Qualitative Comparative Analysis (QCA) and Related Systematic Comparative Methods: Recent Advances and Remaining Challenges for Social Science Research

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abstract: During the past two decades, a set of systematic comparative case analysis techniques has been developing at a steady pace. During the last few years especially, the main initial technique, qualitative comparative analysis (QCA), has been complemented by other related methods and techniques. The purpose of this article is to critically assess some main recent developments in this field. QCA and connected methods can be considered at two levels: as a research strategy and as a set of concrete techniques. The author first argues that such a strategy displays some decisive advantages in social science research, especially in small- and intermediate-*N* research designs. Second, QCA as well as three other related techniques, namely multi-value QCA (MVQCA), fuzzy sets and MSDO/MDSO, are presented in brief, and some current debates with regard to these techniques are also summarized. In the third section, the article surveys recent contributions and ongoing efforts that have provided some advances in the application of these techniques, around five key issues: case selection and model specification; measurement, dichotomization and linkage with theory; contradictions and non-observed cases; the time and process dimension; and the confrontation or combination with other methods. Finally, the article discuss the potential for further development of these methods in social science research broadly defined.

keywords: comparative methods ✦ fuzzy sets ✦ qualitative and quantitative methods ✦ qualitative comparative analysis (QCA) ✦ small-*N* research design

Introduction

Following a seminal volume by Charles Ragin (1987), a set of systematic comparative case analysis techniques has been developing at a steady

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QCA and connected methods can be considered at two levels: as a research strategy, more at the epistemological level, and as a set of concrete techniques. I first argue that such a strategy displays some decisive advantages in social science research, especially in small- and intermediate-*N* research designs. Second, QCA as well as three other related techniques, namely multi-value QCA (MVQCA), fuzzy sets and MSDO/MDSO, are briefly presented and some current debates with regard to these techniques are also summarized. The third section surveys recent contributions and ongoing efforts that have provided some advances in the application of these methods, around five key issues: case selection and model specification; measurement, dichotomization and linkage with theory; contradictions and non-observed cases; the time and process dimension; and the confrontation or combination with other methods. Finally, we discuss the potential for further development of these methods in social science research broadly defined.

Context: Systematic Comparative Case Analysis

During the last few years, an increasing proportion of social scientists have been opting for multiple case studies as a research strategy – more generally speaking, the explicitly comparative design is gaining momentum. The choice of such a strategy often reflects the intention of scholars to meet two apparently contradictory goals. On the one hand, one seeks to gather in-depth insight in the different cases and capture the complexity of the cases – to gain intimacy with the cases (Ragin and Becker, 1992). On the other hand, one still wishes to produce some level of generalization (Ragin, 1987). Indeed, in empirical social science, both case-oriented work and techniques that allow one to generalize (typically quantitative, i.e. statistical, techniques) are useful. One notes that the increasing momentum of such methods also coincides with a renewed interest in case-oriented research (Mahoney and Rueschemeyer, 2003; George and Bennett, 2005; Gerring, 2004; Gerring, forthcoming), and also in new attempts to engage in a well-informed dialogue between the quantitative and qualitative empirical traditions (Brady and Collier, 2004; Sprinz and Nahmias-Wolinsky, 2004; Moses et al., 2005).

In social science research, many relevant and interesting objects are naturally limited in number. This is especially true at the mesosociological level (e.g. specific sets of collective actors, of firms), and at the macrosociological level (e.g. nation-states or regions, policy sectors). In such situations, we face naturally limited or 'small-*N*' (or 'intermediate-*N*') populations. In some other circumstances, when the population of cases is larger, there are still some good reasons for a researcher to pick out a more limited set of cases. Indeed in comparative research, small-*N* situations may either be the result of a limited number of cases, or of a deliberate choice of the researcher to select a limited number of cases (De Meur and Rihoux, 2002).

Case studies constitute a very rich research tradition. Yet when it comes to comparing, in many instances the comparison of the case study material is rather loose or not formalized – hence the scientificity of case studies is often questioned (Ragin and Becker, 1992; Gerring, 2004). This particularly occurs when such comparisons occur *ex post*, and when the collection of the case study material has not been designed to be used for subsequent comparative analysis.

During the last decade especially, following the launching of the QCA technique, a set of specific methods, designed to address small-*N* and intermediate-*N* research situations, has been further developed and increasingly used, in various fields and disciplines. Of course, in any field of study, when one engages in such an endeavour, one is bound to encounter methodological difficulties and dilemmas. Hence, one of the main topics in this contribution will be to demonstrate that such difficulties can indeed be addressed.

QCA and Recently Developed Connected Methods: Some Key Features

The first specific technique, qualitative comparative analysis (QCA), was launched in the late 1980s by Charles Ragin. It has now been applied in a broad variety of fields and disciplines (Ragin, 1987; De Meur and Rihoux, 2002; Rihoux, 2003; Ragin and Rihoux, 2004a; Rihoux and Ragin, forthcoming). In this section, I discuss some key features of this technique, as well as of three related techniques: multi-value QCA (MVQCA), fuzzy sets and MSDO/MDSO.

On a more general level, QCA is first of all an approach, i.e. a way to envisage the confrontation between theory and data (Ragin, 1987). Ragin contends that it is possible to develop an original 'synthetic strategy' as a middle way between the case-oriented, or qualitative, and the variable-oriented, or quantitative approaches (Ragin, 1987, 1997). The goal of this strategy is to 'integrate the best features of the case-oriented approach with the best features of the variable-oriented approach' (Ragin, 1987: 84). This statement has been criticized (e.g. Berg-Schlosser, 2004; Swyngedouw, 2004). As a response to these critiques, QCA and connected methods are now more often presented instead as a specific family of configurational comparative methods (Ragin, 2004; Ragin and Rihoux, 2004a).

