

The Added Value of Multi-Value Qualitative Comparative Analysis

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Abstract: This article aims to qualify the skeptical view of many leading methodologists on multi-value Qualitative Comparative Analysis (mvQCA). More specifically, it draws attention to a distinctive strength of this QCA-variant. In contrast to the other QCA-variants, mvQCA is capable of straightforwardly capturing the specific causal role of every category of a multi-value condition. This provides it with an important advantage over both crisp set (csQCA) and fuzzy set QCA (fsQCA). fsQCA is not capable of capturing the causal effect of an intermediate category if, depending on the context, it can have a different impact than the full presence of the corresponding condition. csQCA, in turn, tends to attribute a causal role to the absence of condition values, which in the case of multi-value conditions often encompass very different cases. The article first discusses the comparative advantage of mvQCA with a constructed data set, after which it reanalyzes two published studies to demonstrate these advantages with empirical data.

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1. Introduction

In the almost three decades since the publication of Charles RAGIN's "The Comparative Method," qualitative comparative analysis (QCA) has developed into a widely-used analytical technique in the social sciences (RAGIN, 1987). In the last few years, the number of QCA-related articles published in peer-reviewed journals has increased exponentially (RIHOUX, ÁLAMOS-CONCHA, BOL, MARX, & REZSÖHAZY, 2013). Strikingly however, nearly all empirical applications build on either the original crisp set version of QCA (csQCA) or the fuzzy set variant (fsQCA). Multi-value QCA (mvQCA) is remarkably less popular. According to the COMPASSS bibliographical database,¹ mvQCA has only been

1 COMPASSS (COMPARative Methods for Systematic cross-caSe analySis) is a network that aims to further develop systematic comparative case analysis. Its bibliographical database contains journal articles that present empirical applications or methodological work on

applied thirteen times in the over ten years since it was introduced in 2003 (CRONQVIST, 2003). This contrasts starkly with the 237 and 213 applications of, respectively, crisp and fuzzy set QCA. [1]

A potential reason for the low number of applications is the lack of attention devoted to mvQCA in introductory volumes on QCA.² Only eight of the 350 pages of SCHNEIDER and WAGEMANN's (2012, pp.255-263) comprehensive textbook are devoted to mvQCA. Furthermore, while book-length volumes were published on csQCA (CARAMANI, 2009; RAGIN, 1987) and fsQCA (RAGIN, 2000, 2008), no comparable work exists on mvQCA. Unsurprisingly, *FQS* has published an excellent introduction to fsQCA (LEGEWIE, 2013), as well as an innovative procedure for applying crisp and fuzzy set QCA to large datasets (COOPER & GLAESSER, 2012), but, so far, no articles on mvQCA. [2]

A second reason for the low number of applications of mvQCA, which also explains the general neglect of the method in methodological volumes, is the skeptical view of many of the leading methodologists on its added value. Strikingly, SCHNEIDER and WAGEMANN (2012, pp.255-263) devote five of the merely eight pages on mvQCA to a very critical assessment of the method. The most comprehensive critical appraisal of mvQCA was however written by VINK and VAN VLIET (2009), who provide five reasons to doubt the method's added value. With the goal of opening a more nuanced debate on mvQCA, THIEM (2013) gave several good arguments to refute these reasons and, in later publications, introduced several valuable extensions of mvQCA (DUŞA & THIEM, 2015; THIEM, 2014a, 2015a). VINK and VAN VLIET (2013) were however not convinced by THIEM's (2013) arguments and reiterated their doubts on the usefulness of the multi-value variant of QCA. The low number of applications suggests that VINK and VAN VLIET's (2009, 2013) negative opinion on mvQCA still reflects the general view on the value of mvQCA. [3]

In this article, I aim to qualify the negative assessments of mvQCA. In Section 2, I present the key steps of mvQCA. In Section 3, I discuss several advantages of using mvQCA instead of fsQCA and csQCA that have so far been overlooked in the debate on the method's added value. In Section 4, I demonstrate the advantages of mvQCA by reanalyzing two published studies. Finally, Section 5 recapitulates the article's main points in the conclusions. [4]

2. mvQCA: Main Analytical Steps

The main analytical steps of the mvQCA procedure are similar to the main steps of the other variants of QCA (HERRMANN & CRONQVIST, 2009, pp.35-38; SCHNEIDER & WAGEMANN, 2012, p.258). First, the researcher has to construct a data table in which each case is assigned a value on the conditions and the outcome (RIHOUX & DE MEUR, 2009, p.39). The key difference between

configurational comparative methods and can be accessed at <http://www.compass.org/bibdata.htm>.

2 An important exception is the chapter of CRONQVIST and BERG-SCHLOSSER (2009) in RIHOUX and RAGIN (2009).

mvQCA and the other QCA-variants is that it allows multi-value conditions. In mvQCA, each category is represented by a natural number (0, 1, 2, 3 ...) (CRONQVIST & BERG-SCHLOSSER, 2009, p.70). For example, a traffic light can be transformed into a multi-value condition by assigning a value of 2 to cases if the light was green, a value of 1 if it was orange and a value of 0 if it was red. In contrast, csQCA only allows assigning a value of either 1 or 0, which indicate that a condition is present or absent, respectively. fsQCA allows for every possible value between 1 and 0. However, these values represent the extent to which a single category is present in a given case, not whether a specific category of a condition is present. [5]

Once a value has been assigned to each case on the conditions and the outcome, the obtained dataset is converted into "truth table." A QCA truth table contains a row for every possible combination of conditions. Table 1 presents a fictional truth table for the outcome "car accident" and the conditions "traffic light" (with a value of 2 for green, 1 for orange and 0 for red) and "drunk driver" (with a value of 1 for drunk and a value of 0 for sober). Row 1 thus corresponds to the combination "green light – drunk driver." Cases are attributed to the row that corresponds to their specific combination of conditions. Leo and Mike were drunk drivers who passed a green light; Rob a sober driver who passed a red light. In mvQCA (as in csQCA), an outcome value of 1 is assigned if the outcome is present in all cases of a row. This indicates that the corresponding combination always leads to the outcome, which suggests that it constitutes a sufficient combination. An outcome value of 0 is assigned to rows where the outcome is absent in every case. If a row contains cases where the outcome is present and cases where the outcome is absent, this row is considered a contradictory configuration. Rows without empirical cases are considered logical remainders. For clarity's sake, there are no remainders or contradictory configurations in the fictional truth table.

Row	Light	Drunk	Accident	Cases
1	2	1	1	Mike, Leo
2	1	1	1	Don
3	0	1	1	Ralph
4	2	0	0	Emma, Jos
5	1	0	0	Dirk
6	0	0	0	Rob

Table 1: Truth table illustration mvQCA [6]

In the next step of mvQCA, the truth table is minimized to arrive at a shorter, more parsimonious, solution (RIHOUX & DE MEUR, 2009, p.35). First, combinations of conditions are represented with set notation. Conditions are expressed in capital letters, their value is presented next to them in brackets.

LIGHT{2} thus indicates a green traffic light. Two basic operators are used in QCA. [*] represents logical AND, which expresses the combination of two conditions. [+] represents logical OR, which indicates that at least one of two (combinations of) conditions is present. Lastly, the arrow symbol [→] is used to indicate that a (combination of) conditions is sufficient for an outcome. The three rows of the truth table with an outcome value of 1 can thus be represented in the following expression (E1):

$$\text{LIGHT}\{2\} * \text{DRUNK}\{1\} + \text{LIGHT}\{1\} * \text{DRUNK}\{1\} + \text{LIGHT}\{0\} * \text{DRUNK}\{1\} \\ \rightarrow \text{ACCIDENT}\{1\} \text{ (E1)}$$

This expression can be read as follows: the combination of a green light with a drunk driver or an orange light with a drunk driver or a red light with a drunk driver is sufficient for the presence of an accident. [7]

