their phones, looking outside, looking at the clock, etcetera.

For observing the facilitator, specifically:

- While observing the facilitator, it is important to find out if the process of the thesis is actually executed as designed. This is necessary to establish the reliability of the results.
- Is the workshop explained as described in the predefined process? Does it follow the same order of events?
- Are the timeslots followed or does the workshop follow a different pace?

E.2 Observation Results

14:35-14:40 *Introduction workshop & agenda*

Time	Observation (wat observeer ik)	Activity (wat speelt zich af)	Actor	
ctr+shift+;				
14:35:00	knikt veel ja	facilitator legt uit wat het doel is		2
14:35:00	Uitleg is volgens plan, kadert af wat het doel is.		f	
14:36:00	reassures facilitator	facilitator betrekt groep	f	
14:36:00	vraagt om verduidelijking van wat AR is	tijdens introductie slide wat is AR		1
14:37:00	heeft een opmerking over hoe VR ook gebruikt wordt in een soortgelijke proces			1
14:38:00	allen geven voorbeelden van wat AR allemaal kan	er is veel interactie binnen de groep	1,2,3,	
14:40:00	participant vraagt om verduidelijking, om af te bakenen			4

14:40-14:45 *Communicate goal*

Time	Observation (wat observeer ik)	Activity (wat speelt zich af)	Actor
ctr+shift+;			1,2,3,4,f
14:41:00	vraagt om verduidelijking van de vraag	(moeten we ook in de tech investeren?) of in de kennis?	4
14:42:00	vraagt om verduidelijking van de vraag	wat en hoe? Of alleen of we een soort ja of nee moeten geven?	1

14:45-14:50 *Present key question*

Time	Observation (wat observeer ik)	Activity (wat speelt zich af)	Actor	
ctr+shift+;			1,2,3,4,f	
	x: "I am excited to see the outcome"	The facilitator presents the key question		1

14:50-15:05 *Identify driving forces*

Time	Observation (wat observeer ik)	Activity (wat speelt zich af)	Actor
ctr+shift+;			1,2,3,4,f
14:46:00	participants gaan aan de slag, kijken rond in de		
14:46:00	participant vraagt om afkadering van vraag? KDF voor ons of voor de technologie?		1
14:46:00	participanten zoeken naar antwoorden in de lucht		1,3
14:46:00	vraagt om opheldering van PEST		4
14:47:00	andere participanten helpen met verduidelijking van PEST		1,2,3
14:47:00	Participanten geven aan dat ze moeite hebben met het onderwerp		1,4
14:48:00	Participanten relativeren zich aan AR en pokemong GO	tijdens identificeren van KDF	2,3
14:48:00	Pokemon GO en ervaringen hiermee worden besproken	tijdens identificeren van KDF	1,f
14:49:00	participant is afgeleid, zoekt naar antwoorden		4
14:50:00	kijkt veel naar het bord	tijdens identificeren van KDF	2
14:51:00	vraagt of de sticky notes alvast opgeplakt mogen worden	tijdens identificeren van KDF	1
14:51:00	geeft aan klaar te zijn	tijdens identificeren van KDF	3
14:52:00	geeft aan dat er nog even gewacht moet worden met opplakken van sticky notes		f
14:53:00	geeft aan klaar te zijn		2
14:53:00	allen zijn klaar		

15:05-15:25 *describe driving forces*

Time	Observation (wat observeer ik)	Activity (wat speelt zich af)	Actor
ctr+shift+;			1,2,3,4,f
14:54:00	vraagt specifieke persoon om te beginnen		f
14:55:00	legt uit wat zijn factoren zijn, eenieder let op en		
14:55:00	is afgeleid en denkt aan nog een factor		4
14:56:00	vraagt om verduidelijking van een factor (niet goed gehoord)		f
14:56:00	begint op te plakken, verduidelijkt zijn aanpak		2
14:57:00	verduidelijkt waarom hij ergens voor heeft gekozen		2
14:57:00	is enthousiast om op te gaan plakken		1
14:58:00	geeft aan dat het er veel zijn die overlappen	er is een bespreking	1
14:58:00	participant betrekt groep en wordt erkend door de rest		4
14:58:00	veel contact tussen p en f		4,f
14:59:00	maakt aanmoedigende opmerking		2
15:01:00	Toont zijn denkproces en "bedenkingen" bij het product		1
15:01:00	opvallend weinig overlap in KDFs		1,2,3,4
15:02:00	legt uit wat zijn collega bedoelde	1 legt uit wat over kosten	2
15:02:00	stelt de vraagty terug naar f: is dit waar we mee kunnen werken?		2,f
15:03:00	vraag naar f komt niet goed over: zijn vraag, moeten we ze allemaal gebruiken?	factoren zijn opgeplakt	1

