Maturity Models: A Set Theoretical Approach

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Abstract. 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 analyze multi-dimensional associations beyond the linearity assumptions, aggregate effects, unicausal reduction, and case specificity. Based on the developments in set theoretical thinking in social sciences and employing methods like Qualitative Comparative Analysis (QCA), Necessary Condition Analysis (NCA), and set visualization techniques, in this position paper, we propose and demonstrate a new approach to maturity models in the domain of Information Systems. This position paper describes the set-theoretical approach to maturity models, presents current results and outlines future research work.

1 Introduction

In the social sciences, application of set theory has seen a dramatic increase over the last decade. This can be attributed to the method called “Qualitative Comparative Analysis (QCA)” [1] developed by Charles Ragin [2, 3], a political scientist. QCA as a set-theoretical method models causal relations as *subset or superset relations; necessity and sufficiency* and focusses on arriving at *causally complex patterns in terms of equifinality, conjunctural causation and asymmetry* [3-5]. Initially applied by a small academic community of sociologists and political scientists, this method has been widely adopted in the fields of *management sciences* (e.g. strategic management [5], marketing [6]), *engineering* (e.g. disaster management [7]) and recently in the domain of *information systems* (e.g. user resistance to IT [8], IT business value research [9], digital eco dynamics [10] and IT project management [11]). Although developed initially by Ragin [2] for qualitative case study researchers (medium sample size or N < 90), the proponents and supporters of QCA have argued about its unique advantages over regression-based approaches [4, 12, 13] and its application for analysis of large-N datasets [12]. In the adoption trajectory of set theoretical methods in social sciences [1], three variants of QCA methodology (crisp-set QCA(CsQCA), fuzzy-set QCA (fsQCA) [3] and multi-value QCA (MvQCA) [4]), and a novel approach to identifying necessary conditions i.e. NCA [14] has surfaced with a number of software tools helping researchers to conduct set-theoretic social science research (e.g. R packages like QCA and QCAPro, fs/QCA, Tosmana). A detailed review of available set-theoretical analysis software can be accessed at http://www.compasss.org/software.htm. Furthermore, other related domains (e.g. computer science, forecasting) has also seen a steady rise in the application of fuzzy set or multi valued logic ever since the concept was initiated by initiated by Lotfi A. Zadeh [15] in 1965 [16]. Inspired by this application of set theory across domains, a number of scholars, e.g. Smithson and Verkuilen [17], Vatrapu et.al [18] to name a few, have highlighted key advantages of applying classical set theory [19] in general and fuzzy set theory [20] in particular with them being:

(1) Set-theoretical ontology (e.g. Fuzzy Sets) is well suited to conceptualize vagueness, which is a central aspect of social science constructs. For example, in the social science domain of marketing, concepts such as brand loyalty, brand sentiment are vague.
(2) 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 and degrees of a particular type on construct. For example, social science constructs such as culture, personality, and emotion are all both categorical and dimensional.
(3) Set-theoretical methodology can help analyze multivariate associations beyond the conditional means and the general linear model. In addition, set theoretical approaches analyze human associations prior to relations and this allows for both quantitative variable centered analytical methods as well as qualitative case study methods.
(4) Set-theoretical analysis has high theoretical fidelity with most social science theories, which are usually expressed logically in set-terms. For example, theories on market segmentation and political preferences are logically articulated as categorical inclusions and exclusions that natively lend themselves into set theoretical formalization and analytics.
(5) 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 predictive analytics, it is possible to employ set and fuzzy theory to dynamically construct data points for independent variables such as brand sentiment (polarity, subjectivity, etc.).

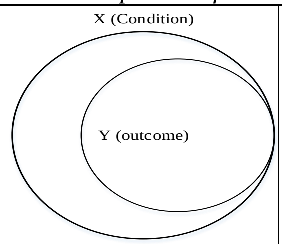
Based on the above developments in set theoretical thinking in social sciences, recent developments in set visualization techniques (e.g. Upset [21], Pathfinder [22], Circles [23], sets as configurations [24]) and employing methods like Qualitative Comparative Analysis (QCA), Necessary Condition Analysis (NCA) and Upset, in this position paper, we propose a new approach to maturity models in the domain of Information Systems. The rest of this position paper is structured as follows. First, we discuss QCA as a set-theoretic method (section 2), and introduce a complimentary method called Necessary Condition Analysis (NCA). Second, we briefly describe the concept of maturity models, and conceptualize maturity models in set-theoretical terms of necessary and sufficient conditions. Third, we present our empirical dataset; showcase the application of Upset in identifying suitable data-set for analysis. Fourth, we present our proposed approach (steps), discuss our results and analysis. Fifth and last is conclusion and future research agenda.

