Country-level investigation of innovation investment in manufacturing: Paired fsQCA of two models

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Abstract

Innovation plays a critical role in the process of economic growth and understanding its determinants remains a key research issue. This study undertakes an analysis of the association between implementing innovation and its antecedents using data from the UNESCO Institute for Statistics (UIS), considering a country-level dataset covering innovation-active manufacturing firms in 47 countries. The relationship considered here is between different drivers of innovation and market preparation for innovation. The technique employed to investigate this relationship is fuzzy-set Qualitative Comparative Analysis (fsQCA). A further aspect of this study is in examining the consideration of different sets of condition variables in the analysis and their impact on the causal recipes found using fsQCA (inclusion/exclusion of a condition variable). This study provides enhanced understanding of variations in the drivers of innovation between sets of countries, as well as an example elucidation of the impact on causal recipes in fsQCA when condition variables are included/ excluded.

Introduction

Government policy makers are striving to encourage innovation activity to benefit their economies (Van der Panne et al., 2003; Hausman, 2005), because of the links between innovation and economic growth more generally, and the importance of location in innovation activities. Specifically, innovation levels vary across countries (Reinstaller and Unterlass, 2012), and there is debate about the underlying drivers of the innovation process itself. Furman et al. (2002) suggest that national innovation capacity is the ability of a country to produce and commercialize a flow of innovative technology over a period of time, determined by a nation's innovation infrastructure and the environment for innovation in a nation's industrial clusters and its interconnectivity.

United Nations Educational, Scientific and Cultural Organization (UNESCO) was realised in 1945/1946, as an organization to contribute to peace and security in the world (UNESCO, 2010). The UNESCO Institute for Statistics (UIS) is the statistical office of UNESCO, estabished in 1999, and is committed to increasing the availability of timely, accurate and policy-relevant statistics in the field of science, technology and innovation. In

2013, for the first time, UIS launched its first global innovation data collection, at the country level, their intention (UIS, 2015, p. 8):

"*... to produce a set of indicators on the types of innovation implemented by firms, the activities and linkages that they made use of, as well as the obstacles they faced when trying to innovate*."

The Statistical Office of the European Communities (2005, p. 47 definition of these innovation-related activities is used here:

"*Innovation activities are all scientific, technological, organizational, financial and commercial steps which actually lead, or are intended to lead, to the implementation of innovations. Some innovation activities are themselves innovative, others are not novel activities but are necessary for the implementation of innovations.*"

Pickernell et al. (2008) suggests drivers of innovation occur from a variety of single sources, or combinations of them, working collaboratively or iteratively to generate collaborative innovation between stakeholders as well as impacting on the industry. The analysis undertaken in this study employs the fuzzy-set Qualitative Comparative Analysis (fsQCA) technique, a set-theoretic technique for causal-oriented investigation (Ragin, 2000b; 2008).

A strength of fsQCA is that it can derive configurational combinations of country level attributes associated with an outcome, from a relatively limited number of units (countries) of analysis. Further, following Berg-Schlosser et al. (2009, p. 9):

"… *causal asymmetry is assumed, meaning that the presence and the absence of the outcome, respectively, may require different explanations*."

Both necessity and sufficiency analyses, using fsQCA, are considered, acknowledging the growing interest in understanding the causal necessity and sufficiency of, rather than the correlations between, configurations (Fiss, 2011).

A novel feature of this study relates to debate over which condition variables to include in the fsQCA based analysis, in particular the impact of considering a five or four condition variable model. Here, therefore, both five and four variable models are developed and considered within the context of fsQCA. With elucidation on two models (five and four variable) the issue of including/excluding a variable from analysis using fsQCA is exposited. Acknowledging the single comparison (of two models) undertaken here, insights into this variable inclusion/exclusion issue in regard to fsQCA are given. Empirical and graphical based results are presented to maximise the exposition of this study, in terms of both applied and technical findings.

The structure of the paper is as follows: the next section considers the nascent understanding of innovation and knowledge, including a description of the considered variables. This is followed by a section describing the fsQCA methodology, UNESCO data sample and data pre-processing. The next section undertakes fsQCA analyses of the UNESCO data, in the form of two models based on five and four condition variables. The penultimate section interprets the results from the direction of innovation and knowledge. In the final section conclusions are given including directions for future research.

Innovation

Innovation has become a cornerstone of economic activity, and policy makers have sought ways to encourage this value-adding activity (Pickernell et al., 2008). Knight and Cavusgil (2004) identify that innovation, knowledge and capabilities are central elements for research on the strategy and performance of the firm.

Specifically, a firm's ability to sustain innovation and create new knowledge leads to the development of improved capabilities, competencies and superior performance (Knight and Cavusgil, 2004). Such innovation normally derives from internal R&D, but also draws on the firm's accumulated knowledge and replication of innovations of other firms (Lewin and Massini, 2003). Crucially, such R&D supports the development of new markets and reinvention of the firm's operations to service those markets with maximum efficiency (Nelson and Winter, 1982). This study focuses on the market introduction and optimisation of innovation within the firm, hereafter considered.

In order to optimise innovation businesses require resources, including knowledge and skills, as well as to grow, enhance efficiency and operational effectiveness. Previously, Dollinger (1995) constructed a typology that can be seen as classifying these resources as different types of capital, namely financial, human, social, technological, reputational and organisational. Investment in such resources, is therefore of key importance in driving both innovation and its related beneficial outcomes for the business more generally.

Whilst investment in research and development (R&D) is of most obvious relevance here, investment in physical capital (Hall et al., 2009) and human capital, through training, is also of potential importance (Jones et al., 2013), because innovation is driven and supported by several processes, which can be seen to represent parts of the "innovation pipeline" (McCarthy et al., 2014). Taking an innovation pipeline approach identifies that innovation, in order to be successfully commercialised, requires R&D activities to be undertaken or bought in (either in terms of the knowledge activity itself or the outcomes in terms of patentable or licensable knowledge), but also potentially, improved physical (including supporting technology) or human capital through training, to allow successful absorption and utilisation of the innovation, broadly following process identified in Acs *et al*. (2012). This, therefore, highlights five potential drivers towards the market introduction of innovation, that will now be further considered.

Market-Introduction of Innovation

Within this study the outcome variable is defined as the “Market introduction of innovations”. This variable describes the market preparation and introduction of new or significantly improved goods and services including marketing research and launch advertising (UIS, 2015). Actually bringing the innovation to market is obviously a key activity, which itself often involves marketing and research activities (Galindo and Mendez, 2014). Improving reputational capital through such marketing (Morris and Paul, 1987), is therefore of relevance to successful innovation-to-market processes.