In spite of these critiques, Ragin's initial statement can, altogether, be confirmed, provided some qualifications and nuances are added. On the one hand, indeed, QCA embodies some key strengths of the qualitative, case-oriented approach (Ragin, 1987; De Meur and Rihoux, 2002). To start with, it is a holistic approach, in the sense that each individual case is considered as a complex entity, as a whole that needs to be comprehended and which should not be forgotten in the course of the analysis. Thus, QCA is in essence a case-sensitive approach. From a mainstream statistical viewpoint, this might be considered a weakness; quite the contrary, from a qualitativist, case-based perspective, this is a strength of QCA.

Furthermore, QCA develops a conception of causality that leaves room for complexity (Ragin, 1987). In most hard sciences, complexity is neutralized by experimental design – something that is not usually available to us in the social sciences. QCA's strategic response to this is the concept of multiple conjunctural causation. This implies that: (1) most often, it is a combination of conditions (independent variables) that eventually produces a phenomenon – the outcome (dependent variable); (2) several different combinations of conditions may produce the same outcome; and (3) depending on the context, on the conjuncture, a given condition may very well have a different impact on the outcome. Thus different causal paths – each path being relevant, in a distinct way – may lead to the same outcome (De Meur and Rihoux, 2002). As J. S. Mill, Ragin rejects any form of permanent causality (Ragin, 1987) since causality is context- and conjuncture-sensitive. Bottom line: by using QCA, the researcher is urged not to specify a single causal model that fits the data best, as one usually does with statistical techniques, but instead to determine the number and character of the different causal models that exist among comparable cases (Ragin, 1987).

On the other hand, QCA indeed embodies some key strengths of the quantitative approach. First, it allows one to analyse more than just a handful of cases, which is seldom done in case-oriented studies. This is a key asset, as it opens up the possibility to produce generalizations. Moreover, its key operations rely on Boolean algebra, which requires that each case be reduced to a series of variables (conditions and an outcome). Hence, it is an analytic approach, which allows replication (De Meur and Rihoux, 2002). This replicability enables other researchers to eventually corroborate or falsify the results of the analysis, a key condition for progress in scientific knowledge (Popper, 1963). This being said, QCA is not radically analytic, as it leaves some room for the holistic dimension of phenomena. Finally, the Boolean algorithms allow one to identify (causal) regularities that are parsimonious, i.e. that can be expressed with the fewest possible conditions within the whole set of conditions that are considered in the analysis – though a maximum level of parsimony should not be pursued at all costs.

On a more specific level, QCA is also a technique based on the formal logic of Boolean algebra[1] and implemented by a set of computer programs, so as to identify so-called 'prime implicants' in a truth table.[2] The key philosophy of QCA as a technique is to '[start] by assuming causal complexity and then [mount] an assault on that complexity' (Ragin, 1987: x).

The researcher must first produce a raw data table, in which each case displays a specific combination of conditions (with 0 or 1 values) and an outcome (with 0 or 1 values). The software then produces a truth table that displays the data as a list of configurations. A configuration is a given combination of some conditions and an outcome. A specific configuration may correspond to several observed cases.

The key following step of the analysis is Boolean minimization – that is, reducing the long Boolean expression, which consists in the long description of the truth table, to the shortest possible expression (the minimal formula, which is the list of the prime implicants) that unveils the regularities in the data. It is then up to the researcher to interpret this minimal formula, possibly in terms of causality.

Far from being a push-button-type technique, the use of QCA is an iterative and creative process. The researcher must first gain enough familiarity with each of the cases examined, and then produce a good-quality truth table – that is, a table devoid of contradictory configurations. These are configurations whose outcome is, in some cases, equal to [1] and in some cases equal to [0], while displaying the same values on the conditions. Such contradictions must thus be resolved before moving ahead with the analysis. This involves frequent returns to the cases, to the initial qualitative or quantitative data. This must also be done at the end of the analysis, when one finally obtains the minimal formula: the researcher must then make sense out of the solution, interpret it by reinterrogating the cases. This involves going back to the cases and examining each case as a whole. This also means that QCA can be a very labour-intensive technique – which, from a case-oriented perspective, should rather be seen as a strength.

As a technique, QCA displays three further qualities. First, it can be used for at least five different purposes (De Meur and Rihoux, 2002: 78–80). The most basic use is simply to summarize data, i.e. to describe cases in a synthetic way by producing a truth table, as a tool for data exploration and typology-building. This use is basic in the sense that it does not rely on a more elaborate, step-wise design of typology-building, such as recently developed by George and Bennett (2005). It can also be used to check coherence within the data: the detection of contradictions allows one to learn more about the individual cases. The third use is to test existing theories or assumptions, to corroborate or refute these theories or assumptions. QCA is hence a particularly powerful tool for theory-testing (e.g. Sager, 2004; Goertz and Mahoney, 2005). Fourth, it can be used to test some new ideas or assumptions formulated by the researcher, and not embodied in an existing theory; this can also be useful for data exploration. Finally, QCA allows one to elaborate new assumptions or theories: the minimal formula ultimately obtained can be interpreted – i.e. confronted with the cases examined – and lead the researcher to formulate new segments of theory. This is probably why QCA is sometimes referred to as a kind of analytic induction (e.g. Hicks, 1994). QCA is indeed inductive, to the extent that it allows the researcher to discover more through a dialogue with the data. However, there is also a significant input of theory in QCA. For instance, the selection of variables that will be used in the analysis, and the way each variable is operationalized, must be theoretically informed (De Meur and Rihoux, 2002). Arguably, though, a more inductive use of QCA raises more methodological difficulties than a simple, deductive theory-testing (Ebbinghaus, 2005).

Second, QCA is a particularly transparent technique, insofar as it forces the researcher not only to make choices on his or her own (that is, the researcher decides, not the computer), but also to justify these choices, from a theoretical and/or empirical perspective. In the course of the procedure, at several stages, the researcher is confronted with choices. For instance, he or she must decide whether or not he or she wants to obtain the shortest solution possible, to achieve a maximal level of parsimony. If this choice is made, some cases that exist logically, but that have not been observed in the data, will be included in the Boolean minimization. In practice, the software will attribute a [0] or [1] outcome value to these logical cases, thus making 'simplifying assumptions' about these cases. The researcher may reject this option, privileging complexity over parsimony. One also has to make clear choices as to the way each variable is dichotomized, and as far as the choice of variables is concerned.