This complex expression can be reduced with a generalization of Boolean minimization. In mvQCA: "A condition can be considered irrelevant if a number of logical expressions differ in only this condition and produce the same outcome, and if all possible values of this condition are included in these logical expression" (CRONQVIST & BERG-SCHLOSSER, 2009, p.74). In the expression above, DRUNK{1} leads to an accident, no matter what value LIGHT takes (2, 1, or 0). This suggests that the latter condition can be considered superfluous and thus be removed from the initial expression. Minimization of expression E1 thus results in the following expression (M1):

$$\text{DRUNK}\{1\} \rightarrow \text{ACCIDENT}\{1\} \text{ (M1) [8]}$$

3. The Added Value of mvQCA in Theory

This section discusses several advantages of mvQCA that have been overlooked in the debate on the method's added value. First, I argue that mvQCA has an advantage over fsQCA for analyzing ordinal conditions: mvQCA can capture the impact of other conditions on the degree to which a condition's presence is needed to produce an outcome. Subsequently, I demonstrate that the crisp set procedure that is commonly suggested as an alternative to mvQCA does not produce that same results as QCA's multi-value variant and is hampered by two significant problems. Finally, I build on an argument of THIEM (2013) to demonstrate that there is no reason to question the set-theoretic status of mvQCA. [9]

3.1 Multi-value vs. fuzzy set QCA

While several authors have argued that mvQCA could be valuable for analyzing categorical conditions such as race or religion, there seems to be a consensus that fsQCA is superior for analyzing ordinal conditions. SCHNEIDER and WAGEMANN (2012, p.260) argue that the distinct methodological contribution of mvQCA is not clear if it operates on ordinal multi-value conditions; while RIHOUX, RAGIN, YAMASAKI, and BOL (2009, p.169) advise to use fsQCA "if the raw data

vary systematically and meaningfully by degree." Similarly, one of the main reasons why VINK and VAN VLIET (2009, p.270) question the added value of mvQCA is that most mvQCA applications use ordinal conditions. THIEM (2013, pp.199-200) agrees with this claim, and only qualifies VINK and VAN VLIET's (2009) assertion that mvQCA was barely used for categorical base-variables. fsQCA is thus considered superior to mvQCA when only ordinal conditions are included in the analysis. [10]

However, mvQCA has an important advantage over fsQCA for analyzing multi-level conditions with an ordinal notion: it can capture an additional dimension of causal complexity. More specifically, mvQCA is capable of capturing the impact of other conditions on the degree a condition's presence is needed to produce an outcome. One of the key strengths of all QCA-variants is that they allow for a complex form of causality, captured under the expression "multiple conjunctural causation." This implies that 1. more often than not, phenomena are produced by a combination of conditions; 2. generally, several of such combinations can cause the same outcome; and 3. causality is asymmetric, meaning that the inverted explanation for the presence of a phenomenon does not automatically imply the absence of this phenomenon (RIHOUX, 2003, p.353; WAGEMANN & SCHNEIDER, 2010, pp.383-385). This complex conception of causality, thus, implies that the impact of a condition is determined by the context in which it takes place. This corresponds with everyday experience, as RAGIN (1987, p.23) illustrates by pointing to the fact that "a funny joke told in the wrong setting can fall flat." A context can however also determine the extent to which a condition has to be present to have a certain causal effect. A joke has to be very funny to cause the same amount of laughter at a funeral as an ordinarily funny joke in a bar, while it does not even have to be funny to do so if the audience is drunk. This is implied by the concept of multiple conjunctural causation. If the effect of a cause "depends on the values or levels of other causal variables" (p.33), these other conditions can also determine the extent to which it has to be present to produce a certain outcome. [11]

In all probability, this dimension of causal complexity applies to many phenomena that interest social scientists. Consider for example the complex causal relationship between electoral cycles and a government's inclination to resort to the use of military force (WILLIAMS, 2013, pp.451-452). According to diversionary theories of war, governments are more likely to resort to the use of force when the next election is close by. This is because they might hope to create a "rallying around the flag effect," thereby enhancing their chances at reelection. Theories on casualty aversion and democratic peace, on the other hand, expect governments to be careful not to upset the public before an election by engaging in costly military adventures. These theoretical expectations are not necessarily contradictory, since the impact of electoral cycle can be expected to depend on other factors, most importantly government popularity. [12]

It seems plausible that only unpopular governments will be tempted to deploy military force for diversionary purposes. Since these already face a high risk at electoral defeat, they have not much to lose and a lot to gain from pursuing this

dodgy strategy. Popular governments, on the other hand, will not put their favorable electoral position at risk for merely the possibility of achieving a greater victory. At the beginning of an electoral cycle, government popularity can however be expected to have no impact on the use of force. This is because executives are less driven by electoral calculations when the next election is still in a distant future. In the middle of a cycle, government popularity probably does matter, but in yet another way than at the end of a cycle. Because of their electoral surplus, popular governments might still be willing to engage in military action, since they do not risk losing all their chances at reelection when things go awry. Not popular governments do face this risk and, contrary to the last year before an election, might hope to have the time to improve their chances without pursuing the risky strategy of diversionary warfare. [13]

Three conjectures follow from the above:

1. At the beginning of an electoral cycle, all governments resort to the use of force.
2. At the middle of an electoral cycle, only popular governments resort to the use of force.
3. At the end of an electoral cycle, only not popular governments resort to the use of force.³ [14]

The extent to which the condition "electoral cycle" has to be present to cause the use of force, can thus be expected to be determined by the value of the condition government popularity. This also holds for the absence of the use of force, which can either occur at the end of an electoral cycle if the a country is ruled by a popular government or at the middle of an electoral cycle if the country is ruled by a not popular government. [15]

mvQCA is capable of straightforwardly capturing the causal relation between the conditions and the outcome. Table 2 presents a multi-value truth table, which assumes that the above conjectures are correct. The condition "electoral cycle" is trichotomized cu in "begin electoral cycle" (value of 2 on condition EC), "middle electoral cycle" (value of 1 on condition EC) and "end electoral cycle" (value of 0 on condition EC). For clarity's sake the condition "government popularity" (POP) is dichotomized, as is the outcome "use of force" (FORCE).

3 These conjectures oversimplify the complex causal processes that lead to the use of force in international relations and would be more plausible if "resort" was replaced by "may resort" (HAESEBROUCK, 2015b). However, the less realistic "resort" is used to more clearly illustrate the argument.

Row	EC	POP	FORCE
1	2	1	1
2	2	0	1
3	1	1	1
4	0	0	1
5	1	0	0
6	0	1	0

Table 2: Truth table mvQCA [16]

Minimization of the multi-value conditions yields the following solution (M2), in which EC{2} covers combination 1 and 2, EC {1}*POP{1} combination 3 and EC{0}*POP{0} combination 4.

$$EC\{2\} + EC\{1\} * POP\{1\} + EC\{0\} * POP\{0\} \rightarrow FORCE (M2)$$

The three conjectures are clearly reflected in this formula. EC{2} corresponds to the first conjecture; EC{1}*POP{1} to the second conjecture and EC{0}*POP{0} to the third conjecture. [17]

The above example only uses ordinal conditions, each of which can be derived from a continuous base variable. The time remaining until the next elections, for instance, constitutes a very straightforward indicator for operationalizing "begin electoral cycle" (EC). Countries at the beginning of a cycle (e.g. over 3 years till next election) could be assigned a score of 1, countries at the middle of a cycle (e.g. between 3 and 1 year till next election) a score of 0.4 and countries at the end (e.g. less than 1 year till next election) a score of 0. Data extracted from opinion polls could be used to operationalize government popularity (POP), conflict duration or intensity to calibrate use of force (FORCE). For clarity's sake, these conditions are however dichotomized in the example below. Assuming the three conjectures on p.4 are correct, the combinations of fuzzy membership scores on the conditions and the outcome presented in Table 3 are possible.

