

Using fsQCA

**A Brief Guide and Workshop for Fuzzy-Set Qualitative
Comparative Analysis**

Ray Kent
Department of Marketing
University of Stirling
r.a.kent@stir.ac.uk

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Preface

Ray Kent of the University of Stirling has been working on qualitative comparative analysis for several years now. His publications (see below) include several which utilise the configurational logic. In this working paper, Ray Kent explains how a causal analysis is done with the FS QCA software. FS QCA stands for Fuzzy Set Qualitative Comparative Analysis. Not all users of FS QCA agree that causality is what they are studying. For example some historians use QCA to examine change over time through qualitative data. Their use of QCA software is mainly as an organising tool. There are also hermeneutic specialists who use FS QCA to look at patterns of co-occurrence in sets of linguistic data. However these users can utilise the software by making small amendments – notably by putting a constant ($x=1$) as the outcome variable – and then looking at the truth table in terms of typologies or trajectories.

Thus FS QCA software has numerous users. It has its own support site and manual, but Ray Kent's paper is a much shorter and very logical introduction to the possibilities of configurational analysis. We are grateful that Ray has agreed to provide the working paper for online use.

Some other upcoming publications are cited at the end of his paper. Ray himself has a chapter in a forthcoming book edited by David Byrne (*The Handbook of Case Study Research*, Sage Publications, 2009) which gives some history and background to QCA.

Wendy Olsen

Senior Lecturer in Socio-Economic Research

University of Manchester

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Using fsQCA

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By Ray Kent

Introduction

FsQCA (fuzzy set qualitative comparative analysis) is a program that uses combinatorial logic, fuzzy set theory and Boolean minimisation to work out what combinations of case characteristics may be necessary or sufficient to produce an outcome. The program, along with a manual and a selection of working papers, is available for free at www.compass.org.

The data matrix

The program begins with a data matrix. Although this lists the cases as rows, as with a conventional data matrix, in the columns, case characteristics are not 'variables' in the usual sense, but degrees of membership of a defined category, for example, 'democratic country', 'profitable organisation' or 'satisfied customer'. Membership may be binary: cases are either members or non-members of a category. These result in 'crisp sets' in fsQCA terminology. Crisp sets record a value of 1 for membership and 0 for non-membership. Alternatively, fuzzy sets allow for degrees of membership of categories. They record a value of 1 for full membership of a set, zero means total non-membership, and a fuzzy score of 0.5 means neither in nor out of the set – it is the point of maximum ambiguity. A fuzzy score of 0.75 might mean, for example, that a customer is 'mostly in' the set 'loyal customer'. Fuzzy sets are binary and metric at the same time. They combine categorical and metric assessments in a single instrument, distinguishing between cases that are 'more in' a set than others.

The truth table

The next step is the construction of a truth table. The researcher selects one of the characteristics as the 'outcome' that he or she wishes to explain or investigate plus two or more membership scores or 'conditions' that may potentially be necessary or sufficient for the outcome to happen. The truth table now treats each case as a combination of the characteristics selected (or 'configuration' in fsQCA terminology). Only cases with exactly the same configuration are considered to be the 'same' type of case. Each row in a truth table lists all the possible 2^k combinations of potential causal conditions (where k is the number of causal conditions); it records the number of cases with that configuration and whether or not the outcome happened.

There are four possible kinds of result for each configuration.

1. All the cases characterised by that configuration are instances of the outcome (positive cases).
2. All the cases characterised by that configuration are negative - they are not instances of the outcome.
3. Some of the cases characterised by that configuration are instances of the outcome, while others are not (a 'contradiction' in fsQCA terminology).
4. Particularly for small-n studies, there will be limited diversity, so that there will be some configurations for which there are no cases (or 'remainders' in fsQCA terminology) and for which we cannot say whether or not the outcome happened. These are normally excluded from the analysis of sufficiency and necessity. If the variables are fuzzy sets, then a remainder is a combination (or corner in vector space) for which there are no cases with greater than 0.5 membership. For large-n studies, there may be a 'relevance threshold', so that instead of only

configurations with no cases being treated as ‘remainders’, configurations with, say, fewer than five instances are treated as non-existent.

