A Set Theoretical Approach to Maturity Models: Guidelines and Demonstration

Completed Research Paper

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Abstract

Maturity Model research in IS has been criticized for the lack of theoretical grounding, methodological rigor, empirical validations, and ignorance of multiple and non-linear paths to maturity. To address these criticisms, this paper proposes a novel set-theoretical approach to maturity models characterized by equifinality, multiple conjunctural causation, and case diversity. We prescribe methodological guidelines consisting of a six-step procedure to systematically apply set theoretic methods to conceptualize, develop, and empirically derive maturity models and provide a demonstration of it application on a social media maturity data-set. Specifically, we employ Necessary Condition Analysis (NCA) to identify maturity stage boundaries as necessary conditions and Qualitative Comparative Analysis (QCA) to arrive at multiple configurations that can be equally effective in progressing to higher maturity.

Keywords: *Maturity Model, Set Theory, Necessary Conditions, Sufficient Conditions, Necessary Condition Analysis (NCA), Qualitative Comparative Analysis (QCA)*

Introduction

Maturity models in information systems (IS) academic research are understood as tools that can (a) aid the facilitation of internal and/or external benchmarking, (b) showcase possible process and outcome improvements, and (c) provide guidelines for the evolutionary process of organizational development and growth (Mettler et al. 2010). Maturity models in IS industry practice are normative and prescriptive by nature (Davenport and Harris 2007; Lahrmann et al. 2011; Nolan and Gibson 1974). However, developing a theoretically informed, methodologically rigorous, and empirical validated maturity model is subject to intense debate and fierce critique in IS research (Becker et al. 2010; King and Kraemer 1984a) and related disciplines (Andersen and Henriksen 2006; Kazanjian and Drazin 1989; Wendler 2012). Scholars have been debating back and forth on maturity models' design without really maturing on argumentation types, methodological techniques, or evidential grounds. In particular, the criticism that progression towards maturity does not necessarily occur through a linear sequence, but instead through configurations of multiple complex organizational and environmental conditions (Solli-Sæther and Gottschalk 2010) been left unaddressed.

In our quest to address this fundamental criticism with maturity models research, we drew from the recent developments in management science on the application of set-theoretic methods in typology and configurational research (Bedford et al. 2014; Fiss 2011). While a literature review on typology research is beyond the scope of this paper, after reviewing the relevant literature in management science (Bedford and Sandelin 2015; Doty et al. 1993; Fiss 2011; Miller 1996), we find two main similarities between maturity models and typologies in terms of underlying principles and problems encountered: (1) both maturity models and typologies allow users to cognitively simplify a complex environment by highlighting commonalities, allowing comparisons and providing holistic understanding, and (2) typologies move beyond traditional linear or interaction models of causality and maturity models also need to do so. While the lack of empirical research for conceptualizing and testing configurations is primarily attributed to lack of appropriate methods, the set-theoretic approach addressed these pressing concerns (Bedford et al. 2014; El Sawy et al. 2010; Fiss 2007; Fiss 2011). Given that maturity model research in IS faces isomorphic problems and challenges as typology research in management research, we employ the methodological advancements in set theoretic methods, specifically Qualitative Comparative Analysis (QCA) (Ragin 2008; Thiem and Dusa 2012; Wagemann and Schneider 2010), and a novel method called Necessary Condition Analysis (NCA) (Dul 2016c) to address the following research question:

"How can maturity stages, boundary conditions and stage configurations be conceptualized by using set theoretical methods?"

The rest of the paper is organized as follows. First, we provide a brief exposition of the set-theoretical approach to social science in terms of its central attributes and advantages; review relevant literature on set theoretic methods in social sciences, especially QCA; and briefly discuss its advantages and recent advancements. We then present the NCA as a method that can complement QCA in identifying necessary conditions. Second, we discuss maturity models in IS research and define the core components that constitute a maturity model. We conceptualize maturity components in terms of necessary and sufficient conditions and present our research propositions. Third, we present guidelines consisting of a six-step procedure to derive a set-theoretic maturity model. Fourth, we demonstrate it on a social media maturity dataset. Fifth and last, we discuss our results, limitations and outline future research directions.

Set-Theoretical Social Science

Set theory constitutes the foundations of mathematics (Halmos 1960; Kechris and Kechris 1995) with direct applications to social science research (Ragin 2008). Set theoretical approach to social science (Ragin 2000; Ragin 1987; Schneider and Wagemann 2012) is characterized by three central attributes: *equifinality* (multiple pathways to the outcomes), *multiple conjunctural causation* (configurations of multiple causes rather than unicausal reduction), and *case diversity* (inclusive of both posit8ive and negative outcome cases). Based on Smithson and Verkuilen (2006), Vatrapu et.al (2014; Vatrapu et al. 2016) have highlighted key advantages of applying classical set theory (Kechris and Kechris 1995) in general and fuzzy set theory (Zadeh 1965) in particular to social science research:

(a) *Set-theoretical ontology* (e.g. Crisp Sets, Fuzzy Sets) is well suited to conceptualize vagueness, which is a central aspect of many social science constructs. For example, the concept of organizational maturity in is quite vague compared to the concept of maturity in biology.
(b) *Set-theoretical epistemology* is well suited for analysis of social science constructs that are both categorical and dimensional. That is, set-theoretical approach is well suited for dealing with different degrees of a particular type on construct. For example, the concept of organizational maturity like social science constructs such as culture, personality, and emotion is both categorical and dimensional.
(c) *Set-theoretical methodology* can analyze multivariate associations beyond the conditional means and the general linear models which allows for both quantitative variable centered analytical methods as well as qualitative case study methods. In the case of maturity models, this allows for both variable centered analytical methods like surveys as well as qualitative case studies.
(d) *Set-theoretical analysis* has high theoretical fidelity with most social science theories which are usually expressed logically in set-terms. For example, maturity model stages like theories on market segmentation and political preferences are logically articulated as categorical inclusions and exclusions that natively lend themselves into set theoretical formalization.
(e) *Set-theoretical approach* systematically combines set-wise logical formulation of social science theories and empirical analysis using statistical models for continuous variables. For example, in the case of maturity models, it is possible to employ crisp set and fuzzy set theory to dynamically derive data points for maturity variables.

Given the above advantages, applications of set theory are not new to social science research; however, its application to management science and IS research has been very recent. Apart from use of Venn diagrams to visualize big social data (Jussila et al. 2016; Vatrapu et al. 2015), formalized applications of set theory in IS research are mainly attributed to the method of "Qualitative Comparative Analysis (QCA)" developed by (Ragin 1987). Examples of application of QCA include; (i) use of fsQCA to develop and test typologies in management sciences (Bedford and Sandelin 2015; Fiss 2007); (ii) investigation of user resistance to IT (Rivard and Lapointe 2012) and electronic service failures (Tan et al. 2016) in IS. Although developed initially by Ragin (1987) for qualitative case study researchers (medium sample size of N < 90), the proponents of QCA have since then argued about its unique advantages over regression-based approaches (Cooper 2005; Emmenegger et al. 2014; Wagemann and Schneider 2010) and its application for analysis of large-N datasets (Cooper 2005; Emmenegger et al. 2014). In the increasing adoption trajectory of QCA in social sciences (Thiem and Dusa 2012), three variants have surfaced: (a) crisp-set QCA (CsQCA), (b) fuzzy-set QCA (fsQCA) (Ragin 2008), and (c) multi-value QCA (MvQCA) (Wagemann and Schneider 2010), with a number of software tools supporting set-theoretical social science researchers (e.g. fs/QCA, Tosmana , R packages like QCA and QCAPro).

Qualitative Comparative Analysis (QCA)

QCA is a set-theoretical method that models causal relations as subset or superset relations in terms of necessity and sufficiency. QCA focusses on arriving at casually complex patterns in terms of equifinality, multiple conjunctural causation and asymmetry (Fiss 2007; Ragin 1987; Ragin 2008; Wagemann and Schneider 2010). QCA is designed to compare multiple cases in terms of complex configurations of conditions and outcomes (Bedford and Sandelin 2015). The ultimate goal of QCA is to *analyze set-theoretic sufficiency relations* (Ragin 1987). QCA is grounded in the analysis of set relations, not correlations (Ragin 2006; Ragin 2008) and hence unlike conventional statistical methods it does not measure the average effect of an increase or decrease of one variable on another. Instead, QCA analyses complex connections between attributes and outcomes in terms of set relationships (Bedford and Sandelin 2015). As such, identifying the necessary and sufficient conditions form the core of any set-theoretic approach. In their simplest form, either Euler/Venn diagrams or cross-tabulation techniques are used or in the case of continuous membership scores (fuzzy set), the X-Y plot is adopted (Goertz 2006; Mahoney and Vanderpoel 2015; Wagemann and Schneider 2010). Figure 1 illustrates the core analytical logic of set-theoretical approach in general and QCA in particular.