2 Set Theoretic Methods: QCA and NCA

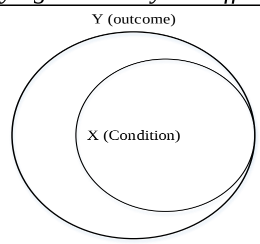
Qualitative Comparative Analysis (QCA) and other set-theoretic methods investigate social phenomena of interest by using sets and the search for set relations[4]. Many researchers ([13], [3], [24], [25], [4]) advocate for the ontology of a social phenomenon being framed in terms of set relations, and using set-theoretic methods to investigate these statements [4]. This section briefly presents the basic principles of set theory (e.g. necessary, sufficient conditions and configurations) and discusses the two methods applied till date in the social sciences (QCA and NCA).

Firstly, in any set theoretic method, it is very important to identify “necessary conditions”, as without them the outcomes cannot occur, and other conditions cannot compensate for their absence [14]. A necessary condition is an antecedent condition that is a superset of the outcome [3]. As shown in Table1, depending on the set formulation (i.e. crisp or fuzzy), in a perfect world one could detect a necessary condition, just by looking at the graph. With both crisp and fuzzy sets (Table 1: 1a & 1c), 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 by visualizing crisp sets in a tabular format (1d). 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 as shown in 1d. Test for necessity is followed by a test for sufficiency (1b, 1e, and 1f). Test for sufficiency however proceeds from the *observation of some condition(s) X to the observation of the outcome Y* [1] as illustrated in Table 1.

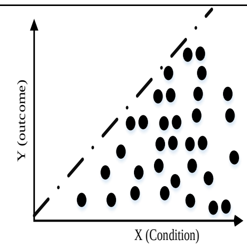
Table 1: Perspectives for identifying Necessary & Sufficient conditions



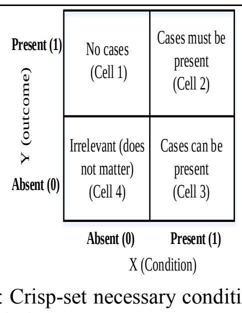
1a: Necessary condition (X is a superset of Y)



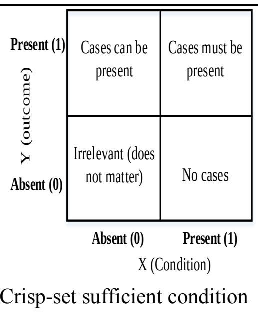
1b: Sufficient condition (Y is a superset of X)



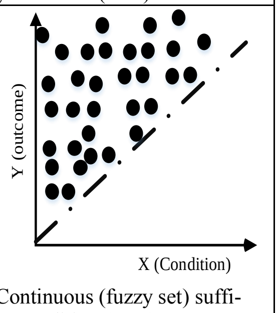
1c: Continuous (fuzzy set) necessary condition (X-Y)



1d: Crisp-set necessary condition (Tabular)



1e:Crisp-set sufficient condition (Tabular)



1f:Continuous (fuzzy set) sufficient condition (X-Y)