Examination of a truth table by itself facilitates certain kinds of analysis. It allows for a study of diversity, showing which configurations are common and which ones do not happen or happen very seldom. If the cases are named, for example they are countries, regions or named organisations, then it is possible to study groupings of countries that display the outcome – marital breakdown, civil war, successful product launches or whatever – bringing to bear on the analysis researcher knowledge and familiarity with particular cases.

Where variables are fuzzy sets - cases exhibit varying degrees of membership of specified categories - fsQCA generates a truth table by including as ‘positive’ cases on a causal factor only cases with membership scores of 0.5 or greater.

The analysis of causal sufficiency

The main analysis from fsQCA, which it calls a ‘truth table solution’, is a list of different combinations of causal factors that have met specified criteria of sufficiency for the outcome to occur. This entails that the membership score on the outcome is consistently higher than the membership score of the causal combination. In an x-y plot, this means that the proportion of cases in the upper triangle will be above a specified level, as in Figure 1. In an earlier version of fsQCA, the ‘inclusion’ algorithm just took the proportion of cases above or below the diagonal as a measure of ‘consistency’. The most recent ‘truth table’ algorithm takes account both of the degree of inconsistency and of the notion that cases with strong membership of the causal condition or causal combination provide the most relevant cases. The procedure uses fuzzy membership scores to weight the relevance of each case; the result is more an index of consistency rather than a simple proportion of inconsistent cases.

Figure 4 A Fuzzy-set Sufficient but not Necessary Condition

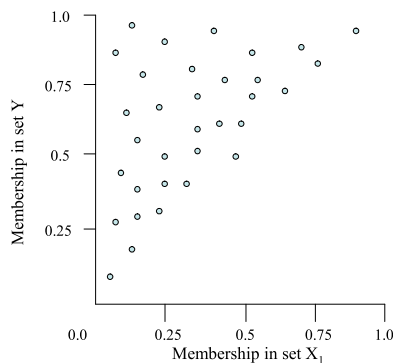


Figure 1 A sufficient, but not necessary condition

The inclusion algorithm has been temporarily removed from the software since, according to Ragin, the truth table algorithm is more parsimonious and more transparent, it is possible to investigate the consequences of different simplifying assumptions, and it facilitates the analysis in situations where there is limited diversity. It also gives a measure of coverage (the proportion of the total number of cases covered by the causal expression). Coverage is a proportional measure of the extent to which the solution ‘explains’ the outcome. It assesses the relative importance of a causal combination and plays a role analogous to variance explained in a regression analysis. Consistency and coverage often work against one another so that a combination with high consistency may have low coverage and vice versa.

Although a truth table has 2^k rows, one for each combination of *all* the causal conditions included in the analysis, the sufficient conditions analysis in fsQCA also looks at *groupings* combinations. Thus for three binary variables, besides the 2^k or 8 theoretically possible combinations, there will also be 12 groupings that share two of

the characteristics and 6 that share a single characteristic, totalling 26 in all. The total number of combinations is 3^k-1 .

The analysis of causal necessity

The analysis of necessary conditions in fsQCA is a separate procedure that looks at which individual factors may be necessary or mostly necessary for the outcome to occur. This entails that the membership score on the outcome is consistently lower than the membership score of the causal factor under consideration. In an x-y plot, a sufficiently high proportion of cases will be in the lower triangle.

Entering data into fsQCA

Data can either be entered directly into fsQCA or imported from other sources including SPSS, Excel and a range of other programs or formats. The exercise below takes you through entering data directly, but the editing facilities in fsQCA are limited and in practice it may be advisable to create the data matrix first in SPSS, Excel, Minitab, Stata or SAS. To import data from SPSS, first save the SPSS file in a DAT (tab delimited) format. SPSS will ask you whether you want to 'Write variable names to spreadsheet'. Do not uncheck this option. In fsQCA select *File/Open/Data* and browse, if necessary, to your .dat file.