Combination	EC	POP	FORCE
1	1	1	1
2	1	0	1
3	0.4	1	1
4	0	0	1
5	0.4	0	0
6	0	1	0

Table 3: Fuzzy membership scores [18]

Like all QCA-variants, fsQCA uses a truth table to examine causal relations.⁴ In fsQCA, the construction of a truth table starts with calculating each case's membership score in every possible combination, using logical AND. Subsequently, an outcome value is assigned to each row. A combination of conditions is assumed to be sufficient if the membership scores in this combination are consistently below or equal to the corresponding scores in the outcome. This is calculated with the formula $(\sum(\min(X_i, Y_i)) / \sum(X_i))$, in which X denotes the membership scores in the combination of conditions and Y the scores in the outcome. The resulting value is the consistency score, which can vary between 0 and 1. An outcome value of 1 is assigned to rows with a high consistency score (HAESEBROUCK, 2015a). [19]

If one case is included for every possible combination, this results in the truth table presented in Table 4. Only the consistency of the first row is sufficiently high to assign it an outcome-value of 1. This would lead the researcher to the conclusion that only popular governments that are at the beginning of an electoral cycle will resort to the use of force. He will thus fail to uncover the three causal combinations that were assumed to cause military deployment. This is because, in fsQCA, it is assumed that the intermediate presence of a condition basically has the same causal effect as its full presence in every possible context. Only the extent to which it affects the outcome is assumed to differ. In other words, if the full presence of a condition leads to the presence of an outcome in a certain context, it is assumed that, in the same context, its intermediate presence will lead to an intermediate presence of the outcome. fsQCA is therefore unable to capture the causal effect of an intermediate category if, depending on the context, it can have a different impact than the full presence of the corresponding condition.

⁴ For a detailed explanation of how truth tables are constructed in fsQCA, see RAGIN (2008, pp.122-144); for a practical introduction, see LEGEWIE (2013).

Row	EC	POP	Consistency	FORCE
1	1	1	1	1
2	1	0	0.71	0
3	0	0	0.63	0
4	0	1	0.38	0

Table 4: Truth table fsQCA [20]

Row 2 of the truth table, for example, represents the combination of the presence of "begin electoral cycle" and the absence of "government popularity" which is assumed to be sufficient for the use of force. Two types of cases have a non-zero membership score in this row, and thus affect its consistency value. Countries without a popular government that are at the beginning of an electoral cycle have a score of 1 (cf. Table 3, combination 2), countries without a popular government at the middle of a cycle a score of 0.4 (cf. Table 3, combination 5). Only the former resort to the use of force and thus have a score of 1 in the outcome, the latter do not, and thus have a score 0. Scores in the condition thus exceed the corresponding scores in the outcome in the cases at the middle of an electoral cycle, causing the consistency score of this row to drop.⁵ The latter wrongfully leads researchers to the conclusion that being a not popular government at the beginning of a cycle is not sufficient for the use of force, based on the observation that not popular governments do not use force at the middle of a cycle. [21]

The argument also holds if all conditions would be calibrated to continuous fuzzy sets. The following thresholds could be used for "begin electoral cycle": four years till next election for full membership, three years for the crossover threshold and one year for non-membership. If the conjectures on p.4 are correct, two cases with 0.6 in the combination $EC\{0\} * POP\{0\}$ would have a different score in the outcome. A case with a score of 0 in EC and 0.4 in POP would have a score of at least 0.6 in FORCE, since it is a not popular government at the end of an electoral cycle and thus expected to resort to the use of force at least to the extent that it is a member of this combination. This case would provide evidence for the sufficiency of this combination and, thus, cause its consistency to rise. A case with a score of 0.4 in EC and 0 in POP would however have a score below 0.5 in the outcome, since it is not a popular government which is at the middle of an electoral cycle and, thus, will not resort to the use of force. The latter case would cause the consistency score of the row to drop. Whether or not $EC\{0\} * POP\{0\}$ would be considered as sufficient for the use of force will depend

5 The consistency of row 2 is calculated as follows. First, the minimum value of the membership scores in the outcome and the row is selected for every single case ($\min X_i, Y_i$). Subsequently, these scores are added up and divided by the sum of the membership scores in the truth table row. Since cases with a score of 0 in the truth table row do not add anything to numerator or the denominator of the formula, only the cases with non-zero membership are relevant. These are the cases in combination 2 (score of 1 in row 2, score of 1 in the outcome) and combination 5 (score of 0.4 in row 2, score of 0 in the outcome). The sum of the minimum values in the outcome and the truth table row equals 1, the sum of the scores in the truth table row equals 1.4. Dividing the former by the latter results in a score of 0.71.

on the ratio between cases at the middle of the electoral cycle and cases at the end of the electoral cycle, as well as the consistency cut off point used in the research. Either way, the researcher would draw wrong conclusions from the analysis. If the results would show it is not sufficient, the researcher would fail to discover that not popular governments at the end of an electoral cycle use force. Conversely, if the results would show it is sufficient, the research would wrongfully imply that not popular governments at the middle of an electoral cycle resort to the use of force. [22]

In sum, fuzzy set QCA does not always constitute a superior alternative to mvQCA for analyzing ordinal conditions. The above example shows that a multi-value condition cannot be represented by one fuzzy set if the intermediate presence of a condition does not have the same impact as the condition's full presence in every possible context. This would require using a different fuzzy set for every category of the condition that is expected to have a specific causal effect. So far, critical assessments of mvQCA have only argued that creating such "dummy conditions" is required for dealing with categorical conditions, not for ordinal conditions. The fact that analyzing ordinal conditions with fuzzy set QCA would also require such dummy conditions provide an important argument in favor of mvQCA. Since the procedure for minimizing a truth table in fuzzy set QCA is basically the same as in crisp set QCA (THIEM, 2014b, p.320); using dummy fuzzy conditions would cause the same problems that are discussed in the next sections. Consequently, fuzzy set QCA should not always be preferred over mvQCA if ordinal base conditions are used. [23]

3.2 Multi-value vs. crisp set QCA

Scholars skeptical on the usefulness of mvQCA generally contend that there is a straightforward procedure for analyzing multinomial conditions with csQCA (SCHNEIDER & WAGEMANN, 2012, p.255; VINK & VAN VLIET, 2013, p.210). More specifically, they argued that

"[c]risp-set QCA can be used as an alternative to multi-value QCA by creating a binary condition for each category except one, as long as the impossible logical remainders are set to 'don't care' or are excluded from the truth table" (VINK & VAN VLIET, 2013, p.210). [24]

Table 5 applies this procedure to the multi-value truth table presented in Table 2. The multinomial condition, electoral cycle, is represented by two binary conditions: "EC2" for the beginning of electoral cycle and "EC1" for the middle of electoral cycle. The third possible value for electoral cycle is shown indirectly, through the combinations where both EC1 and EC2 are absent (cf. row 4 and row 6).

Row	EC 2	EC 1	POP	FORCE
1	1	0	1	1
2	1	0	0	1
3	0	1	1	1
4	0	0	0	1
5	0	1	0	0
6	0	0	1	0
7	1	1	1	?
8	1	1	0	?

Table 5: csQCA truth table (1) [25]

An important difference with the multi-value truth table is that the truth table contains two additional combinations, represented in row 7 and row 8. These correspond to impossible remainders, combinations of conditions that cannot exist in the real world (SCHNEIDER & WAGEMANN, 2012, p.206). The debate on the advantages of mvQCA has mainly focused on whether or not it is good practice to make assumptions on impossible logical remainders for reducing complexity. While THIEM (2013) demonstrates the latter is necessary to arrive at a minimal solution and argues this is problematic, VINK and VAN VLIET (2013, p.210) maintain that impossible remainders should not be allowed to stop minimization. In contrast to VINK and VAN VLIET (2013) and in line with THIEM (2013), most scholars argue against making impossible remainders available for minimization (cf. SCHNEIDER & WAGEMANN, 2012, pp.206-209). BAUMGARTNER (2015, p.852), for example, contends that everything can be inferred from assumptions that cannot possibly be true and that building on necessarily false assumptions entails the risk of complete trivialization. However, he points out that there is another Boolean method for causal data analysis that allows maximizing parsimony, without making assumptions about logical remainders: Coincidence analysis (CNA). Basically, CNA eliminates factors from combinations if the resulting, reduced, combination does not occur in combination with the outcome's absence.⁶ A condition is thus removed from a combination if the latter is sufficient without this condition. [26]

However, even if maximum parsimony is achieved, either by using CNA or by introducing untenable assumptions, there are still two considerable problems with the procedure of representing a multinomial condition with a binary condition for every category except one. First, the category for which no binary condition is created risks disappearing from the solution. Second, the choice of the category that is not replaced by a binary condition has an impact on the result of the analysis. [27]

6 The procedural details of CNA are explained in BAUMGARTNER (2009a, 2009b and 2013). For an empirical application, see BAUMGARTNER and EPPLÉ (2014); for a discussion of the comparative strengths of CNA and QCA, see THIEM (2015b).