Third and not least, QCA allows one to consider phenomena that vary both qualitatively and quantitatively. Both of these phenomena can be operationalized in the conditions and outcome variables used for software treatment (De Meur and Rihoux, 2002). Ragin uses the term 'qualitative' to indicate that QCA enables the researcher to analyse phenomena that vary in nature, that are present or absent, and not only in degree (Ragin, 2002), that each case is considered as a complex and specific combination of features (Ragin et al., 1996), and that QCA allows examination of constellations, configurations and conjunctures (Ragin, 1987).

Because of some of its limitations, some of which are discussed in more detail later, and also due to the diversifying demands of a broadening community of users, three connected techniques have been developing during the last few years: respectively fuzzy sets, MVQCA and MSDO/MDSO.

Fuzzy sets, currently developed by Ragin (2000), prolong and expand the logic of QCA, but allow the researcher to analyse not only crisp dichotomous variables, but also fuzzy variables, which can be defined in terms of degree of membership in a well-defined set. On the one hand, fuzzy sets can be regarded as a response from Ragin, in the view of some critiques vis-a-vis QCA, notably around the limits of crisp sets analysis. In this sense, they can be viewed, to a certain extent, as a prolongation of QCA. However, on the other hand, they are quite distinct from QCA, technically and in terms of approach. Indeed, in technical terms, fuzzy sets are not restricted to small-*N* situations. They are actually quite well suited to large-*N* situations, i.e. to research designs in which the comprehension of each individual case matters much less. In terms of approach, it may be argued that they are a somewhat distinct route to attempt to bridge the gap between qualitative and quantitative approaches: QCA's starting point lies more in cases (more in the qualitative world), whereas fuzzy sets' starting point lies more in variables and generalization (i.e. in the quantitative world). Hence, fuzzy sets should rather be considered more as a challenge towards conventional statistical and correlational quantitative analysis.

In contrast with fuzzy sets, multi-value QCA (MVQCA) (Cronqvist and Berg-Schlosser, forthcoming; Cronqvist, 2005), can be considered as a direct extension of QCA. Indeed MVQCA retains the main idea of QCA: it performs a minimization of a data set with the result that cases with the same value of the outcome variable are covered by a parsimonious solution. As with QCA, the solution contains one or several prime implicants, each one of which covers a number of cases with this outcome, while no cases with a different outcome are explained by any of the implicants. The major difference, though, is that while QCA only allows dichotomous variables to be processed, MVQCA also includes multi-value variables in the analysis. This is a response to one of the recurrent critiques of QCA, that the constraint to use only dichotomous variables causes two key problems: information loss and risk of obtaining a large number of contradictory configurations.[3] Actually, 'MVQCA is a generalisation of QCA, and each dichotomous variable is a multi-value variable (with two possible values)' (Cronqvist, 2005: 2).

Finally, MSDO/MDSO (most similar, different outcome/most different, similar outcome) is the most recent linked technique, at least in the form of software[4] tools – some applications of this technique have already been performed in the 1990s (Berg-Schlosser and De Meur, 1994; De Meur and Berg-Schlosser, 1996; Berg-Schlosser and De Meur, 1997; Bursens, 1999; De Meur et al., 2006). It is meant to be a help in the prior steps of the comparative research design, more precisely in model specification, so as to take into account many potential explanatory variables or conditions that are systematically grouped into categories, producing a reduction in complexity.

In conclusion, one could say that dichotomous QCA is more specifically designed to address small-*N* situations, say: less than 30–40 cases,[5] with a key emphasis laid on case-based knowledge. Conversely, fuzzy sets are more targeted at larger-*N* situations, as a challenge to mainstream statistical data treatment. Finally, MVQCA lies in some sort of middle ground between QCA and fuzzy sets – it is more powerful in medium-*N* situations. Herrmann and Cronqvist (2005) have recently confronted the three techniques, and have refined this general argument. According to them, the three respective techniques are best used in different research situations, following two dimensions. The first dimension is the sheer number of cases – the size of the data set. The second dimension is the necessity to preserve the richness of the data information in the raw data set. Figure 1 summarizes situations in which each one of the three techniques is best used. I have also picked out two other

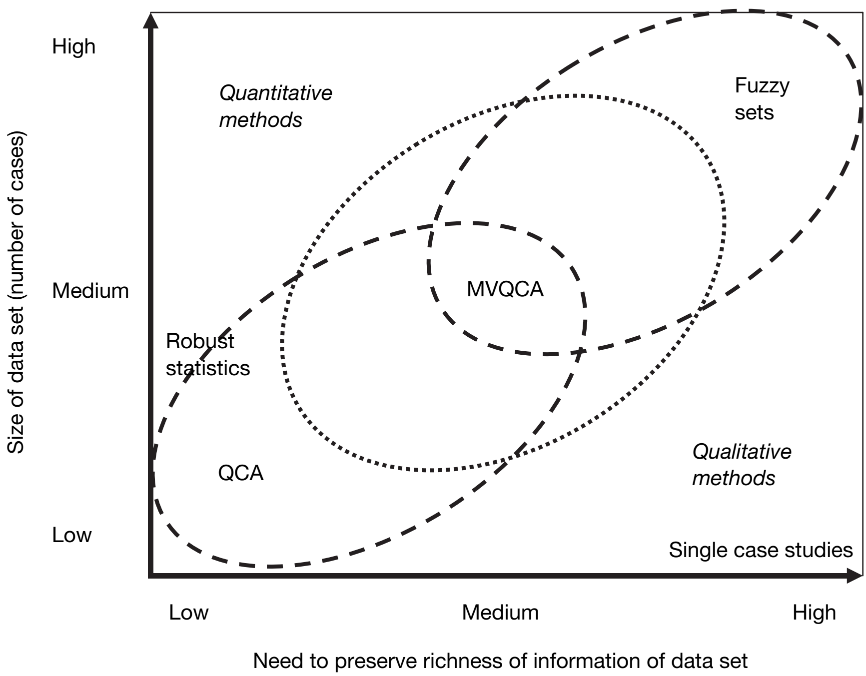

Figure 1 *Best Use of QCA, MVQCA and Fuzzy Sets*

specific sets of techniques and placed them on these two dimensions. On the one hand, single, in-depth case studies probably constitute the most demanding form of empirical qualitative methods with regard to the requested richness of case information. On the other hand, robust statistics are designed to tackle small-*N* situations (Hampel et al., 1986). As far as we know, QCA and robust statistics haven't been thoroughly confronted so far.

