The Fuzzy Truth Table Algorithm

1. Create a data set with fuzzy-set membership scores. (Crisp sets may be included among the causal conditions.) The fuzzy sets must be carefully labeled and defined (e.g., degree of membership in the set of “countries with persistently low levels of class voting”). Pay close attention to the calibration of fuzzy membership scores, especially with respect to the three qualitative anchors: full membership, full nonmembership, and the cross-over point. Fuzzy sets are often uni-modal at 1.0 or 0.0, or bimodal at both 0.0 and 1.0. In general, calibration requires good grounding in theoretical and substantive knowledge, as well as in-depth understanding of cases. The procedures described here work best when the 0.5 membership score and membership scores close to 0.5 are used sparingly, preferably not at all, when coding the causal conditions.

2. Input the fuzzy-set data directly into fsQCA or into a program that can save data files in a format compatible with fsQCA (e.g., Excel: comma or tab delimited files; SPSS: tab delimited files; STATA “*.raw” files). Use simple variable names with no embedded spaces or punctuation. These names should appear on the first row of the data file. The data set should include both the outcome and relevant causal conditions. Open the data file using fsQCA version 2.0 or later. (Click *Help* on the start-up screen to identify fsQCA version and date; the most up-to-date version can be downloaded from www.fsqca.com.)

3. Select a preliminary list of causal conditions. In general, the number of causal conditions should be modest, in the range of three to eight. Often causal conditions can be combined in some way to create “macrovariables” using the procedures described in chapter 11 of *Fuzzy Set Social Science*. These macrovariables can be used in place of their components to reduce the dimensionality of the vector space. For example, a single macrovariable might be used to replace three substitutable causal conditions joined together by logical *or*, which dictates using their maximum membership score. (In the *Data Sheet* window of fsQCA, click *Variables*, then *Compute*, and then use the *fuzzyor* function to create this type of macrovariable.)

4. Create a truth table by specifying the outcome and the causal conditions. In fsQCA this function is accessed by clicking *Analyze*, *Fuzzy Truth Table Algorithm*. The resulting truth table will have 2^k rows, reflecting the different corners of the vector space defined by the k causal conditions. (The 1s and 0s for the causal conditions identify the different corners of the vector space defined by the causal conditions.) For each row, the program reports the number of cases with greater than 0.5 membership in the vector space corner (in the column labeled *number*). Two columns to the right of *number* is a column labeled *raw consist*, the consistency measure assessing the degree to which membership in each corner is a subset of membership in the outcome. ("*PRI consist"* is an alternate measure of consistency; "*SYM consist*" is another version of "*PRI consist*.").

5. The researcher must select a frequency threshold to apply to the data listed in the *number* column. When the total number of cases included in a study is relatively small, the frequency threshold should be 1 or 2. When the total *N* is large, however, a more substantial threshold should be selected. It is very important to inspect the distribution of the cases when deciding upon a frequency threshold. This can be accomplished simply by clicking on any cell in the *number* column and then clicking the *Sort* menu and then *Descending*. The resulting list of the number of cases with greater than 0.5 membership in each corner will provide a snapshot of the distribution and also may reveal important discontinuities or gaps. After selecting a threshold, delete all rows that do not meet it. This can be accomplished (for tables that have been sorted according to *number*) by clicking on the first case that falls below the threshold (in the *number* column), clicking the *Edit* menu, and then clicking *Delete current row to last*. The truth table will now list only the corners of the vector space that meet the frequency threshold.

6. Next is the selection of a consistency threshold for distinguishing causal combinations that are subsets of the outcome from those that are not. This determination is usually made using the measure of set-theoretic consistency reported in the *raw consist* column. In general, values below 0.75 in this column indicate substantial inconsistency. It is always useful to sort the consistency scores in descending order so that it is possible to evaluate their distribution. This should be done *after* rows that fall below the frequency threshold have been deleted from the table (step 5). Click on any value in the *raw consist* column; click the *Sort* menu; and then click *Descending*. Identify any gaps in the upper range of consistency that might be useful for establishing a threshold, keeping in mind that it is always possible to examine several different thresholds and assess the consequences of lowering and raising the consistency cut-off. Often, it is useful to present two analyses, one with a relatively low consistency threshold (e.g., around 0.8) and another with a relatively high consistency threshold (e.g., around 0.9).

