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The author information on the title page below might be outdated. Check for current information on Ingo Rohfing:

ORCID: 0000-0001-8715-4771

Analyzing multilevel data with QCA – A straightforward procedure

Ingo Rohlfing

Cologne Center for Comparative Politics
Faculty of Management, Economics and Social Sciences
Universität zu Köln
Germany

phone: +49 (0) 221 470 89973
i.rohlfing@uni-koeln.de
http://ingorohlfing.wordpress.com

The social sciences are witnessing a growing body of multilevel theories and debates about the proper methodological tools for the analysis of multilevel data. In a recent contribution to this journal, Thomas Denk (2010) proposes multilevel *Qualitative Comparative Analysis* (QCA) as a new methodological tool for discerning set-relational patterns in multilevel data. I argue that the presentation of multilevel QCA is erroneous in two respects. First, multilevel QCA ignores the fact that equifinal solutions entail *diversity* and therefore leads one to overestimate the complexity of QCA solutions. Second, the ordinary minimization procedure of truth tables that contain multilevel data yields the same solutions as multilevel QCA, but is much easier to implement. I conclude that the established inventory of QCA does not need to be extended by a special multilevel approach.

Keywords: diversity; equifinality; minimization; set relations

1. Introduction

The social sciences are witnessing a continuing debate about multilevel theories (e.g. Hooghe & Marks, 2003), and the proper methodological tools for the analysis of multilevel data (e.g. Franzese Jr., 2005). The largest share of methodological contributions falls into the field of quantitative methods. In this regard, Thomas Denk's (2010) recent contribution in the *International Journal of Social Research Methodology* is to be welcomed. Denk proposes a new methodology for comparative multilevel analysis that is elaborated for comparative case studies as well as for *Qualitative Comparative Analysis* (QCA). My paper specifically reconsiders the application to what I call multilevel QCA.[1] I argue that the presentation of multilevel QCA is erroneous in two respects. First, the inter-system comparison of QCA solutions obtained from the analysis of intra-system data ignores the fact that equifinal solutions entail *causal heterogeneity and diversity*. The detection of diversity is one of QCA's key goals. However, the neglect of diversity in multilevel QCA is likely to produce solutions that are unnecessarily complex. This means that the solution tends to include more and more complex paths than a solution that does justice to the central principle of causal diversity.

Second, the entire logic of inter-system and intra-system comparisons in multilevel QCA is dispensable when an ordinary QCA is run on multilevel data. A standard minimization of truth tables that contain multilevel data yields the same solutions as multilevel QCA. On the basis of these criticisms, I conclude that the established inventory of QCA does not need to be extended by a special multilevel approach. In order to substantiate these claims, I first discuss those elements of QCA that are central to my arguments in section two. In section three, I set out multilevel QCA as proposed by Denk. My two main arguments are elaborated in the fourth section and illustrated with a brief empirical example in section five. The final section concludes.

2. Elements of QCA

QCA is suitable for the identification of necessary conditions and sufficient conditions, or configurations, for a given outcome (Ragin, 1987). Since Denk's example pertains to the analysis of sufficiency, I focus on this set relation as well. Similarly and without loss of generality, I do not specifically distinguish between crisp sets, which take scores of 0 or 1, and fuzzy sets, which can take intermediate scores between 0 and 1 (Ragin, 2000, 2008).

The starting point of QCA's "analytic moment" (Schneider & Wagemann, 2010) is the *truth table*. It contains all logically possible combinations of conditions and has 2^k rows, where k signifies the number of conditions. After one has assigned cases to the truth table's rows and an outcome to each configuration (which is an issue that is not of further interest here (see Ragin, 2008), it is possible to minimize the information captured by the truth table. The logic of minimization is illustrated by the hypothetical truth table in table 1. For ease of presentation, I only focus on the conservative solution that does not include logical remainders.[2]

Table 1: Hypothetical truth table

Row	A	B	C	D	O
1	1	1	1	0	1
2	1	1	1	1	1
3	1	0	1	0	1
4	0	0	1	1	1
5	1	0	1	1	1
6	0	0	0	0	0
7	0	1	0	0	0
8-16	Logical remainders				

