Journal of Business Research xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Journal of Business Research

The root cause of innovation system problems: Formative measures and causal configurations☆

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A R T I C L E I N F O

Article history:
Received 1 February 2016
Received in revised form 1 March 2016
Accepted 1 April 2016
Available online xxxx

Keywords:
Fuzzy set qualitative comparative analysis
Innovation failure
Innovation policy
Innovation system performance metrics

A B S T R A C T

Innovation systems provide a structured approach to understanding innovation performance and failure. Two innovation system theories, structural and functional, provide the basis for understanding the failures of projects within the single innovation system under investigation. Many indicators of the strength of conditions in the model are important to innovation system performance. Fuzzy set qualitative comparative analysis is suitable for the validation of formative measurement models. The survey instrument meets validity criteria to the extent of this research and is a useful diagnostic tool for innovation system performance.

1. Introduction

Innovation systems (IS) approaches attempt to provide a holistic understanding of the environment and interactions that are necessary for the occurrence of innovation (Edquist, 1997); these approaches are influential in setting a national innovation policy (Manjón & Merino, 2012). Recent research shows two approaches to understanding innovation system performance (ISP), from sectoral and technological perspectives, both equally applicable at the project level. This research, using fuzzy set qualitative comparative analysis (fsQCA), is also useful for developing a causal recipe for IS failure (Jenson, Leith, Doyle, West, & Miles, in this issue-2016). According to IS theory, ISP can occur only when all conditions (in the QCA sense) occur. For example, the sectoral theory describes the conditions of interaction, infrastructure, and institutions, whereas the functional theory describes conditions such as provision of resources, direction of the search, knowledge development, and knowledge dissemination. This study uses fsQCA to identify recurrently weak conditions that the theories specify, in a selected IS, and therefore are likely to affect negatively ISP and the success of innovation projects. Poor ISP can be the result of weakness in conditions from either theory; however, the relationship between both theories' conditions is unclear.

The literature broadly defines the conditions of an IS (Bergek, Jacobsson, Carlsson, Lindmark, & Rickne, 2008; Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007; Klein Woolthuis, 2010; Klein Woolthuis, Lankhuizen, & Gilsing, 2005). Scholars of IS failure theory tend to combine in categories the many reasons why innovation may fail, sometimes resulting in including combinations of indicators orthogonal to each other within the same condition. Therefore, the identification of weakness in a condition may be insufficient to allow policy or management action to correct the performance of the system because the definition of the conditions is not sufficiently precise.

The measurement model (Fig. 1) has several formative indicators for each condition. Formative measurement scales, or indexes, assume that the indicators are causing the latent construct, in this case, the conditions of the IS model (Coltman, Devinney, Midgley, & Venaik, 2008; Diamantopoulos, Riefler, & Roth, 2008). These indicators compose carefully constructed formative measurement indexes, which scholars may use in model development (Diamantopoulos & Winklhofer, 2001).

The structural and functional theories claim to predict the performance of an IS through the strength of the IS conditions. A previous analysis (Jenson et al., in this issue-2016) of an IS using fsQCA identifies recurrent weaknesses in the conditions that the two theories propose. The previous analysis identifies market factors and interactions from structural theory as recurrently weak (Klein Woolthuis, 2010; Klein

☆ The authors acknowledge provision of information, cooperation, and financial support from Meat & Livestock Australia. The authors thank Andreas Kiermeier, Statistical Process Improvement Consulting and Training Pty Ltd., for producing Fig. S1 and Arch Woodside, Boston College, and Domingo Ribeiro, University of Valencia, for their support and guidance.
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http://dx.doi.org/10.1016/j.jbusres.2016.04.127
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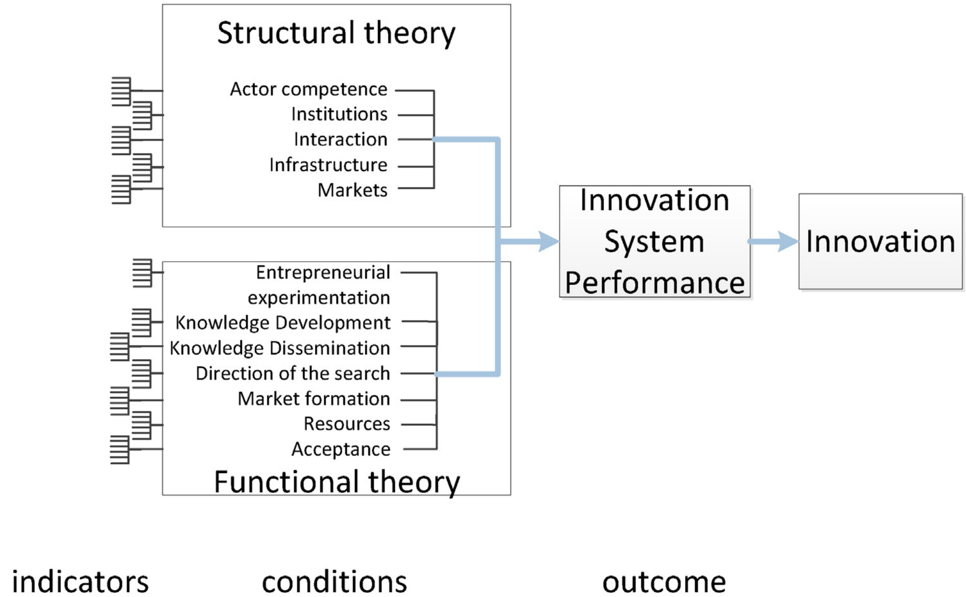

Fig. 1. The structure of measurements, theories, and innovation outcomes. The calibration of the indicators and conditions is in Table 1.