Once the necessary and sufficient conditions are identified, set-theoretical social science researchers focus on configurations of how relevant these conditions fit together to achieve the desired outcome (Y). In the real world, empirical data about a certain social phenomenon is often noisy, and in order to detect necessary and sufficient conditions, QCA researchers have developed measures of *consistency*, *coverage* [3], *relevance*, *trivialness* [25] and also some diagnostics to detect paradoxical relations[1]. QCA adopts Boolean minimization using the Quine-McCluskey algorithm combined with qualitative counterfactual analysis to arrive at the final solution [1, 3, 4]. This final solution is presented as the optimal configuration for achieving the desired outcome (Y). However, the ultimate goal of QCA is to *analyze set-theoretic sufficiency relations* [2] and researchers applying QCA are sometimes accused of ignoring necessary but not sufficient conditions. Moreover, calibration of the original data into set-memberships and the construction of the truth table forms central core of this method. Since calibration involves transforming the original dataset, some scholars(e.g. [26], [25]) point to possibility of this step leading to a failure to detect some of the necessary conditions. Furthermore, recent methodological advancements in set-theoretical thinking include a technique called "NCA" for identifying *relationships of necessity that can make both statements in kind and in degree,* thus making full use of variation in the data [26]. The degree of necessity is measured in terms of effect size (i.e. area of emptiness in the top right corner of the X-Y plot). A comparison of the results of NCA and QCA [14] highlighted the advantages of NCA identifying more single necessary conditions than QCA, moreover also specifying the degree of necessity as a clear advantage. In line with these developments and for the purposes of this paper, we complement QCA with NCA in deriving a maturity model (steps discussed in section 5).

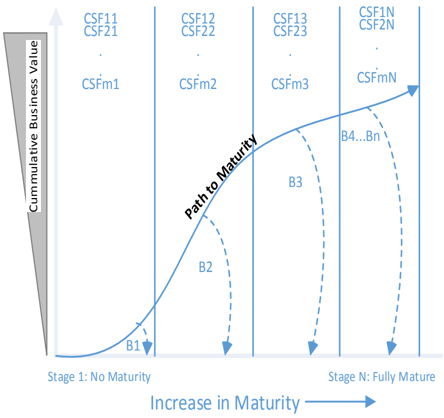
3 Maturity Models

Maturity models are organizational tools that facilitate internal and/or external benchmarking while also showcasing future improvement and providing guidelines through the evolutionary process of organizational development and growth [27, 28]. The term "maturity" is defined as "the state of being complete, perfect or ready" [27]. A maturity model usually consists of a sequence of maturity stages [29], mostly four or five [30]. Each stage expects the entity (people, process, technology, organisation etc.) under maturation to fulfil certain requirements that constitute that particular stage [31]. Usually, this is determined by defining *critical success factors* and *boundary conditions*. The critical success factors as prescribed by the maturity model also mean better outcomes and thus higher business benefits (value) as the organization progresses on the path to increased maturity. In general, maturity assessment is understood as a "*measure to evaluate the capabilities of an organization"*[29], with an underlying assumption of a single linear path to maturity as shown in Figure 1.

From Figure 1, it is evident that without satisfying the boundary conditions, an entity cannot progress further irrespective of satisfying all other conditions. For example, in the case of intranet maturity models [19], active support of a technology champion or a sponsor from the top management team is a boundary condition to progress from stage 1 to stage 2. By formulating boundary conditions as necessary conditions, we can infer that “the absence of the necessary conditions guarantees failure in terms of progression to the next stage of the maturity model”. Thus, adopting the set-theoretic thinking, we postulate stage boundary conditions as necessary conditions and list our propositions:

P1a*: Stage boundary conditions are subsets of critical success factors and can be identified as necessary conditions.*

P1b*: Once identified as Stage boundary conditions, their degree of necessity can be paired with the outcome to derive maturity stages.*



Critical Success Factors (CSF_{mn}, m factors and n stages]: “Dimensions”, “Factors”, “Benchmark Variables” and “Capabilities” are some of the other terms used for critical success factors [28]. CSF’s describe multi-dimensional factors that decide the entities maturity stage. Each CSF is also further classified into a number of sub-factors with specific characteristics at each stage [29].

Boundary Conditions [B1… Bn] Boundary conditions, also termed Triggers, are very specific conditions (usually a sub-set of CSF’s) that the entity has to satisfy in order to progress from one stage to another.

Figure 1: Critical success factors (CSF), boundary conditions [32].