First, let's look at "*necessary conditions*", as without them the outcomes cannot occur, and other conditions cannot compensate for their absence (Dul 2016c; Goertz 2006; Ragin 2008), "X is a necessary condition of Y, if Y cannot happen without X". A necessary condition, therefore is an antecedent condition that is a superset of the outcome (Mohr 1982; Ragin 2008). As shown in Figure 1, one could detect a necessary condition, just by inspecting the Euler/Venn diagram or the X-Y plot. With both crisp and fuzzy sets (Figure 1: 1st and 3rd column - 1st row), the necessary condition is represented as a superset relation and indicated as $X_i \geq Y_i$ (X is a superset of Y). Another way of identifying necessary conditions is using cross-tabulation (lower left corner of Figure 1). A test for necessity essentially requires us to look at only the first row (cells 1 & 2), while cells 3 and 4 are completely irrelevant. The test for sufficiency however proceeds from the *observation of some condition(s) X to the observation of the outcome Y* (Thiem and Dusa 2012; Wagemann and Schneider 2010) as illustrated in Table 1, i.e. "X is a sufficient condition of Y, if X implies Y or X is a subset of Y".

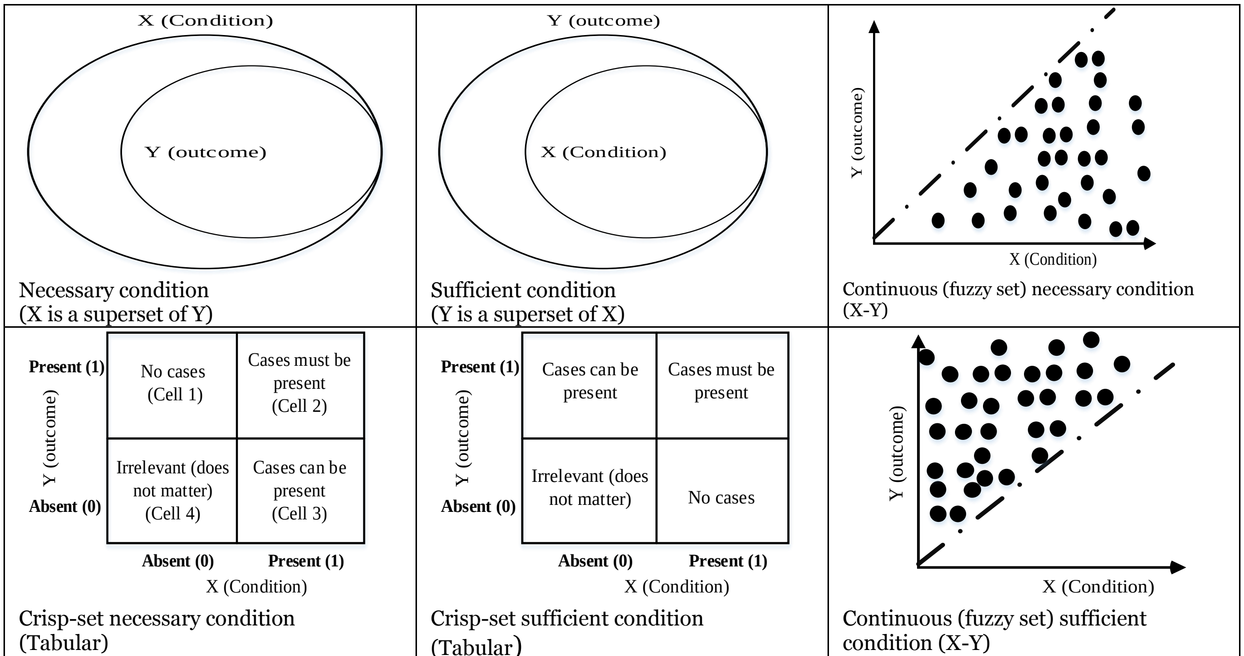


Figure 1: Necessary and Sufficient Conditions

While the method of single condition analysis (Figure 1) is of analytical value, according to Ragin (2006)), examining relations between binary variables "*might be considered adequate as a descriptive starting point, but this approach is too crude to be considered real social science*'. Moreover, social sciences in general (Mohr 1982) and information systems in particular deal with what are INUS conditions: *insufficient but non-redundant part of an unnecessary but sufficient condition* (Ortiz de Guinea 2014). QCA scholars have argued the advantages of set-theoretical methods in explaining INUS conditions and developed a number of measures (Goertz 2006; Ragin 2006) and guidelines (Wagemann and Schneider 2010) to make analysis of complex causations possible. These include guidelines to develop a truth table, calibration of original data to sets, measures of *consistency*, *coverage* (Ragin 2006), and also some diagnostics to detect logical contradictions and paradoxical relations (Bedford and Sandelin 2015; Thiem and Dusa 2012). QCA uses crisp and fuzzy set algorithm (Quine-McCluskey) combined with qualitative counterfactual analysis to arrive at the final Boolean solution i.e. intermediate solution (Ragin 2008; Thiem and Dusa 2012; Wagemann and Schneider 2010). While the detailed discussion explaining the purpose of each of these measures in not warranted within this paper's scope, we discuss the steps of applying QCA in the forthcoming demonstration section.

Necessary Condition Analysis (NCA)

"NCA[1]" is a technique for identifying *relationships of necessity that can make both statements in kind and in degree* (Dul 2016a). NCA uses *Data Envelopment Analysis* (DEA) based techniques. While QCA as set-theoretic method has a number of advantages in the analysis of complex causations, some scholars

[1] Steps to perform NCA has been discussed and demonstrated on page 8, 9 and 12 in this paper.

(Goertz 2006; Vis and Dul 2016) argue that in few cases QCA fails in identifying all necessary conditions, specially single necessary conditions. Vis and Dul (2016) argue that calibration of original data into set-memberships leads to non-detection of some necessary conditions. In order to address this problem, NCA (Dul 2016c) is proposed as a method for identifying necessary conditions in data sets, be they categorical or dimensional in nature. A comparison of NCA and QCA (table 1) highlights NCA's advantage in identifying more single necessary conditions, and calculating the level of the condition that is necessary for the outcome.

Characteristic	QCA	NCA
Underlying logic	Configurations are sufficient but not necessary to produce the outcome ("equifinality")	Single conditions are necessary but not sufficient to allow the outcome
Measures to detect presence of "in kind" necessary condition(s).	Necessity Consistency >0.9	Effect Size "d" >0.1
Formulation of an "in degree" necessary hypothesis	Not Applicable (NA)	"Level X is necessary for Level Y" (Ceiling line)
Identification focus	Sufficient but not necessary configurations Necessary "OR" Configurations	Single Necessary conditions
Analytic approach	Boolean Algebra (Set theory)	Ceiling line (Data envelopment analysis)

Table 1: Comparison of NCA and QCA (Vis and Dul 2016)

After reviewing of literature on QCA and NCA, it is clear that while QCA works on configurational logic and assumptions of equifinality, NCA focusses primarily on single conditions. We concur with Vis and Dul (2016) that NCA can compliment QCA and apply both these techniques to empirically derive a maturity model, while addressing the criticisms pertaining to multiple paths to maturity.