The information in the truth table can just as easily be presented as *ABCd* + *ABCD* + *AbCd* + *abCD* + *AbCD* -> *O*.[3] Upper-case letters symbolize the presence of a condition, lower-case letters the absence. The + between the conjunctions represents the logical OR-operator and signifies *causal heterogeneity*, *diversity* or *equifinality*. Pending the production of the conservative solution, the data suggests that there is more than one way or path via which the outcome can be attained. The identification of multiple paths is one of the key goals of running a QCA (Berg-Schlosser, De Meur, Ragin & Rihoux, 2008; Ragin, 1987, 168). It is therefore important to consider the entire QCA solution as well as the individual paths that constitute it.

The general purpose of minimization is to simplify the information in the truth table by dropping logically redundant conditions. This is achieved by performing pairwise comparisons between all paths and the search for conditions that are not individually necessary components for the conjunctions at hand. In the hypothetical example, the comparison of *ABCd* and *ABCD* in row 1 and 2 shows that the outcome occurs independently of whether *D* is present or absent. *D/d* can be dropped and the two configurations are simplified to the configuration *ABC*. In the course of the minimization process, configurations can be used multiple times to eliminate conditions. The conjunction in row 1 can also be compared with row 3 and simplified to *ACd*. An additional comparison between row 3 and row 5 shows that they can be simplified to *AbC*. Finally, rows 4 and 5 can be merged into the new, less complex configuration *bCD*. Altogether, minimization then simplifies the original statement to *ABC+ACd+AbC+bCD -> O*. These paths can be compared again in order to determine whether there are further conditions that are logically redundant. Path one and three only differ with respect to *B/b*, which allows them to be reduced to *AC*. Since the second conjunction *ACd* is a subset of *AC*, it follows that *D/d* can also be eliminated from it, with the final QCA solution being *AC+bCD*.[4]

3. The logic of multilevel QCA

Multilevel QCA comprises two minimizations that are performed sequentially. The application of the two-step procedure first requires a regrouping of cases on the *macro dimension*. In the following, I use this term synonymously with the term *system level* and *context*. Cases that share the same context, like regions belonging to the same country, are in the same group of cases. Cases that differ as regards the macro conditions, like regions from different countries, are assigned to different groups. The cases that are assigned to groups are located on the *micro level*, which is also referred to as the *sub-systemic* or *intra-system level*. For the purposes of illustration, assume for instance that one aims to explain high budget deficits of sub-national units through a range of sub-national specific conditions like the regional growth of GDP per capita and the partisan composition of the sub-national government. On the systemic level, one presumes that it is important to consider the type of territorial organization –

federalism vs. unitarism – and the regime type – parliamentarism vs. presidentialism. In total, one has four possible combinations of context conditions: federal countries with parliamentary and presidential regimes, and unitary countries with parliamentary and presidential systems. The data table and cases are then sorted into four groups according to the different types of context configurations.

In the first step of multilevel QCA, one produces a QCA solution for each group of cases by exclusively using conditions that are located on the micro level. With regard to the previous example, one would determine for each of the four systems what configuration of conditions leads to high sub-national budget deficits. The second step of multilevel QCA takes an integrated perspective at the micro level and the macro level. This is achieved by conducting a comparison of the sub-systemic solutions that one obtained for each system. With respect to the example, for each of the configurations of macro conditions one would check whether the sufficient solutions are similar or different between contexts. When the solutions are different, one should infer that contextual conditions matter because the outcome is attributable to different solutions. If one does not spot differences between the sub-systemic solutions, the context does not matter for the outcome. With regard to the hypothetical example, one would assign a role to the context if paths to high regional budget deficits vary across systems, i.e. regions that are characterized by different macro conditions. However, the latter do not seem to play a role if one observes that high regional budget deficits are the result of the same micro conditions across different contexts. For example, one would infer that the regime type is irrelevant if a left-wing regional government goes along with a high deficit in federal and parliamentary countries as well as in federal and presidential countries.