Furthermore, as highlighted in Figure 1, a review of extant literature on maturity models reveals the predominant idea of a single path to maturation (i.e. something better, advanced, higher performance) mostly linear, forward moving (rarely regressing), in which the entity improves considerably in terms of desired results i.e. capabilities, value creation, performance, etc. While notion of maturity has been criticized widely by King and Kraemer [33], Pöppelbuß [34] and indirectly by Cleven, Winter [35], Vlahovic [36] and many more, there have not been any solution proposed till date. In this paper, we propose that by applying QCA, we can provide multiple configurations, translated as multiple paths to maturity. In set-theoretical terms, we adopt the notion of “equifinality” i.e. an entity or system can *reach the same outcome from different initial conditions and through many different paths* [10] and list our final proposition:

P2*: A Boolean minimization solution of the Critical success factors (CSF’) would yield multiple configurations to move from one stage to another, finally reaching full maturity.*

Once the above propositions are empirically validated, i.e. conceptualizing stage boundaries as necessary conditions and multiple paths to maturity using the logic of sufficiency, we finally combine the above to inductively derive a maturity model. In this section we have formulated three propositions and in the next section we explain our dataset, followed by a demonstrating our approach.

4 Dataset: Selection of Social Media Maturity and Assumptions.

This study uses a dataset of organizations measured for digital maturity by Networked Business Initiative (NBI). NBI measured digital maturity of organizations in Denmark in terms of five digital technologies (i.e. social media, web, cloud, data analytics and mobile) and 6 business functions (PR, Sales & Marketing, Services, HR, R&D and Leadership). The full description of the data and access to the benchmarking tool is available via the NBI website (www.networkedbusiness.org). The data was collected through a cross-sectional survey whose primary purpose was comparative benchmarking of participating organizations in Denmark.

The design of the cross-sectional survey was open ended, wherein the respondents were free to choose any technology(s) and any business function(s). This open ended design with 5 technologies and 6 business functions had possibility of having 1953 unique combinations. NBI measured around 300 organizations, with over 345 respondents over a period of 5 months (October 2015 to March 2016). Given the open ended design of the survey and not enough respondents, the challenge was to identify data for analysis. In order to tackle this challenge, we scanned the literature in the visualization community [22, 23] and decided to apply Upset [21]. Upset [21] is a technique for the *quantitative analysis of sets and their intersections*,, with a capability of handling *combinatorial explosion of the number of set intersections*. Moreover, Upset is web-based and open source, thus making is very accessible to us. Given these advantages of Upset, we used the web tool (http://vcg.github.io/upset) to select data from the NBI dataset as shown in figure 2.

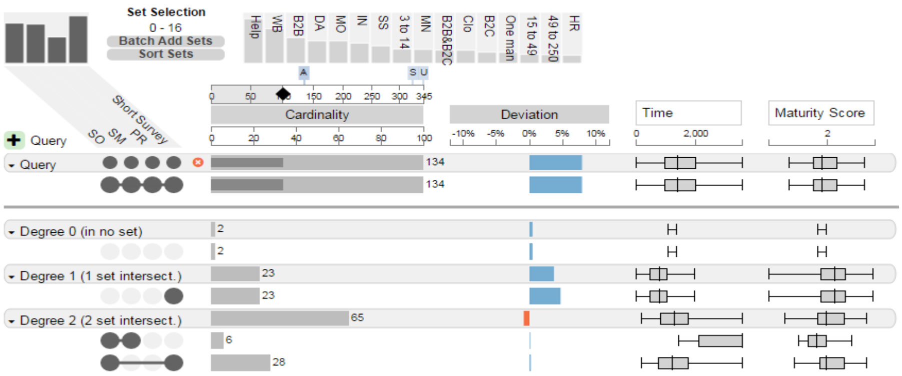


Figure 2: Social media maturity selection using UpSet technique [21].

After inspecting the Upset visualization (figure 2), we selected data for a single technology (i.e. social media) and its impact on 2 business functions (i.e. PR, Sales and Marketing). From the 134 data points, post cleaning we were able to identify 85 data points worthy for further analysis. The detailed descriptive statistics can be found in appendix 1 & 2. Given the page constraints, we do not go into the depth of the dataset (i.e. social media maturity across PR, Sales & Marketing), but list out the assumptions briefly:

1. The social media maturity dataset consists of 14 critical success factors (CSF's), also known as conditions (X's) in set theoretic terminology.
2. Business value realized in PR and Sales and Marketing is the outcome (Y). We used the average, which is an accepted practice.
3. As shown in Figure 1, "social media maturity $\propto$ Business value", this means higher the social media maturity of an organization, better or higher outcomes or business value.
4. Critical Success Factors (CSF's) identified as "necessary but not sufficient conditions" would be the "stage boundary conditions".
5. Critical Success Factors (CSF's) identified as "sufficient but not necessary" would be another path to maturity.
6. Critical Success Factors (CSF's) identified as "both necessary and sufficient" would be termed as "most important condition" that an organization must possess them irrespective of which maturity stage there are in.