Set Theoretical Approach to Maturity Models

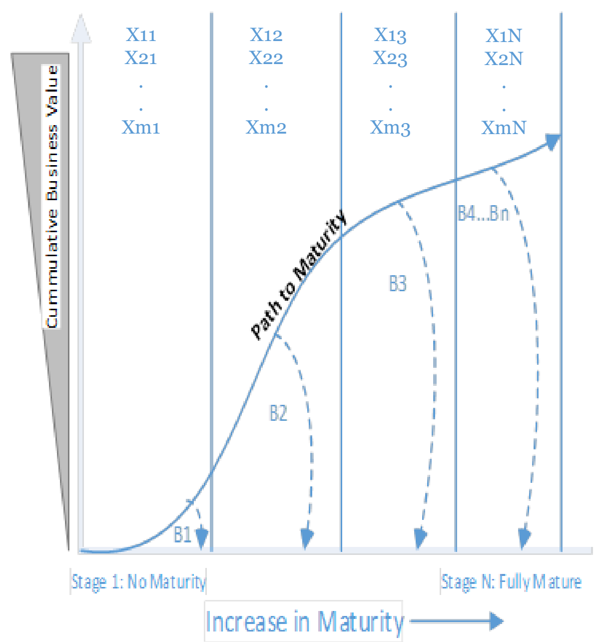
In this section, we present the formulation of maturity model components as necessary and sufficient conditions. First, we briefly discuss the core components of maturity models, current criticisms and then state our propositions to address these criticisms.

Concept and Core Components of a Maturity Model

In IS research, the purpose of maturity models is to outline the path to organizational maturation with regard to a business technology and/or process, including defining the stages and relationship between them (Pöppelbuß et al. 2011). We analyzed a number of maturity models (Damsgaard and Scheepers 1999; Duane and OReilly 2012; Joachim et al. 2011; Nolan and Gibson 1974; Paulk et al. 1993; Van Steenbergen et al. 2013). We found that they can be classified into three broad types of stage fixed, stage continuous and focus area models, and that the underlying core components constituting a maturity model can be characterized in terms of: (1) Maturity Stage, (2) Conditions, (3) Boundary conditions, and finally (4) Path to maturity as illustrated in Figure 2.

With regard to the criticism of maturity models in IS, some researchers (King and Kraemer 1984a; Solli-Sæther and Gottschalk 2010) have questioned the very concept of stages of growth while others have criticised the lack of theoretical foundations and accusing researchers of blindly adopting influential models such as the Capability Maturity Model (CMM) for their structure and not conceptually grounding the maturity model characteristics in theory (Pöppelbuß et al. 2011; Renken 2004). Moreover, the lack of empirical validation in the selection of variables (Lahrmann et al. 2011; Wendler 2012), and rarity in use of empirical (i.e. qualitative, quantitative) or other demonstration methods (Lasrado et al. 2015; Wendler 2012) have also been widely critiqued. While most of the research related to maturity models has been largely conceptual (Pöppelbuß et al. 2011), very few maturity models (Damsgaard and Scheepers 1999; Raber et al. 2012) have acknowledged and attempted to address these criticisms. Finally, the underlying assumption of a single linear path towards maturation with no possibility of equifinality has been widely critiqued (King and Kraemer 1984b; Lasrado et al. 2015; Solli-Sæther and Gottschalk 2010). Overall, the fundamental criticism of maturity models research in IS can be summarised as follows:

"IS literature has mostly ignored theoretical approaches to maturation – the process of becoming more mature has been understood rather vaguely.... Maturity models in IS research requires conceptualizations and analytical perspectives better grounded in theory" (Becker et al. 2010)



Maturity Stage [Stage1... Stage n]: "Level" and "Maturity Score" are some of the other terms used. Stages typically are archetypal states of maturity of the entity that is being assessed. Each stage has a set of distinct characteristics that are testable (Nolan and Gibson 1974; Raber et al. 2012).

Conditions (X_{mn}, m factors and n stages): "Critical Success Factors", "Dimensions", "Factors", "Enablers" "Benchmark Variables" and "Capabilities" are some of the other terms. Conditions describe multi-dimensional factors that decide the entity's maturity stage. Each condition is also further classified into a number of sub-factors with specific characteristics at each stage (Raber et al. 2012).

Boundary Conditions [B1... Bn]: Also termed "Triggers", "Dominant Problems" (Solli-Sæther and Gottschalk 2010) and "Inhibitors", boundary conditions are specific conditions that the entity has to satisfy in order to progress from one stage to another (Lasrado et al. 2015).

Figure 2: Core Components of a Maturity Model (Lasrado et al. 2016)

Mapping Maturity Stages and Stage Characteristics to Set Theoretical Concepts

From the definition stated in Figure 2, it is evident that without satisfying the boundary conditions criteria, an entity cannot progress from a state of low maturity to high maturity further irrespective of satisfying all other conditions. For example, in the case of Intranet Maturity Model (Damsgaard and Scheepers 1999), every stage has a boundary condition. While active support of a technology champion is a boundary condition to progress from stage 1 to stage 2, critical mass of intranet users is a boundary condition to progress to stage 3. Similarly, in the case of Analytics Maturity (Davenport and Harris 2007), an enterprise wide implementation is required to progress from stage 3 to stage 4. Hence, active support of a technology champion, critical mass of intranet users, and enterprise wide implementation are compulsory pre-conditions for increase in maturity. By definition, such pre-conditions are known as "necessary conditions" (Dul 2016c). In other words, the absence of these necessary conditions guarantees failure in terms of progression to the next stage of the maturity model. Moreover, if both the maturity (Y) and conditions (X) causing it can be quantitatively measured, then the level of condition (X) necessary to cause certain level of maturity (Y) can be established using Necessary Condition Analysis (NCA). In line with the above two arguments, we state our first two propositions:

P1a: Boundary conditions are necessary conditions.

P1b: Necessary Condition Analysis (NCA) would facilitate formulation of maturity stage boundaries by calculating the level of boundary conditions necessary for the level of maturity required.

Furthermore, although scholars agree that maturation means path to something better and advanced, many scholars (Becker et al. 2010; Kazanjian and Drazin 1989; King and Teo 1997) have contested the assumption that the path to maturity is linear. We agree that this linear path of progression posited excludes the possibility of equifinality. We further concur with Kazanjian and Drazin (1989) and (Solli-

Sæther and Gottschalk 2010) that progression towards maturity does not necessarily occur through a linear sequence of stages and we argue that maturity progression occurs through configurations of multiple complex conditions. Drawing from recent set-theoretical research through application of QCA (El Sawy et al. 2010; Fiss 2011), we propose the configurational approach for deriving multiple paths to maturity. In other words, we adopt the notion of "equifinality" that an entity or system can *reach the same outcome from different initial conditions and through many different paths* (El Sawy et al. 2010) and list our final proposition:

P2: Qualitative Comparative Analysis (QCA) would yield multiple configurations for an entity to be in a particular maturity stage.

In the next section, we present guidelines for set-theoretical maturity models consisting of a six-step procedure and empirically demonstrate the set-theoretical approach stated above using a real-world dataset.

Set Theoretical Maturity Models: A Six-Step Procedure

In this section we propose a six-step procedure (see figure 3), the elements of which are informed by (a) detailed review of guidelines and procedures for developing maturity models (Becker et al. 2011; Mettler et al. 2010; Solli-Sæther and Gottschalk 2010), (b) guidelines for standard practices in QCA (Fiss 2011; Goertz 2006; Thiem and Dusa 2012; Wagemann and Schneider 2010), and (c) guidelines for NCA (Dul 2016a; Vis and Dul 2016). The six-steps are represented in the form of a flow chart, with explanations of the notation used given at bottom-right of the figure 3.