In addition to the above example, one can illustrate multilevel QCA with hypothetical data that is provided by Denk and reproduced in table 2.[5] The sub-systemic solution for cases that include the context factor *S* is *AC+Bc -> O*. The solution for countries in which *S* is absent is *AB+aC -> O*. Since the two solutions are different, one should conclude that the context condition *S* matters for an explanation of the outcome (Denk, 2010, 35). If the solutions were exactly the same, the conclusion would have been that the context is irrelevant and that the outcome can be explained with sub-systemic conditions alone.[6]

Table 2: Table reproduced from Denk (2010, 36)

Row	Sub-systemic condition			Systemic condition	Sub-systemic
	A	B	C	S	Outcome (O)
1	1	0	0	1	1
2	0	1	0	1	1
3	1	1	0	1	1
4	1	1	1	1	1
5	1	1	0	0	1
6	0	0	1	0	1
7	0	1	1	0	1
8	1	1	1	0	1
9-16	Logical remainders				

As a note on the side (which is relevant for the following discussion of multilevel QCA), note that Denk's solution for countries with *S* present is not entirely correct. The proper sub-systemic solution is *Ac+Bc+AB -> O*. This solution results because *Abc* (row 1) and *ABc* (row 3) can be minimized to *Ac*. *ABc* can be compared with *aBc* (row 2), leading to *Bc*. Finally, a comparison of *ABc* and *ABC* (row 4) shows that the two paths can be simplified to *AB*. Altogether, this yields a solution containing three paths, each of which contains two conditions.

4. Multilevel QCA vs. ordinary QCA

4.1. Methodological discussion

Though compelling at first sight, multilevel QCA exhibits two shortcomings. The first point of criticism accepts multilevel QCA as a viable method but questions the actual procedure behind it. The second point of criticism is more fundamental and questions the entire approach. I first present the criticism that stays within the logic of multilevel QCA and then turn to the more fundamental issue.

According to the example presented in the previous section, one should infer that the context matters for the outcome because the two sub-systemic solutions are different. However, this conclusion ignores the fact that both micro level solutions entail causal diversity. There are multiple paths to the outcome for countries that have the context condition *S* present and those in which *S* is absent. Diversity is ignored in multilevel QCA because the solutions are compared *in toto*. While it is useful to take a look at the entire solution, it is equally important to consider the individual paths one after another in order to understand the diverse ways in which the outcome comes about (Ragin, 1987, 168). The fact that diversity is neglected in the multilevel procedure becomes clear from Denk's (2010, 36) argument that different micro solutions indicate that "a different cause" accounts for different outcomes in different contexts. A QCA solution is not the same as a *single* cause, but includes the entirety of paths that are *individually* sufficient for the outcome. In the hypothetical example, there are three distinct ways in which the outcome can result when the context condition is present. Correspondingly, there are two sufficient paths for the outcome in countries that lack the macro condition.

Diversity in sub-systemic solutions has profound implications for the analysis of multilevel data with QCA that are not adequately reflected in the current procedure. Doing justice to diversity in the minimization procedure requires one to *compare individual paths across systems*. In other words, having produced a micro level solution for each system, it is necessary to determine whether it is possible to further minimize the solutions across systems. *Cross-system minimization* follows the idea that the effects of conditions on the micro level may depend on the presence of certain macro conditions, but the macro conditions may also be irrelevant for individual paths.

Returning to the hypothetical example presented above, a look at the correct sub-systemic solutions demonstrates that cross-system minimization is feasible. The solution for countries with the context condition *S* present – *Ac+Bc+AB* – can also be written as *AcS+BcS+ABS*, i.e. the macro condition is turned into an explicit element of the solution. By doing the same for countries in which the macro condition *S* is absent, one obtains the solution *aCs+ABs*. A cross-system comparison shows that the systemic condition is logically redundant if *A* and *B* occur in conjunction. Cross-system minimization therefore leads to *AB+AcS+BcS+aCs*. If one wants to emphasize again the importance of systemic factors, one can factor out the remaining context conditions and rewrite the solution as *AB+S(Ac+Bc)+s(aC)*.