In-House-R&D

Love and Roper (2015) suggest in-house R&D plays a critical role in a firm’s ability to generate knowledge, potentially providing the basis for proprietary intellectual property and innovation (Griffith et al., 2003). Hölzl (2009) noted a positive relationship between R&D activity and high firm growth in countries with high levels of technology deployment. Raymond and St. Pierre (2010) identify a link between R&D and product innovation (mediated by process innovation). Baldwin and Hanel (2003) suggest investment in R&D as one of the most important mechanisms, other than the development of knowledge and competencies, in determining overall level of innovation in a given sector/industry. Love et al. (2009) and Roper et al. (2008) note R&D capability is positively linked to innovation, a relationship which is stronger in research-intensive industries. Given the potential range of factors affecting the relationships between R&D activity and innovation outcomes, including those related the human capital, further research is required. Literature on firm-level R&D has emphasised both knowledge creating and absorbing roles of in-house R&D (Veugelers and Cassiman, 1999), suggesting a strongly complementary role between in-house and external research.

External-R&D

An alternative to internally generated R&D is to purchase R&D directly from external organisations utilising a transactional as opposed to networked approach (de Lurdes Veludo et al., 2006). Beneito (2006) notes, the most commonly used measure of innovativeness which can be purchased is patent counts, McCarthy et al. (2014) identify licensing as an alternative way in which R&D external to a firm can be purchased.

Beneito (2006) indicates that a combination of in-house and contracted R&D is likely to enhance the significant innovation outcome expected, being economically more valuable. Issues that can arise from such external R&D, is whether the internal capacity exists to successfully absorb this and generate successful innovation for market (Pickernell et al., 2008). One potentially key variable of relevance here, therefore, is related to human capital development, for example, through training.

External-Knowledge

Current paradigms emphasise the need for multidisciplinary and interactive knowledge production among governments, universities and research institutions, and firms in relevant industries: the "Triple Helix" for innovation (Etzkowitz and Leydesdorff, 2000). While conventional processes for fostering organisational learning and innovation were based primarily on individual behaviour and linear models (Weick, 1990), there is increased understanding that learning and innovation occurs through highly interactive, iterative, networked approaches (Cooke, 1998; Gulati, 2007; Lundvall, 1992). There also appears to be positive relationships between growth, use of innovation, and the external relationships of various kinds (Carroll and Hannan, 2000).

Training

The human resource represents a significant asset and a source of potential competitive advantage to any business (Penrose, 1959; Wernerfelt, 1995; Barney, 2001). The value of the human resource within the enterprise can be associated with Becker's (1993) perspective on human capital, in its consideration and recognition of the skills, knowledge and competencies of the individual. Frenz and Oughton (2006) argue that the most consistent finding of regional total factor productivity growth studies is that the stock of human capital enhances the absorptive capacity of firms, facilitating local technology transfer, local and regional knowledge spillovers, innovation and ultimately, growth.

The training of the human resource is therefore essential to have suitably qualified, flexible, prepared and motivated employees (Raghuram, 1994; MacDuffie and Kochan, 1995). Hallier and Butts (1999) found business performance can be constrained by neglect of training activity. Smith and Whittaker (1999), Huang (2001) and Aragon-Sanchez *et al*. (2003) identified the importance of training as a tool to assist in the creation of sustainable competitive advantages based on their human resources. Cassell *et al*. (2002) suggest training is offered to provide a tactical solution to business problems, whilst Patton and Marlow (2002) posit that training demand is explicitly linked to improving the business operation, thus improving efficiency, reducing costs and knowledge regarding protocols.

Therefore, employee training is generally accepted as a mechanism to enhance SME business performance (CEDEFOP, 2011) through enhanced profitability and productivity (Chandler and McEvoy, 2000; Litz and Stewart, 2000; Reid and Harris, 2002), organisational performance and capabilities (DeSimone and Harris, 1998; Chandler and McEvoy, 2000; Kotey and Folker, 2007), business survival (Marshall *et al*., 1995; Ibrahim and Ellis, 2003) and enable growth (Cosh *et al*., 1998; CEDEFOP, 2011).

Physical-Capital

In terms of investment in physical capital, information communication technology (ICT) hardware and software are of particular relevance (Diaz-Chao et al., 2015). Jorgenson and Vu (2007) claim that ICT usage is crucial for economic activity at its increases firm productivity and economic growth (Jorgenson et al., 2008). Moreover, ICT usage generates complementary innovations that improve economics total factor productivity (Ceccobelli et al., 2012).

For example, Lesjak and Vehovar (2005) recognised that internet use contributed to the creation of current and future economic benefits, which was reflected in increased market value. Indeed, Lee (2001) described the process of transforming to a more e-commerce based approach as representing a potentially disruptive innovation which could radically alter operating procedures. Diaz-Chao et al. (2015) identify that ICTs effect on firm productivity shows that return rates on digital investment are higher than for physical investment. This is explained by digital investment often occurs alongside other investment into human capital or organisational change (Brynjolfsson and Hitt, 2003).

While the final five variables discussed are the considered condition variables in our study, there was debate regarding the inclusion of Physical-Capital, given that of the five, it was the least directly related to innovation in the literature, though more obviously related to the marketing of the innovation into the marketplaces through e-commerce, for example. It was decided, therefore, to compare a five with a four variable model of innovation, both to examine the impact of the addition of the physical capital variable, but also to explore the fsQCA methodological issues associated with a five versus a four variable model.

UNESCO Data set, Methodology and Data Pre-processing

UNESCO Data set

The dataset encompasses “innovation-active” firms, which, according to UNESCO (2015), are those that implemented product or process innovations, had abandoned or had ongoing innovation activities to develop product or process innovations. As such, the study focuses on the activities of firms that are active in processes that are related to innovation, in particular, manufacturing firms. One reason for this subset of firms to be considered was to enable comparability across the considered countrues (UIS, 2015). Descriptions of the condition and outcome variables are presented in Table 1.

Table 1. Definition of variables

Condition variables	Description
In-house-R&D	Creative work undertaken within your enterprise On an occasional or regular basis to increase the stock of knowledge and its use to devise new and improved goods, services or processes.
External-R&D	Same activities as above, but purchased by your enterprise and performed by other companies (including other enterprises within your group) or by public or private research organisations.
External-Knowledge	Purchase or licensing of patents and non-patented inventions, know-how, and other types of knowledge from other enterprises or Organisations
Training	Internal or external training for your personnel specifically for the development and/or introduction of innovations.
Physical-Capital	Acquisition of advanced machinery, equipment and computer hardware or software to produce new or significantly improved goods, services, production processes, or delivery methods.
Outcome variable	**Description**
Market-Introduction	Activities for the market preparation and introduction of new or significantly improved goods and services, including market research and launch advertising.