The data in Table 1¹ show the results of a study into the causal conditions relevant to the breakdown/survival of democracy in 18 countries interwar Europe. The outcome of interest is the degree of membership in the set of countries with democracies that survived the many political upheavals of this period (SURVIVED). Degree of membership in the set of countries experiencing democratic breakdown (BREAKDOWN) is simply the negation of SURVIVED. The causal conditions are degree of membership in the sets of developed countries (DEVELOPED), urbanised countries (URBAN), industrialised countries (INDUSTRIAL), literate countries (LITERATE) and politically stable countries (STABLE).

Table 1 The survival of democracy in interwar Europe

COUNTRY	SURVIVED	BREAKDOWN	DEVELOPED	URBAN	LITERATE	INDUSTRIAL	STABLE
Austria	0.01	0.99	0.74	0.14	0.98	0.76	0.35
Belgium	0.98	0.02	0.99	0.89	0.96	0.98	0.96
Czech	0.85	0.15	0.42	0.96	0.97	0.91	0.87
Estonia	0.12	0.88	0.15	0.07	0.96	0.02	0.87
Finland	0.64	0.36	0.43	0.03	0.98	0.09	0.51
France	0.98	0.02	0.97	0.02	0.97	0.83	0.93
Germany	0.01	0.99	0.85	0.83	0.98	0.96	0.23
Greece	0.03	0.97	0.05	0.10	0.11	0.38	0.35
Hungary	0.41	0.59	0.08	0.20	0.81	0.08	0.09
Ireland	0.91	0.09	0.62	0.04	0.96	0.02	0.93
Italy	0.01	0.99	0.25	0.11	0.38	0.49	0.51
Netherlands	0.98	0.02	0.97	0.99	0.99	0.94	0.99
Poland	0.12	0.88	0.03	0.22	0.55	0.02	0.02
Portugal	0.01	0.99	0.02	0.01	0.02	0.12	0.02
Romania	0.25	0.75	0.02	0.03	0.15	0.02	0.78
Spain	0.03	0.97	0.04	0.41	0.08	0.22	0.14
Sweden	0.98	0.02	0.93	0.15	0.99	0.70	0.87
UK	0.98	0.02	0.98	0.98	0.99	0.98	0.96

After opening fsQCA, select *File/New* and the *Add New Variables* window will open. Type in the variables names, clicking on *Add* after each one. COUNTRY should be *String* under *Variable Type* and the rest should be *Free Numeric*. Use capitals for the names. This makes it consistent with fsQCA output, which uses capitals for a condition and lower case for the negation of a condition.

When all variables have been entered, click on *Ok* and enter 18 as the number of cases. Click on *Ok* and the *Data Sheet* will open. Enter the data from Table 1. It is

¹ The data are derived from Ragin (2008a, forthcoming), 'Qualitative Comparative Analysis Using Fuzzy Sets'. In Rihoux, B. and Ragin, C. (eds), *Configurational Comparative Analysis*, Sage Publications, Chapter 5.

easiest to do this by column since pressing *Enter* will move the highlight to the cell underneath.

Before closing the data sheet, you need to save it. There is no automatic backup save procedure. When you next log on to fsQCA, select *File/Open/Data*.