Now that we have discussed the dataset, assumptions and our propositions, in the next section, we explain and demonstrate our proposed approach on the social media maturity dataset.

5 Demonstration of the Proposed Approach

After a detailed review of guidelines and procedures for developing maturity models [37-39], the guidelines for standard practices in QCA [1, 4, 24, 25], guidelines for NCA [26, 40] and Fuzzy logic [16], we propose the following 6 steps to design an empirically driven set theoretical maturity model (Figure 3 - Appendix 3). Next we briefly explain each step using the NBI social media maturity dataset.

Step1- Define the Attributes/Variables (CSF's): Define the CSF's, outcome variables and macro conditions along with the scales used for measurement. Explain the calculation if and when multiple items are used to measure the CSF (Appendix 1).

Step2- Determine Degree of necessity & Boundary Conditions: by using Necessary condition analysis [14, 41], calculating the effect size and constructing the bottleneck table (refer [32]). In the case of social media maturity, we identified 5 single necessary conditions and one "necessary and sufficient" condition (Appendix 2). However, after studying the scale of measurement, Employee empowered culture (EEC) was determined as a not necessary condition.

Step3 & 4-Fuzzification i.e. rules for Set Membership & propose maturity stages: Fuzzification also popularly known as "calibration" is a crucial step in QCA requiring the researcher to assign set membership scores to both outcomes (Y) and conditions (X). Here the researcher needs to *establish qualitative crossover points* [3, 24] to assign membership to particular sets. QCA and fuzzy logic scholars [4] have proposed a taxonomy of calibration scenarios [1, 16]. We adopt the logistic transformational assignment (Eq1) as proposed by Ragin [3] and Theim et.al [1] for assigning full exclusion, full inclusion and crossover points.

$$\varphi SET(x, \forall[\ldots], p, q) = \begin{cases} 0 & \text{If } \forall ex \geq xi, \\ \frac{1}{2}\left[\frac{\forall ex - xi}{\forall ex - \forall cr}\right]^{p} & \text{If } \forall ex < xi \leq \forall cr, \\ 1 - \frac{1}{2}\left[\frac{\forall in - xi}{\forall in - \forall cr}\right]^{q} & \text{If } \forall cr < xi \leq \forall in, \\ 1 & \text{If } \forall in < xi \end{cases} \quad \ldots\ldots\ldots Eq1$$

Where x is the variable to be transformed, ∀ex is full exclusion from the set, ∀cr is the cross-over point and ∀cr is full inclusion, p and q are for controlling the shape of the membership function.

Our primary interest in this step was defining the maturity stages in terms of set memberships, which we measured through a proxy of business value realized (Y). Following the configurational approach [10, 24], we also created fuzzy set measures of above-average business value realized (i.e. set with high maturity). This "benchmark" of above-average was set at 50% business value realized (i.e. score of 2). The reasoning was equally motivated by calibration of survey data for QCA [12] and qualitative reasoning among the authors that if an organization has derived "at least high value" in either PR or Sales & Marketing (2.5 and above), then it is more in the set of high maturity. For this first set, we coded full inclusion of $\forall in$ = 0.5 and full exclusion of $\forall ex$ = 3.5 with a cross over point of $\forall cr$ = 2.1. As highlighted in Figure 3 (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 was organizations with very high business value realized (i.e. Very High maturity). Here the crossover point was raised to 3, while full exclusion for the higher end point was 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 was simply coded as the negation of the set with high maturity (Appendix 3), with a full exclusion of 2.5 and 0, with a cross over at 1.5. Following the fuzzification of the Outcome (Y), the conditions (CSF's) are now fuzzified or calibrated using both the empirical evidence at hand and qualitative interference. For example, FTE (measured as 0 for none, 1 for part time resource, 2 for one resource, 3 for two or more) was 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. Other CSF's were similarly coded and the inclusion, exclusion and cross over points have been listed in appendix 1.