Source: D’Este et al., (2012)

Note: One further variable, ‘Other preparations’ was available for inclusion, but was not deemed specific enough to be further considered.

In the UNESCO country-innovation dataset there were 59 countries reported (UIS, 2015), when considering the variables described in Table 1, 47 countries had the complete information required, and were considered in the rest of the paper.

Methodology

Fuzzy-set Qualitative Comparative Analysis (fsQCA), is a set-theoretic technique for the investigation of the relationship between potential causal condition variables and an outcome (a development on the original QCA, Ragin, 1987). Moreover, it formulates a configurational exposition of the ways in which condition variables combine to prescribe an outcome, crucially it is a practical analysis tool in the presence of potential causal complexity (see Ragin, 2000; 2008). With cases contributing to the prevalence of certain configurations of variables, it is this level of comparison that enables future practical interpretation.

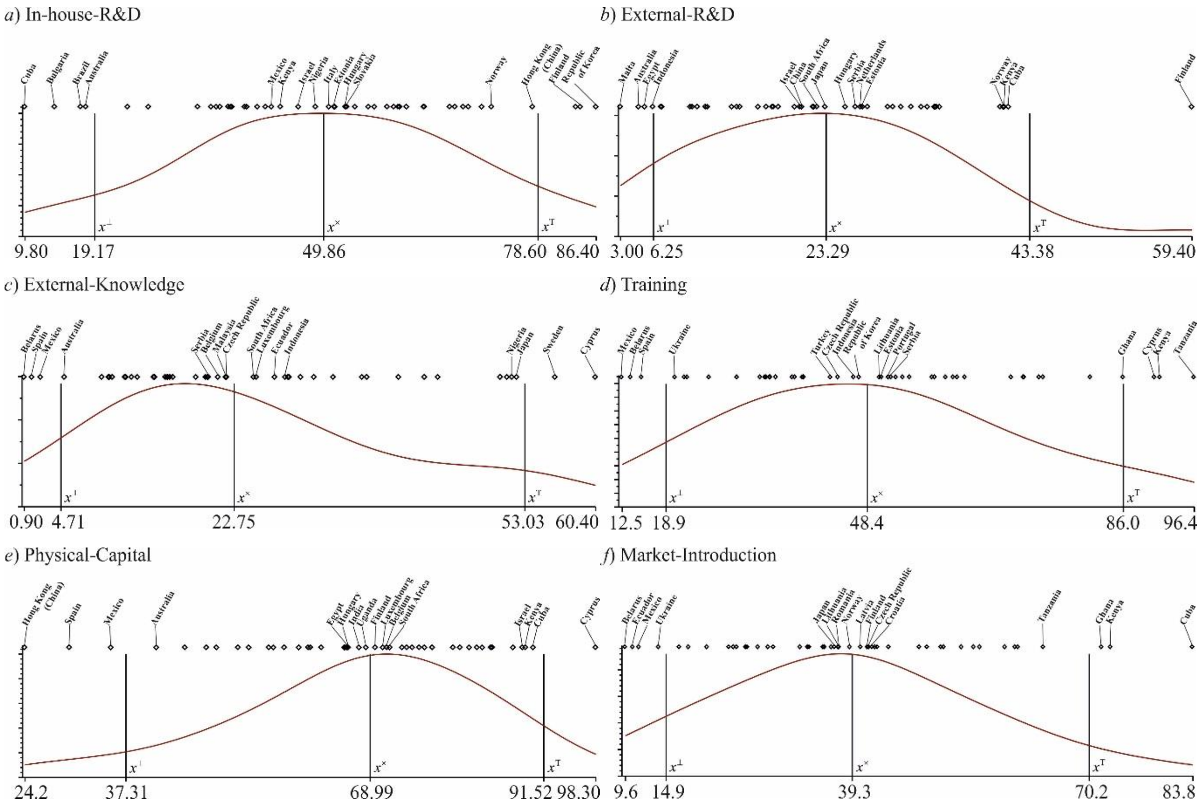
Through comparison, fsQCA identifies the causal conditions associated with each outcome, including the minimal causal conditions necessary or sufficient for the outcome to occur. As described in Rihoux and Ragin (2009), conditions are necessary when the outcome cannot occur without them, whereas conditions are sufficient when the outcome always occurs when the condition is present, although the outcome could also result from other conditions.

Data pre-processing

To enable the employment of fsQCA on the country-innovation data set a level of pre-processing is undertaken. Moreover, with the intent of transforming the condition and outcome variable values from their respective interval-scale values to fuzzy membership scores over the consistent 0.0 (which signals full exclusion "non-membership" from a set) to 1.0 (which signals full inclusion "membership") domain. This study adopts the approach presented in Andrews et al. (2015), Barton and Beynon (2015) and Beynon et al. (2015), as a means of identifying the three researcher-specified threshold qualitative anchors to determine full membership (upper-threshold), full non-membership (lower-threshold) and the crossover point, within the direct method approach to establishing the required fuzzy membership scores (Ragin, 2008a).

In summary, this threshold qualitative anchor evaluation process is initially based on the identification of the respective 5th percentile (lower-threshold), 95th percentile (upper-threshold) and 50th percentile (crossover point) values, by building on a probability-density function (*pdf*) graph for each variable, see Figure 1.

Figure 1. *Pdf* graphs of condition (*a* to *e*) and outcome (*f*) variables, with thresholds for full-non-membership ($x^{\perp}$), crossover point ($x^{\times}$) and full-membership (x^{T}) highlighted



In Figure 1, the *pdf* representations of the spread of the variable values over their respective domains is given (see Andrews et al., 2015). Within each graph above the respective *pdf* are points representing the individual case (country) values over that variable.

The highlighted countries shown demonstrate the information considered by experts in the field of innovation (more countries were considered). In particular, the crossover point ($x^{\times}$) in each graph was considered, in terms of the possible impact of moving them across neighbouring case values (both to the left and right of their original values). The potential changes in case associations to configurations subject to the possible changes in crossover points were not felt pertinent enough to make such change (also considered visually using Venn diagrams – see later for discussion of them). This was accompanied by discussions with experts knowledgeable in the field of innovation research, which confirmed the threshold values as acceptable across all variables.

Following the direct method of Ragin (2008a), the threshold values identified in each graph in Figure 1 are used to evaluate respective fuzzy memebrship score values (see also Andrews et al., 2015). One advantage of the use of the *pdf* approach to establishment of the qualitative anchors (subject to expert verification) is the almost certain avoiding of a precise 0.5 membership score to any case variable value (an issue highlighted in Ragin, 2008b).