Truth table analysis

Select *Analyze/Fuzzy Sets/Truth Table Algorithm*. FsQCA will prepare an *Elimination Table* and give you a *Select Variables* box. Put SURVIVED into the *Outcome* box and DEVELOPED, URBAN, LITERATE, INDUSTRIAL and STABLE, into the *Causal Conditions* box. Click on *Run*. The *Edit Truth Table* screen lists each of the 2k possible combinations of 5 causal conditions (32 in this analysis), each configuration occupying a row. A value of 1 indicates a fuzzy set membership score of 0.5 or above and 0 a score below 0.5. The *number* column gives you the number of cases that exhibit the configuration listed. Thus there are three countries that are not developed, not urban, not industrial, not literate and not stable (having scores of <0.5 on each) and three that have all these characteristics. In all there are 10 configurations that exist and 22 that do not. These are the 'remainders' to be excluded from the minimisation process. To delete them from the truth table, put the highlight in the first row that has no cases (0 in the number column), and select *Edit/Delete current row to last row*. N.B. check that the *number* column is sorted before you do this so that all remainders are at the bottom of the table. If not, put the highlight in the top row of the *number* column and select *Sort/Descending*.

The *consist* column gives the measure of consistency explained above. It means that the membership score on the outcome is consistently higher than the membership score of the causal combination, weighted by the relevance of each case. The membership score of a causal combination is the minimum fuzzy score in each of the conditions. Consistency scores of less than 0.75 or even 0.8 mean that there is considerable inconsistency. Ideally, scores should be above 0.9. To see the range of consistency scores, it is best to sort the *consist* column into descending values. Put the highlight in the top box under *consist* and select *Sort/Descending*. Only the top configuration has a consistency above 0.8. The next is at least above 0.75. The rest have too much inconsistency. So, only the first two rows are consistent with those configurations being, for the most part, sufficient for democracy to survive.

Table 2 The completed truth table

DEVELOPED	URBAN	LITERATE	INDUSTRIAL	STABLE	Number	SURVIVED	consist
1	1	1	1	1	3	1	0.884337
1	0	1	0	1	1	1	0.77381
1	0	1	1	1	2	0	0.725352
0	1	1	1	1	1	0	0.675497
0	0	1	0	1	2	0	0.508197
0	0	1	0	0	2	0	0.506173
1	1	1	1	0	1	0	0.392857
1	0	1	1	0	1	0	0.37931
0	0	0	0	1	2	0	0.306977
0	0	0	0	0	3	0	0.225543

So, enter 1 under SURVIVED for the first two rows and a zero on the remainder, as in Table 2. There are now two forms of analysis possible: a *Standard Analysis*, which gives an intermediate solution, and a full analysis which is accessed by clicking on the *Continue* button. Click on *Continue*. You will obtain a *Truth Table Analysis* box that allows you to specify the minimisation process. (The program seems to automatically minimise this box, so you may have to click on the *Truth Table Analysis* box in your *Task Bar* at the bottom of the screen.) For the least parsimonious solution click on the *True* button for *Positive Cases*, on the *False* button for *Negative Cases*, leaving *Don't Care*s, *Contradictions* and *Remainders* excluded from the analysis. The solution is presented in Table 3.

Table 3 The least and most parsimonious solutions

```

fs/QCA
File Analyze Graphs Window
*****
*TRUTH TABLE ANALYSIS*
*****
File: H:\WORDDOCS\Fuzzy sets\DemocFS.dat
Model: SURVIVED = DEVELOPED + URBAN + LITERATE + INDUSTRIAL + STABLE

Least parsimonious solution

                raw      unique
                coverage coverage consistency
-----
DEVELOPED*urban*LITERATE*industrial*STABLE+  0.234940  0.168675  0.773810
DEVELOPED*URBAN*LITERATE*INDUSTRIAL*STABLE  0.442169  0.375904  0.884337
solution coverage: 0.610843
solution consistency: 0.869640

*****
*TRUTH TABLE ANALYSIS*
*****
File: H:\WORDDOCS\Fuzzy sets\DemocFS.dat
Model: SURVIVED = DEVELOPED + URBAN + LITERATE + INDUSTRIAL + STABLE

Most parsimonious solution

                raw      unique
                coverage coverage consistency
-----
DEVELOPED*industrial+  0.248193  0.161446  0.783270
DEVELOPED*URBAN*STABLE  0.454217  0.367470  0.887059
solution coverage: 0.615663
solution consistency: 0.870528