Of course there are some overlaps between these techniques. For instance, if the number of cases is low to medium (say, between 40 and 50 cases), one will have the possibility to choose between dichotomous QCA and MVQCA. It is probably advisable to try first with dichotomous QCA, provided that the model doesn't display too many contradictions and that some conditions don't obviously require a non-dichotomous treatment. For instance, in a social stratification study, a researcher may not find it acceptable, from a theoretical and/or empirical perspective, to transform a three-value working-class–middle-class–upper-class variable into a dichotomous variable, thereby losing too much information.

Key Issues and Recent Advances

During the last 15 years, and more so during the last few years, these methods have been applied in a variety of ways, in a growing number of disciplines, covering various topics as well. Naturally, in that process, scholars have encountered difficulties and have developed strategies to overcome these difficulties, thereby improving the use of these techniques. In this section, I attempt to survey and comment on some of the most important recent advances, in a more detailed way for dichotomous QCA.

Case Selection and Model Specification

In any comparative research effort, one is confronted with two classical research design issues. The first is case selection: how to select genuinely comparable cases? The second one is variable selection, which of course refers to model specification. Actually, these two issues are quite closely linked.

With regard to case selection, in any small-*N* or medium-*N* design, arguably, one should not broaden too much the variety of cases. In other words, the quest for generalization should always be bounded, by comparing cases that share a sufficient number of features and that operate within sufficiently comparable contexts (Lijphart, 1971; Collier, 1993; Ragin et al., 1996). By contrast to most large-*N* research, in this effort, one should treat cases as singular, whole entities purposefully defined and selected, not as homogeneous observations drawn at random from a pool of equally plausible selections (Ragin, 2004). Hence in such a research design, in contrast, the population of cases is not a given; it is actually delimited by the researcher, informed by theory and empirical knowledge. As social science theories are not always so consolidated, this process is often iterative. This being said, it is of vital importance that these comparable cases display enough diversity with regard to the conditions which will be included in the model, and also with regard to the outcome variable.

This first view is in line with the 'most similar systems design' as defined by Przeworski and Teune (1970): as one matches similar cases as much as possible, most of the variables can be controlled, which allows one, following Mill's indirect method of difference, to attribute different outcome values to the remaining factors – to those factors which are included as conditions in the QCA model. In medium-*N* settings, however, the opposite strategy defined by Przeworski and Teune, the most different systems design, also makes sense. It seeks maximal heterogeneity in the selection of cases that share an identical outcome. This allows one to eliminate all factors that are not linked to an identical outcome. In this way, more general explanations can be reached (Berg-Schlosser, forthcoming).

The recent development of MSDO/MDSO is a first attempt to systematically combine these two designs. Hence MSDO/MDSO is a tool which assists both case selection and model specification (De Meur et al., 2006; Berg-Schlosser, forthcoming; De Meur, forthcoming). This technique is to be used as a prior step before using a technique such as QCA and its extensions, so as to take into account many potential explanatory variables, which are grouped into categories, producing a reduction in complexity. This is done through the step-wise elaboration of distance matrices and (dis)similarity graphs, which allow one to identify the most similar pairs of cases that display a different outcome, as well as the most different pairs of cases that display a similar outcome. This, in turn, enables the researcher to select the key conditions to be used further, typically for a QCA-type analysis. De Meur et al. (2006) have applied MSDO/MDSO in the field of policy-making processes in EU institutions, using material from a study performed by Bursens (1999). Their main goal is to identify the variables that explain why certain types of policy networks develop through the elaboration of EU legislative proposals. MSDO/MDSO ultimately enables them to narrow down the number of conditions in a systematic way, and then to perform a QCA that yields empirically robust conclusions on how institutions matter in the formation of EU policy networks.

In spite of the development of tools such as MSDO/MDSO, case selection and model specification are still very difficult tasks. One of the key remaining problems is how to increase the number of cases, without losing in-depth case knowledge. Building upon Lijphart's (1971, 1975) and King et al.'s (1994) advocated designs, which meet respectively the contradictory needs of internal validity by control and comparison and external validity by correlation and broadening of the scope, Levi-Faur (2006) puts forward an original strategy. More precisely, he first develops four case-based strategies, each one of which consists of a two-by-two combination of, respectively, Przeworski and Teune's most-similar system design (MSSD) or most different system design (MDSD), and Mill's method of difference or method of agreement. They are to be used in a step-wise and iterative model.

These developments are pretty much in line with some other recent contributions on case selection in small- and medium-*N* research designs, especially through two major books (Mahoney and Rueschemeyer, 2003; George and Bennett, 2005). Both Mahoney (2003b) and Ebbinghaus (2005) refine the initial argument made by Ragin and by others, according to which, in qualitative comparative research, cases are selected both for intensive within-case analysis and systematic cross-case analysis. To put it more precisely: sufficiently detailed within-case studies are a condition sine qua non for successful cross-case comparison. Ebbinghaus (2005) also examines a third research design besides MSDO and MDSO, namely MSSO (most similar, same outcome), which obviously raises difficulties if one aims at establishing patterns of causality. However, provided some care is taken in the definition of necessary conditions (Braumoeller and Goertz, 2000) such a design can be useful in the process of model-building, in particular to eliminate some non-necessary conditions. Thus, especially at the first stages of a comparative research enterprise, cases with a similar outcome variable can be used as a heuristic device to pick out the most interesting potential conditions. Later on in the research process, such a model can then be tested against cases with different outcome values (George and Bennett, 2005) – this is also in line with Mahoney and Goertz's (2004) demonstration on the usefulness and importance of selecting negative cases as well. QCA and its parent techniques are very much in line with a step-wise, case-oriented research design, as convincingly advocated by George and Bennett (2005).