The first problem can be illustrated by minimizing the crisp truth table represented in Table 5 and comparing the result with solution M2, which resulted from the multi-value truth table represented in Table 2. Even if logical remainders are used, Boolean minimization of the crisp condition yields a somewhat different solution (M3), in which $EC\{2\}$ results from the minimization of combination 1 and 2, $EC\{1\} * POP\{1\}$ from 3 and 7 and $EC1\{0\} * POP\{0\}$ from 2 and 4.⁷

$$EC2\{1\} + EC\{1\} * POP\{1\} + EC1\{0\} * POP\{0\} \rightarrow \text{FORCE (M3)}$$

$EC2\{1\}$ and $EC\{1\} * POP\{1\}$ basically have the same denotation as the first two terms of the multi-value solution. The third causal path, $EC1\{0\} * POP\{0\}$, however, has a different denotation than the third path in M2, $EC\{0\} * POP\{0\}$. In the latter, it describes the combination of "end electoral cycle" with "not popular government," in M3 the combination of "not middle electoral cycle" and "not popular government." [28]

The third path of M2 has more explanatory power than the third path of M3, since the specific causal effect of the not-included binary condition, "begin electoral cycle," got lost in the latter. Instead, the formula attributes a causal role to the absence of another binary condition: "middle electoral cycle." As argued by SCHNEIDER and WAGEMANN (2012, p.47), "the complement of sets often comprises many different cases. (...) It is particularly important to take stock of this diversity when trying to attribute some causal role to the negation of a set." "Not middle electoral cycle" refers to countries at the end of an electoral cycle and to countries at the beginning of one. While the former only leads to the use of force in combination with not popular governments, confirming the diversionary use of force hypothesis; the latter leads to the use of force independent of government popularity, confirming literature on casualty aversion and democratic peace. Although it is correct that $EC1\{0\} * POP\{0\}$ is sufficient for the use of force, this term refers to two very different causal mechanisms. First, it implies that countries with a not popular government will use force at the beginning of an electoral cycle. This is however already more precisely covered by the first path, that indicates that government popularity is not important in the beginning of an electoral cycle. Second, it implies that the use of force will occur at the end of an electoral cycle in countries with not popular governments. While the latter conjunction cannot be directly derived from M3, the third path of M2 straightforwardly describes this causal path. [29]

The second, and even more disturbing, downside of the crisp set alternative is that the choice of the category that is not replaced by a binary condition has a considerable impact on the result of the analysis. If instead of "end electoral cycle," "begin electoral cycle" is not included as a binary condition, the result again differs from both M2 and M3. This can be illustrated with the truth table presented in Table 6, in which "EC0" denotes "end electoral cycle" and no binary condition is included for "begin electoral cycle."

⁷ CNA also produces this solution (and also no alternative formulas).

Row	EC 0	EC 1	POP	FORCE
1	0	0	1	1
2	0	0	0	1
3	0	1	1	1
4	1	0	0	1
5	0	1	0	0
6	1	0	1	0
7	1	1	1	?
8	1	1	0	?

Table 6: Alternative csQCA truth table (1) [30]

Boolean minimization of this truth table yields a different solution:

$$EC0\{0\} * POP\{1\} + EC1\{0\} * POP\{0\} \rightarrow FORCE \text{ (M4)}$$

$EC0\{0\} * POP\{1\}$ results from minimization of combination 1 and 3 and implies that popular governments will use force when it is not the end of an electoral cycle, $EC1\{0\} * POP\{0\}$ results from combination 2 and 4 and implies that not popular ones will use force when it is not the middle of a cycle. While correct in terms of sufficiency, the specific causal effect of the category of electoral cycle that was not included in the analysis, "begin electoral cycle," again disappears. Instead, the formula attributes a causal role to the absence of binary conditions "end electoral cycle" and "middle electoral cycle." [31]

There are three alternative solutions to M4:

$$EC0\{0\} * EC1\{0\} + EC1\{1\} * POP\{1\} + EC0\{1\} * POP\{0\} \rightarrow FORCE \text{ (M4a)}$$

$$EC1\{0\} * EC0\{0\} + EC1\{0\} * POP\{0\} + EC1\{1\} * POP\{1\} \rightarrow FORCE \text{ (M4b)}$$

$$EC1\{0\} * EC0\{0\} + EC0\{0\} * POP\{1\} + EC0\{1\} * POP\{0\} \rightarrow FORCE \text{ (M4c)}$$

M4b and M4c have the same downside as M4: a causal role is attributed to the absence of respectively "middle electoral cycle" and "end electoral cycle." M4a basically has the same denotation as M2. The first path, $EC0\{0\} * EC1\{0\}$, indicates that governments use force when it is neither the end, nor the middle of a cycle. This implies that they will use force at the beginning of an electoral cycle. The second and third path respectively show that popular governments will use force at the middle of an electoral cycle and not popular governments will use force at the end of an electoral cycle. In contrast to M4, the causal impact of each specific condition value can be straightforwardly derived from M4a. A similar formula can, thus, result from the crisp set procedure as from the multi-value procedure. However, whether M4a is one of the possible solutions depends on the category for which no dummy condition was created. If binary conditions were created for the beginning and middle electoral cycle, but not for end electoral

cycle, only solution M3 would be produced. The choice of the category of the multinomial condition for which no binary condition is created thus has an important impact on the results of the analysis. [32]

Moreover, even if M4a is one of the possible solutions, it is highly unlikely that a researcher will prefer M4a over M4. First, while no remainders were used for arriving at M4, M4a requires making assumptions on impossible remainders. The second and third path of M4a result from the minimization of an existing combination with an impossible remainder: combination 3 with remainder 7 for $EC1\{1\} * POP\{1\}$; combination 4 with remainder 8 for $EC0\{1\} * POP\{0\}$. It is unlikely that a researcher would prefer a solution that resulted from minimization with impossible remainders over one where no remainders were used. [33]

Second, most researchers would probably not even realize there are alternatives to M4 because the alternative solutions are not produced by the computer programs fsQCA (RAGIN & DAVEY, 2014) and Tosmana (CRONQVIST, 2011), which have a market share of respectively 83% and 15% (BAUMGARTNER & THIEM, 2015, p.3; THIEM & DUŞA, 2012, p.45). Both fsQCA and Tosmana build on the Quine-McCluskey algorithm, which prefers the solution with the lowest number of disjuncts (or causal combinations) (BAUMGARTNER & THIEM, 2015; THIEM, 2014b, p.505).⁸ In consequence, the most popular QCA computer programs would only produce M4. The only software programs that are capable of producing the other solutions are the QCA package (THIEM & DUŞA, 2013a, 2013b) and CNA package (AMBUEHL, BAUMGARTNER, EPPLE, KAUFFMANN & THIEM, 2015) for the R environment (R DEVELOPMENT CORE TEAM, 2014). A researcher would, thus, only discover M4a if he used the R package QCA and preferred the solution that is based on assumptions on impossible remainders and does not satisfy the criterion of minimal disjunctivity, or used the R package CNA. [34]

Thirdly, even if the researcher uses software that presents M4a amongst the possible solutions, the researcher still has to select this particular solution among four alternatives. If the main objective of the research is to test the three conjectures presented on p.4, the researcher would probably select M4a. However, this would be far less straightforward than with the mvQCA procedure, which only produces M2. If the researcher is inductively exploring causal patterns in the data, it will be very difficult to derive clear conclusions on the interaction between electoral cycles and government popularity from the four possible solutions produced by the crisp set procedure. [35]

In sum, the proposition that csQCA can be used as an alternative to mvQCA "by creating a binary condition for each category except one" is not correct (VINK & VAN VLIET, 2013, p.210). First of all, it creates the risk of overlooking the specific causal impact of the category for which no binary condition was created. Second, the choice of the excluded category determines which paths are included in the resulting formula. The only way around this problem is creating a dummy

⁸ For a discussion of model ambiguity and minimal disjunctivity in configurational comparative research, see BAUMGARTNER and THIEM (2015).

condition for each category of the multi-value condition. However, as will be argued in the next section, this will lead to similar problems. [36]