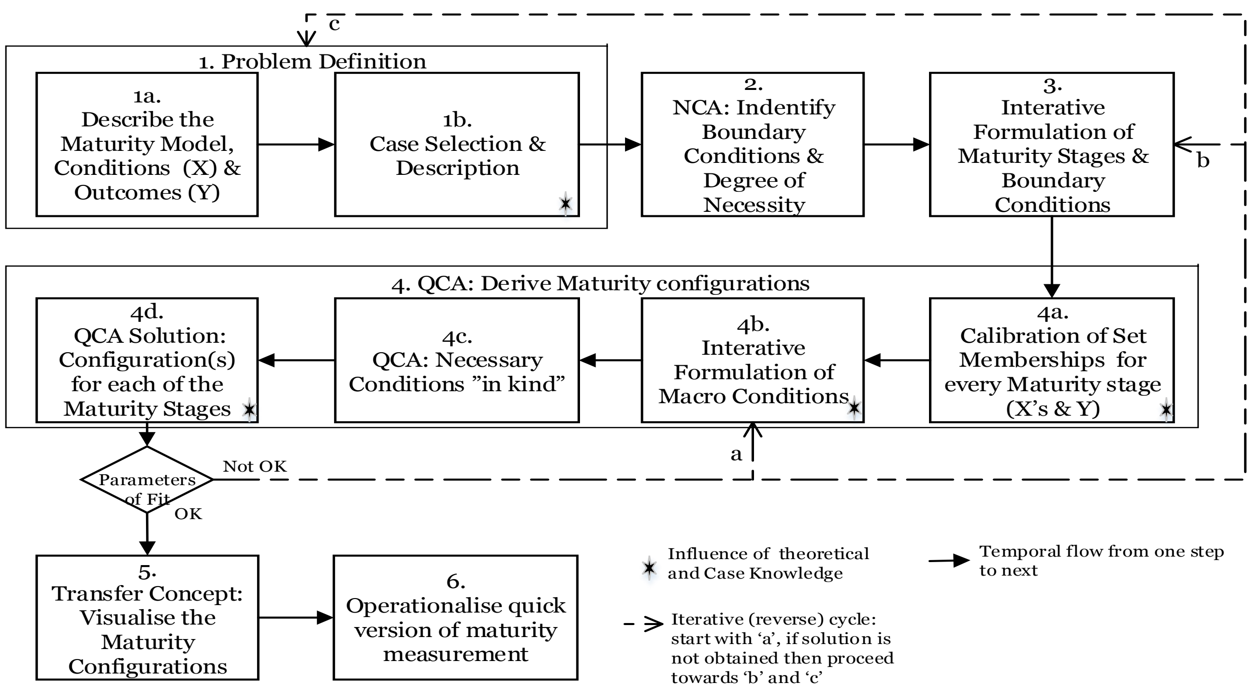
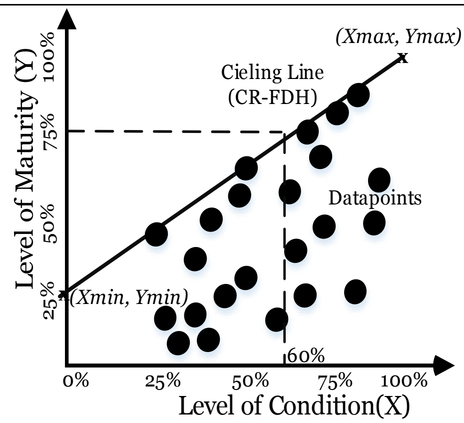


Figure 3: A Six-Step Procedure for Set Theoretical Maturity Models

Step 1: The first step starts with *problem definition* (1a & 1b). Step 1a calls for a detailed description of maturity model that includes its scope, targeted audience and main stakeholders involved (Mettler et al. 2010). The purpose of this step is to facilitate comparison with similar maturity models and check for practical relevance. Further, it is important to formulate maturity, while emphasizing what conditions (X), both individually or in combination need to be in place (i.e. necessary conditions) and what conditions (X), both individually or in combination would produce maturity (i.e. sufficient conditions). Therefore, step 1a also requires developing and describing a conceptual model together with detailed description of conditions (X), the measurement of maturity or its proxy (Y) and the direction of causality. This step also guides and informs the case selection (step 1b). While random sampling should suffice for NCA, purposeful case selection is a crucial step for QCA as it seeks to identify both necessary and sufficient conditions (Kane et al. 2014; Ragin 2008). Step 1b requires the researcher to include cases that both exhibit and do not exhibit the outcome of maturity. The purpose of this case diversity is to ensure that the analysis leads to multiple configurations or pathways to maturity. A thorough understanding of the conditions and cases in question must be achieved and documented well before proceeding to analysis phase (step 2).

Step 2: This step requires performing *NCA* on the original dataset, examining the NCA graphs (X-Y plots) and evaluating the effect size. Following proposition 1a and 1b, the purpose of NCA is to identify stage boundary conditions and the level necessary for maturity. In NCA this is done by calculating the area of emptiness in the top right corner of the X-Y plot as illustrated in Figure 4. To draw ceiling lines, various techniques are prescribed in the R package (Dul 2016b) for NCA. Depending on how the condition is measured (i.e. discrete or continuous) and the interpretability of the results, the appropriate type of ceiling line (i.e. CE-FDH, CR-FDH or any other) is selected[2]. The necessary condition effect size ranges from 0 to 1 and Dul (2016c)) suggests to use effect size of 0.1 as the threshold as "any necessary condition hypothesis in the continuous case (X is necessary for Y) is rejected if the effect size d is less than 0.1" (Dul 2016a; Dul 2016c). Finally, the level of conditions (X) that are necessary are listed against the outcome (i.e. level of maturity) as shown in Figure 4 and reflected upon in a tabular format[3] as this step informs formulating maturity stage boundaries (step 3) and also influences calibration (step 4a).



The strength of the necessary condition is evaluated using **effect size**, "the constraint that the ceiling poses on the outcome" (Dul 2016c). Effect size (d) = C/S, where C is the size of the ceiling zone, and scope (S) = $(X_{max} - X_{min}) / (Y_{max} - Y_{min})$, with the line separating the area with and without data points called the ceiling line.

Example of formulating **maturity stages**: While condition (X) is not necessary (NN) to achieve up to 25% maturity, it is necessary above it. Therefore, 25% maturity level can be considered as a stage boundary. Furthermore, we can infer that to be at 75% level of maturity (Y) at-least 60% of the condition (X) is necessary. The same logic when applied to conditions individually or in combination would assist in the construction of provisional maturity stages.

Figure 4: Necessary Condition Analysis & Maturity Stages

Step 3: *Formulation of maturity stages, boundary conditions* for those maturity stages form the central phase of the six-step procedure. As illustrated in Figure 3, step 3 is iterative, wherein the number of maturity stages and stage boundaries are arrived at through while traversing between theoretical ideas from prior maturity model literature, empirical results from the NCA bottleneck table and from QCA (step 5) up until the parameters of fit[2] are satisfied. In the first iteration, in line with prior maturity model design practices (Karkkainen et al. 2011; Lahrmann et al. 2011; Lasrado et al. 2015; Raber et al. 2012), the first strategy is to select the number of stages as 4 or 5 and draw the stage boundaries by evenly dividing the maturity measure (Y). For example, if the maturity is measured using a 5 point Likert scale (0-5) and the number stages are 5; the stage boundaries are drawn at equal intervals (0, 1, 2, 3, and 4). The second strategy is to use the NCA results to propose stage boundaries (Lasrado et al. 2016) as illustrated in figure 4. The third strategy is to follow the configurational approach (El Sawy et al. 2010; Fiss 2011) and draw the maturity boundaries against a benchmark; choice of the benchmark must be supported by strong theoretical arguments or empirical evidence. The execution of the third strategy is in tandem with

[2] A piecewise linear ceiling with free disposal hull technique (CE-FDH) and a ceiling regression with free disposal hull technique (CR-FDH) is suggested for discrete and continuous data respectively as "they produce stable results with relatively large ceiling zones" (Dul 2016c).

[3] The tabular format is referred to as the bottleneck table (Dul 2016c).

calibration of set memberships (4a). Using one or a combination of the three strategies listed above, the first provisional maturity stages and their respective boundaries are drawn.

Step 4: The purpose of this step is to facilitate the extraction of configurations for maturity stages using QCA. QCA is a well-established method with prescribed guidelines[3] that involves calibration of data into set memberships, formulating the truth table, Boolean minimization, counterfactual analysis, and finally arriving at the most parsimonious and intermediate solutions. Calibration of set memberships (4a) is a crucial step in QCA requiring the researcher to assign set membership scores to both outcome (Y) and conditions (X). Here the researcher needs to establish qualitative crossover points (Fiss 2011; Ragin 2008) to assign membership to particular sets. Calibration[4] is done either by direct or transformational assignment (Ragin 2008). While a taxonomy of calibration scenarios have been proposed in the literature (Thiem and Dusa 2012), QCA scholars (Wagemann and Schneider 2010) state that it is the responsibility of the researcher to find valid reasons to assign these set membership scores. Following the calibration of the outcome (i.e. maturity), the conditions (X) are also calibrated into set memberships and macro conditions[3] are formulated (4b). The next step (4c) involves testing for necessity again using QCA. The purpose of step 4c is to (i) validate the single necessary conditions identified via NCA and, (ii) check if the necessary conditions identified are valid even after the maturity stage boundaries are drawn. Prior research on NCA and QCA (Vis and Dul 2016), highlight the fact that NCA identifies more necessary conditions that QCA; if this fact is proved it is required to revisit the calibration logic and document the impact of calibration on the results. QCA works in an iterative cycle until an optimal solution is obtained in what Ragin (2008) terms as an “analytical moment”. This iterative cycle leads to formulations of new macro conditions, new maturity stage boundaries and improved case knowledge as illustrated in figure 3.