Still with regard to model-building, another promising avenue is being developed by Schneider and Wagemann (forthcoming), who draw a useful distinction between remote and proximate conditions, and who also apply a practical two-step procedure to implement this distinction. Such a strategy also allows one to filter out some more remote (i.e. distant, more contextual) conditions, and hence to encompass more conditions in exploratory (MV)QCA or fuzzy sets tests. One further interest of this is that the remoteness/proximity distinction could also be a way to tap time and sequence (as discussed here later).

Of course, whatever design is used with QCA, one still bumps into the contradictions/uniqueness trade-off. If one includes too many variables, a problem of uniqueness might occur, i.e. each case is then simply described as a distinct configuration of variables, which results in full complexity and no parsimony. On the other hand, if one uses too few variables the probability of contradictions increases. Varone et al. (2006) discuss some possibilities to deal with this trade-off.

Measurement, Dichotomization and Linkage with Theory

In spite of the analytical strength of dichotomization (De Meur and Rihoux, 2002), the progress made on the issue of dichotomization and categorization of the data, and the development of new tools such as MVQCA and fuzzy sets, which enable one to process finer grained data, there is still a lot to be discussed on how and why to categorize data. This issue is quite important, as QCA and related techniques are evidently case-sensitive and variable-sensitive. Hence modifying the operationalization even only on one single condition, in dichotomous QCA for instance, may very well bring profound modifications to the minimal formulae. Some good practices have been recently laid out. One of them is that one should only use statistical criteria (mean, median, etc.) in the last resort (Ragin and Rihoux, 2004a). Attention must also be paid to the size of the two subsets (Herrmann and Cronqvist, 2005), a current rule of thumb being that each subset should contain at least one-third of the cases.

Of course, dichotomization should not be pursued at any cost. Braumoeller and Goertz (2000) argue that the forced dichotomization of fundamentally non-dichotomous phenomena can introduce problematic measurement biases. MVQCA is one of the obvious alternative strategies. Some first real-life applications are indeed promising in this respect. Cronqvist and Berg-Schlosser (2006), for instance, confront mainstream quantitative methods with dichotomous QCA and with MVQCA. Their goal is to explore the causes in the differences of HIV prevalence rates between Sub-Saharan African countries. While regression tests and factor analysis show that the religious context and colonial history have had a strong impact on the spread of HIV, the popular thesis, according to which high education prevents high HIV prevalence rates, is invalidated. Further, they perform some dichotomous QCA tests, which are not uninteresting, but which still contain some contradictory configurations – this problem is precisely solved with MVQCA. In countries with a high HIV prevalence rate, MVQCA then allows them to find connections between the mortality rate and the increase of the prevalence rate, as well as between the economical structure and the increase of the prevalence rate, which might be of interest for further HIV prevention policies. Methodologically, the introduction of finer graded scales with MVQCA is proved useful, also in empirical terms, as it allows a more genuine categorization of the data.

QCA is also designed for more theory-driven work. If it is well used, QCA allows for a three-way comparison. First and more obviously, it is designed for cross-case analysis. Second, it is also a tool for within-case analysis, in the phase of interpretation of the minimal formulae. Third and not least, it allows one to perform comparisons between empirical reality and theoretical ideal types (Varone et al., 2006). This more theory-oriented use of QCA has been explored in different, promising ways. For instance, Watanabe (2003), Peillon (1996) and Yamasaki (2003) have used more advanced features of the software to examine the Boolean intersections between theory and empirical observations. Befani and Sager (2006), and Befani et al. (forthcoming) have also begun to develop an original theory-driven QCA strategy in the field of policy evaluation. They have modelled a 'realist' theory (Pawson and Tilley, 1997) consisting of context–mechanism–outcome (CMO) configurations, which explain the different types of policy results. A model deriving from this initial theoretical construct is then elaborated, and empirical data are collected in order to fill in a data matrix on which QCA is performed. The QCA produces minimal combinations of conditions, which are, in turn, used to refine the initial theory. The theory refinement made possible by QCA covers both directions on the abstraction to specification scale: downward, it offers more elaborate configurations able to account for a certain outcome; upward, it aggregates relatively specific elements into more abstract ones (realist synthesis).

Last but not least, it is obvious that fuzzy sets offer some interesting alternatives when one is confronted with coding problems, in particular linked with dichotomization.. The conception of variables in terms of fuzzy set membership (Ragin, 2000) provides a way to operationalize and typologize phenomena that sticks closer to theoretical discourse (see also Goertz and Mahoney, 2005; Goertz, 2006). Indeed Kvist (2006) demonstrates how fuzzy sets can be used to perform a more precise operationalization of theoretical concepts. He further shows how to configure concepts into analytical concepts. Using unemployment insurance and child family policies in four Scandinavian countries as test cases, he exemplifies these approaches by using fuzzy memberships indicating the orientation towards specific policy ideal types.

Another advantage of fuzzy sets is that they provide some flexibility in the hard deterministic nature of QCA and MVQCA – indeed the crisp QCA does not leave room for manoeuvre: either a specific condition (or a specific combination of conditions) is sufficient to produce the outcome of interest, or it is not. By allowing some input of probabilistic propositions more precisely (through statistical tests with predefined benchmarks that can be adjusted by the researcher) one may produce propositions in terms of 'quasi-sufficiency' (Ragin, 2000). This is a response to criticisms on the deterministic nature of Boolean algorithms (e.g. Dion, 1998).