Step5 - Fuzzy Inference System based on Qualitative Comparative Analysis: Inferencing is a process to "evaluate all pre-defined rules to perform the reasoning process" [16]. In our case, we employ the pre-defined rules of Qualitative Comparative Analysis [1, 2] to first convert the fuzzy sets into crisp truth table values, then employ Boolean minimization to arrive at final solution[1]. Steps 3, 4 and 5 work in an iterative cycle as illustrated in Figure 3 (Appendix 3) until an optimal solution is obtained in what Ragin [3] terms as an "analytical moment". This iterative cycle might also lead to formulations of some macro conditions, improved case and theoretical knowledge.

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[1] Refer 1. Thiem, A. and A. Dusa, *Qualitative comparative analysis with R: A user's guide*. Vol. 5. 2012: Springer Science & Business Media. Page 54 – 79 for detailed steps.

In our case, we dropped digital strategy (DS) as it did not contribute to achieving a solution, and created two macro conditions. The first macro condition termed "FUE" was combination of common necessary conditions (Appendix 2) required for high and very high maturity stages. The second macro condition "IT Policy (ITP)" was arrived through what Ragin [3] terms "colligations", i.e. meaningful collections of facts or evidence. The logic for the macro conditions is described in table 2. The next logical step was to employ the prescribed steps[1, 42] for QCA. We set the inclusion criteria of 0.72 and tested the final the configurations for paradoxical relations [1]. Post this analysis, we found 3 configurations for high maturity stage and one configuration for the low maturity stage, but none for very high maturity stage.

Table 2: Macro Conditions for QCA.

Macro Condition	Reasoning & Calibration
FUE = (U*ESC * FTE)	Extent of use (U), Presence on social media (ESC), and # of resources (FTE) are all necessary conditions for high 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)]

Step 6 – Visualize and present the maturity logic: The sixth and final step was visualizing the set theoretical maturity model and assessment logic for the future. There were multiple options suggested in literature to present the results [e.g. Core-Periphery configuration chart [24], Solution as Boolean expression [1, 3], Relevance-trivialness table [25]]. We considered all these options and chose the Core-Periphery configuration chart, given its visual symmetry with prior maturity models. Figure 4 shows the results for high maturity stage and low maturity stage respectively. From the configurations, it is possible to present the maturity logic as a set of fuzzy rules [16]. Some of the rules are as follows:

1. IF ESC is less than two THEN maturity is LOW.
2. IF ESC is more than one and FTE is zero THEN maturity is LOW
3. IF ESC is more than one and Extent of Use high and FTE is at least one and management support is high and explorative culture is present THEN maturity is HIGH.
4. IF ESC is more than one and Extent of Use high and FTE is at least one and management support is high and explorative culture is present and Investment is increasing THEN maturity is definitely HIGH and may be VERY HIGH.

With the current dataset, while we have established boundary conditions for progressing towards very high maturity, we can only speculate about the configurations in the very high maturity stage. Therefore, the fuzzy rules would call for qualitative interference or collection of more data to determine if an organization is in the very high maturity stage. Another possibility is the use the max-membership principle [16] or the concept of misfit [43] to assess an organizations maturity.

		Low Maturity	Paths to High Maturity		
CSF		**1a**	**2a**	**2b**	**2c**
Technology					
Social media Presence					
Extent of Use	**FUE**	⨂	⬤	⬤	⬤
Ressource (FTE)					
Skills	SK				•
Metrics	M	⊗	⨂	⨂	
Management					
Encouragement to use	MUS	⊗		•	•
Increased Investment	INV			•	•
Culture					
Employee Driven	EEC	⨂	•		
Structured	PSC				
Explorative	NSC	⊗		•	•
IT Policy					
IT security Policy					
BYOD	**ITP**	⊗	⬤		⨂
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; circles with "X" indicate its absence. Large circles indicate core conditions; small ones indicate peripheral conditions. Blank spaces indicate "don't care", i.e. presence or absence has no impact [24]

Figure 4: Visualisation of set theoretical social media maturity configuration.