Step 5: The fifth step called *transfer concept* provides visualization of maturity configurations in a format that is easily understood by the target audience. There are multiple options suggested in literature to present the results [e.g. Core-Periphery Configuration Chart (Fiss 2011), Solution as Boolean Expression (Ragin 2008; Thiem and Dusa 2012), Relevance-Trivialness Table (Goertz 2006)]. Since the audience for maturity models is usually management oriented, we recommend the Core-Periphery Configuration Chart, given its visual symmetry with prior maturity models and ease of understanding for non-experts who are not familiar with Boolean expressions.

Step 6: Last but not the least; we propose to create and *operationalize a condensed version of maturity measurement* to serve as a quick diagnostic tool. In order to do so, it is very important to clearly understand the requirements of the main stakeholders (De Bruin et al. 2005). Apart from direct communication with the main stakeholders, a review of existing maturity measurement instruments must be performed before developing the quick diagnostic tool.

Demonstrative Case Study: Social Media Maturity Model

This section demonstrates the application of the six step procedure on a real-world dataset to derive a Social Media Maturity Model. Although, both QCA (Ragin 2008) and NCA (Dul 2016c) are advocated as research approaches as well as data analysis techniques, in this section, we demonstrate primarily their data analysis capabilities in line with the six-step procedure outlined in the previous section.

Step 1: Maturity Model & Case Description, Conditions (X’s) and Outcome (Y)

The main stakeholder for social media maturity model is the consortium of IT consultants and Danish organizations led by Networked Business Initiative (http://www.networkedbusiness.org/). NBI measured

[4] Given the page constraints of this paper we are unable to include detailed steps on how to perform QCA including calibration. Readers are referred to the next section wherein calibration, creating macro conditions and application of QCA is demonstrated using a social media maturity dataset; especially reasons for formulating macro conditions are discussed in detail. Furthermore, in order to understand the philosophy of QCA, readers are referred to Ragin (2008). For a detailed description of the steps and the guidelines to perform QCA, readers are referred to Wagemann and Schneider (2010) and Thiem and Dusa (2012). Finally for application of QCA in configurational research, we refer the readers to Fiss (2011) and Bedford and Sandelin (2015). Parameters of fit are prescribed tests to approve the final QCA solution. Readers are referred to Thiem and Dusa (2012) for prescribed tests and formulae (page 69-73).

digital maturity of organizations with regard to five digital technologies and six business functions. The dataset used in this demonstration comes from a survey of 231 organizations. The targeted audiences are managers (top and middle management) in Danish SME(s) interested in comparing their digital performance against peers. For the purpose of this demonstration, we limit our scope to customer facing activities (i.e. Sales & Marketing, and PR) and use a sample of 85 organizations (Table 2) that responded to a survey on social media maturity (details on items, scales, and definitions are provided in Table 3).

Size/founded	2000 to 2008	After 2008	Before 2000	Grand Total
50 to 250	2	2	22	26
15 to 49	8	1	7	16
Less than 15	14	19	10	43
Grand Total	24	22	39	85

Domain	N
B2C	15
B2B	45
Both B2B & B2C	24
Others	1

Table 2. Overview of Companies in the Demonstration Dataset

The data is collected through a cross-sectional survey linked to a live dashboard whose primary purpose is comparative benchmarking of participating organizations in Denmark. Given the space constraints and the demonstrative purposes of the dataset, we do not discuss the survey design, administration and data collection aspects in detail. The social media maturity dataset consists of 14 conditions (X's) and one outcome (Y) as listed in Table 3. We use Business value realized in PR and Sales & Marketing as the outcome (Y). The rationale behind this is based on our first assumption about maturity: *"Maturation means the path to something better"*, which translated to our demonstrative case is "**social media maturity ∝ business value**". We thus infer that higher the social media maturity of an organization, better or higher business value is realized. Thus, we employ business value realized in PR, Sales & Marketing (Y) as a proxy measure for the maturity.

	Condition (X)		**Scale; # of items**
Management	Top Management encourages the use of social media throughout the organization.	MUS	Likert (0-4); 1
	IT investment within the organization as compared to previous years, understanding the intention of management towards digitalization.	INV	Ordinal scale (0=decreased,1=Same, 2=increased); 1
	Digital strategy Index[5]	DS	Index (0 to 4); 1
IT Policy	Allowing access to Own Devices (OD) measured on access to number of systems, and/or Providing Employees With Devices (PEWD) measured on number of employees, while having a high IT Security Index [1](ITS) is considered as an organization with high social media maturity.	ITS	Index (scaled to 4); 1
		OD	Likert Scale (0-4); 1
		PEDW	Likert Scale (0-4); 1
Technolog	Social media presence, measured as the number of social media channels.	ESC	Count (0 -8); 1
	Extent of Use of social media, measured as an average of PR and Sales & Marketing	U	Likert Scale (0-4); 2

[5] The criterion for this index is the presence or absence of an overall digital strategy (measured as Yes/No), the extent to which this policy has been aligned with the company strategy, communicated and implemented across the company (measured using a 5-point Likert scale from 0 to 4). For example, if Organization A has no digital strategy (X1=0) then the index is calibrated as 0.0. However, if Organization B has digital strategy (X1=1), is aligned fully (X2=4), communicated largely (X3=4) and implemented to a small degree (X4=2). Then the digital strategy index for organization B is (X1+X2+X3+X4)*4/13 = 3.384, wherein 4 is calibration range and 13 is actual scale range. IT Security Index is also calculated in the same manner.

	Number of resources (FTE) hired specifically for social media activities, measured as none, part time, full time and more than one. Sometimes, in case of SME's, a marketing manager or any other employee manages social media. Hence NBI also measured professional skills (S) available inside the organization that can manage social media.	FTE	Ordinal (0,1,2,3); 1
		S	Likert Scale (0-4) i.e. Not at all to Very high degree; 1
	Metrics (M) is a measure of formalized social media activities. It is measured through the presence of either KPI's, workflows or both.	M	Ordinal (0,0.5,1); 2
Culture	The measures for Culture are based on an organization orientation towards employee driven style of working and decision making (EEC), a well-planned and structured style (PSC), and an explorative culture wherein new IT systems are always sought after. These are based on a factor analysis of seven items measured on 5-point scale i.e. Completely disagree (-2) to Completely agree (2).	EEC	Likert Scale (-2 to 2); 4
		PSC	Likert Scale (-2 to 2); 2
		NSC	Likert Scale (-2 to 2); 1
Y	Business Value from social media in customer facing activities measured as an average of PR and Sales & Marketing	BV	Likert Scale (0-4); 2

Table 3. Overview of Conditions

Step 2: Identify Boundary Conditions using NCA

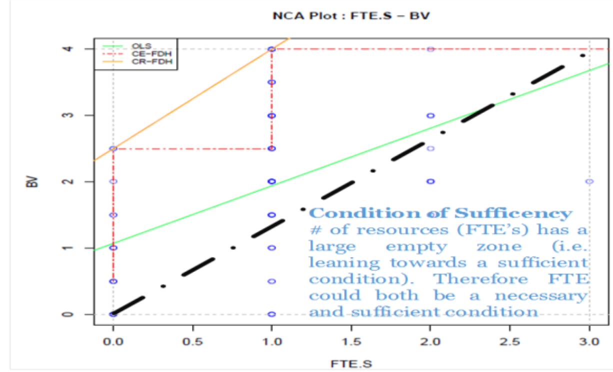
Now that the conditions (X) and outcome (Y) are established, we apply NCA to identify the single necessary conditions. Following the steps proposed in the six-step procedure, 6 necessary conditions are identified as highlighted in figure 5. While the extent of social media use (U) has a large effect and can be determined as the most important necessary condition, rests of the 5 necessary conditions have a medium effect on maturity. As proposed in the six-step procedure, we use CE-FDH whenever the condition is discrete while CR-FDH is used when the condition is continuous in nature. In this demonstrative case, we use CE-FDH, for conditions INV and FTE. Using CE-FDH, we infer that hiring a part time resource (FTE) to work on social media is a necessary condition for delivering greater than 70% of the business value. CR-FDH in this case would make no sense as one cannot hire 20% of a part time resource. Furthermore, using the X-Y plot logic we also find that FTE is both necessary and sufficient as illustrated in figure 5. By definition, a sufficient condition "ensures the existence of the outcome (i.e., if X=1 then Y=1). But the outcome can also exist without the sufficient condition (i.e., if X=0, Y can still be 1)" unlike a necessary condition (Ragin 2008). In our case, we thus interpret that at least a part time FTE to handle social media operations is both necessary and sufficient, thus making it the most important condition to achieve high maturity.

