



# Combining the scenario technique with bibliometrics for technology foresight: The case of personalized medicine



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## ABSTRACT

The purpose of this article is to present a novel method for combining bibliometrics and scenario technique for the sake of conducting technology foresight. First, we derive an eight-step scenario approach and add the identification of emerging technologies as well as their respective effects on each scenario. Second, we illustrate this combined method in the field of personalized medicine (PM). Existing literature on method combination often focuses singular challenges and benefits associated with the scenario technique. In this paper, however, we integrate the results of a bibliometric analysis at each step of the scenario technique. Herein, we refer mainly to the citation analysis and bibliographic coupling network. Third, we describe the findings of our case study for every step of the application of the scenario technique. In doing so, we offer practical guidelines for applying this novel combined method in other contexts. The overall benefit of the method combination is the integration of scientifically based information that exceeds the knowledge bases of the scenario team and other experts. Most notably, the examination of vast amounts of technology-specific information facilitates the identification of emerging technologies. Moreover, the combined method allows for a more precise projection of future states when narrowing the scenario funnel. Using this eight-step scenario approach, we build three scenarios for the field of PM, discuss disruptive events, and identify and integrate emerging technologies into each scenario. Finally, we explore strategic decisions for various stakeholders in the PM field.

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## 1. Introduction

Technology foresight relates to the generation of accurate assumptions regarding the emergence of various technologies to inform strategic management decisions (Rohrbeck, 2011; Reger, 2001). Foresight experts within both academia and practice emphasize that available methods and tools should be combined to integrate expert knowledge with other valuable sources of information (Haegeman et al., 2013; Lüdeke, 2013; Popper, 2008; Malanowski and Zweck, 2007). Similarly, authors stress

the importance of combining qualitative and quantitative methods (Haegeman et al., 2013; Lüdeke, 2013). However, the integration of quantitative, technology-specific information represents a significant challenge, particularly with respect to technology foresight. The most prominent qualitative technique that has been proposed for a method combination is scenario technique – a prominent and versatile tool designed to assist strategic management in coping with an unknown future (Ringland, 2010; Marcus, 2009). In the literature and in practice, the construction of scenarios is a systematic method for depicting a number of comprehensive pictures of possible futures (Ringland, 2010; Marcus, 2009; Schoemaker, 1995). Scenarios do not represent definite future states, but visions generated in a structured and creative process based on assumptions about what could happen (Schwartz, 1991; Wack, 1985). These assumptions are generated in a step-by-step

*Abbreviations:* PM, Personalized medicine; WoS, Web of Science; PESTEL, Political, economic, social, technological, ecological, and legal.

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procedure and are incorporated into strategy development (Mietzner and Reger, 2005). The inherent benefit of the scenario technique is its facility in coping with the range of possible futures, thereby opening up the horizon of participants and stakeholders to these futures and reducing their risk of making incorrect decisions (Schoemaker, 1995). Researchers have proposed a number of quantitative methods to optimize the accuracy of the scenario technique, including fuzzy clustering (Pishvae et al., 2008), system dynamics (Pirainen et al., 2010), and diffusion models like the Fisher-Pry model (Daim et al., 2006).

In this paper, we emphasize the added value associated with combining methods and linking academia to practice. Specifically, we report a case study in the field of personalized medicine (PM) where we have used a combination of scenario technique and bibliometric methods to conduct technology foresight. In doing so, we contribute to existing scholarship on the method combination in three principal ways. First, we derive a scenario approach that is specifically focused on technology foresight; this approach is based on prominent approaches that have been described in the literature. Second, we demonstrate that the output creation in each step of the scenario technique can be complemented with bibliometric information. The combination of the scenario technique and bibliometrics represents a novel method within the field of technology foresight. The novelty of this approach fills a gap in a literature in which most scholars have focused on addressing single challenges in a single step of the scenario technique, e.g., a consistent clustering process (Pishvae et al., 2008; Hirsch et al., 2013). Third, the description of our case study findings provides practitioners with guidelines for replicating our methodological approach. The applied nature of this paper extends current research about comprehensive methodologies, which has often remained conceptual in kind (Brose et al., 2013).