On Contradictions and Non-Observed Cases

It is actually good to obtain contradictory configurations with observed cases, at some stages of the analysis: the researcher can learn from these contradictions, as it forces him or her to go back to the empirical cases and to theory. In practical, real-life research, one of the potential signals of the existence of such contradictions is that, most probably, the researcher has forgotten to include at least one key condition so as to explain variation in the outcome of interest. Another original way to treat these contradictions has been developed by Roscigno and Hodson (Roscigno and Hodson, 2004; Hodson and Roscigno, 2004), in their meta-analysis of organizational ethnographies. For each configuration of observed cases, they consider the relative frequency of the cases with [1] and with [0] outcomes, respectively, and then use a conventional statistical method (*t*-tests) to make comparisons between the distribution of outcomes for that configuration, on the one hand, and that of the outcomes for cases not captured by the configuration, on the other hand. With this technique, they are able to demonstrate that, from a statistical – i.e. probabilistic – perspective, some of the contradictory configurations that would otherwise be unconsidered with a standard QCA minimization procedure, do indeed enable one to discriminate the outcome, to a certain extent at least.

On the other hand, when one uses a small-*N* research design, a problem of limited diversity is raised with QCA, as the number of logically possible combinations of conditions quickly overwhelms the number of empirically observed combinations (Ragin, 1987). An early answer of QCA to this has been to allow the software to use non-observed cases (called 'remainders', 'logical cases' or 'counterfactuals'). The software then makes simplifying assumptions on these additional cases, which produces shorter, more parsimonious minimal formulae. To a certain extent, the use of logical cases can be justified (De Meur and Rihoux, 2002; Ragin and Rihoux, 2004b; Rihoux et al., 2004). This has however been criticized, especially if one includes some logical cases that would be empirically or theoretically very unlikely, or even inconceivable (Markoff, 1990; Romme, 1995). Actually, the epistemological issue at stake here is the arbitration between parsimony and complexity, or, to put it differently, the level of reduction of complexity one should aim at.

During the last few years, different responses to these critiques have been developed. The first strategy has been to draw a distinction between 'easy' and 'hard' simplifying assumptions (Ragin and Sonnett, 2004; Ragin and Rihoux, 2004a). The former are counterfactuals, which can be sustained from an empirical and/or theoretical perspective, whereas the latter are more counterintuitive. For instance, if one would consider a non-observed case with a [1] value on all conditions, assuming that such a case would have a [0] outcome value would constitute a hard simplifying assumption. The strategy is then quite straightforward: allow the software to consider only easy, simplifying assumptions, empirically and/or theoretically qualified. A quite parallel strategy has been pursued by Grassi (2004) in his analysis of democratic consolidation in Latin American political systems, and by Clément (2004) in her exploration on the causes of state collapse in Somalia, Lebanon and former Yugoslavia.

Another strategy has consisted not in putting restrictions on non-observed cases, but in providing a treatment of contradictory simplifying assumptions. In short, such contradictions appear when the software uses the same non-observed combinations of conditions for both the minimization of [0] outcome cases and [1] outcome cases – i.e. it allocates two different outcome values on the same combination of conditions. The quite labour-intensive solution that has been applied so far consists of three main phases. First, the respective minimal formulae for the [0] and [1] outcomes are systematically intersected, to detect the presence of contradictory simplifying assumptions. Second, the non-observed cases that create such contradictions are included in the data set, with the allocation of a [0] or [1] outcome value. This step necessitates some empirical and/or theoretical justifications. Third, the minimizations are run again, in the hope that at least one intersection of the minimal formulae for the [0] and [1] outcomes, respectively, will not display contradictions anymore. With real-life data, this procedure must often be replicated two or three times, in a more iterative way. This strategy has been successfully implemented in a few applications, e.g. on the determinants of organizational change in Green parties (Rihoux, 2001) and on agenda-setting processes with regard to basic income proposals (Vanderborght and Yamasaki, 2004).

The bottom line is that, by explicitly tackling contradictions and non-observed cases, one actually gains a lot in the understanding of the phenomena of interest.

Bringing in the Time and Process Dimension

At first sight, there is a stark contrast between the wealth of recent developments, both epistemological and methodological, with regard to the time and process dimension, and the apparently static character of QCA. Indeed, in its Boolean treatment, QCA is not designed to explicitly integrate the time and process dimension, and seems to provide only a form of static comparison (Boswell and Brown, 1999). This may seem surprising, as QCA is after all more a case-oriented method.

This is only one part of the picture, though, which only looks at the Boolean nuts and bolts of QCA. Already from the earlier applications onwards, time and process have been – only to a certain extent admittedly – taken into account in QCA. First and most obvious, in all well-conducted QCA applications, the minimal formulae are not static: they tell some bits of a thick story, which must be interpreted, obviously also taking into account considerations of time and sequence (De Meur and Rihoux, 2002; Cress and Snow, 2000). Second, it is possible, at the model-building stage, to construct conditions that, themselves, integrate the time dimension. For instance, one may operationalize a condition as follows: 'an A-type of event has preceded a B-type of event: yes/no'. Third, following the suggestion made by King et al. (1994), a case might also be circumscribed a subunit of a case that displays a sufficient degree of differentiation with the other subunits of that case. It is then possible to integrate the time dimension in the definition of the cases themselves. For instance, Rihoux (2001) has segmented party organizations through time, using a chronological sequence and also relying on the sequence of [0] and [1] outcomes as cut-off points, so as to produce several cases – or rather units of observation – per party. The same has been done by Clément (2004). Obviously, however, such a design raises some difficulties as far as the independence of the cases is concerned.

These first responses are thus only partial, and do not respond to the more ambitious challenge of really integrating time and process into QCA itself. This opens up a huge methodological Pandora's Box, as one should then attempt to take into consideration concepts and phenomena such as cumulative causes, threshold effects, causal chains, path dependency, feedback processes (Pierson, 2003) and critical junctures (Abbott, 1992), to mention but a few. One should also take into account the complexity of causal processes (e.g. Mahoney, 2003a; Rueschemeyer and Stephens, 1997; Stephens, 1998; George and Bennett, 2005; Gerring, 2005), which goes far beyond the rather simple QCA conceptualization in terms of multiple conjunctural causation. If one wishes to address these issues, several potential concrete paths open up, especially around sequence analysis broadly defined (Krook, 2005). A first set of existing or developing techniques concentrate on structures of whole sequences, such as optimal matching (Abbott, 1995), comparative narrative analysis (Abell, 1987, 2004) or Gibbs sampling (Abbott and Barman, 1997). A second set of techniques breaks down the components of individual sequences, such as event-structure analysis (ESA) (Griffin, 1992, 1993; Heise, 1989), narrative analysis or process tracing (George and Bennett, 2005; Rueschemeyer and Stephens, 1997). There are also some other formal techniques, such as game-theoretic interaction models, which self-contain dynamic processes.