FSQCA Analysis of UNESCO Data

This section presents output of the two fsQCA analyses undertaken on the five and four variables models considered (including/excluding Physical-Capital condition variable), conducted using fs/QCA Version 2.5 (Ragin and Davey, 2014). Central to these analyses is the notion of a truth table (Ragin et al., 2008), which includes the possible configurations within which countries can be associated, see Table 2.

Table 2. Truth table showing all configurations based on five (32) and four (16) condition variables considered with associated raw consistency (Raw Cons) values to outcome (Otcm), not-outcome (~Otcm) and frequency (No) of countries in that configuration (Cnfig), for when five and four condition variables are considered (inclusion/exclusion of Physical-Capital condition variable)

In-house -R&D	External-R&D	External-knowledge	Training	Physical-Capital	Market-Introduction							
					5 variable model				4 variable model			
					Cnfg	Raw Cons Otcm	Raw Cons ~Otcm	No	Cnfg	Raw Cons Otcm	Raw Cons ~Otcm	No
0	0	0	0	0	1	0.523	**0.924**	**7**	1	0.496	**0.913**	**10**
0	0	0	0	1	2	0.628	**0.945**	**3**				
0	0	0	1	0	3	0.801	0.900	2	2	0.772	0.850	**5**
0	0	0	1	1	4	0.791	0.865	3				
0	0	1	0	0	5	0.844	**0.916**	**1**	3	0.817	**0.925**	**2**
0	0	1	0	1	6	0.811	**0.964**	**1**				
0	0	1	1	0	7	~~0.929~~	~~0.880~~	~~0~~	4	~~0.932~~	~~0.843~~	~~0~~
0	0	1	1	1	8	~~0.928~~	~~0.857~~	~~0~~				
0	1	0	0	0	9	~~0.769~~	~~0.961~~	~~0~~	5	~~0.787~~	~~0.942~~	~~0~~
0	1	0	0	1	10	~~0.840~~	~~0.937~~	~~0~~				
0	1	0	1	0	11	~~0.933~~	~~0.910~~	~~0~~	6	~~0.938~~	~~0.903~~	~~0~~
0	1	0	1	1	12	~~0.937~~	~~0.902~~	~~0~~				
0	1	1	0	0	13	~~0.923~~	~~0.958~~	~~0~~	7	**0.916**	0.858	**1**
0	1	1	0	1	14	**0.911**	0.850	**1**				
0	1	1	1	0	15	~~0.968~~	~~0.881~~	~~0~~	8	**0.960**	0.697	**4**
0	1	1	1	1	16	**0.959**	0.688	**4**				
1	0	0	0	0	17	0.699	**0.901**	**3**	9	0.698	0.899	4
1	0	0	0	1	18	0.793	**0.953**	**1**				
1	0	0	1	0	19	0.850	0.853	**1**	10	0.862	0.828	**1**
1	0	0	1	1	20	~~0.890~~	~~0.869~~	~~0~~				
1	0	1	0	0	21	0.892	**0.903**	**1**	11	0.893	0.896	1
1	0	1	0	1	22	~~0.879~~	~~0.948~~	~~0~~				
1	0	1	1	0	23	**0.928**	0.814	**2**	12	**0.930**	0.777	**3**
1	0	1	1	1	24	**0.931**	0.822	**1**				
1	1	0	0	0	25	0.785	**0.970**	**2**	13	0.807	**0.945**	**3**
1	1	0	0	1	26	0.885	**0.937**	**1**				
1	1	0	1	0	27	~~0.938~~	~~0.888~~	~~0~~	14	**0.931**	0.843	**3**
1	1	0	1	1	28	**0.931**	0.837	**3**				
1	1	1	0	0	29	~~0.927~~	~~0.966~~	~~0~~	15	0.844	**0.905**	**2**
1	1	1	0	1	30	0.863	**0.931**	**2**				
1	1	1	1	0	31	**0.908**	0.821	**4**	16	**0.903**	0.720	**8**
1	1	1	1	1	32	**0.946**	0.728	**4**				
Number of 'non-remainder' configurations						7	10	20		5	4	13

In Table 2, the results for the five and four variable models are shown in terms of the possible configurations, and the associated raw consistency values to the outcome (Market-Introduction) and not-outcome (~Market-Introduction) and frequency of countries associated with a configuration based on strong membership (see Beynon et al., 2015). In the case of five and four variable models, 32 (= 2^5) and 16 (= 2^4) possible configurations exist, respectively. Hence, there are 32 and 16 sets of raw consistency and frequency values presented seperately for the five and four variable models.

In this analysis, we detail the specific necessity and sufficiency findings (separately for Market-Introduction and ~Market-Introduction), respectively. That is, analysing if a condition must be present for capability to occur (analysis of necessity), or if a given condition or combination of conditions can produce this result (analysis of sufficiency), see Andrews *et al*. (2015).

For the necessity analysis, in relation to individual condition variables and Market-Introduction and ~Market-Introduction, see Table 3.

Table 3. Analysis of Necessity results for Market-Introduction and ~Market-Introduction (Cons - Consistency and Cov - Coverage)

Variable		5 vars model				4 vars model			
		Market-Introduction		~Market-Introduction		Market-Introduction		~Market-Introduction	
		Cons	Cov	Cons	Cov	Cons	Cov	Cons	Cov
In-house-R&D	var	0.713	0.662	0.590	0.613	0.713	0.662	0.590	0.613
	not-var	0.583	0.559	0.675	0.725	0.583	0.559	0.675	0.725
External-R&D	var	0.735	0.740	0.515	0.580	0.735	0.740	0.515	0.580
	not-var	0.583	0.518	0.769	0.765	0.583	0.518	0.769	0.765
External-knowledge	var	0.774	0.786	0.495	0.562	0.774	0.786	0.495	0.562
	not-var	0.569	0.501	0.811	0.801	0.569	0.501	0.811	0.801
Training	var	0.762	0.694	0.596	0.607	0.762	0.694	0.596	0.607
	not-var	0.568	0.557	0.699	0.767	0.568	0.557	0.699	0.767
Physical-Capital	var	0.801	0.789	0.507	0.559	-	-	-	-
	not-var	0.552	0.500	0.808	0.820	-	-	-	-

From Table 3, there are no condition attributes with a consistency value above the often employed threshold value of 0.90 (Young and Park, 2013), hence there are no single condition attributes considered a necessity in terms of the Market-Introduction or ~Market-Introduction. While the sets of consistency and coverage values are given for both the five and four variables models, across a condition variable the values are the same, signifying within a necessity analysis the number of variables considered does not impact on these findings, it is at the individual condition variable level the results are established.