We have chosen to combine bibliometrics with scenario technique for multiple reasons. First, bibliometrics is a sophisticated and versatile technique that yields a variety of types of information, each of which is useful for integration at different steps of the scenario technique. Bibliometrics builds upon a large data basis of scientific articles. Applied to a specific field of technology its results include the intellectual structure, current research topics and publishing organizations, authors, and countries (Ma et al., 2014; Vogel and Güttel, 2013). Second, bibliometrics has long been used for forecasting using term frequency analysis (Woon et al., 2011) or bibliographic coupling (Huang and Chang, 2014; Kuusi and Meyer, 2007). Third, bibliometrics is useful for the analysis of only relatively short timeframes (Lichtenthaler, 2002) and scarcely captures the influence of socio-economic factors. However, when combined with the scenario technique, bibliometric information narrows the so-called scenario funnel by reducing the number of possible developments in the near future. As such, integrating bibliometrics results in more accurate long-term scenarios because the regular foresight timeframe of scenario technique is retained. The overall benefit of the combined method is the integration of broad, current and scientifically based information that exceeds the respective knowledge bases of both the scenario team and experts. Moreover, as will be demonstrated over the course of this paper, this combined method offers a holistic tool for technology foresight with a focus on identifying and evaluating emerging technologies.

The sections of this paper are organized as follows. In Section 2, we offer a short overview of the literature on method combination, with a particular emphasis on the research gaps identified above. In Section 3, we describe our eight-step scenario approach designed specifically for technology foresight. In addition, we outline challenges associated with each step in the technique, and emphasize the need to integrate quantitative information with it. In Section 4, we describe the applicability of bibliometric analysis and the types of information it can provide. In this section, we argue that the results borne from bibliometric analysis can complement every step of the scenario technique. To address our primary research goals, in Section 5, we describe how we integrated key results from bibliometric analysis into the scenario technique in the context of PM. We discuss in detail how bibliometrics has enriched output creation. Finally, in Section 6, we present our key findings and avenues for future research in this area.

## 2. Overview of literature on method combination

Several researchers and practitioners have suggested that combining methods can be a particularly effective foresight tool (Haegeman et al., 2013; Lüdeke, 2013; Popper, 2008; Malanowski and Zweck, 2007). To provide a comprehensive synopsis of various method combinations in the context of technology foresight, we used the Web of Science (WoS) database to perform a detailed literature review of relevant articles from the last ten years. This overview reveals that research has principally focused the combination of quantitative methods with either scenario technique or roadmapping (Table 1). The purpose was to improve single steps within these two underlying foresight tools. For example, researchers have combined the scenario technique with systems dynamics approaches to quantify the clustering process (Pishvae et al., 2008; Hirsch et al., 2013). Bibliometric analysis has been used in combination with roadmapping or diffusion models to make qualitative assumptions more accurate by providing quantified information (e.g., performance measures of research efforts, identification of key experts in a research field). The inclusion of quantitative input into the whole scenario process, however, has not been researched to date. This highlights that our proposed method combination of bibliometrics and scenario technique is novel to the field of foresight. In the subsequent sections, we discuss the scenario technique and bibliometrics independently before describing the benefits associated with their combination in Section 5.

## 3. Scenario technique

### 3.1. The scenario technique as a key foresight tool

Within the field of strategic management, the scenario technique is considered a useful tool for long-term business planning (Bradfield et al., 2005). It enables the analysis of the current situation while systematically identifying areas of influence and accordingly deducing driving forces with their relationships (van der Heijden, 2000). A critical benefit associated with integrating scenario technique into strategic management is that it provides greater awareness of the factors that influence future events. In this way, scenario planning is “educational” [31, p.119], and has a substantial impact on

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