Already quite a few attempts have been made so far. In an analysis of the outcomes of local environmental policies in the US, Stevenson and Greenberg (2000) have convincingly used, in their research design, both QCA and ESA. Quite similarly, in a research on closure processes of non-profit organizations, Duckles et al. (2005) have first elaborated an expected sequence of events leading to the outcome of interest, i.e. organizational closure. Then they have used thick case information (narratives, interviews) to reconstruct the actual sequence of events in the empirical cases. With the help of ESA, they were then able to construct 31 event structures, some of which were operationalized in sequential submodels for successive QCA minimization procedures. Eventually, they elaborated a complete model that enabled them to identify some key precipitating factors in the chain of events, at least for some clusters of cases. In another vein, Brown and Boswell (1995) have combined QCA with game modelling, on their study of ethnic conflicts in split labour market conditions. They use a game-theoretic – by definition dynamic – model to construct dynamic hypotheses to be tested through QCA.

An attempt of another kind, by Caren and Panofsky (2005), consists in integrating temporality directly into QCA. Using an hypothetically constructed example, they argue that it is possible to develop an extension of QCA (TQCA – temporal QCA) to capture causal sequences. First, they include sequence considerations as a specific case attribute, hence increasing dramatically the number of possible configurations. Second, they place theoretical restrictions to limit the number of possible configurations. Third, they perform a specific form of Boolean minimization; this allows them to obtain richer minimal formulae, which also include sequences and trajectories. This is an interesting attempt, although it dramatically increases the problem of limited diversity, and it should still be tested against real-life data.

Combining or Confronting QCA with Other Methods

Another series of innovations pertains to the confrontation (or dialogue, rather) between QCA and connected techniques and other methods, be they more qualitative or quantitative. This occurs as growing debates develop on how to combine, or possibly even mix methods in real-life empirical research (e.g. Tashakkori and Teddlie, 2003).

By definition, a vast number of QCA applications are de facto developed in sequence with more qualitative, thick case-oriented methods. Especially in the smaller-*N* analyses, with dichotomous QCA, most consolidated applications stem from more qualitative case studies. Most often, there is already a lot of upstream qualitative work involved in the process of achieving an in-depth understanding of cases. One of the recent illustrations is Grimm's (2006) analysis on entrepreneurship policy and regional economic growth in the US and Germany. She uses QCA in a more exploratory way, to enrich her qualitative knowledge of the specific cases, by helping her to identify some particular contextual factors that are influencing some cases while others are unaffected.

As for the connection with mainstream statistical methods, in numerous recent contributions, especially in medium-*N* and larger-*N* settings, researchers use both statistical techniques and QCA-type techniques to analyse the same initial data, and confront the conclusions of both techniques. Quite often, the empirical conclusion is that QCA-type techniques allow one to learn more out of the data. For instance, by reanalysing with fuzzy sets the bell curve data on social inequalities in the US, Ragin (2006) demonstrates that there is much more to be found when one takes into account the fundamentally configurational nature of social phenomena, which cannot be grasped with standard statistical procedures. Another example is Luoma's (2006) study of social sustainability in local Finnish communities, in which QCA enriches the conclusions reached by prior regression analyses. The same goes for Cronqvist and Berg-Schlosser's (2006) aforementioned MVQCA analysis of explanatory factors of AIDS prevalence in Sub-Saharan Africa. We should also mention the confrontation between fuzzy sets and regression analyses by Katz et al. (2005) on socioeconomic development in Spanish American countries during the 18th and 19th centuries. From a methodological viewpoint, they are able to demonstrate that OLS regression yields less robust and more unstable results, especially as the *N* becomes low. QCA has in fact already been confronted with quite a few different statistical techniques: discriminant analysis (Berg-Schlosser and De Meur, 1997), factor analysis (Berg-Schlosser and Cronqvist, 2005), various types of multiple regression (e.g. Amenta and Poulsen, 1996; Ebbinghaus and Visser, 1998; Kittel et al., 2000; Nelson, 2004), logistic regression (Amoroso and Ragin, 1999; Ragin and Bradshaw, 1991) and logit regression (Heikkila, 2003; Dumont and Bäck, forthcoming).

In another vein, an original attempt is made by Yamasaki and Spreitzer (2006), who combine QCA with social network analysis (SNA). First, they identify some key problems of applied research: representing and deciphering complexity, formalizing social phenomena, allowing generalization and providing pragmatic results. It is argued that both QCA and SNA provide useful answers to these problems: they assume complexity as a pre-existing context, they assume multiple and combinatorial causality, they offer some formal data processing, as well as some visualization tools. The authors follow by envisaging two ways of combining those methods: a QCA can be followed by a SNA, e.g. for purposes of visualization and interpretation of the QCA minimal formulae; conversely, a QCA can complement a SNA, e.g. by entering some network data into a

QCA matrix. This is applied on two empirical examples. Stevenson and Greenberg (2000) have also, in other ways, explored this connection.

At this stage of combination/confrontation with other methods, the most contested topic is probably the respective pros and cons of QCA and connected techniques vs statistical techniques. Answering recent critiques (e.g. Lieberson, 2004; Seawright, 2004), Ragin and Rihoux (2004b) raise some counterarguments and, in essence, conclude that the intention of QCA is certainly not to supplant regression and related analyses, especially since the underlying logic and goals of the respective methods display stark differences. One of the key differences is that regression-based methods focus primarily on the problem of estimating the net, independent effect of each variable included in an analysis on the outcome. By contrast, it would be a serious mistake to apply QCA to this task, as the latter focuses on combinations of conditions. From the perspective of QCA, the idea of isolating the net, independent, context-free effect of each independent variable makes no sense.