In terms of the sufficiency analysis next undertaken (see Andrews et al., 2015), only those configurations with at least one 'strong membership' associated country are considered. Hence, where a configuration has no such countries associated with them, within either the five or four variable models, their consistency and frequency values are struck through in Table 2.

Across the considered five and four variable models, a consistency threshold value of 0.90 was employed, to enable distinction of configurations strongly associated with Market-Introduction and ~Market-Introduction. This was based on the least possible threshold value (to 2 decimal places of accuracy), while not imposing any configuration to be associated with both Market-Introduction and ~Market-Introduction in the same analysis. Of note is that the identified threshold values identified for the five and four variable models were the same value, namely 0.90, under this criteria. In the raw consistency value columns in Table 2, for both the five and four variable models, the consistency values in bold indicate for those configurations which are above the threshold value 0.90 in terms of raw consistency (and here only those with at least one country associated with them).

Because of the employment of this consistency threshold value, a number of groups of countries (configurations) were excluded in the five and four variable models, because of the failure to exceed the 0.90 value for either Market-Introduction or ~Market-Introduction, termed remainders (see Schneider and Wagemann, 2013). At the bottom of Table 2, the last row shows the number of non-remainder configurations associated with Market-Introduction and ~Market-Introduction outcomes across the five and four variable models.

With configurations identified in terms of whether they are associated with Market-Introduction and ~Market-Introduction, Tables 4 and 5 present the "sufficiency analyses" used to interpret the complex and parsimonious fsQCA solutions (as advocated by Wagemann and Schneider, 2010).

Table 4. Sufficiency analyses results for Market-Introduction in case of five and four variable models (including complex and parsimonious solutions)

Conditions	Market-Introduction						
	5 variable model				4 variable model		
In-house-R&D	⊖	●	•		⊖	•	•
External-R&D	●				●		●
External-Knowledge	•		●		•	●	
Training		●	●			●	●
Physical-Capital	•	●			-	-	-
Complex Solution	**5CO1**	**5CO2**	**5CO3**		**4CO1**	**4CO2**	**4CO3**
Configurations	14, 16	24, 28, 32	23, 24, 31		7, 8	12, 16	14, 16
Consistency	0.939	0.923	0.890		0.941	0.890	0.870
Raw Coverage	0.407	0.474	0.556		0.424	0.556	0.538
Unique Coverage	0.102	0.027	0.108		0.108	0.053	0.035
Solution Consistency	0.881				0.869		
Solution Coverage	0.684				0.699		
Parsimonious Solution	**5PO1**	**5PO2**	**5PO3**		**4PO1**	**4PO2**	**4PO3**
Configurations	14, 16	24, 28, 32	23, 24		7, 8	12, 16	14, 16
Consistency	0.862	0.900	0.893		0.862	0.893	0.885
Raw Coverage	0.455	0.502	0.683		0.455	0.683	0.634
Unique Coverage	0.064	0.022	0.139		0.064	0.089	0.028
Solution Consistency	0.837				0.832		
Solution Coverage	0.780				0.786		

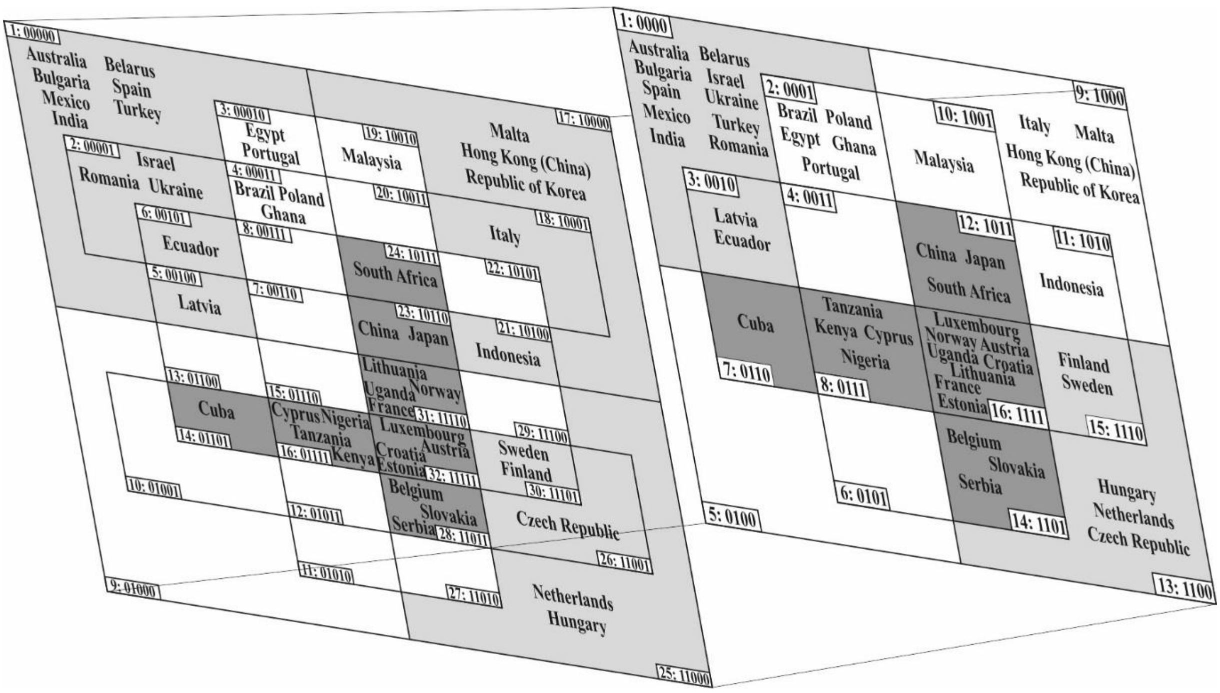
Table 5. Sufficiency analyses results for ~Market-Introduction in case of five and four variable models (including complex and parsimonious solutions)

Conditions	~Market-Introduction						
	5 variable model					4 variable model	
In-house-R&D	●	●	⊝			⊖	●
External-R&D	•		⊖	⊖		⊖	●
External-Knowledge		⊝					
Training	⊖	⊖	⊖	⊖		⊖	⊖
Physical-Capital	•			⊝		-	-
Complex Solution	**5CN1**	**5CN2**	**5CN3**	**5CN4**		**4CN1**	**4CN2**
Configurations	26, 30	17, 18, 25, 26	1, 2, 5, 6	1, 5, 17, 21		1, 3	13, 15
Consistency	0.918	0.911	0.884	0.903		0.911	0.904
Raw Coverage	0.338	0.563	0.510	0.409		0.563	0.397
Unique Coverage	0.044	0.086	0.014	0.022		0.314	0.148
Solution Consistency	0.880					0.889	
Solution Coverage	0.752					0.711	
Parsimonious Solution	**5PN1**		**5PN2**			**4PN1**	**4PN2**
Configurations	17, 18, 25, 26, 30		1, 2, 5, 6, 17, 21			1, 3	13, 15
Consistency	0.860		0.882			0.911	0.904
Raw Coverage	0.487		0.651			0.563	0.397
Unique Coverage	0.113		0.487			0.314	0.148
Solution Consistency	0.864					0.889	
Solution Coverage	0.765					0.711	

