Journal of Engineering and Technology Management xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of Engineering and Technology Management

journal homepage: www.elsevier.com/locate/jengtecman

Balancing comprehensiveness and parsimony: Towards a context-specific barrier identification across multiple levels combined with complexity reduction through barrier groups

Anne-Karen Hueske[a], Edeltraud Guenther[b,*]

[a] PRISMA – Centre of Sustainability Assessment and Policy, Technische Universität Dresden, Muenchner Platz 1/3, 01062 Dresden, Germany
[b] Faculty of Business and Economics, Chair of Environmental Management and Accounting, Technische Universität Dresden, Muenchner Platz 1/3, 01062 Dresden, Germany

ARTICLE INFO

JEL classifications:
O31
O33

Keywords:
Barrier
Innovation barrier
EOI barrier model
Barrier groups
Biotechnology

ABSTRACT

We address the criticism of barrier groups as incomplete and overlapping using a mixed-method barrier analysis. Striving for comprehensiveness, a set of forty-five context-specific barrier manifestations is identified through qualitative expert interviews guided by the multilevel theory-driven EOI (External environment Organization Individual) barrier model. The perceived relevance of the barrier manifestations is assessed based on survey data. Striving for parsimony and reduced complexity, eleven barrier categories across three levels of analysis are derived through an exploratory factor analysis (suppliers, investors, business-to-business customers, potential employees, competitors, legislator, attitudes towards technology, tangible resources, strategy and structure, human resources, and employees).

1. Introduction

Innovation is fundamental for organizations to sustain in a competitive environment (e.g., Baregheh et al., 2009; Bessant et al., 2005; Damanpour, 1991; Zain et al., 2002). In our context, innovation means something that is newly created or something existing that is improved or changed (Baregheh et al., 2009). According to the OECD definition, innovation is "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" (OECD and Eurostat, 2005, p. 46).

Of innovations, 90% fail (Hilgers and Piller, 2009). Therefore, "bottlenecks limiting innovation activity" (Hölzl and Janger, 2014, p. 707) and "'hygiene' factors […] that must be attended [to] if the project is to survive" (Link, 1987, p. 111), so-called barriers, which impede, delay, or completely block innovation (Mirow et al., 2008), have to be identified, understood and overcome (Cooper, 1998; Huang and Chi, 2013, 1999; OECD and Eurostat, 2005) to re-establish the flow of innovation (Hadjimanolis, 1999).

Barriers to innovation are "a complex, multifaceted phenomenon" (Sandberg and Aarikka-Stenroos, 2014, p. 1294). Case studies and surveys have identified a multitude of manifestations of barriers (Hueske and Guenther, 2015). A recent review of barrier studies (Hueske and Guenther, 2015) concluded that empirical barrier studies tend to simply list barriers or group them in sub-dimensions.

Lists of seven plus or minus two items exceed the human capacity for information processing (Miller, 1956). As human decision-making is constrained by resources, the state of the art, norms and values, and knowledge about alternatives (Frey and Foppa, 1986), a variety of barrier groups have been proposed to reduce the multitude of barriers to several categories. These barrier groups have

* Corresponding author.
E-mail addresses: anne-karen.hueske@tu-dresden.de (A.-K. Hueske), ema@mailbox.tu-dresden.de (E. Guenther).

https://doi.org/10.1016/j.jengtecman.2018.05.002
Received 18 July 2016; Received in revised form 23 February 2018; Accepted 11 May 2018

been criticized as they are neither free of overlaps nor comprehensive enough to capture all innovation barriers; thus, barrier groups remain a controversial topic (Rohdin and Thollander, 2006; Wymer and Regan, 2005).

Acknowledging innovation and barriers as complex and context-specific phenomena (Hadjimanolis, 2003; Hueske et al., 2015; Klein and Kozlowski, 2000; Klein and Sorra, 1996; Sandberg and Aarikka-Stenroos, 2014) as well as acknowledging the human limits for processing information (Frey and Foppa, 1986; Miller, 1956), we aim to balance comprehensiveness and reduced complexity. The advantages of mixed methods approaches (Ametowobla et al., 2015; Cameron, 2009; Edmonson and McManus, 2007) allow us to combine these at the first glance of a conflicting target. We extend barrier analysis beyond the qualitative context-specific identification of innovation barriers by adding a quantitative second step taking into consideration the interdependencies between manifestations of barriers when grouping them.