Woolthuis et al., 2005) drawing from the sectoral innovation system theory. The previous analysis also identifies direction of the search and knowledge development from functional theory as recurrently weak (Bergek et al., 2008; Hekkert et al., 2007), drawing from technological innovation system theory.

Given that four conditions are recurrently weak, and therefore, are frequently contributing to poor ISP, recurrently weak indicators or combinations of indicators for these recurrently weak conditions that are leading to the lack of an innovation outcome may also exist. Examining individual indicators within the measurement model should allow finding those that most directly contribute to ISP. In this context, the conditions are the latent constructs in the IS model resulting from a number of indicators. Occurrence of an innovation outcome implies ISP.

QCA builds on the application of set theory to determine the cause of an outcome without assuming the additionality of the conditions, or the uniform effect of factors or a single solution. This fact makes QCA an approach apt to the analysis of complex systems (Berg-Schlosser, De Meur, Rihoux, & Ragin, 2009; Woodside, 2013).

The objectives of this article are to use QCA to understand the relationship between the formative indicators and four recurrently weak conditions for ISP, and to determine whether a few critical indicators determine ISP in this IS. A further objective is to consider how researchers may use formative measurement models in QCA as an alternative to regression and structural equation approaches (Woodside, 2013). This work explores an approach to identifying both combinations of indicators that commonly lead to strong and weak conditions in an IS. The fsQCA identifies, qualitatively, the indicators that most associate with strength and weakness of a condition (Fig. 1). The terms that this study uses consistently are indicator, condition, and outcome. This nomenclature maintains a consistent use of terms within this article and results in no modification of the assumptions and practices of QCA. Linear regression assists in the selection of indicators. The reconstruction of the model, using only the indicators selected as important as conditions to explain ISP and lack of ISP outcomes, validates the analysis through the calculation of goodness of fit metrics.

2. Method

The data came from an online survey of IS actors (including researchers, industry personnel, and regulators) in projects in which the managers expected some change (innovation) at the commencement of the project and in which the research phase concluded successfully more than 2 years before the date of data collection. The study uses data from an IS within the domains of food safety (technology) in the Australian red meat industry (sector). Data covered 41 projects (cases), with an average of 5.8 respondents per case. A previous article describes the data collection process (Jenson et al., in this issue-2016). Briefly, the study measured the conditions from the structural and functional theories through the collection of responses to a number of indicator statements. Taking the mean of 6–7 indicators, each using a 7-point Likert scale, the study formed the indexes for the four conditions. The ISP measure resulted from the identification of innovation, with indicators contextualized to the sectoral and technological system according to the OECD innovation typology (Organisation for Economic Co-Operation and Development, 2005).

This study applies the fsQCA(Rihoux & Ragin, 2009; Schneider & Wagemann, 2010, 2012) using fsQCA software version 2.5 (Ragin & Davey, 2014). The conditions that this study investigated (Table 1) contribute repeatedly in the IS to poor ISP. To identify significant indicators, the study performed a calibration using the same parameters for both the condition and indicators with two different points of indifference, which, in the context of this study, represent an indicator's level of achievement of an IS condition or innovation outcome (Table 1). At the lower level of certainty, the point of indifference is 3.8, whereas at the higher level of certainty, the point of indifference is 4.9. A score of 4 on the Likert scale means that the average respondent "neither agrees nor disagrees," whereas a score of 5 means that the average respondent "somewhat agrees" that at least one example of innovation resulted from the project. A qualitative assessment of the configurations making up the complex solution considers the relative magnitude of each configuration's raw coverage and the number of configurations in which each indicator appears. The purpose of the assessment is understanding which indicators are most prominent in determining the condition, consistent with the qualitative roots of the method (Berg-Schlosser et al., 2009).

This study determined regression equations between calibrated condition indexes and calibrated single indicators using Microsoft Excel. The value of m, the slope of the line in the linear regression equation, is of interest because the condition index is the mean of all indicator values. A value close to 1.0 may suggest that the changes in the indicator contribute significantly to the condition index.

Please cite this article as: Jenson, I., et al., The root cause of innovation system problems: Formative measures and causal configurations, *Journal of Business Research* (2016), http://dx.doi.org/10.1016/j.jbusres.2016.04.127