Now that the "6 necessary conditions and their level necessary for maturity" are identified using NCA, the next logical step is to reflect and validate the necessary conditions. In this process of reflection, we observe that one necessary condition (EEC) is measured on a 5-point scale using values "-2 to 2" (completely disagree to completely agree); indicating any value less than "0" means that employee empowered culture (EEC) is actually not present. A value of "0" means at least 50% in the bottleneck table in figure 3. However, our results indicate that even to achieve 100% business value (Y), only 44.9% of EEC is necessary, which is less than 50% (required in this specific case) providing us strong empirical reasons to drop employee driven culture (EEC) as a necessary condition although it has an effect size of 0.115. Therefore, we can conclude that that presence of EEC is not necessary for high or very high business value (Y)[6]. Similarly, both top management encouragement for use of social media (MUS) and investment in IT (INV) are not necessary (NN) to achieve up to 60% and 70% of business value (Y) respectively[5]. Therefore, in the next step if the high maturity stage boundary is drawn at 50% of business value (Y), then by

[6] QCA necessity test (Consistency = 0.92, coverage = 0.5) validates the claim that presence of EEC, MUS and INV a not necessary for high maturity stage. Moreover EEC is part of an INUS condition (configuration P2a). Similarly MUS and INV are part of configuration P2b and P2c, but not P2a.

definition MUS and INV will not be stage boundary conditions to be in high maturity. In addition to the above reflections, this necessity validation happens iteratively and in tandem with the next 2 steps.

	BV (%)	**MUS**	**FTE**	Skills	**USE**	**ESC**	EEC	PSC	**INV**
Low	0	NN	NN	NN	NN	NN	NN	NN	NN
	10	NN	NN	NN	NN	12.5	NN	NN	NN
	20	NN	NN	NN	4.7	12.5	NN	NN	NN
	30	NN	NN	NN	14.2	12.5	NN	NN	NN
	40	NN	NN	NN	23.8	12.5	NN	NN	NN
	50	NN	NN	NN	33.4	12.5	0.9	NN	NN
High	60	NN	NN	NN	43.0	12.5	9.7	5.7	NN
	70	12.8	33.3	5.0	52.6	12.5	18.5	11.4	NN
	80	26.1	33.3	11.7	62.2	12.5	27.3	17.1	50.0
Very High	90	39.4	33.3	18.3	71.8	25.0	36.1	22.9	50.0
	100	52.8	33.3	25.0	81.3	25.0	44.9	28.6	50.0
MATURITY Y->	Effect Size	0.104*	0.125*	0.047	0.402**	0.141*	0.115*	0.071	0.125*
	Effect	Medium	Medium	Small	Large	Medium	Medium	Small	Medium
	Ceiling Line	CR-FDH	CE-FDH	CR-FDH	CR-FDH	CE-FDH	CR-FDH	CR-FDH	CE-FDH



Necessary: Using the CE-FDH ceiling approach, an effect size of 0.125 is calculated showing that number of dedicated resources hired is a necessary condition with medium effect.

Also Sufficient: The bottom right of the X-Y scatter plot is almost empty indicating that # of resources hired is a sufficient condition for realising business value. It is not a fully sufficient condition as there are 5 cases wherein presence of a part time resource has failed to produce the outcome (i.e. at least some business value).

Figure 5: X-Y Plot, Ceiling Zone, Effect Size and Bottleneck Table

Step 3 & 4a: Formulation of Maturity Stages, Boundary Conditions and Calibration

As shown in figure 3, step 3 is part of an iterative cycle and can also be performed in tandem with calibration set memberships for QCA. Following the recommendations from procedure model, we adopt a combination of second (NCA bottleneck table), and third strategy (benchmarking) to propose maturity stages. While in our first iteration we propose 4 maturity stages (No, Low, High, Very High), after two iterations we end up with 3 maturity stages as illustrated in Figure 5.

Moreover, our primary interest in this step is in defining the social media maturity stages in terms of set memberships, which we have measured through a proxy of business value realized (Y). It is measured using a Likert scale (interval of 0 – 4) for PR and Sales & Marketing respectively, which we then average to get a score between 0 – 4. First, following the configurational approach (El Sawy et al. 2010; Fiss 2011), we also create two fuzzy set measures of above-average business value realized (i.e. set with high maturity). This "benchmark" of average is set at 50% business value realized (i.e. score of 2). The reasoning is equally motivated by calibration of survey data for QCA (Emmenegger et al. 2014) and qualitative reasoning among the authors that if an organization has derived "at least high value" in either PR or Sales & Marketing (above 2), then it is more in the set of high maturity. For this first set, we coded full exclusion of 0.5 and 3.5 with a cross over point of 2.1 (Figure 6). As highlighted in Figure 6 (High Maturity), an organization with business value less than 2 is "more out than in", while business value more than 2 is "more in than out". The second set is organizations with very high business value realized (i.e. Very High maturity). The fact that in order to realize more than 80% businesses value it is necessary to be present on at least two social media channels (figure 5); we raise the crossover point for very high maturity stage to 3, while full exclusion for the higher end point is set at 4. Finally, in order to examine what configurations lead to low business value realized, we created measures of membership not-high and low business value realized. This third set is simply coded as the negation of the set with high maturity (Figure 4), with a full exclusion of 2.5 and 0, with a cross over at 1.5.

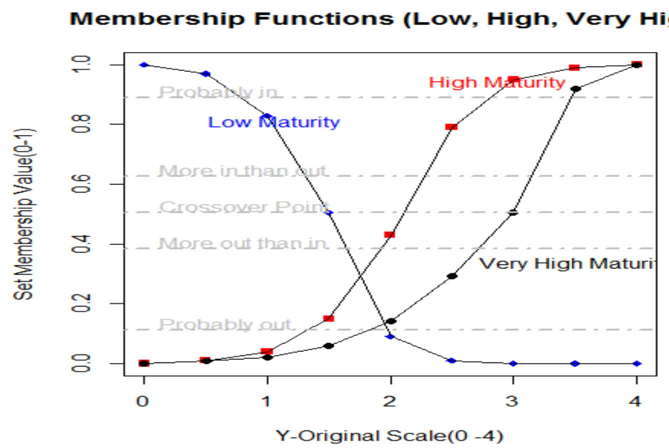


Figure 6: Calibration Logic and Maturity Stages

Next, following the calibration guidelines for QCA (Ragin 2008; Thiem and Dusa 2012), we adopt the direct method of logistic transformational assignment for assigning full exclusion, full inclusion and crossover points. While QCA literature provides with linear, trapezoidal and many more membership functions (Thiem and Dusa 2012), we chose the logistic option. The rationale for choosing logistic transformation is based on prior configurational research using fuzzy set QCA [E.g. Fiss (2011), Yi et al. (2011)] using logistic transformation over linear or trapezoidal options. Following step 4, we first calibrated Outcome (Y), then the conditions (X) and in the process also defined the maturity stages (i.e. Low, High and Very high). Translating the calibrated inclusion and exclusion scores for each of maturity stages into percentage (as indicated by dashed lines in Figure 5), we can now determine the “boundary conditions” for each maturity stage. For instance, extent of social media use (U) of more than 33.4% (i.e. score of 1.67), presence on at least one social media channel (ESC) and at least a part-time resource (FTE) forms the boundary condition for an organization to be in high maturity stage.

The NCA findings also informed the choices regarding the calibration of some conditions (X). For example, FTE (measured as 0 for none, 1 for part time resource, 2 for one resource, 3 for two or more) is coded a full exclusion of 0 and 3, with a crossover of 0.9, indicating that at least a part time resource (i.e. score of 1) is required for an organization to achieve high maturity. Few other X’s are similarly coded based on the empirical evidence at hand. Finally, calibration for some of the conditions measuring culture, top management encouragement (MUS) and skills (S) are also motivated by calibration of survey data for QCA (Emmenegger et al. 2014) and qualitative reasoning similar to the outcome (Y). For example, MUS is coded a full exclusion of 0 and 4 with a cross over point of 2; this means only when MUS is to a high (3) and very high degree (4) will it contribute as a positive case (truth table=1). Any response below that i.e., some degree (2), small degree (1) and no support (0) actually indicates that top management encouragement (MUS) is actually not visible and contribute as a negative case (truth table=0), hindering a positive outcome (Y).