3.3 The set-theoretic status of mvQCA

A third critique on mvQCA relates to its set-theoretic status. According to VINK and VAN VLIET (2009, p.272) and SCHNEIDER and WAGEMANN (2012, pp.258-260), the set-theoretic status of mvQCA is not entirely clear. THIEM (2013, p.205; 2014a) refutes this claim by asserting that mvQCA is actually a generalization of crisp set logic which "simply extends the number of categories beyond csQCA's two possible states." THIEM (2013, p.204) points out that much of VINK and VAN VLIET's confusion is caused by the incoherent notional systems used in crisp set and multi-value QCA, which respectively use membership-score and value notation. In order to solve the confusion, THIEM (2013, p.205), quite brilliantly, develops a unified notational system for all QCA-variants, in which the membership score S_i of some case i in value $\{v\}$ of set S_j is given by the value-score term $S_j\{v\}S_i$. [37]

THIEM (2013) does not explicate the set-theoretic implications of his notational system and confusingly uses phrases like "category of a set" and "set-value." Since cases are attributed membership scores in these concepts, it is not clear how they differ from actual sets. Adding to the confusion, THIEM (2013, p.205) only uses the set-value indicator for multi-value condition C2 in the illustration of his notational scheme. For crisp condition C1, this indicator is constantly set to 1. This leads VINK and VAN VLIET (2013) to the conclusion that the value of 0 has lost the meaning of negation or absence of category in mvQCA. The latter adds to their suspicion that mvQCA has a diverging set-theoretic status (p.212). [38]

This suspicion is however misguided. While VINK and VAN VLIET (2013) correctly assert that multi-value conditions consist of multiple sets combined in one, this does not differentiate mvQCA from the other QCA-variants. In crisp set QCA, two values are possible for each condition and each of these values refers to a different set. Crisp condition "government popularity" has two possible values, "popular government" and "not popular government," which respectively refer to the set of countries with a popular government and the set of countries with a not popular government. Cases can have a membership score of either 1 or 0 in these sets. [39]

In THIEM's (2013) notational scheme, the composite nature of the conditions in crisp set QCA is represented in the set-value indicator $\{v\}$. A case in the set of popular governments is represented as $POP\{1\}1$, a case outside this set as $POP\{1\}0$, a case in the set not popular government $POP\{0\}1$ and a case out of this set as $POP\{0\}0$. The connotation of 0 is basically the same in csQCA as in mvQCA. When it refers to a set-value, it indicates a specific set; when it refers to a membership-score, it indicates that a particular case is outside a set. Since $\{v\}$ refers to a value of a condition, which corresponds to an actual set, the notion of set-value is however somewhat confusing. Condition-value seems a more appropriate term. [40]

Both crisp set and multi-value QCA thus use conditions that refer to multiple sets. The only difference between the two QCA variants is the number of values, and thus sets, that is allowed for each condition. While in csQCA the number of possible values is limited to two; in mvQCA, each condition can have an infinite number of values. An important implication of the latter is that membership in the set defined by one of the condition values cannot be deduced from non-membership in the set defined by another. The latter is possible in csQCA, in which non-membership in the set of one condition value corresponds to full membership in the set defined by the other. Therefore, traditionally, only membership scores in the set of one condition-value (generally {1}) are represented in csQCA, from which membership in the other value is deduced. Since there are more than two condition values possible in mvQCA, non-membership in the set defined by one value does not automatically imply membership in the set of the other condition-value. This is why the condition value indicator is more clearly needed in mvQCA. [41]

While this seems to constitute a downside of mvQCA, it is from clearly distinguishing condition-values from the absence of other condition values that mvQCA draws its distinctive strength. A downside of csQCA, is that it tends to attribute causal roles to the absence of categories of multi-value conditions instead of to their presence. This was already illustrated in the previous section with an example in which a binary condition was used for each category except one of a multi-value condition. However, even if every category is represented by a binary condition, csQCA still tends to attribute causal roles to the absence of categories of multinomial conditions. This can be illustrated with the example used throughout, only this time every condition value is represented by a binary condition. The resulting truth table is presented in Table 7.

Row	EC 0	EC 1	EC2	POP	FORCE
1	0	0	1	1	1
2	0	0	1	0	1
3	0	1	0	1	1
4	1	0	0	0	1
5	0	1	0	0	0
6	1	0	0	1	0

Table 7: Alternative csQCA truth table (2) [42]

If the popular fsQCA or Tosmana software was used, minimization of this truth table results in the following formula:

$$EC0\{0\} * Popularity\{1\} + EC1\{0\} * Popularity\{0\} \rightarrow FORCE (M5)$$

Contrary to M2, which was arrived at using multi-value conditions, this formula attributes a causal role to the absence of two condition values: "end electoral cycle" in the first path, "middle electoral cycle" in the second path. [43]

There are again several alternative formulas, which can be produced with the CNA and QCA R-packages, if minimum disjunctivity is set to false.

$$\begin{aligned} EC2\{1\} + EC0\{1\}*POP\{0\} + EC1\{1\}*POP\{1\} &\rightarrow \text{FORCE (M5a)} \\ EC0*POP\{0\} + EC1\{0\}*EC0\{0\} + EC1\{1\}*POP\{1\} &\rightarrow \text{FORCE (M5b)} \\ EC0\{0\}*POP\{1\} + EC0\{1\}*POP\{0\} + EC1\{0\}*EC0\{0\} &\rightarrow \text{FORCE (M5c)} \\ EC2\{1\} + EC1\{0\}*POP\{0\} + EC1\{1\}*POP\{1\} &\rightarrow \text{FORCE (M5d)} \\ EC1\{0\}*EC0\{0\} + EC1\{0\}*POP\{0\} + EC1\{1\}*POP\{1\} &\rightarrow \text{FORCE (M5e)} \\ EC2\{1\} + EC0\{0\}*POP\{1\} + EC0\{1\}*POP\{0\} &\rightarrow \text{FORCE (M5f)} \end{aligned}$$

M5a basically denotes the same as M2 and, like the latter, is preferable to M5 because the specific impact of each condition-value can be straightforwardly deduced from it. When using the crisp conditions, the researcher has to pick this formula and not the ones included in M5. This does not constitute an obvious choice, since 8 logical remainders were used to arrive at M5a, while only four were used to arrive at M5. Moreover, the popular fsQCA and Tosmana software will only report M5, since the Quine-McCluskey algorithm prefers the solution with the lowest number of disjuncts (cf. supra). In sharp contrast to the many, generally not most obvious, choices that are required when using csQCA, a researcher straightforwardly arrives at the formula M2 when using mvQCA. [44]

4. The Added Value of mvQCA in Empirical Research

To illustrate the advantages of using mvQCA, this section reanalyzes two published studies. The first is drawn from CRONQVIST and BERG-SCHLOSSER's (2009) textbook example of mvQCA and illustrates the latter's advantage over fsQCA for analyzing ordinal conditions. The second illustration is drawn from a study by BALTHASAR (2006) and illustrates the pitfalls of using csQCA instead of mvQCA for analyzing multi-value conditions. [45]

4.1 mvQCA vs. fsQCA: "The Inter-war Project"

The first example is drawn from the mvQCA chapter in RIHOUX and RAGIN's (2009) introductory volume on QCA. The empirical example used throughout this book is "The Inter-war Project," a research project that aims to explain why some European democracies survived in the period between World War I and World War II, while others broke down. In the mvQCA chapter, CRONQVIST and BERG-SCHLOSSER (2009) select four causal conditions: wealth (WEALTH), industrialization (IND), education (LIT) and urbanization (URBAN). Their study was selected to illustrate the benefits of mvQCA over fsQCA for two reasons. First, the conditions and the outcome are operationalized with interval-level data. In consequence, fsQCA would generally be considered the most appropriate method. Second, the conditions and the outcome are calibrated in the fsQCA chapter of the book, which allows replicating the analysis with fuzzy data. [46]

CRONQVIST and BERG-SCHLOSSER trichotomize the condition "WEALTH." A score of 2 was assigned to countries with a GNP per capita above \$850, a score of 1 to cases with a GNPCAP between \$850 and \$550 and a score of 0 to cases with a GNPCAP below \$550. The other conditions and the outcome were dichotomized. The resulting truth table is presented in Table 8.