In Tables 4 and 5, the top rows describe the causal recipes based association of configurations with Market-Introduction and ~Market-Introduction, over the different five and four variable models. The notation employed, follows Ragin and Fiss (2008), where black circles ("●") indicate the presence of a condition, and circles with a cross-out ("⊖") indicate its absence, with the size of the circle, indicating, small – core conditions and large – peripheral conditions (blank spaces indicate a 'don't care' inference), see Fiss (2011).

Figure 2 presents the groupings of the 47 countries in the sample, over the five and four variable models (a two tier Venn diagram). Each cell, in the shown Venn diagrams, is labelled with their configuration index and a summary of the representation of the configuration, in terms of absence (0) or presence (1) of each condition variable.

Figure 2. The two-tier Venn diagram showing spread of 47 countries across configurations based on strong membership, for when five (left) and four (right) condition variables are considered (dark and light shaded cells signify association to causal recipes describing Market-Introduction and ~Market-Introduction)



In Figure 2, several results are presented in the form of a two-tier Venn diagram, with each of the two layers (of the tier) offering information on the five (left) and four (right) variable models. In each tier (in a Venn diagram), a cell denotes a configuration (refer to the configurations presented in Table 2). For each model, the countries associated with each configuration are presented, again the numbers of countries associated with a configuration align with the numbers presented in Table 2.

Following Beynon et al. (2015), those cells in the Venn diagrams shaded dark gray and light gray correspond to the outcome a configuration is associated with from the fsQCA analyses, namely Market-Introduction and ~Market-Introduction, respectively. The white shaded region signifies no assignment to Market-Introduction and ~Market-Introduction. The following broad points can be made from the paired fsQCA analyses undertaken, with emphasis across both the technical and applied aspects of this study.

First, while the number of identified causal recipes shown in the complex solutions for Market-Introduction across the five and four variable models are the same (recipes 5CO1, 5CO2, 5CO3 and 4CO1, 4CO2 and 4CO3), a greater number causal recipes are identified in the five variable model compared to the four variable model with respect to ~Market-Introduction (four recipes compared to two).

Second, there is a strong overlap between the five and four variable models, with two recipes identical for the five and four variable models (5CO3 and 4CO2 for the Market-Introduction and 5CN3 and 4CN1 for ~Market-Introduction), and two recipes (5CO1 and 4CO1 for the Market-Introduction and 5CN1 and 4CN2 for ~Market-Introduction) where the only difference was that the five variable model included the fifth variable (Physical-Capital).

Third, the condition variable that appears most consistently in the causal recipes is Training, being present in (all but one of – not 5CO1) the recipes for the Market-Introduction, and absent from the recipes for the ~Market-Introduction. This suggests an important role for human capital and its development in assisting innovation into the market (and the absence of training preventing innovation into the market), in combination with innovation creation and absorption activities. This finding confirms the prior work of Frenz and Oughton (2006) regarding the importance of human capital towards innovative activity in the firm.

By contrast, In-house-R&D appears in several recipes, both for Market-Introduction and ~Market-Introduction, but the relationship is not consistent. For example, for Market-Introduction, it appears that an absence of In-house-R&D innovation can be substituted for the by the presence of External-R&D and External-Knowledge. Conversely, the presence of In-house-R&D, where there is an absence of Training, is associated with ~Market-Introduction. This suggests that In-house-R&D is neither necessary or sufficient as a variable in driving market introduction of innovation (or its absence explaining a lack of market introduction of innovation).

External-Knowledge also appears inconsistently in the causal recipes. The presence of External-Knowledge is more strongly associated with Market-Introduction, appearing in two of the recipes compared with its absence being in only one of the four recipes describing

~Market-Introduction. The presence of Physical-Capital is also associated with Market-Introduction for two of the three recipes, whilst its absence is associated with an ~Market-Introduction in one of the four recipes. In the 5CN1 recipe however, the presence of Physical-Capital, along with the presence of In-house-R&D and presence of External-R&D, when combined with an absence of Training, is associated with the ~Market-Introduction. This reinforces the strength of the role of Training (and its absence) in explaining Market-Introduction and ~Market-Introduction outcomes.

In terms of countries, for most, a single causal recipe is relevant. The results indicate that effectively bringing an innovation to market is not the preserve of the developed countries with a diverse range of countries present across the spectrum of results. For some countries, however, (South Africa (in configuration 24) for Market-Introduction, and (Australia, Belarus, Bulgaria, Spain, Mexico, Turkey, India (configuration 1), Latvia (configuration 5), and the Czech Republic (configuration 26) for ~Market-Introduction, two causal recipes are of relevance.

Conclusions

This paper has considered a country level comparison of innovation marketing when collated aginst knowledge development strategies within each country. The study offers a novel contribution to knowledge in identifying the required receipes to bring an innovation to market. An interesting additional feature of this study has been the acknowledgement of uncertainty in the specific model to be considered. Specifically, examining the question of whether to include or exclude a fifth variable has offered a technical elucidation of its impact.

Appreciating this is only one example analysis to take evidence from, there are interesting features to appreciate. The combined five and four variable models' truth tables shows how pairs of configurations in five variable model relate to single configurations in the four variable model. Associated with this is the variations in row consistency value across the pairs and single configurations.

While a consistent consistency threshold value was identified for both models, based on not having a configuration strongly associated with both Market-Introduction and ~Market-Introduction, there was variations in the configurations subsequently strongly associated with the outcome or not-outcome, in terms of the five and four variable models (the variations is more in the countries – see Figure 2), with a greater number of countries able to be pertinently included in the five variable model.

Therefore, a number of configurations differ across the models, in terms of going from association changing between either Market-Introduction and ~Market-Introduction and not considered. While there is not evidence of changing from Market-Introduction to ~Market-Introduction, or vice-versa, across two models of different numbers of varables (based on one variable included/excluded).