6 Conclusions and Future Work

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. Based on these developments, in this paper, we proposed a new approach to maturity models. The primary contribution of this paper is to conceptualize stage boundaries of maturity models as necessary conditions using NCA [14], conceptualize maturation in terms of configurations using QCA [3], and assess maturity using fuzzy logic. The paper provided researchers with a six step procedure to systematically apply set theoretic methods to design a maturity model.

However, the paper has a number of limitations. One major limitation of is the social media maturity dataset used. Although practically relevant and used by practitioners, the critical success factors are simplistic. In order to overcome this limitation, future work will be to apply set theoretical methods to multiple datasets especially those that have been published and validated like E-Government Maturity Model [44], BI maturity model [29] and others. Furthermore, future research would also include studying the applicability of the Core-Periphery configuration chart [24] for visualising maturity configurations through a user study.

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Appendix-1: 14 Critical Success Factors, Scales, Calibration, Respondent Information

	Condition or CSF (X)		Scale; # of items	∀in,∀cr,∀ex
Management	Top Management encourages the use of social media throughout the organization.	MUS	Likert (0-4); 1	0,2,4
	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	0,1,2
	Digital strategy Index[2]	DS	Index (0 to 4); 1	0,1.5,3.692
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	0, 1.33, 4
		OD	Likert Scale (0-4) ; 1	0,2,4
		PEDW	Likert Scale (0-4) ; 1	0,2,4
Technology	Social media presence, measured as the number of social media channels.	ESC	Count (0 -8) ; 1	0,1,4
	Extent of Use of social media, measured as an average of PR and Sales & Marketing	U	Likert Scale (0-4) ; 2	0,2,4
	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	0,0.9,3
		S	Likert Scale (0-4) i.e. Not at all to Very high degree; 1	0,2,4
	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	0,0.95,2
Culture	The measures for Culture were 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 were 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	-0.5,0.5,1.5
		PSC	Likert Scale (-2 to 2) ; 2	-0.5,0,1.5
		NSC	Likert Scale (-2 to 2) ; 1	-1,0,2
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	Low: 2.5, 1.5, 0 High: 0.5, 2.1, 3.5 Very High: 0.5, 3, 4

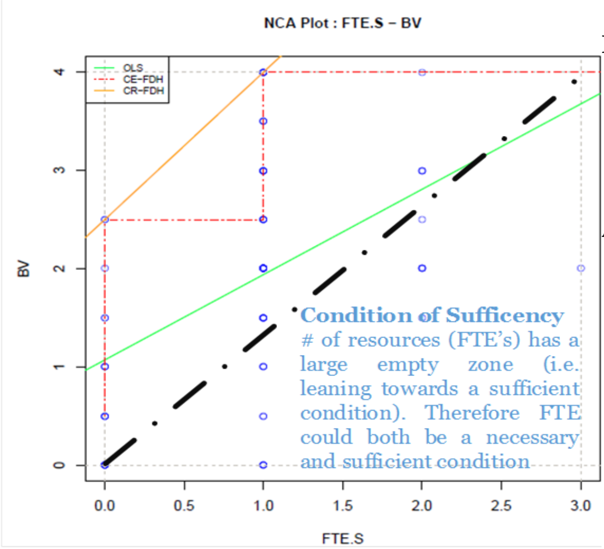
Size/founded	2000 - 2008	After 2008	Before 2000	Grand Total
50 to 250	2	2	22	26
15 to 49	8	1	7	16
Less than 15	14	19	10	43
Grand Total	24	22	39	85

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

[2] 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. Organization B however has digital strategy (X1=1), has been aligned fully (X2=4), has been communicated largely (X3=4) and implemented to a small degree (X4=2). 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.

Appendix-2: Necessary Condition Analysis Results

	BV (%)	MUS	FTE	Skills	USE	ESC	EEC	PSC	INV
	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
Low	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	90	39.4	33.3	18.3	71.8	25.0	36.1	22.9	50.0
High	100	52.8	33.3	25.0	81.3	25.0	44.9	28.6	50.0
MATURITY->	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). As NCA has no measures to identify sufficieny conditions, we use QCA.