15:35-15:45 *Prioritize driving forces in impact-uncertainty matrix*

Time	**Observation (wat observeer ik)**	**Activity (wat speelt zich af)**	**Actor**
ctr+shift+;			1,2,3,4,f
15:05:00	bevestigt uitleg van f	f legt uit wat er moet gebeuren en wat het doel is hiervan	2
15:05:00	stelt de vraag hoeveel mensen ideaal was voor de workshop	f pakt stickers	2
15:06:00	hebben moeite met de opdracht? Wat wordt er precies van ons verwacht?	wordt uitgelegd	3
15:08:00	vraagt of de hoofdvraag belangrijk is bij deze stap	zijn stickers aan het plakken	2
15:11:00	vraagt om mening van anderen	stickers aan het plakken	1
15:11:00	veel interactie	stickers aan het plakken	1,2,3,4
15:12:00	participanten geven aan onzekerheid moeilijk te vinden	stickers aan het plakken	2,4
15:12:00	merkt op dat niemand aan safety heeft gedacht	stickers aan het plakken	2
15:13:00	trekt een papiertje safety tevoorschijn	stickers aan het plakken	4
15:14:00	geeft aan het moeilijk te vinden het moeilijk de uncertainty van een te bepalen	stickers aan het plakken	2
15:14:00	geeft aan dat de metaverse nog zo niet tastbaar is	stickers aan het plakken	2
15:15:00	wordt veel gesproken over de vraag: betrekken alles met de relatie tot elkaar in plaats van de factor zelf	stickers aan het plakken	1,2,3

15:25-15:35 *Break*

Time	Observation (wat observeer ik)	Activity (wat speelt zich af)	Actor
ctr+shift+;			1,2,3,4,f
15:17:00	zoekt interactie met observer	break	2
15:17:00	halen koffie	break	3,4
15:18:00	legt uit wat er normaliter gebeurt met scenario planning	break	1
15:22:00	f is bezig met het opschrijven		

16:10-16:45 *Discuss scenarios (impact-likelihood matrix)*

Time	Observation (wat observeer ik)	Activity (wat speelt zich af)	Actor
ctr+shift+;			1,2,3,4,f
15:58:00	verlaat de kamer, wordt gebeld		3
15:58:00	vertelt scenario 1	personalized onsight experience, vooral voor B2B	4
15:59:00	toont zijn begrip van scneario 1 expliciet	scenario wordt uitgelegd	2
16:01:00	vertelt scenario 2	Co-created onsight experience	1
16:02:00	neemt over van partner	scenarios worden uitgelegd	2
16:02:00	geeft weer over aan partner	scenarios worden uitgelegd	2
16:03:00	interactie met het uitleggen van scenario	scenar	2,3
16:03:00	geeft aan dat er veel aannames zijn	scenarios worden uitgelegd	1
16:04:00	geeft aan waar zijn zorgen liggen binnen dit scenario		1
16:05:00	verduidelijkt hun scenario	scenarios worden uitgelegd	2
16:07:00	maakt een grap over investeren in BP en piratenpartij	scenarios worden uitgelegd	1
16:09:00	scenario 4 wordt uitgelegd	High risk, high reward	4
16:11:00	heeft wat onbegrip in uitleggen van scneario	uitleggen scenario	4
16:13:00	identificeert een mooie gap van waar BP kan werken	beschrijft nuancering van regels en mogelijkheden	3
16:13:00	worden grappen gemaakt over scenario 3		
16:14:00	uitleg scenario 3	unlimited possibilities	1,2
16:15:00	veel discussie over scenario 3	erg positief beeld	1,2,3,4
16:15:00	vult aan op 2		1
16:16:00	trekt twijfel bij de scenario gezien wetgeving		3
16:18:00	creert een uiterst positieve transitie voor BP dat data analytics in alles wordt toegepast		2
16:22:00	stelt vraag: impact op wat?	uitleg over plot scenarios	3
16:23:00	ieder zoekt naar antwoorden in de ruimte		1,2,3,4
16:24:00	pakt en kijkt op telefoon	scenarios plotten	3
16:24:00	kijkt wat 3 heeft gedaan op de plot	scenarios plotten	4
16:25:00	verbeterd zichzelf meerdere malen	scenarios plotten	2
16:25:00	geeft aan een notitie te missen	scenarios plotten	1
16:27:00	verwarring over de regulations as	gezamenlijk scenarios plotten	