The substantive meaning of this solution is different from the original one for three reasons. First, there are only two unique paths instead of three for cases that display the context condition *S*. Second, there is only one path instead of two for countries that lack the macro condition. Third, and most importantly, there is one path – *AB* – that accounts for the outcome *independently* of the context condition. This is an important insight because this inference can only be made in the original multilevel procedure under very special conditions. If one compares sub-systemic solutions in their entirety, one can only discard context conditions as irrelevant if all the paths are exactly the same across systems. This is possible in principle, but very unlikely to happen in practice precisely because the social world is governed by diversity. A single condition that differs across sub-systemic solutions would be sufficient to conclude that the context condition matters even if the solutions are otherwise perfectly similar. To give an example, suppose you have the sub-systemic solutions *S(AB+CD+EF+GH)* and *s(AB+CD+EF+Gh)*, *S/s* again denoting the presence and absence of a context condition. The solutions only differ with respect to the presence and absence of *H* in combination with condition *G*. Nevertheless, multilevel QCA would let one conclude that the context matters in general and, thus, also for the paths *AB*, *CD*, and *EF*. But why should differences in relation to one path influence the conclusions about contextual effects for other paths? The answer is they shouldn't because multiple paths express diversity. In contrast to multilevel QCA, cross-system minimization therefore allows for mixed results in the sense that the context matters for some micro level paths, but not for all.

The possibility of producing a mixed solution, i.e. one that covers paths that include macro conditions and paths that do not, resonates with findings made in various fields of research. In the realm of welfare state research, Obinger et al. (2010) observe some convergence of the welfare states of small countries independently of contextual factors like their type of political regime. Similarly effects do not take place in large countries. Schneider and Wagemann's (2006) inquiry into the conditions for the successful consolidation of democracy is an example from the field of democratization studies. They find that ten paths lead to the consolidation of democracy, two of which do not include any context condition (2006, 772). For example, a conjunction that is conducive to the consolidation of democracy includes a parliamentary system and a proportional electoral system. This configuration is sufficient for the outcome, regardless of whether context conditions like a developed economy or ethno-linguistic homogeneity are present or absent.

The previous criticism of multilevel QCA is vital because it aligns this procedure with the fundamental principle of diversity. Yet it still accepts multilevel QCA as worth doing in principle. The second point of criticism is more fundamental and concerns the claim that multilevel QCA is not necessary at all. If multilevel QCA takes account of the notion of diversity, for which there are very compelling reasons, a straightforward, ordinary QCA produces the same result as multilevel QCA. When one produces the complex solution for the truth table in table 2 with a standard QCA, one also obtains *AB+AcS+BcS+aCs* -> *O*.[7] The fact that the two solutions are identical does not come at a surprise. Multilevel QCA breaks the minimization process into an intra-systemic part and an inter-systemic part. This means that one first searches for redundant micro level conditions within each system. In the second stage, one takes an inter-system perspective and checks whether one can drop further conditions. Ordinary QCA does not minimize a truth table in the same orderly fashion. Instead, the minimization process simply entails the comparison of configurations for individually redundant conditions, regardless of whether the configurations belong to the same or different system or whether a sub-systemic or systemic condition is involved.

In fact, the logic of minimization in standard QCA shows that it is fully in line with what multilevel QCA aims to achieve. The possibility of eliminating system-level conditions at any round of the minimization process is in accord with the purpose of testing for contextual effects. If two configurations are identical with respect to the sub-systemic configurations and only vary regarding the systemic conditions, dropping the context condition for this specific path is straightforward because the presence or absence of the context condition does not matter. With regard to Denk's hypothetical example, this holds true for the configurations *ABS* and *ABs* and there is no apparent reason why one should not drop the context condition in the first stage of the minimization process. It is equally possible that two conjunctions only differ in relation to a sub-systemic condition. The micro level conditions should then be dropped and taken as evidence for contextual effects. Taken together, the standard minimization process allows for mixed results in the sense that contextual conditions may matter for some sub-systemic paths. This is a much more plausible basis for the analysis of multilevel data than the premise that the context matters or does not matter for all sub-systemic configurations.