```

This shows that if all five conditions are present, then this is sufficient, for the most part, to ensure the survival of democracy. However, the absence or presence of URBAN or INDUSTRIAL appears to make little difference, so this can be reduced to DEVELOPED, LITERATE and STABLE. For the most parsimonious solution, change *Remainders* to *Don't Care*. The result is shown in the lower half of Table 3. This suggests either DEVELOPED, URBAN and STABLE, or DEVELOPED and not industrial as sufficient configurations. Notice that the solution coverage is 0.61.

If BREAKDOWN is substituted for SURVIVAL (and this is only 1 – SURVIVAL), then a different analysis emerges. In the truth table, there are now 8 configurations with a consistency or over 0.8. The results are shown in Table 4. These are not just a mirror image of Table 3, but show that the conditions leading to the breakdown of democracy are very different from those that are sufficient for survival. Thus, being developed, literate, industrial, but unstable is sufficient to produce democratic breakdown. However, an alternative pathway is being not developed, not urban and not industrial. The most parsimonious solution is perhaps too parsimonious.

Notice, too, that the solution coverage is much higher than for the analysis of survival. Finding sufficient conditions for the breakdown of democracy is more effective than looking for conditions for its survival.

An analysis of necessary conditions shows that the condition of being not developed and the condition of being not urban are separately consistent with necessity with a score of over 0.8

Conditions for the use of fsQCA

FsQCA was designed for use on small-n and medium-n datasets. Since traditional frequentist statistics were designed largely for large-n studies, it is not surprising that most of the applications of fsQCA have been on small-n datasets where the cases are at the macro level – countries, nation-states, geographical areas or large organisations – and thus limited in number and often limited in diversity. However, the approach of fuzzy-set analysis also offers an alternative to traditional frequentist approaches that are centred on variable distributions and the search for patterns of covariation, difference or frequency clusterings. FsQCA can operate with any number of cases and is equally suitable for large-n datasets.

There are, however, circumstances, whatever the size of the sample or population of cases, that lend themselves to the fuzzy-set approach.

1. There are hypotheses or at least justifiable hunches about the underlying causal structure of an outcome being studied.
2. It is expected that the causal structure is complex, equifinal (there are different pathways to an outcome) and conjunctural (conditions are often sufficient only in combination).
3. The researcher wishes to interpret the results in terms of necessary and sufficient conditions.
4. The number of cases is too low for frequentist techniques to be applied.
5. The researcher has good knowledge and understanding of cases and wishes to use it in the entire research process.
6. Careful thought has been given to the definition and measurement of the key concepts.

Table 4 The least and most parsimonious solutions taking BREAKDOWN as the outcome

```

*****
*TRUTH TABLE ANALYSIS*
*****
File: H:/WORDDOCS/Fuzzy sets/DenocFS.dat
Model: BREAKDOWN = DEVELOPED + URBAN + LITERATE + INDUSTRIAL + STABLE

              raw      unique
              coverage  coverage  consistency
-----
developed*urban*industrial+  0.661856  0.597732  0.866397
DEVELOPED*LITERATE*INDUSTRIAL*stable  0.231959  0.127835  0.918367
solution coverage: 0.789691
solution consistency: 0.871445

*****
*TRUTH TABLE ANALYSIS*
*****
File: H:/WORDDOCS/Fuzzy sets/DenocFS.dat
Model: BREAKDOWN = DEVELOPED + URBAN + LITERATE + INDUSTRIAL + STABLE

              raw      unique
              coverage  coverage  consistency
-----
stable+  0.708247  0.117526  0.901575
developed*industrial+  0.697938  0.001031  0.847309
developed*urban  0.739175  0.050515  0.878676
solution coverage: 0.892783
solution consistency: 0.863410

```

An evaluation of fsQCA

The results from fsQCA are very sensitive to the decisions and assumptions the researchers will have made in the process of producing the analysis. These will include the following points.