16:28:00	stellen onderling vragen aan elkaar	gezamenlijk scenarios plotten		4,3
16:28:00	meningen zijn redelijk gelijk	gezamenlijk scenarios plotten	2,3,4	
16:29:00	vormt een gezamenlijke opinie	gezamenlijk scenarios plotten		2
16:29:00	consensus gevormd over scenario 1	gezamenlijk scenarios plotten		
16:31:00	relatieve gelijke mening over scenario 2	gezamenlijk scenarios plotten	1,3,4	
16:31:00	vindt het nog extremer dan andere opinies	gezamenlijk scenarios plotten		2
16:31:00	consensus gevormd over scenario 2	gezamenlijk scenarios plotten		3
16:32:00	geeft aan weg te moeten	gezamenlijk scenarios plotten		3
16:33:00	verduidelijkt de regulatie as	gezamenlijk scenarios plotten		1
16:34:00	onbegrip over regulation	gezamenlijk scenarios plotten		1
16:35:00	consensus gevormd over scenario 3	gezamenlijk scenarios plotten	1,2,4	
16:36:00	moet opnieuw nadenken over scenario 4	gezamenlijk scenarios plotten		1
16:37:00	geeft mening sterker dan in eerdere scenarios (4)	gezamenlijk scenarios plotten		4
16:38:00	relativeert scenario 4 met high risk dus ook likelihood & impact	gezamenlijk scenarios plotten		1
16:40:00	geeft een volgende stap door te zeggen wat de meest likely	bespreken plot		1
16:40:00	relativeert het naar corona en wat de trendlijn gaat worden	bespreken plot		2
16:41:00	stelt de hoofdvraag nog een keer	bespreken plot		4
16:41:00	geven antwoord op de hoofdvraag	bespreken plot		1,2
16:43:00	stelt voor dat het een bundeling moet zijn van scenario 1,3 en 4	bespreken plot		2
16:43:00	komen tot consensus over volgende stap (investeren op gebruikers gedrag en verschillende scenarios bij verschillende klanten	bespreken plot		2
16:51:00	participanten geven aan een duidelijk beeld gevormd te hebben, te weten waar ze aan de slag moesten	bespreken plot	1,2,3,4	
16:45:00	geeft een conclusie: een scenario kiezen of verschillende in de	bespreken plot		2
16:11:00	alle scenarios zijn eigenlijk positief beschreven, er wordt altijd wel een mogelijkheid gevonden voor BP	gezamenlijk scenarios plotten	1,2,3,4	
16:52:00	weet niet welke tech forecasting methode nu gebruikt wordt en stelt vraag aan participant 4			1