This study contributes to the discussion of barrier groups and therefore to technology and innovation management and barrier research by proposing a mixed method barrier analysis. (1) Acknowledging the context specificity of barriers, barriers are identified in a qualitative manner. To this end, we use a multi-level model that identifies barriers on the external environmental, organizational, and individual levels. Furthermore, each level is further sub-categorized by drawing on stakeholder theory, dynamic capabilities, and organization psychology. By this means, a multitude of barrier manifestations is identified to answer the first research question: How do barriers manifest themselves? (2) Acknowledging the human limits of information processing of the variety of barriers identified, the analysis needs to be focused. Striving for parsimony and reduced complexity of the barrier analysis, the manifestations of barriers are grouped via exploratory factor analysis to answer the second research question: How can the multitude of barriers be reduced to valid barrier groups?

As an illustrating example, we survey the German biotechnology industry. Ten managers of biotechnology companies are identified by selective sampling and interviewed to identify manifestations of barriers on three levels of analysis. The transcripts of these interviews are content analyzed. A set of forty-five barrier manifestation items on three levels of analysis is derived from the expert interviews. These items are assessed in an online questionnaire survey of the German biotechnology industry. The survey results are grouped into the following eleven barrier factors using exploratory factor analyses: suppliers, investors, business-to-business customers, potential employees, competitors, state as legislator, external attitudes towards biotechnology, lack of resources, strategy and structure, human resources, and employees.

The paper is structured as follows: The next section provides the research context of the biotechnology sector. Section three is devoted to the mixed-method methodology, the context and the data of the illustrating example. The fourth section presents and discusses the results. Finally, conclusions are drawn and implications are derived.

2. Mixed level barrier analysis

The variety of lists of barrier manifestations and groups of barriers (Hueske and Guenther, 2015; Sandberg and Aarikka-Stenroos, 2014) as well as the multiple levels of analysis demonstrate the complexity of the phenomena. This complexity calls for qualitative research, such as case studies, which examine the subject via observations or interviews. This qualitative step can be complemented by a quantitative step to reduce the complexity. Factor analysis searches for underlying latent constructs, and exploratory factor analyses are used for each level of analysis. In this way, this paper combines the advantages of qualitative and quantitative research in a mixed-method approach. This methodology benefits from the advantages of a qualitative research design, which allows a deeper understanding of complex phenomena, and a second quantitative step, which reduces the complexity to eleven factors. This paper not only applies a multi-method approach but also proposes the combination of qualitative expert interviews for context specificity and comprehensiveness with a quantitative exploratory factor analysis to reduce the complexity and assure parsimony.

2.1. Striving for comprehensiveness by identifying barriers to innovation on multiple levels: external stakeholders, organization, and individuals

Acknowledging innovation and barriers as complex and context-specific phenomena (Hadjimanolis, 2003; Hueske et al., 2015; Sandberg and Aarikka-Stenroos, 2014) and the human limits for processing information (Frey and Foppa, 1986; Miller, 1956), the identification of barriers should go beyond the simple question in expert interviews of what are barriers to innovation. Such an approach could neglect an encompassing identification and limit the analysis to the most salient barriers. A recent review of empirical barrier research (Hueske and Guenther, 2015) indicates that barriers can occur on all levels of analysis and that theory-driven sub-dimensions can contribute to a more encompassing barrier identification. Therefore, we strive for more fine-grained research questions.

Considering innovation and therefore innovation barriers as multilevel phenomena (e.g., Anderson et al., 2004; Crossan and Apaydin, 2010) and in line with former classifications in innovation research (Anderson et al., 2004; Damanpour, 1996), we apply a multilevel perspective. The most frequently used barrier classification distinguishes external and internal barriers (e.g., Harris, 2000; Puhlmann and Gouy, 1999; Shi et al., 2008; Thun and Müller, 2010). External barriers are further linked with demand, supply, or other external environmental issues (Hadjimanolis, 1999), which brings to mind the five forces of Porter (Porter, 2008, 1979) and stakeholder theory (Freeman, 2004, 1984). A more detailed internal barrier categorization can be summarized by barrier groups called technological barriers, organizational barriers or people barriers (e.g., Heinemann et al., 2010; Kunda and Brooks, 2000; Love et al., 2001; McLaughlin et al., 2008; Nagesha and Balachandra, 2006; Seifert, 2018; Herrmann and Guenther, 2017). These groups facilitate a differentiation between organizational and individual barriers. However, they neglect the external environment. In contrast, the TCOS model (Hall et al., 2011; Hall and Martin, 2005), which addresses technological, commercial, organizational and