1. The manner in which variables will have been measured² in the first place. Measures may be direct, indirect, or derived from some arithmetic operation on a number of observations or items in questionnaire, as in deriving a total score from a set of Likert items. Direct measurement, for purposes of fsQCA, may be:
 - made by the researcher from observation or checking documents,

² Ragin (2008b, forthcoming) makes a distinction between measurement and calibration. The former requires only that measures vary in a distribution that relates to the underlying concept. Calibration, by contrast, means attending to the actual metric being used and its interpretation according to external standards. The latter, while common in the physical sciences is neglected in the social sciences, but is required for fuzzy set analysis.

- a result of asking respondents directly for information about themselves, their behaviour or their views, attitudes and opinions,
- asking questions already in fuzzy set form, for example, 'On a scale of one to 10, where 1 means 'not at all', 10 means 'totally' and 5 means 'neither/ undecided/ not sure', to what extent would you say that you are a loyal customer?'

2. The manner in which observations or responses are converted into either crisp sets or fuzzy sets. This may involve taking binary categories and overlaying them with carefully calibrated measures of the extent to which cases are 'in' or 'out' of a set (for example, a 'satisfied' customer) or, for continuous metric scales, it may involve overlaying the scale with conceptually appropriate criteria of what 'full membership', 'partial membership' and 'non-membership' of a set entails (for example, how many units of alcohol per week classify a person as a 'heavy' drinker). Where scores have been derived from summated rating scales like Likert scales, then there will need to some transformation of those scores into degrees of set-membership (see Ragin et al, 2006, the *fsQCA User Guide*, on ways in which this can be achieved). Where individual items on a rating scale are converted into fuzzy scores, then if there is a middle, neutral point (for example, neither agree nor disagree with the item) then these automatically become the crossover point of 0.5, which creates problems for the analysis if many respondents have selected this category.

3. The number of potential causal factors included in a particular run of fsQCA. Any more than 10 or so produces a truth table with many rows, for example 10 conditions will result in 2^{10} or 1024 rows and huge number of combinations to check: $(3^{10} - 1)$ or 59,048 combinations.

4. The number of configurations excluded from the analysis by using a frequency threshold. Thresholds greater than zero, however, are unlikely to be applied unless it is a large-n dataset.

5. The level of consistency chosen as a minimum requirement. Ragin suggests that this will normally be above 0.8, but certainly not less than 0.75. A sensitivity analysis shows that changing the acceptable level of consistency can change the analysis quite considerably. Note that with fuzzy set analysis, there can be no 'contradictions'. Contradiction, whereby some cases in a configuration display different outcomes, will simply lower the consistency score.

6. The assumptions made about 'remainders'. Normally, these will be excluded from the analysis (declared 'false' in the program), but may be included in the sense that whatever assumption is made about a configuration that has no cases (the outcome is true or false, or above/below 0.5 membership in fuzzy sets) is deployed in a way that minimises the complexity of the solution. These are called 'don't care's' in the program.

FsQCA has been criticised for being static and cross-sectional, but it is possible to include a time dimension in several ways.

1. Incorporate directional expectations into simplifying assumptions about remainders.
- 2 Empirically record sequencing of events into a truth table and incorporate sequence A -> B or B -> A into minimisation process (TCQCA).
3. Transform time-series data into QCA format and focus on the cross-temporal variation of the data (TSQCA). There are various ways of doing this.
4. Seeing cases as trajectories in a descriptive sense and looking at changing configurations over time. This has parallels with cohort studies.