DNA	data & Analytics

15:45-16:10 *Give name to scenarios*

Time	Observation (wat observeer ik)	Activity (wat speelt zich af)
ctr+shift+;		
15:24:00	er wordt gevraagd wat de facilitator heeft gedaan en hoe de schaal verdeeld is	start aan uitleg van KDF
15:25:00	f stelt voor om af te wijken van normale methode en te stemmen op de twee factoren	uitleg over maken van scenarios
15:26:00	vraagt verduidelijking om scneario matrix	uitleg over maken van scenarios
15:27:00	stelt vraag: kiest er twee toch?	nadenken over stemmen
15:27:00	stemmen vindt plaats	
15:28:00	stelt vraag waarom deze twee en of het versimpeling is van proces	
15:32:00	merkt op dat hij moeite heeft met het tastbaar maken	uitleg over creeren scneario
15:32:00	groep gaat meteen aan de slag	scenarios creeren
15:33:00	beginnen met filosoferen over wat het betekent betreft privacy	scenarios creeren
15:33:00	stellen voornamelijk vragen aan elkaar om het doel duidelijker te krijgen	scenarios creeren
15:35:00	begint met eerste scenario uit te schrijven	scenarios creeren
15:36:00	begint met eerste scenario uit te schrijven	scenarios creeren
15:36:00	Raakt in zijn gedachten	scenarios creeren
15:37:00	vraagt zich af of het een reeel scenario is	scenarios creeren
15:37:00	gebruikt voorbeelden om zijn mening duidelijekr te maken	scenarios creeren
15:38:00	kadert zijn eigen vragen verder af, creert ook extra lastigheden voor het onderwerp	scenarios creeren
15:38:00	pakt de focus weer, er moeten enkele assumptions gemaakt worden	scenarios creeren
15:38:00	haakt in op wat er gezegd wordt door een groep	scenarios creeren
15:39:00	verduidelijkt de as regulations	scenarios creeren
15:39:00	geeft aan het pittig te vinden	scenarios creeren
15:39:00	f betrekt zich bij groep	scenarios creeren
15:40:00	spreekt zijn zorgen uit over een specifieke toepassing, suggereert dat je het wellicht precieser moet stellen	scenarios creeren
15:41:00	suggereert dat er vooral naar hun sectoren gekeken moet worden	scenarios creeren
15:42:00	betrekt persoonlijke mening en ervaringen er bij	scenarios creeren

15:44:00	creeren duidelijkheid voor zichzelf en het beeld wordt steeds concreter	scenarios creeren
15:45:00	hebben een duidelijker beeld van de opdracht de hele tijd	scenarios creeren
15:45:00	verlaat de kamer want heeft een meeting	scenarios creeren
15:46:00	gaat alleen verder met scenario uitschrijven	scenarios creeren
15:46:00	betrekt facilitator bij zijn denkproces	scenarios creeren
15:49:00	komt terug de ruimte in, meeting geannuleerd	scenarios creeren
15:49:00	zijn nog steeds samen lekker bezig	scenarios creeren
15:49:00	helpt groep 1 (1,2) meer dan groep 2	scenarios creeren
15:50:00	geeft aan dat hij denkt dat het een iteratief proces is	scenarios creeren
15:51:00	stelt een vraag wat de gevolgen zijn van consortions die samenkomen om een scenario uit te laten komen	scenarios creeren
15:52:00	zijn tevreden met hun uitwerking en punten	scenarios creeren
15:53:00	zijn klaar met hun scenarios beschrijven	scenarios creeren
15:55:00	lopen over tijd heen	scenarios creeren
15:56:00	legt compleet scenario als geschreven uit aan partner	

NOTE:	het blijkt dat er nog een afbakening mist, of dat de vraag te breed is door het scala aan de verschillende klanten van BP

16:45-16:55 *Complete individual questionnaire*

Time	Observation (wat observeer ik)	Activity (wat speelt zich af)	Actor
ctr+shift+;			1,2,3,4,f
16:47:00	spreekt zijn complimenten uit over hoe hij van een warrig beeld naar een duidelijke opgave is gegaan	uitdelen questionnaire	2
16:47:00	stelt de vraag over tekst mining (wat heb je gedaan daarmee?)	invullen questionnaire	1
16:49:00	vraagt of tekst mining geautomatiseerd kon worden	invullen questionnaire	2

16:55-17:00 *Thank you & closing*

Time	Observation (wat observeer ik)	Activity (wat speelt zich af)	Actor
ctr+shift+;			1,2,3,4,f
	Workshop timing was just as planned	Facilitator is thanking the participants	