	WEALTH	URBAN	LIT	IND	SURVIVE	Cases
1	2	1	1	1	1	BEL, NET, UK
2	1	0	1	0	1	FIN, IRE
3	2	0	1	1	1	FRA, SWE
4	1	1	1	1	C	CZE, GER
5	0	0	0	0	0	GRE, ITA, POR, ROM, SPA
6	0	0	1	0	0	EST, HUN, POL
7	1	0	1	1	0	AUS

Table 8: mvQCA truth table Inter-war Project [47]

The minimization procedure with the inclusion of logical remainders results in the following formulas.

$$\text{WEALTH}\{2\} + \text{WEALTH}\{1\} * \text{IND}\{0\} \rightarrow \text{SURVIVE}\{1\}$$

$$\text{WEALTH}\{0\} + \text{WEALTH}\{1\} * \text{URBAN}\{0\} * \text{IND}\{1\} \rightarrow \text{SURVIVE}\{0\}$$

The formulas suggest that the intermediate presence of "WEALTH" does not have the same impact as the condition's full presence or absence in every possible context. While a high income level is sufficient for the presence of "SURVIVE" and a low income level is sufficient for its absence, whether or not democracies survived in middle-income countries depends on the value of the other conditions. [48]

It is not possible to capture the specific causal role of the different categories of "WEALTH" with fsQCA. This can be demonstrated by using the fuzzy scores that were assigned to the conditions and the outcome in the chapter on fsQCA by RAGIN (2009). For the outcome and the conditions that were dichotomized in mvQCA, the dichotomization threshold is used as cross-over point (0.5-anchor) (RAGIN, 2009, p.93). In consequence, the cases have the same qualitative status in these conditions as in the mvQCA. To calibrate "WEALTH," the anchor for full membership was fixed at \$900, the anchor for full non-membership at \$400 and the cross-over point was fixed at \$550. In consequence, the countries that were considered middle-income countries in the mvQCA have the same qualitative status as the countries with a high income level in the fsQCA. Table 9 represents the truth table rows that correspond to empirical cases, both for the outcome's presence and its absence. Each case is located in the row where its membership exceeds 0.5.

	WEALTH	URBAN	LIT	IND	SURVIVE{1}	SURVIVE{0}	Cases
1	1	1	1	1	0.813	0.326	BEL (0.95), NET (0.95), UK (0.95), CZE (0.89), GER (0.05)
2	1	0	1	0	0.806	0.502	FIN (0.77), IRE (0.92)
3	1	0	1	1	0.641	0.543	AUS (0.05), FRA (0.95), SWE (0.95)
4	0	0	1	0	0.461	0.841	EST (0.12), HUN (0.42), POL (0.12)
5	0	0	0	0	0.184	0.991	GRE (0.06), ITA (0.05), POR (0.05), ROM (0.21), SPA (0.06)

Table 9: fsQCA truth table Inter-war Project. Note: The cases' membership scores in the outcome are presented between brackets; contradictory configurations are marked in grey. [49]

The truth table of the fuzzy set analysis has two rows less that correspond to empirical cases than the multi-value truth table. This is because countries with a high income level and countries with an intermediate income level were assigned the same qualitative status and allocated in the truth table rows with a score of 1 on "WEALTH." The high-income countries of row 1 and 3 of the multi-value truth table are assigned to the same rows as the middle-income countries of row 4 and row 7, respectively. Since the intermediate presence of "WEALTH" does not have the same impact as the condition's full presence, this results in contradictory truth table rows (SCHNEIDER & WAGEMANN, 2012, p.185). The latter are rows that contain cases that are good instances of the outcome and cases that are good instances of the non-occurrence of the outcome. This strongly contradicts the sufficiency of the row for both the outcome's presence as well as its absence. Row 1 of the fuzzy set truth table contains four cases where the outcome is strongly present and one case where the outcome is strongly absent, row 3 contains two cases of the outcome's presence and one case of the outcome's absence. A researcher would conclude from this truth table that the conditions do not explain the variation in the outcome, since 2 out of 5 truth table rows (which cover 8 of the 18 cases) correspond to contradictory configurations. [50]

In contrast, the multi-value analysis clearly shows that the conditions explain a considerable amount of the variation in the outcome. Only one out of seven truth table rows, which only covered 2 of the 18 cases, was contradictory. The introduction of the intermediate category in "WEALTH," moreover, allowed to draw interesting conclusions on the causal role of this category, as well as on high and low income countries. In spite of operating solely on interval-level base variables, mvQCA thus clearly had advantages over fsQCA in this study. Not only did it help to explain more of the variation in the outcome, mvQCA also allowed to

draw conclusions on how each of the three income levels had a different, but very important, impact on the outcome. [51]

4.2 mvQCA vs. csQCA: Institutional design and the utilization of evaluation

The second example illustrates the problems that hamper an analysis when a multinomial condition is represented with binary conditions. It draws on an article by BALTHASAR (2006), which examines the impact of institutional design on the instrumental use of the results of evaluations (INST). Four conditions are included in the analysis: distance (DIST), routine (ROUT), usefulness (USEF) and purpose (PURP). The first three conditions and the outcome were dichotomized, purpose was trichotomized. A score of 0 was assigned if the purpose of the evaluation was more formative, a score of 1 if it was more summative and a score of 2 if the evaluation pursued both summative and formative goals. This results in the truth table presented in Table 10.

Row	PURP	DIST	ROUT	USEF	INST	Cases
1	0	0	0	1	1	FOM
2	0	0	1	0	1	SDC
3	2	0	0	1	1	FOT
4	0	1	1	1	1	SFOPH
5	1	1	1	1	1	DDPS
6	1	0	0	1	0	FOP
7	1	0	1	1	0	SFVO
8	2	1	0	0	0	PCA
9	2	1	1	0	0	SFOE
10	2	1	1	1	0	SFAO

Table 10: mvQCA truth table BALTHASAR (2006) [52]

The minimization procedure with the inclusion of logical remainders results in the following formulas.

$$\text{PURP}\{0\} + \text{DIST}\{1\} * \text{PURP}\{1\} + \text{DIST}\{0\} * \text{PURP}\{2\} \rightarrow \text{INST} \text{ (M1a)}$$

$$\text{PURP}\{0\} + \text{DIST}\{1\} * \text{PURP}\{1\} + \text{PURP}\{2\} * \text{ROUT}\{0\} * \text{USEF}\{1\} \rightarrow \text{INST} \text{ (M1b)}$$

BALTHASAR (2006, p.366) only presents the first formula⁹, from which he concludes that the instrumental use of evaluations results if the latter pursue:

9 Only the first formula results if the analysis is conducted with Tosmana (cf. THIEM, 2014a, pp.500-505). There is no formal reason to prefer the first formula over the second one. For the sake of clarity and because BALTHASAR (2006) only focuses on this formula, this section mainly discusses the first solution. However, it would be even more difficult for the researcher to find both equally fitting solutions with csQCA.

1. formative goals, irrespective of the distance between evaluator and evaluatee;
2. summative goals and the distance between evaluator and evaluatee is large;
3. formative and summative goals and the distance between evaluator and evaluatee is small. [53]

Scholars that are skeptical about mvQCA would conduct the analysis with csQCA and use a binary condition for every category of distance except one. Hereby, they would risk producing a formula that does not include the category for which no binary condition is created. In the truth table presented in Table 11, purpose is represented with two binary conditions: PURP0 for formative evaluations and PURP1 for evaluations that pursued summative goals.