In the current version of fsQCA it is possible to enter only one outcome variable in a single analysis. However, several 'passes' at the data can be made with different outcomes and potential conditions. Where the number of cases is limited, for example below 20 or so, then each case is likely to be singularised, that is, will have its own unique configuration. This will be so particularly if more than three causal conditions are employed. With four causal conditions, for example, there will be 16 configurations and perhaps only 16 cases. The result is that few minimisations are

possible (which means that the truth table solution will just describe the data), and there will be many remainders. If these are included as 'don't cares', the analysis will not distinguish between necessary and sufficient conditions. Ragin suggests that the number of causal conditions can be kept low by using higher order concepts that incorporate several variables.

FsQCA, in short, works better if the number of cases is above 30 or so. It will work fine with large-n studies as well. The downside is that the researcher's familiarity with each case declines and some of the benefits of a case-centred approach are lost. FsQCA, in any event, loses the identity of cases as soon as the truth table is reached. It will not, for example, list which countries have the configurations listed in Table 2. They can, however, be deduced from Table 1, so that Belgium, the Netherlands and the UK are the three countries where democracy survived and are developed, urban, literate, industrial and stable.

The output from fsQCA can be very tricky to interpret. There is usually no single result such as would emerge from a multiple regression analysis; instead there may be several different causal expressions, each with its own level of consistency and its own level of coverage. The role played by any particular condition may vary considerably depending on which other conditions it is combined with. The sets of conditions can also change dramatically depending on the frequency threshold and the level of consistency selected in constructing the truth table.

Where all or nearly all the cases possess a causal condition, then that condition automatically becomes necessary, but perhaps in a trivial sense: as in it is necessary for armies to have food and water to win a war. Where all or nearly all the cases manifest the outcome, then most potential conditions become sufficient, but again could be in a trivial manner.

The presentation of results.

The presentation of fsQCA results to an audience often causes problems and misunderstandings, particularly to scholars unfamiliar with this approach (Schneider & Grofman, 2006).

A truth table is an intermediate result of fsQCA analysis and should always be presented wherever possible. Where the number of causal conditions is limited, a presentation of a truth table to an audience can;

- reveal analytic similarities and differences between cases,
- indicate combinations with contradictory outcomes,
- evaluate the limits to diversity - combinations that are not empirically observed.

According to Schneider and Grofman, truth tables should always be reported, but if the number of conditions is large - more than 5 or so - the number of rows in the table becomes unwieldy and unlikely to offer clarification to an audience.

There is no way to print off a truth table directly from fsQCA. However, in the *Edit Truth Table* window, you can save the table (after editing) as a .csv file. Select File/Save As CSV File. This file can then be opened in Excel and copied into Word.

Another form of presentation is the XY plot. This produces a two-dimensional plot of membership scores for each case for the outcome, and for either a single condition or a causal configuration. From the *FS/QCA Data Sheet* select *Graphs/Fuzzy /XY Plot*. In the *Fuzzy-Set XY Plot* screen select your outcome variable from the *Y-Axis* drop-down list, e.g. SURVIVED and a causal condition variable from the *X-Axis* drop-down list. You can also put in a title. Click on *Plot*. By trying all the causal conditions in turn, you can see visually any triangular patterns. These will show any conditions that may tend towards sufficiency or necessity.

To obtain membership scores for a causal combination, it is necessary to create a new variable that records membership scores for that configuration. From the *FS/QCA Data Sheet* select *Variables/Compute*. In the *Target Variable* box, give your new variables a name. e.g. CONFIG5. In the *Functions* box, select *fuzzyand(x,...)* and click on the up arrow to put this expression in the *Expression* box. Now select each of the five causal conditions in turn, putting them into the *Expression* box. Each condition needs to be separated by a comma. Click on *OK* and check your *Data Sheet*. CONFIG5 should appear as the last variable and have given you the minimum set

membership for each of the five causal conditions, for example 0.14 for Austria (this has a membership score of 0.14 for URBAN). You can now use CONFIG5 in an XY plot. The output is shown in Figure 2.

This shows all cases either in the upper triangle or near to it. The important cases with high membership scores on the outcome are all in the upper triangle, giving a high consistency score on sufficiency. Table 2 shows this to be 0.884.