There are future directions of research work in both the applied and technical dimensions from this study. From an applied analysis perspective it would be interesting to assess the relationship receipe trends over a longitiundinal perspective to evaluate the country trends. In terms of the technical developments, clearly the variable inclusion/exclusion issues is a problem that many researchers will face. This will need further future consideration, with more examples of its occurment necessary to fully appreciate its impact.

References

Acs, Z., Brooksbank, D., O'Gorman, C., Pickernell, D., & Terjesen, S. (2012). The knowledge spillover theory of entrepreneurship: an application to foreign direct investment, *International Journal of Entrepreneurship and Small Business, 15*(2), 237-261.

Andrews, R., Beynon, M.J., & McDermott, A.M. (2015). Organizational Capability in the Public Sector: A Configurational Approach, *Journal of Public Administration Research and Theory*, forthcoming.

Audretsch, D. (2004). Sustaining innovation and growth: Public policy support for entrepreneurship. *Industry and Innovation*, *11*(3), 167–191.

Barton, H., & Beynon, M.J. (2015). Do the Citizens of Europe Trust Their Police. *International Journal of Emergency Services*, *4*(1), 65–85.

Beneito, P. (2006). The innovative performance of in-house and contracted R&D in terms of patents and utility models. *Research Policy*, *35*(4), 502–517.

Berg-Schlosser, D., De Meur, G., Rihoux, B., & Ragin. C.C. (2009). Qualitative comparative analysis (QCA) as an approach. In *Configurational comparative methods*, eds. Benoit Rihoux and Charles C. Ragin, 1–18. Thousand Oaks, CA: Sage.

Beynon, M.J., Jones, P., & Pickernell, D. (2015). Country-based comparison analysis using fsQCA investigating entrepreneurial attitudes and activity. *Journal of Business Research*, forthcoming.

Brynjolfsson, E., & Hitt, L.M. (2003). Computing productivity: Firm-level evidence. *Review of Economics and Statistics*, *85*(4), 793-808.

Carroll, G.R., & Hannan, M.T. (2000). *The Demography of Corporations and Industries*. Princeton University Press, Princeton, NJ.

Cassell, C., Nadin, S., Gray, M., & Clegg, C. (2002). Exploring human resource management practices in small and medium sized enterprises, *Personnel Review*, *31*(6), 671-692.

Ceccobelli, M., Gitto, S., & Mancuo, P. (2012). ICT capital and labour productivity growth: a non-parametric analysis of 14 OECD countries. *Telecommunications Policy*, *36*(4), 282-292.

CEDEFOP (2011). The impact of vocational education and training on company performance. RP 19, European Centre for the Development of Vocational Training Research, Publications Office of the EU, Luxembourg.

Chandler, G.N., & McEvoy, G.M. (2000). Human resource management, TQM, and firm performance in small and medium-size enterprises. *Entrepreneurship Theory and Practice*, *25*(1), 43-58.

Cooke, P. (1998). Introduction: Origins of the concept. In *Regional innovation systems —The role of governance in a globalized world*, ed. H. Braczyk, P. Cooke, and M. Heidenreich, 2–25. London: University College London Press.

Cosh, A., Hughes, A., & Weeks, M. (2000). *The Relationship Between Training and Employment Growth in Small and Medium-Sized Enterprises*, WP188, Cambridge, Centre for Business Research, Cambridge University.

de Lurdes Veludo, M., Macbeth, D., & Purchase, S. (2006). Framework for relationships and networks, *Journal of Business & Industrial Marketing*, *21*(4), 199-207.

D'Este, P., Iammarino, S., Savona, M., & von Tunzelmann, N. (2012). What hampers innovation? Revealed barriers versus deterring barriers. *Research Policy*, *41*(2), 482-488.

Diaz-Chao, A., Gonzalez, J.S., & Torrent-Sellens, J. (2015). ICT, innovation, and firm productivity: New evidence from small local firms. *Journal of Business Research*, *68*(7), 1439-1444.

Dollinger, S.M. (1995). Identity styles and the five-factor model of personality. *Journal of Research in Personality*, *29*(4), 475–479.

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and 'Mode 2' to Triple Helix of university-industry-government relations. *Research Policy*, *29*(2), 109-123.

Fiss, P.C. (2007). A set-theoretic approach to organizational configurations. *Academy of Management Review*, *32*(4), 1180-1198.

Fiss, P.C. (2011). Building Better Causal Theories A Fuzzy Set Approach to Typologies in Organisation Research. *Academy of Management Journal*, *54*(2), 393-420.

Frenz, M., & Oughton, C. (2006). *Innovation in the UK regions and devolved administrations: A review of the literature*. Final Report for the Department of Trade and Industry and the Office of the Deputy Prime Minister. London: Department of Trade and Industry.

Furman, J., Porter, M., & Stern, S. (2002). The determinants of national innovative capacity. *Research Policy*, *31*(6), 899-933.

Galindo, M.-A., & Méndez, M.T. (2014). Entrepreneurship, economic growth, and innovation: Are feedback effects at work? *Journal of Business Research*, *67*(5), 825-829.

Griffith, R., Redding, S., & Van Reenen, J. (2003). R&D and Absorptive Capacity: Theory and Empirical Evidence. *Scandinavian Journal of Economics*, *105*(1), 99-118.

Giuliani, E., & Bell, M. (2007). Catching up in the global wine industry: innovation systems, cluster knowledge networks and firm-level capabilities in Italy and Chile. *International Journal of Technology and Globalisation*, *3*(2/3), 197–223.

Hall, B.H., Lotti, F., & Mairesse, J. (2009). Innovation and productivity in SMEs: empirical evidence for Italy. *Small Business Economics*, *33*(1), 13-33.

Hallier, J., & Butts, S. (1999). Employers' discovery of training: self-development, employability and the rhetoric of partnership. *Employee Relations*, *21*(1), 80–95.

Hausman, A. (2005). Innovativeness among small businesses: theory and propositions for future research. *Industrial Marketing Management*, *34*(8), 773–782.

Hölzl, W. (2009). Is the R&D behaviour of fast-growing SMEs different? Evidence from CIS III data for 16 countries. *Small Business Economics*, *33*(1), 59-75.

Huang, T.C. (2001). The relation of training practices and organizational performance in small and medium size enterprises. *Education + Training*, *43*(8/9), 437–444.

Ibrahim, A.B., & Ellis, W. (2003). *Family Business Management, Concepts and Practices*, Dubuque, IA, Kendall/Hunt.

Jones, P., Beynon, M.J., Pickernell, D., & Packham, G. (2013). Evaluating the Impact of Different Training Methods on SME Business Performance. *Environment & Planning C – Government and Policy*, *31*(1), 56-81.

Jorgenson, D.W., & Vu, K. (2007). Information Technology and the world growth resurgence. *German Economic Review*, *8*(2), 122-145.