Appendix 3: A six step procedure for designing a set theoretical maturity model.

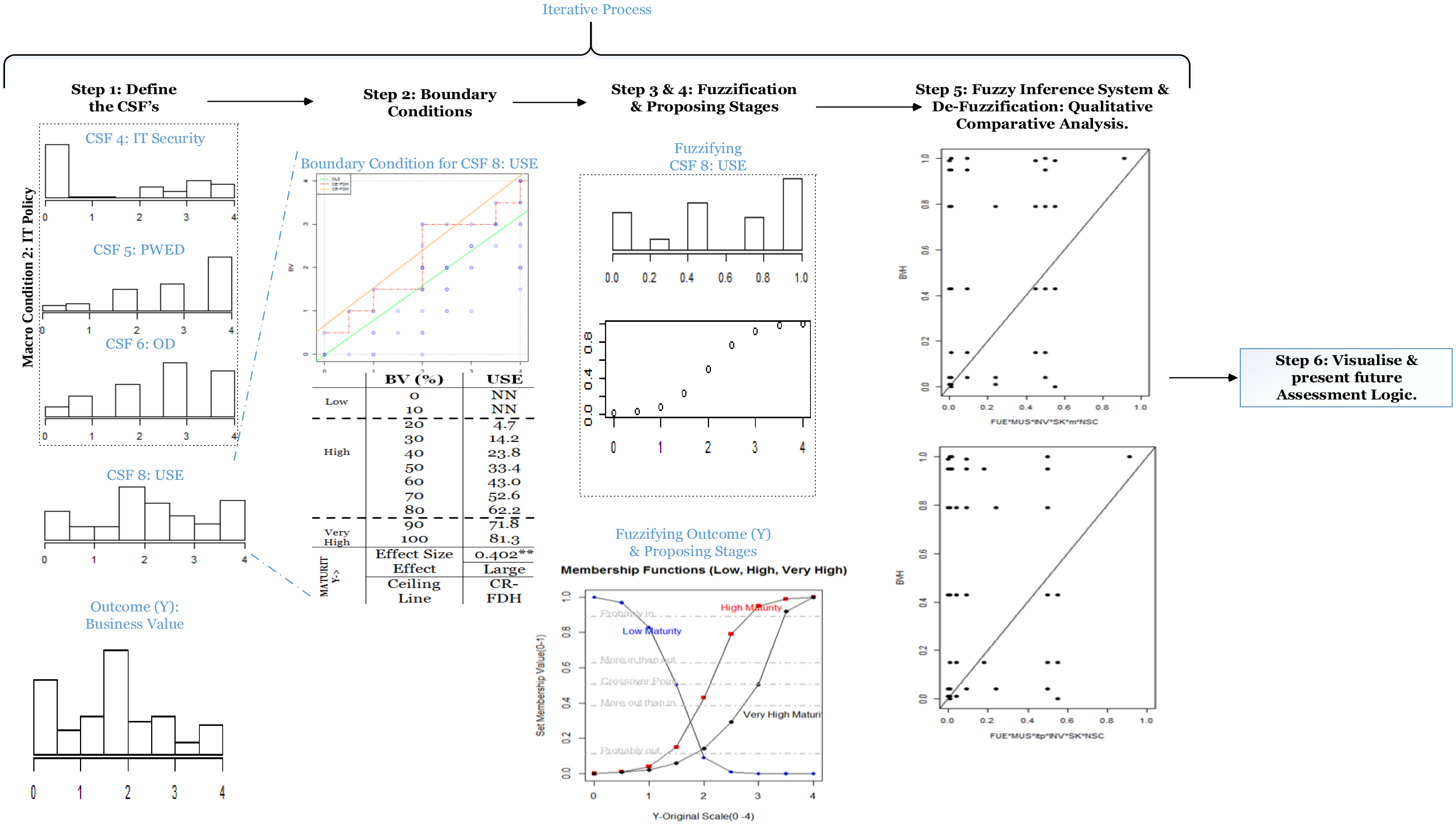


Figure 3: Proposed Approach for designing a set theoretical maturity model