Tentative Conclusions: A Broad Potential to be Exploited

In the field of systematic comparative case analysis methods, the technique that so far has been most widely applied , QCA, has met some fierce criticisms, especially from researchers with a quantitative – i.e. mainstream statistical – worldview. A detailed discussion of these critiques, and answers to these critiques, goes beyond the scope of this contribution.[7] The bottom line is that many of these critiques are technically incorrect, for they are based on assumptions that are simply not valid for Boolean-type data treatment. This is not to say, of course, that QCA is devoid of limitations (Rihoux, 2003). In this contribution, I have shown that a more advanced exploitation of dichotomous QCA, on the one hand, and the development of three connected methods, MVQCA, fuzzy sets and MSDO/MDSO, on the other hand, have begun to bring some solutions to these limitations.

With respect to dichotomous QCA, out of the more than 300 published applications[8] surveyed at the time of writing, in terms of disciplinary orientation, more than two-thirds are found in political science (comparative politics, welfare state studies, policy analysis and so on) and sociology (historical sociology, organizational sociology and so on). There is also a growing number of applications in other disciplines such as political economy, management studies and criminology. Finally, a few applications can be found in history, geography, psychology and education studies.

Although QCA is mainly designed for small- and intermediate-*N* research, there is substantial variation across studies in the number of cases. Quite a few applications have a very small *N*, as low as five (e.g. Kitchener et al., 2002), six (e.g. Vanderborght and Yamasaki, 2004) or seven cases (e.g. Brueggemann and Boswell, 1998; Hellström, 2001). In the intermediate-*N* range, most applications are to be found in the broad range from 10 to 50 cases. However, several applications address between 50 and 80 cases (e.g. Williams and Farrell, 1990; Rudel and Roper, 1996; Nomiya, 2001). Still further, some applications are to be found in the large-*N* domain, up to more than 100 (Drass and Spencer, 1987; Yonetani et al., 2003) or even more than 1000 cases (Ragin and Bradshaw, 1991; Amoroso and Ragin, 1999; Miethe and Drass, 1999). Hence the method has been applied fruitfully in a very broad range of research designs.

The nature of the cases studied is also diverse. In most applications, cases and outcomes are macro- or meso-level phenomena, such as policy fields, collective actors, organizations, country or regional characteristics, and so on. Only very few scholars have applied QCA to micro-level data, though there is arguably a potential to do so – indeed some PhD projects are currently under way in this direction, especially in the field of education research and psychology.

This quick and selective mapping of QCA applications, as well as the recent developments discussed in this contribution, shows the quite large potential of QCA, in terms of discipline, number of cases, research design and types of uses. However, probably it is a bit overstated to argue that QCA is a middle path between case-oriented and variable-oriented research, as Ragin (1987) initially argued. All things considered, QCA is more related to case study methods. Hence, as with any case-oriented methods, a researcher using QCA meets a trade-off between the goals of reaching a certain level of theoretical parsimony, establishing explanatory richness, and keeping the number of cases at a manageable level (George and Bennett, 2005). What is specific about QCA, as compared with George and Bennett's 'focused, structured comparison', is that it enables one to consider a larger number of cases, provided one is willing to accept a certain level of simplification and synthesis necessitated for Boolean treatment. Still, in that process, one does not sacrifice explanatory richness, and the possible generalizations that are produced will always be contingent, in the sense that they only apply to some specific types or clusters of well-delineated cases that operate in specific contexts (George and Bennett, 2005).

Naturally, QCA and connected techniques should not be viewed in isolation. They are clearly compatible with other overarching efforts, especially around comparative historical analysis (Mahoney and Rueschemeyer, 2003) and theory-led case-oriented research (George and Bennett, 2005). In addition, much progress can be expected within the next few years, when QCA and connected techniques will hopefully be combined/confronted more systematically with other techniques, be they more qualitative or more quantitative. At the same time, we can also expect some significant further development in terms of software to perform QCA, MSDO/MDSO, MVQCA and fuzzy sets analyses, e.g. in terms of visualization, connections with other software packages, user interface, etc. In addition, dissemination of these techniques is now being amplified through training programmes and specialized courses in various institutions. Among other dissemination efforts, an English-language textbook (Rihoux and Ragin, forthcoming) is also in the making. Though of course neither QCA, nor MVQCA nor fuzzy sets constitute miracle techniques – no technique should be expected to perform miracles or solve all research questions – these techniques still display a broad potential to be exploited, in many fields across the social sciences broadly defined.

Notes

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1. For an accessible presentation of key elements of Boolean logic and operations, see Ragin (1987). For details on using the software for analysis, see De Meur and Rihoux (2002) and Rihoux and Ragin (forthcoming), as well as the COMPASSS resource site: at: www.compasss.org
2. Two main free-access software are being developed. Fs/QCA is available through www.compasss.org and at www.u.arizona.edu/~cragin/QCA.htm, and performs dichotomous crisp set as well as fuzzy set analysis. TOSMANA performs dichotomous crisp set analysis as well as MVQCA, with some additional features. It is available through www.compasss.org and at www.tosmana.net/. Some other efforts are under way, such as the development of a QCA module in the 'R' package.
3. See, however, De Meur and Rihoux's (2002) defence of the analytical strength of dichotomous QCA.
4. No public version is yet available at the time of writing. Some 'beta' versions are being elaborated.
5. However QCA has also been applied in large-*N* settings as well (see later).
6. Adapted from Herrmann and Cronqvist (2005).
7. For an overview of the critiques, see De Meur and Rihoux (2002), Rihoux (2003), Rihoux et al. (2004) and De Meur et al. (forthcoming).
8. Among other resources, an exhaustive list of applications can be found on the COMPASSS resource site: www.compasss.org

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