Row	PURP1	PURP0	DIST	ROUT	USEF	INST	Cases
1	0	0	0	0	1	1	FOT
2	0	1	0	0	1	1	FOM
3	0	1	0	1	0	1	SDC
4	0	1	1	1	1	1	SFOPH
5	1	0	1	1	1	1	DDPS
6	1	0	0	0	1	0	FOP
7	1	0	0	1	1	0	SFVO
8	0	0	1	0	0	0	PCA
9	0	0	1	1	0	0	SFOE
10	0	0	1	1	1	0	SFAO

Table 11: csQCA truth table (1) BALTHASAR (2006, p.364) [54]

The minimization procedure with the inclusion of logical remainders results in the following formulas.

$$\text{PURP0}\{1\} + \text{DIST}\{1\} * \text{PURP1}\{1\} + \text{DIST}\{0\} * \text{PURP1}\{0\} \rightarrow \text{INST} \text{ (M2a)}$$

$$\text{PURP0}\{1\} + \text{DIST}\{1\} * \text{PURP1}\{1\} + \text{PURP1}\{0\} * \text{ROUT}\{0\} * \text{USEF}\{1\} \rightarrow \text{INST} \text{ (M2b)}$$

The first two paths of these formulas are identical as in M1a-b, which resulted from the mvQCA. However, the last path of both formulas includes the absence of PURP1 instead of the presence of PURP{2}. In his article, BALTHASAR (p.366) focused on M1a, from which he, *inter alia*, concluded that "evaluations that pursued formative as well as summative goals benefitted from a small distance between evaluator and evaluatee." This conclusion can however not easily be deduced from M2a. The last path of this formula implies that the combination of not summative evaluation and small distance is sufficient for the instrumental use of evaluations. While correct in terms of sufficiency, the specific causal effect of the category of "purpose" that was not included in the analysis is not

represented in the formula. Instead, the latter includes the absence of "summative purpose," which refers to formative evaluations as well as to evaluations that have both a formative and a summative character. However, the first path (PURP{0}) shows that a formative purpose is sufficient by itself. Distance, thus, only matters for cases that have both a formative and summative character. While the latter conclusion cannot be directly derived from M2a, the third path of M1a straightforwardly describes this causal path. [55]

The second downside of the crisp set alternative is that the choice of the category that is not replaced by a binary condition affects the result of the analysis. If instead of "PURP2," "PURP0" is not included as a binary condition, the result differs from both M1a-b and M2a-b.

Row	PURP2	PURP1	DIST	PURP2	PURP1	ROUT	USEF	INST	Cases
1	0	0	0	0	0	0	1	1	FOM
2	0	0	0	0	0	1	0	1	SDC
3	1	0	0	1	0	0	1	1	FOT
4	0	0	1	0	0	1	1	1	SFOPH
5	0	1	1	0	1	1	1	1	DDPS
6	0	1	0	0	1	0	1	0	FOP
7	0	1	0	0	1	1	1	0	SFVO
8	1	0	1	1	0	0	0	0	PCA
9	1	0	1	1	0	1	0	0	SFOE
10	1	0	1	1	0	1	1	0	SFAO

Table 12: csQCA Truth Table (2) BALTHASAR (2006, p.364) [56]

The fsQCA and Tosmana software produce the following formula:

$$\text{DIST}\{0\} * \text{PURP1}\{0\} + \text{DIST}\{1\} * \text{PURP2}\{0\} \rightarrow \text{INST (M3)}$$

The specific causal effect of the category of purpose that was not included in the analysis again disappears. Rather than straightforwardly indicating that a formative purpose (PURP0) is sufficient for the outcome, the formula attributes a causal role to the absence of the two other binary conditions. In consequence, the specific causal role of every category of purpose cannot be deduced from the formula. Each path of this formula covers two different types of cases. DIST{0}*PURP1{0} applies to evaluations with a formative purpose, which is sufficient by itself; and to evaluations with both a formative and a summative goal, which is only sufficient in combination with the absence of distance. Similarly, DIST{1}*PURP2{0} covers evaluations with a formative goal, a sufficient condition irrespective of the value of distance, and evaluations with a summative goal, which are only used instrumentally in combination with large distance. [57]

There are again several alternative formulas possible, which can be produced with the CNA and QCA R-software, if minimum disjunctivity is set to false.

$$\begin{aligned} & \text{PURP2}\{0\} * \text{PURP1}\{0\} + \text{DIST}\{1\} * \text{PURP1}\{1\} + \text{DIST}\{0\} * \text{PURP2}\{1\} \rightarrow \text{INST(M3a)} \\ & \text{PURP2}\{0\} * \text{PURP1}\{0\} + \text{DIST}\{1\} * \text{PURP1}\{1\} + \text{PURP2}\{1\} * \text{ROUT}\{0\} * \text{USEF}\{1\} \\ & \quad \rightarrow \text{INST(M3b)} \\ & \text{DIST}\{1\} * \text{PURP2}\{0\} + \text{PURP2}\{0\} * \text{USEF}\{0\} + \text{PURP1}\{0\} * \text{ROUT}\{0\} * \text{USEF}\{1\} \\ & \quad \rightarrow \text{INST(M3c)} \\ & \text{DIST}\{1\} * \text{PURP2}\{0\} + \text{PURP2}\{0\} * \text{PURP1}\{0\} + \text{PURP2}\{1\} * \text{ROUT}\{0\} * \text{USEF}\{1\} \\ & \quad \rightarrow \text{INST(M3d)} \\ & \text{DIST}\{1\} * \text{PURP2}\{0\} + \text{PURP2}\{0\} * \text{PURP1}\{0\} + \text{PURP1}\{0\} * \text{ROUT}\{0\} * \text{USEF}\{1\} \\ & \quad \rightarrow \text{INST(M3e)} \\ & \text{DIST}\{1\} * \text{PURP2}\{0\} + \text{DIST}\{0\} * \text{USEF}\{0\} + \text{PURP1}\{0\} * \text{ROUT}\{0\} * \text{USEF}\{1\} \rightarrow \text{INST(M3f)} \\ & \text{DIST}\{0\} * \text{PURP2}\{1\} + \text{DIST}\{1\} * \text{PURP2}\{0\} + \text{PURP2}\{0\} * \text{PURP1}\{0\} \rightarrow \text{INST(M3g)} \\ & \text{DIST}\{1\} * \text{PURP1}\{1\} + \text{PURP2}\{0\} * \text{PURP1}\{0\} + \text{PURP1}\{0\} * \text{ROUT}\{0\} * \text{USEF}\{1\} \\ & \quad \rightarrow \text{INST(M3h)} \\ & \text{DIST}\{0\} * \text{PURP1}\{0\} + \text{DIST}\{1\} * \text{PURP1}\{1\} + \text{PURP2}\{0\} * \text{PURP1}\{0\} \rightarrow \text{INST(M3i)} \end{aligned}$$

M3a and M3b have the same denotation as M1a and M1b, since the absence of both PURP2 and PURP1 implies the presence of PURP0. The researcher would, thus, be able to draw the same conclusions from M3a as from M1a. Similarly, he could also draw the same conclusion from M3b as from M1b. The other solutions have the same downside as M3: a causal role is attributed to the absence of PURP1 and/or PURP2. [58]

It is highly unlikely that the researcher would prefer M3a over M3. Not only does the popular fsQCA and Tosmana software only produces M3, the latter solution also does not require assumptions on impossible remainders. Table 13 presents the logical remainders that were used to produce M3 and M3a. The former only requires assumptions on 11 remainders, none of which is impossible. In contrast, M3a requires assumptions on 14 remainders, five of which combine the presence of PURP1 with the presence of PURP2 and are thus impossible remainders.

	PURP2	PURP1	DIST	ROUT	USEF	M3	M3a
1	0	0	0	0	0	x	x
2	0	0	0	1	1	x	x
3	1	0	0	0	0	x	-
4	1	0	0	1	0	x	-
5	1	0	0	1	1	x	-
6	1	1	0	0	1	-	x
7	0	0	1	0	0	x	x
8	0	0	1	0	1	x	x
9	0	0	1	1	0	x	x

	PURP2	PURP1	DIST	ROUT	USEF	M3	M3a
10	0	1	1	0	0	x	x
11	0	1	1	0	1	x	x
12	0	1	1	1	0	x	x
13	1	0	1	0	1	-	x
14	1	1	1	0	0	-	x
15	1	1	1	0	1	-	x
16	1	1	1	1	0	-	x
17	1	1	1	1	1	-	x

Table 13: Logical remainders [59]

Moreover, whether or not M3a is one of the possible solutions depends on the specific category of the multinomial condition that is not represented by a binary condition. As demonstrated above, this solution does not result if a binary condition is included for PURP0 and not PURP2 (cf. formula M2a-b). Since there are no guidelines for choosing the binary condition that is included in the analysis, creating a dummy condition for every single category of the multi-value condition seems the only appropriate procedure for representing a multinomial condition in crisp set QCA. Table 14 represents the data of BALTHASAR (2006), with every category of purpose represented by a binary condition.