Step 4b, 4c & 4d & 5: QCA & Visualizing Maturity Stages

Now that set membership score for each of the conditions (X) and the outcome (Y) has been calibrated, the next step is to translate this data into what is called a truth table. The property space for the truth table is a function of number of conditions (CSF's). A truth table contains all logically possible combinations (2k) of k number of conditions (Bedford and Sandelin 2015). The truth table for our demonstration dataset is created using R-QCAGUI package (Thiem and Dusa 2012). One of the difficulties routinely faced by researchers using QCA is the staggering number of logical combinations than can be generated by a relatively small number of causal conditions (Ragin 2008; Wagemann and Schneider 2010). With our demonstration dataset we had two main challenges;

1. With 14 X's, there is a limitation with number of empirical cases to get enough positive outcomes (i.e. with inclusion criteria of 0.72 and frequency threshold=1)
2. Technical limitations with available fsQCA software: A truth table as large 4,096 rows is the practical limit of fsQCA tool (Ragin 2008), while the R packages (i.e. QCA, QCAGUI or QCAPro) can handle up to 17 conditions, we are unable to get the Boolean solutions due to software limitations.

Given these challenges, the analytical strategy available at this stage is to either reduce the number of conditions (X's) by dropping or merging conditions (i.e. using AND, OR, any other set logical operations) and arriving at macro conditions (Ragin 2008). We dropped digital strategy (DS) as it did not contribute to achieving a solution and we also chose the second option and identified two macro conditions (Table 4). The first macro condition termed "FUE" is combination of common necessary conditions required to be in a high and very high maturity stages. The second macro condition "IT Policy (ITP)" is arrived through what Ragin (2008)) terms "colligations", meaningful collections of facts or evidence. IT Policy (ITP) is arrived at with the logic that an organization realizing high business value from use of social media must either provide employees with devices (PEWD) or allow them to access organizational IT systems with their own devices (OD), while having a formalized IT security policy in place.

Once the macro conditions are established, step 4c requires testing for necessary conditions. This is in line with QCA's prescribed guidelines as testing for necessity should always precede the test for sufficiency in QCA (Thiem and Dusa 2012). However, in our demonstrative case, we found no single or conjunctive necessary conditions using QCA's test for necessity, while NCA identified three necessary conditions. First, this fact validates the claim by Dul (2016a) and Vis and Dul (2016) that NCA identifies more necessary conditions. Second, it reemphasizes the importance of step 2 in our six-step procedure and justifies our proposition to use NCA before applying QCA.

Macro Condition	Reasoning & Calibration
FUE = (U*ESC * FTE)	Extent of use (U), Presence on social media (ESC), resource for social media activities (FTE) are all common necessary conditions for high and very high maturity stage. Hence it is logical to combine the three and treat it as one macro condition as the absence of even one would mean low maturity stage. Formula: [PSF = min (U, ESC, FTE)].
ITP= [ITS*(OD+PEWD)]	With this calibration, an organization with no IT security policy would be coded 0, while an organization with a formalized and well communicated IT security policy that also provides employees with devices or lets them operate their own devices is coded 1. All other combinations are in between 0 and 1. Formula:[ITP=min [ITS*max(OD,PEWD)]

Table 4. Macro Conditions

Next step in the analysis is using Boolean algebra method known as logical minimization to determine the commonalities between configurations that consistently lead to the outcome (Fiss 2011; Ragin 2008). We followed the prescribed steps (Ragin 2006; Thiem and Dusa 2012) to arrive at the final solution. The directional expectations or counterfactuals (Thiem and Dusa 2012) are coded as present (positive or +1) as all the conditions (X) are expected to be present in high maturity stage, while low maturity stage are coded as absent. It is an easy counterfactual as the decision is based on theoretical knowledge. With regards to the parameters of fit[7] for QCA, literature suggests that the minimum consistency score should

[7] Refer (Thiem and Dusa 2012) page 69-73 for prescribed tests and formulae.

be 0.75, and there is no minimum requirement for coverage in literature (Bedford and Sandelin 2015; Rivard and Lapointe 2012). Hence we followed this benchmark of 0.75. The results from QCA give us with five solutions (i.e. configurations of conditions leading to maturity). While all the three configurations for high maturity stage (P2a, P2b, P2c) satisfied the parameters of fit, only one out of the two configurations (P1a) satisfied the criteria for low maturity stage. The existence of these multiple solutions sufficient for progression towards high maturity (configurations P2a, P2b, P2c) thus point to a notion of equifinality (Fiss 2011), justifies proposition 2 and indicates existence of multiple paths towards maturity. Figure 7 shows the QCA final solution of high maturity and low maturity stages respectively (step 5).

CSF		Low Maturity P1a	Paths to High Maturity P2a	P2b	P2c
Technology					
Social media Presence					
Extent of Use	**FUE**	⊗	●	●	●
Ressource (FTE)					
Skills	SK				•
Metrics	M	⊗ (small)	⊗	⊗	
Management					
Encouragement to use	MUS	⊗ (small)		•	•
Increased Investment	INV			•	•
Culture					
Employee Driven	EEC	⊗	•		
Structured	PSC				
Explorative	NSC	⊗ (small)		•	•
IT Policy					
IT security Policy					
BYOD	**ITP**	⊗ (small)	●		⊗
Provide devices					
Consistency		0.84	0.76	0.78	0.80
Raw Coverage		0.07	0.23	0.36	0.29
Unique Coverage		0.03	0.09	0.02	0.04
Overall Solution Consistency		**0.84**		**0.78**	
Overall Solution Coverage		**0.07**		**0.49**	

Black circles indicate presence of a condition, and circles with "X" indicate its absence. Large circles indicate core conditions; small ones indicate peripheral conditions. Blank spaces indicate "don't care" condition, i.e. presence or absence has no significant impact (Fiss 2011)

Consistency refers to the "degree to which cases correspond to the set-theoretic relationships expressed in a solution" (Fiss 2011) or the proportion of cases consistent with the outcome.

Coverage is the measure for the answering: "what proportion of cases with the outcome has been explained or how common is the cause among the cases with the outcome"? (Ragin 2006).

Figure 7: Low and High Maturity Characteristics.

Results are summarized as follows:

1. Social Media Use (U), Number of Social Media Channels (ESC) and Number of Resources (FTE) are established as necessary conditions and hence form the stage boundary conditions between low and high maturity. In practical terms, this means if an organization does not hire at least a part time resource to manage its social media, while maintaining presence on one or more social channels and showcasing some degree of use, it will not be able to progress towards high maturity.
2. Absence of Metrics (M), i.e. workflows and KPI's for social media is seen as a core condition for achieving high maturity. Formalization of social media practices and activities in an organization is considered high maturity in prior literature (Duane and OReilly 2012; Karkkainen et al. 2011; Lehmkuhl et al. 2013). However, these models have been developed for large organizations that lean towards formalization and streamlining of business processes. Given the flexible and entrepreneurial style of working in SME's, the newness of social media adoption in many companies, we infer that social media in itself is a new domain or business activity in most SME's and thus require fair amount of flexibility, before formalizing business processes. Moreover, social media platforms keep changing their functions and social media managers are currently expected to experiment and explore, thus justifying path P2a and P2b.
3. Management's encouragement to use social media (MUS) and increased investment (INV) are not necessary to achieve high maturity, as a path without them (configuration P2a) exists that also guarantees a path to high maturity. These results are consistent with our NCA results. Although, we identified MUS and INV as necessary conditions (effect size >0.1), we reflected and established that

they are not necessary (NN) to achieve up to 60% and 70% of the level maturity, hence not a stage boundary condition for high maturity, whose boundary is drawn at 50% level of maturity.