The XY plot cannot be printed directly from fsQCA. It needs first to be saved as a Post Script file (.ps). Click on the *Save* button and select *PostScript file*. Open it in a program that reads .ps files. Alternatively, hit your *Print Screen* button on your keyboard and paste into a Powerpoint slide.

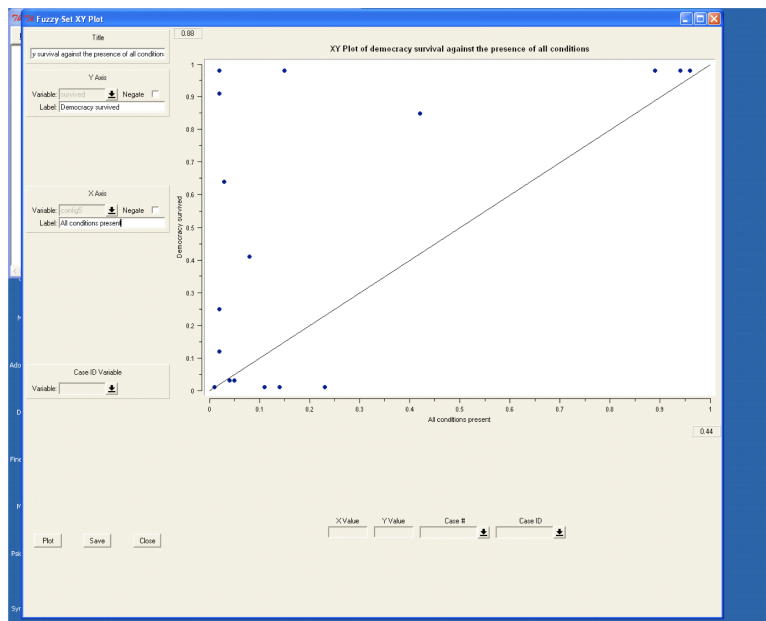


Figure 2 An XY plot of democracy survived by membership score of five causal conditions

The main analysis from fsQCA is a set of equations that offer solutions, with varying degrees of parsimony, concerning configurations that meet the selected criteria for causal sufficiency. The procedure uses the Quine-McClusky algorithm which includes a minimisation procedure, the use of 'prime implicants' and De Morgan's law. The equations appear as a representation of the causally relevant conditions that are linked to the outcome using Boolean operators. The results, however, will vary, sometimes quite radically, depending on the choices made by the researcher in terms of thresholds used for defining remainders, the level of consistency selected for the outcome, and the simplifying assumptions made in respect of remainders. Accordingly, the decisions and assumptions made and the results of any sensitivity analyses should always be presented. A sensitivity analysis showing what happens with different decisions would also be helpful.

The procedure for producing truth table solutions for causal sufficiency is explained above. The solution itself can be directly printed by selecting *File/Print*. Parts of the output not required for presentation purposes can be selected and deleted before printing. There is no Edit/Copy procedure. Required outputs can be selected: whether or not they can be copied depends on the set-up of your mouse. An alternative is to use the *Print Screen* on your keyboard and paste into Powerpoint.

The analysis of necessary conditions is a separate procedure. From the *FS/QCA Data Sheet*, select *Analyze/Necessary Conditions*. You will be asked if you want to save output before closing. Select *Yes*. In the *Select Conditions* window select either *SURVIVED* or *BREAKDOWN* as your outcome, then add the conditions from the *Add Condition* box. Notice that the conditions listed have a different convention for the positive and negative conditions. The negative conditions are indicated as *~stable* for

not stable rather than lower case. You can put in both, but for the most part put whatever you think might be necessary, e.g. ~stable for breakdown or stable for survived. In the output, consistency and coverage is listed for each condition entered.

References

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Ray Kent

Department of Marketing

University of Stirling

Scotland.

r.a.kent@stir.ac.uk

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