Row	PURP2	PURP1	PURP0	DIST	ROUT	USEF	INST	Cases
1	0	0	1	0	0	1	1	FOM
2	0	0	1	0	1	0	1	SDC
3	1	0	0	0	0	1	1	FOT
4	0	0	1	1	1	1	1	SFOPH
5	0	1	0	1	1	1	1	DDPS
6	0	1	0	0	0	1	0	FOP
7	0	1	0	0	1	1	0	SFVO
8	1	0	0	1	0	0	0	PCA
9	1	0	0	1	1	0	0	SFOE
10	1	0	0	1	1	1	0	SFAO

Table 14: csQCA truth table (3) BALTHASAR (2006, p.365) [60]

The fsQCA and Tosmana software produce the same formula as the last analysis (cf.M3):

$$\text{DIST}\{0\}*\text{PURP1}\{0\} + \text{DIST}\{1\}*\text{PURP2}\{0\} \rightarrow \text{INST (M4)}$$

There are again several alternative formulas possible, which can be produced with the CNA and QCA R-software, if minimum disjunctivity is set to false.

$$\begin{aligned} & \text{PURP0}\{1\} + \text{DIST}\{1\}*\text{PURP1}\{1\} + \text{DIST}\{0\}*\text{PURP2}\{1\} \rightarrow \text{INST M4a} \\ & \text{DIST}\{1\}*\text{PURP2}\{0\} + \text{PURP2}\{0\}*\text{USEF}\{0\} + \text{PURP1}\{0\}*\text{ROUT}\{0\}*\text{USEF}\{1\} \\ & \quad \rightarrow \text{INST M4b} \\ & \text{DIST}\{1\}*\text{PURP2}\{0\} + \text{PURP2}\{0\}*\text{PURP1}\{0\} + \text{PURP2}\{1\}*\text{ROUT}\{0\}*\text{USEF}\{1\} \\ & \quad \rightarrow \text{INST M4c} \\ & \text{DIST}\{1\}*\text{PURP2}\{0\} + \text{PURP2}\{0\}*\text{PURP1}\{0\} + \text{PURP1}\{0\}*\text{ROUT}\{0\}*\text{USEF}\{1\} \\ & \quad \rightarrow \text{INST M4d} \\ & \text{DIST}\{1\}*\text{PURP2}\{0\} + \text{DIST}\{0\}*\text{USEF}\{0\} + \text{PURP1}\{0\}*\text{ROUT}\{0\}*\text{USEF}\{1\} \\ & \quad \rightarrow \text{INST M4e} \\ & \text{DIST}\{0\}*\text{PURP2}\{1\} + \text{DIST}\{1\}*\text{PURP2}\{0\} + \text{PURP2}\{0\}*\text{PURP1}\{0\} \\ & \quad \rightarrow \text{INST M4f} \\ & \text{DIST}\{1\}*\text{PURP1}\{1\} + \text{PURP2}\{0\}*\text{PURP1}\{0\} + \text{PURP2}\{1\}*\text{ROUT}\{0\}*\text{USEF}\{1\} \\ & \quad \rightarrow \text{INST M4g} \\ & \text{DIST}\{1\}*\text{PURP1}\{1\} + \text{PURP2}\{0\}*\text{PURP1}\{0\} + \text{PURP1}\{0\}*\text{ROUT}\{0\}*\text{USEF}\{1\} \\ & \quad \rightarrow \text{INST M4h} \\ & \text{DIST}\{1\}*\text{PURP1}\{1\} + \text{DIST}\{0\}*\text{PURP2}\{1\} + \text{PURP2}\{0\}*\text{PURP1}\{0\} \rightarrow \text{INST M4i} \\ & \text{DIST}\{0\}*\text{PURP1}\{0\} + \text{DIST}\{1\}*\text{PURP1}\{1\} + \text{PURP2}\{0\}*\text{PURP1}\{0\} \rightarrow \text{INST M4j} \\ & \text{PURP0}\{1\} + \text{DIST}\{1\}*\text{PURP2}\{0\} + \text{PURP2}\{1\}*\text{ROUT}\{0\}*\text{USEF}\{1\} \rightarrow \text{INST M4k} \\ & \text{PURP0}\{1\} + \text{DIST}\{1\}*\text{PURP2}\{0\} + \text{PURP1}\{0\}*\text{ROUT}\{0\}*\text{USEF}\{1\} \rightarrow \text{INST M4l} \\ & \text{PURP0}\{1\} + \text{DIST}*\text{PURP2}\{1\} + \text{DIST}\{1\}*\text{PURP2}\{0\} \rightarrow \text{INST M4g} \\ & \text{PURP0}\{1\} + \text{DIST}\{1\}*\text{PURP1}\{1\} + \text{PURP2}\{1\}*\text{ROUT}\{0\}*\text{USEF}\{1\} \rightarrow \text{INST M4h} \\ & \text{PURP0}\{1\} + \text{DIST}\{1\}*\text{PURP1}\{1\} + \text{PURP1}\{0\}*\text{ROUT}\{0\}*\text{USEF}\{1\} \rightarrow \text{INST M4i} \\ & \text{PURP0}\{1\} + \text{DIST}\{0\}*\text{PURP1}\{0\} + \text{DIST}\{1\}*\text{PURP1}\{1\} \rightarrow \text{INST M4j} \end{aligned}$$

M4a has the same denotation as M1a and can thus also be used to straightforwardly draw conclusions on the specific impact of every category of purpose. However, it will be difficult for the researcher to select this formula out of the 17 possible solutions. Moreover, the popular fsQCA and Tosmana software do not produce this formula, while the QCA R-package will only produce it when minimum disjunctivity is set to false. On top of that, M4a requires assumptions on 43 logical remainders, of which 23 are impossible remainders. In contrast, M4 only requires assumptions on 27 remainders, of which 12 are impossible. [61]

In sum, the three straightforward conclusions that BALTHASAR (2006) draws from the results of his mvQCA would be very difficult to deduce if crisp set QCA would have been used instead. If a binary condition would have been included for every category except one, the researcher risked not producing the formula that led to this conclusion. If a binary condition would have been included for every category, there are 17 alternative models, of which the solution that led to BALTHASAR's conclusion is not the most obvious choice. [62]

5. Conclusion

mvQCA is by far the least popular variant of QCA. An important reason for the small number of empirical applications of the method is the skeptical view of leading QCA-scholars on the method's added value. While fsQCA is generally considered the most appropriate variant for analyzing ordinal conditions, several scholars have argued that csQCA can be used as an alternative to mvQCA irrespective of the conditions' level of measurement. In contrast to the other QCA-variants, mvQCA is however capable of straightforwardly capturing the specific causal role of every category of a multi-value condition. [63]

In fsQCA, it is assumed that the intermediate presence of a condition basically has the same causal effect as its full presence in every possible context. If the full presence of a condition leads to the full presence of an outcome in a certain context, it is assumed that, in the same context, its intermediate presence will lead to an intermediate presence of the outcome. As illustrated by reanalyzing the data of the Inter-War Project, fsQCA is not capable of capturing the causal effect of an intermediate category if, depending on the context, it can have a different impact than the full presence of the corresponding condition. This would require creating a fuzzy set for every category of the condition that is expected to have a specific causal effect, which would cause the same problems as in csQCA. In consequence, fsQCA should not always be preferred over mvQCA if ordinal base variables are used. [64]

csQCA, in turn, tends to attribute a causal role to the absence of categories of multinomial conditions, which often encompass very different cases. The commonly suggested crisp set alternative, creating a binary condition for every category except one, is hampered by two severe problems. First, the category for which no binary condition is created risks disappearing from the solution, making it difficult to draw conclusions on its specific causal effect. Second, the choice of the category that is not replaced by a binary condition has a decisive impact on the result of the analysis. The only way around both problems is to create a dummy condition for each category of the multi-value condition. As illustrated by reanalyzing the data of BALTHASAR (2006), the number of solutions that fit the data equally well can hereby rise considerably. Moreover, the most obvious solution still tends to include the absence rather than the presence of categories of the multi-value condition. In sharp contrast to the many, often counterintuitive, choices required to arrive at a straightforward solution in csQCA, a researcher automatically arrives at a solution that includes the presence rather than the absence of multi-value categories when using mvQCA. Suspicion regarding the added value of mvQCA as a tool for capturing complex causal relations thus seems to be misguided. [65]

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