4.2. A brief empirical example

Building on the previous discussion, the equivalence of multilevel QCA and ordinary QCA can be further illustrated with an empirical example. I draw on Rihoux and De Meur's (2008) crisp-set QCA of the survival of 18 European democracies in the interwar period. The outcome of interest thus is the survival of a country (SURV). The conditions under scrutiny are a high level of industrial labor force (INDLAB), a high GNP per capita (GNPCAP), a high level of urbanization (URBAN), a high level of literacy (LIT), and stable governments (GOVSTAB). Since issues like calibration and case selection are discussed extensively by Rihoux and De Meur, I leave these salient issues aside here and focus on the actual QCA.

The truth table for the ordinary QCA is presented in table 3. In the following, I focus on the conservative solution for the outcome that only draws on the truth table rows that have the outcome in place. I note that the example does not involve any intricacies like contradictory truth table rows and logical remainders. However, a simple example is necessary in order to be able to focus on those aspects that are central to a discussion of multilevel QCA.

Table 3: Truth table for csQCA of outcome SURV (building on Rihoux and De Meur 2008)

Row	INDLAB	GNPCAP	URBAN	LIT	GOVSTAB	SURV (Outcome)	Countries
1	1	1	1	1	1	1	BEL, NET, UK
2	1	0	1	1	1	1	CZE
3	1	1	0	1	1	1	FRA, SWE
4	0	1	0	1	1	1	FIN, IRE
5	1	1	0	1	0	0	AUS
6	1	1	1	1	0	0	GER
7	0	0	0	1	1	0	EST
8	0	0	0	0	0	0	GRE, POR, SPA
9	0	0	0	1	0	0	HUN, POL
10	0	0	0	0	1	0	ITA, ROM
11-32	Logical remainders						

The solution that one obtains from the minimization of the first four rows is

*INDLAB*URBAN*LIT*GOVSTAB+ GNPCAP*urban*LIT*GOVSTAB -> SURV*.

I refer to this solution as the *full solution* because it includes information from the full set of cases that have the outcome present.[8] Let's suppose now that we take *INDLAB* as a macro condition that represents a country's degree of industrialization and the economic context more generally. Again, I note that one can think of more difficult examples that include more than one context condition. Since this is only an illustrative example, one context condition suffices for my purposes. If we take INDLAB as a macro condition, we first produce two conservative solutions for cases that have the context condition present and absent. In order to obtain a solution for countries that meet the context condition, the QCA only draws on the first three rows of table 3. The conservative solution for these rows is *INDLAB*[LIT*GOVSTAB* URBAN +LIT*GOVSTAB*GNPCAP] -> SURV.*

The conservative solution for cases with INDLAB absent only draws on the fourth row, meaning that the solution simply reads

indlab[GNPCAP*urban*LIT*GOVSTAB] -> SURV.*

A comparison of the two multilevel solutions does not seem to indicate further potential for minimization because one path includes five conditions, whereas the other two paths include four conditions. In addition, a comparison of the multilevel solutions with the full solution does not immediately point to their logical equivalence. However, it can be easily shown that there is more room for minimization and that the full solution and the multilevel solutions are fully equivalent. The multilevel solution for countries with *INDLAB* present is logically equivalent to the expression[9]

INDLAB*LIT*GOVSTAB*URBAN*GNPCAP+

INDLAB*LIT*GOVSTAB*URBAN*~gnpcap+

INDLAB*LIT*GOVSTAB*GNPCAP*~urban -> SURV.

A look at table 3 shows that these are the three truth table rows that we used for the calculation of this multilevel solution in the first place. Now, we can add the multilevel solution for rows that have *INDLAB* absent in order to determine whether there is room for cross-system minimization. If we add the second multilevel solution, however, we are looking at all four truth table rows that have the outcome present and that we used for the generation of the full solution. Consequently, this empirical example demonstrates that multilevel QCA produces the same solution as an ordinary QCA, thereby underscoring my point that an ordinary QCA achieves the same as multilevel QCA and that the latter is not warranted.