4. With regards to Very High Maturity stage, we found no positive cases with inclusion criteria of 0.72 and hence could not propose any configurations for this stage. The only solution to this problem is going back to step 1b and expand the case selection by including organizations that have achieved very high degree of maturity. However, using the existing NCA results we established 5 stage boundary conditions to move from High to Very High Maturity (NCA). In practical terms, this means to be in the Very High Maturity stage, an organization has to hire at least a part time resource to manage its social media activities (FTE), maintain presence on at least two social channels (ESC), showcase at least high extent of social media use (U), while having some Top Management Support (MUS) and at least have the same the investment in IT (INV) as compared to the previous year. If any of these "boundary conditions" are not met, the organization will not progress to a very high maturity stage.

Step 6: Operationalize the Maturity Measurement Instrument

The last step is to present the results to the main stakeholders of the academic-industry project consortium (NBI) and operationalize the instrument. It is very important to clearly understand the requirements of the main stakeholders (De Bruin et al. 2005). Therefore, as suggested, apart from direct communication with NBI, we reviewed a list of practitioner tools measuring maturity using online self-assessment surveys. We found that such tools typically require around 3 to 4 minutes of time for answering simple questions and finally viewing the output. In line with these industry conventions, Figure 8 is an illustration of our proposal for a quick diagnostic tool for presenting set-theoretical maturity models to industry practitioners.

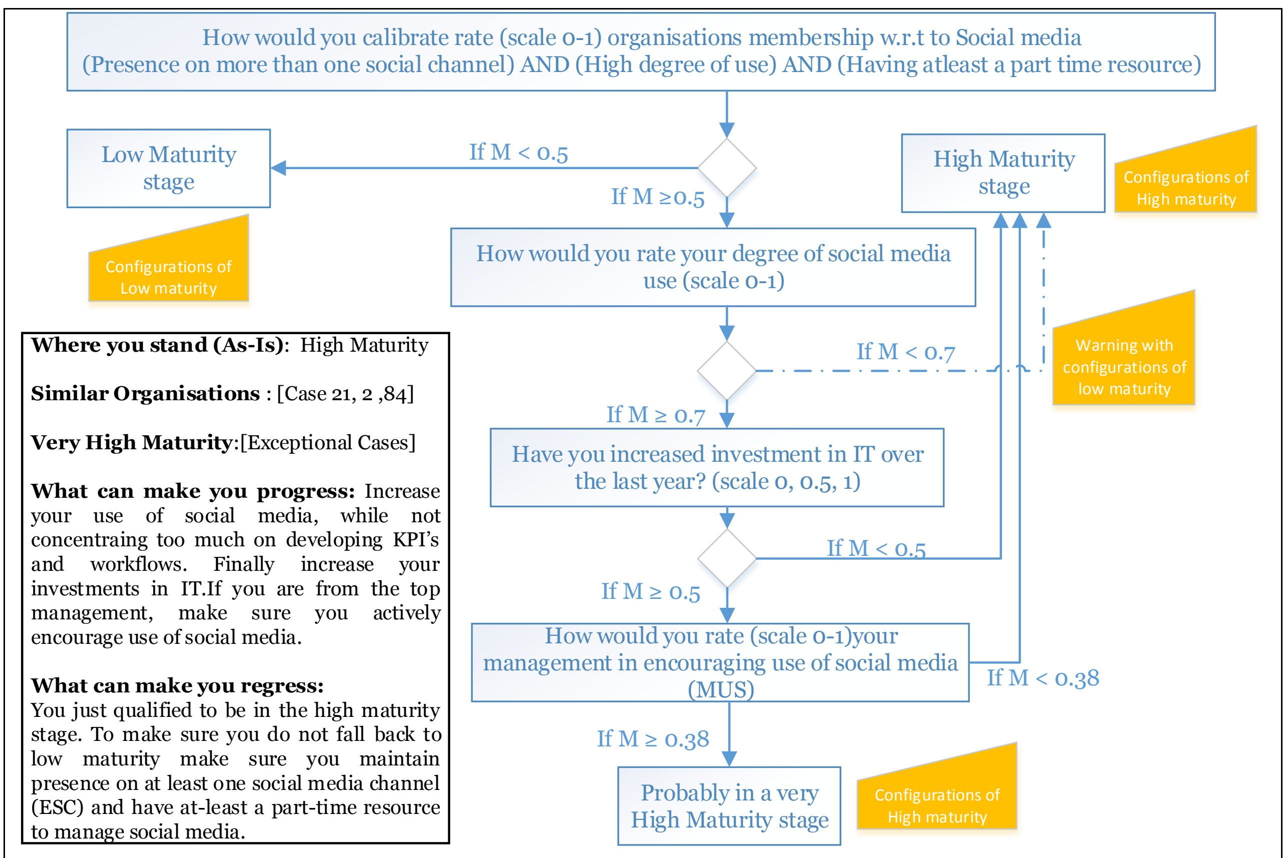


Figure 8: Illustration of the proposed maturity instrument logic.

However, as suggested by many maturity model scholars (Becker et al. 2011; De Bruin et al. 2005; Mettler et al. 2010), it is very important to test and validate the maturity design logic before operationalizing the instrument. Thus, while this paper has designed maturity logic (Figure 8) from empirical analysis of a social media maturity dataset, this is done only with the purpose of demonstrating how both researchers and practitioners can use set-theoretic methods to derive and use a maturity model. Therefore, Figure 6 should be understood as a preliminary illustration of how QCA and NCA results can be used to develop an online maturity measurement tool.

Limitations and Future Work

Although the proposed set-theoretical approach to maturity models provides major opportunities for both research and practice, we acknowledge that it entails certain challenges and limitations. First and foremost, in order to apply this method a high level of declarative and procedural knowledge of Qualitative Comparative Analysis (QCA) and Necessary Condition Analysis (NCA) is required. The second limitation of this paper is the social media maturity dataset used. Although practically relevant and used by practitioners, the conditions are simplistic. Moreover, the dataset did not have enough positive cases to derive configurations for very high maturity stage. That said, the scope of this paper is to conceptualise maturity as concept using set-theoretic methodology and the purpose of the dataset is to demonstrate the method using a real-world dataset that is available to us. In order to address this limitation, as part of future research we will apply the six-step procedure to multiple datasets including those that have been published before in IS or related journals such as the E-Government Maturity Model (Andersen and Henriksen 2006), BI Maturity (Raber et al. 2012) and Intranet Maturity Model (Damsgaard and Scheepers 1999). Application of the six-step procedure on multiple datasets will allow us to test its generalizability. The third limitation is regarding the use of logistic transformation for calibration in our demonstration. Our rationale for this choice is rather weak and requires transformation function sensitivity analysis (Thiem 2014) which will be part of our future research. Furthermore, future work will also include applying other quantitative methods used in maturity model literature like Rasch Analysis (Cleven et al. 2014), Profile Deviation Analysis (Chen and Huang 2012), etc. on our demonstration dataset and compare the results with the set-theoretic method.

Conclusion

Recent advancements in set theory and readily available software have enabled social science researchers to bridge the variable-centered quantitative and case-based qualitative methodological paradigms in order to analyse multi-dimensional associations beyond linearity assumptions, aggregate effects, unicausal reduction, and case specificity. Based on these developments and employing methods like Qualitative Comparative Analysis (QCA) and Necessary Condition Analysis (NCA), in this paper, we proposed a novel approach to empirically deriving maturity models. The primary contribution of this paper is to the domain of maturity model research. This paper conceptualizes stage boundaries of maturity models as necessary conditions using NCA (Dul 2016c), operationalizes maturation in terms of configurations using QCA (Ragin 2008), and demonstrates the existence of multiple paths to maturity beyond a linear single path. This paper is the first attempt to apply set-theoretical methods to maturity model design and successfully demonstrates its application. It also provides researchers with a six-step procedure with detailed guidelines to systematically apply this approach. In addition, we discuss the challenges faced in the process and offers solutions to help IS researchers interested in applying set-theoretical methods in general. The second contribution is to maturity models design. In all previous inductively derived maturity models (Cleven et al. 2014; Raber et al. 2012); the process of arriving at the number of maturity stages was arbitrary. Most models use 4 to 5 stages referencing prior models. Instead of arbitrary selection of number of stages, we provide researchers with three strategies to formulate maturity stages and their boundaries. Moreover, the iterative cycle of the proposed 6-step procedure ensures that the number of stages are analytically derived and not arbitrarily decided. A third and final contribution of this paper is to successfully compliment NCA with QCA and provide future researchers with a demonstrative use case.

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