Jorgenson, D.W., Ho, M.S., & Stiroh, K.J. (2008). A retrospective look at the US productivity growth resurgence. *Journal of Economics Perspective*, *22*(1), 3-24.

Kotey, B., & Folker, C. (2007). Employee training in SMEs: effects of size and firm type. *Journal of Small Business Management*, *45*(2), 214-234.

Knight, G.A., & Cavusgil, S.T. (2004). Innovation, organizational capabilities, and the born-global firm. *Journal of International Business Studies*, *35*(2), 124-141.

Lee, C-S. (2001). An analytical framework for evaluating e-commerce business models and strategies. *Internet Research: Electronic Networking Applications and Policy*, *11*(4), 349-359.

Lesjak, D., & Vehovar, V. (2005). Factors affecting evaluation of e-business projects. *Industrial Management & Data Systems*, *105*(4), 409-428.

Lewin, A.Y., & Massini, S. (2003). Knowledge Creation and Organizational Capabilities of Innovating and Imitating Firms, in H. Tsoukas and N. Mylonopoulos (eds.) Organizations as Knowledge Systems, Palgrave: Basingstoke.

Litz, R.A., & Stewart. A.C, (2000). Research Note: Trade Name Franchise Membership as a Human Resource Management Strategy: Does Buying Group Training Deliver True Value' for Small Retailers? *Entrepreneurship Theory and Practice*, *25*(1), 125-135.

Love, J.H., & Roper, S. (2015). SME innovation, exporting and growth: A review of existing evidence. *International Small Business Journal*, *33*(1), 28-48.

Love, J.H., Roper, S., & Du, J. (2009). Innovation, ownership and profitability. *International Journal of Industrial Organization*, *27*(3), 424-434.

MacDuffie, J.P., & Kochan, T.A. (1995). Do U.S. Firms Invest Less in Human Resources?: Training in the World Auto Industry. *Industrial Relations: A Journal of Economy and Society*, *34*(2), 147-168.

McCarthy, S., Packham, G., & Pickernell, D. (2014). The potential of and framework for promoting a business angel university and intellectual property exploitation: a case study from Wales. *Handbook on the Entrepreneurial University*, (eds : A. Fayolle and D.T. Redford), 323-345.

Morris, M.H., & Paul, G.W. (1987). The relationship between entrepreneurship and marketing in established firms. *Journal of Business Venturing*, *2*(3), 247-259.

Nelson, R., & Winter, S. (1982). *An Evolutionary Theory of Economic Change*, Belknap Press: Cambridge, MA.

Patton, D., & Marlow, S. (2002). The determinants of management training within smaller firms in the UK. What role does strategy play? *Journal of Small Business and Enterprise Development*, *9*(3), 260-270.

Penrose, E.T. (1959). *The Theory of the Growth of the Firm* (1995 ed.). New York: John Wiley and Sons.

Pickernell, D., Packham, G., Thomas, B., & Keast, R. (2008). University Challenge? Innovation Policy and SMEs in Welsh Economic Development Policy: Towards a New Framework. *International Journal of Entrepreneurship and Innovation*, *9*(1), 51-62.

Raghuram, S., & Arvey, R.D. (1994). Business strategy links with staffing and training practices. *Human Resource Planning*, *17*(3), 55-73.

Ragin, C.C. (2008a). Fuzzy sets: Calibration versus measurement. In *The Oxford Handbook of Political Methodology,* ed. Janet M. Box-Steffensmeier, Henry E. Brady, and David Collier, 174–198. Oxford: Oxford University Press.

Ragin, C.C. (2008b). *Redesigning social inquiry: Fuzzy sets and beyond.* Chicago: University of Chicago Press.

Ragin, C.C., & Davey, S. (2014). *fs/QCA [Computer Programme], Version 2.5*. Irvine, CA: University of California.

Ragin, C.C, Strand, S.I., & Rubinson, C. (2008). *User's guide to fuzzy-set/qualitative comparative analysis*. Tucson, AZ: University of Arizona.

Raymond, L., & St-Pierre, J. (2010). R&D as a Determinant of SMEs: an attempt at empirical clarification, *Technovation 30*(1), 48-56.

Reid, R.S., & Harris, R.I.D. (2002). The determinants of training in SMEs in Northern Ireland. *Education + Training*, *44*(8/9), 443-450.

Reinstaller, A., & Unterlass, F. (2012). Comparing business R&D across countries over time: a decomposition exercise using data for the EU 27. *Applied Economics Letters*, *19*(12), 1143-1148.

Rihoux, B., & Ragin, C. C. (eds.) (2009). *Configurational comparative methods. Qualitative Comparative Analysis (QCA) and related techniques*. Thousand Oaks, CA: Sage.

Roper, S., Du, J., & Love, J.H. (2008). Modelling the innovation value chain. *Research Policy*, *37*(6/7), 961-977.

Schneider, C.Q., & Wagemann, C. (2013). Doing justice to logical remainders in QCA: moving beyond the standard analysis. *Political Research Quarterly*, *66*(1), 211-220.

Statistical Office of the European Communities. (2005). *Oslo manual: Guidelines for collecting and interpreting innovation data* (No. 4). Publications de l'OCDE.

Smith, A., Whittaker, J., Loan Clark, J., & Boocock, G. (1999). Competence based management development provision to SMEs and the providers' perspective. *Journal of Management Development*, *18*(6), 557-572.

UNESCO (2010). UNESCO Archives: A short Guide, ARC-2011/WS/1, December, http://www.unesco.org/archives/new2010/doc/Short_guide_to_Archives.pdf.

UIS (2015) Summary Report of the 2013 USI Innovation Data Collection, Information Paper No. 24, UNESCO Institute for Statistics, Canada, http://dx.doi.org/10.15220/978-92-9189-175-7-en.

van der Panne, G., van Beers, C., & Kleinknecht, A. (2003). Success and failure of innovation: a literature Review. *International Journal of Innovation Management*, *7*(3), 309-338.

Veugelers, R., & Cassiman, B. (1999). Make and buy in innovation strategies: evidence from Belgian manufacturing firms. *Research Policy*, *28*(1), 63-80.

Weick K.E. (1990). The vulnerable system: an analysis of the Tenerife air disaster. *Journal of Management*, *16*(3), 571-593.

Wernerfelt, B. (1984). A Resource-Based View of the Firm. *Strategic Management Journal*, *5*(2), 171-180.

Young, K.L., & Park, S.H. (2013). Regulatory opportunism: Cross-national patterns in national banking regulatory responses following the global financial crisis. *Public Administration*, *91*(3), 561-581.