5. Conclusion

QCA has witnessed a remarkable degree of development since the first major publication by Charles Ragin (1987) more than 20 years ago. Starting with the analysis of crisp sets and the analysis of deterministic set relations among a limited number of macro phenomena, QCA is now run on data combining proximate and distant causes (Schneider & Wagemann, 2006), and micro data (Cooper & Glaesser, 2011; Glaesser & Cooper, 2010). It now also offers procedures for the handling of fuzzy sets (Ragin, 2000; 2008; Smithson & Verkuilen, 2006), probabilism (Eliason & Stryker, 2009; Ragin, 2006), and checks for robustness (Skaaning, 2011). If one follows Denk (2010), QCA would have to be extended by a special procedure for the analysis of multilevel data, which is a topic that the QCA literature has indeed neglected thus far.

As I argue in this paper, however, one does not need to take special precautions for the analysis of multilevel data with QCA. Multilevel QCA entails the comparison of system-specific solutions between systems *in toto*, which contradicts the idea of diversity that is integral to QCA. Taking the idea of diversity seriously requires comparing individual paths across different systems, which allows for the generation of solutions that are in line with findings made in empirical research.

Furthermore, I have demonstrated that multilevel QCA and ordinary QCA produce the same solution. Altogether, there certainly are many issues that need to be addressed for the further development of QCA (Wagemann & Schneider, 2010), but the formulation of special procedures for the analysis of multilevel data is not among them.

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Notes

[1] Schneider and Wagemann (2006) propose splitting the data into remote and proximate conditions with the aim of alleviating the problem of limited diversity, i.e. truth table rows for which no cases exist. If one takes distant conditions for macro conditions and proximate conditions for micro causes, their approach has a multilevel element. As Schneider and Wagemann point out, though, distant conditions are not necessarily the same as macro conditions and proximate causes are not necessarily

equivalent to micro conditions. Goertz and Mahoney (2005) propose the use of fuzzy-set QCA for the assessment of two-level theories, which are not the same as multilevel theories.

[2] QCA allows one to produce complex, intermediate, and parsimonious solutions (Ragin, 2008). I limit the discussion to the complex solution, as this is the variant that Denk refers to in his article. Later on, the discussion will be extended to parsimonious solutions (see note 7).

[3] Note that -> indicates sufficiency in Boolean Algebra (Rihoux & De Meur, 2008).

[4] Reversing the logic of minimization, one can rewrite *AC* as *ACD+ACd*. If Substituting *AC* with *ACD+ACd* in the solution *AC+ACd+bCD*, it becomes apparent that *D/d* is redundant.

[5] I use the standard Boolean notation for the truth table, which is why it looks slightly different to the original one. Table 2 only includes the truth table rows having the outcome present. A complete truth table conveys information about configurations that have the outcome present, absent, for which no cases exist (logical remainders), and for which at least two cases display different outcomes (contradictory rows). Further note that the hypothetical solution that is discussed in text is the conservative one.

[6] This procedure loosely mirrors Pzreworski and Teune's (1970) most-different systems design that explains similar sub-systemic outcomes in the presence of different system-level variables with similar sub-systemic processes (cf. Anckar, 2008).

[7] The same holds basically true for the parsimonious solution. In order to be able to produce a parsimonious solution, it is necessary to add one truth table row for which the outcome is absent. I add the row *abcS* to table 2. The parsimonious solution that

one obtains depends on the hypothetical row is added to the table. However, the general argument that I aim to illustrate applies regardless of what row is included in the table. The parsimonious solution then is *A+B+s* -> *O* for multilevel QCA and ordinary QCA. (I note that one has to select one prime implicant by hand in the course of the ordinary QCA because the primitive expression *abCs* is implied by *s* and *C*. This means that an alternative solution reads *A+B+C* -> *O*. This solution cannot be derived via multilevel QCA. The failure of multilevel QCA to offer *A+B+C* as one viable parsimonious solution points to an additional problem of this procedure.

[8] I do not report the coverage scores, as they are not relevant for my purposes (consistency scores are 1 anyway).

[9] The transformation of the expression reverses the minimization process and draws on the logical fact that an expression like *A* -> *O* is logically equivalent to *AB+Ab*-> *O*.