7. Next, manually input 1s and 0s into the empty *outcome* column, listed to the left of the *raw consist* column. Using the threshold value selected in the previous step, enter a value of 1 when the consistency value meets or exceeds the consistency threshold and 0 otherwise. If the truth table spreadsheet has many rows, code the outcome column using the *Delete and code* function in the *Edit* menu.

8. Click the *Standard Analyses* button at the bottom of the screen to produce three solutions: the complex, the parsimonious, and the intermediate. The intermediate solution is based on information about the causal conditions that the user inputs, reflecting his or her substantive knowledge.

QCA PROCEDURE ("Standard Analyses")

	Should contribute to Y when cause is:		
	Present	Absent	Present or Absent
Causal Condition:			
a	0	0	0
c	0	0	0
s	0	0	0
i	0	0	0
r	0	0	0

This dialogue box, in effect, makes it possible for you to input your theoretical and substantive knowledge, with respect to the links between causal conditions and the outcome. The impact is to permit the use of "easy" counterfactual cases, which in turn make it possible to remove counterintuitive elements from the complex solutions (provided that these removals do not violate the parsimonious solution).

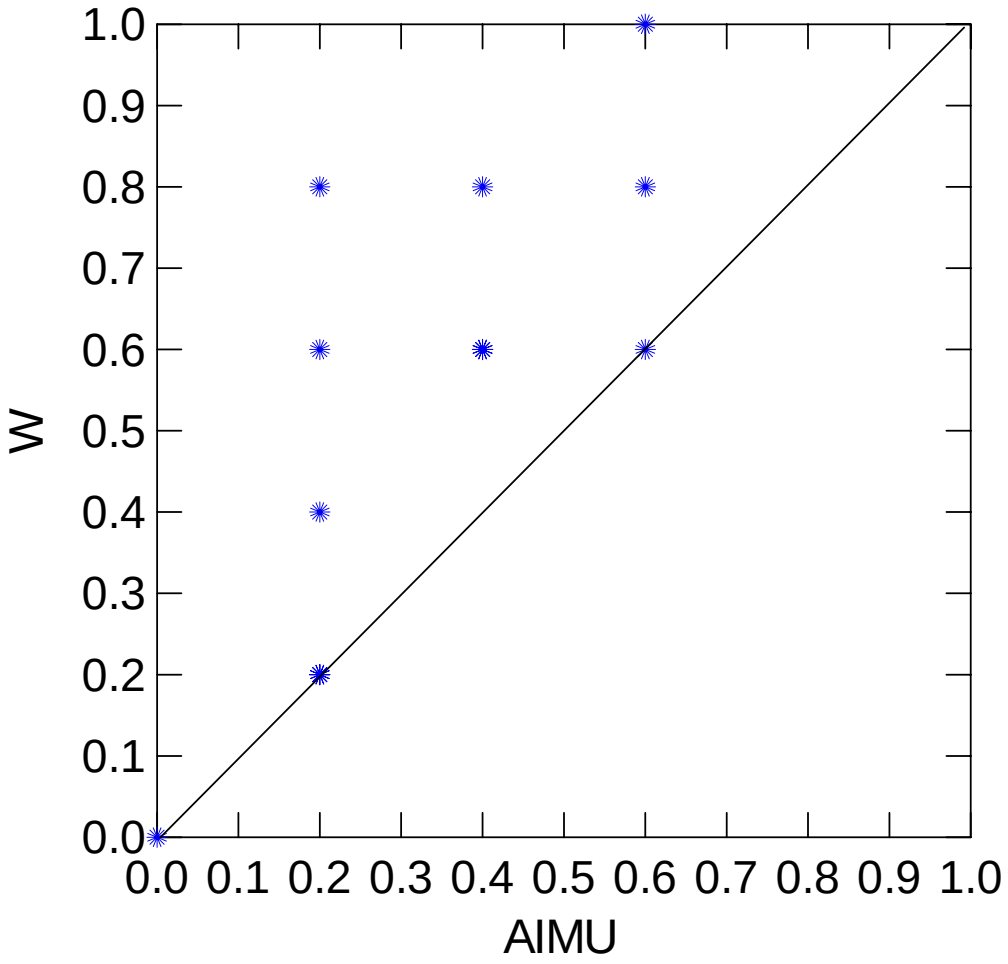
Fuzzy-set data on class voting in the advanced industrial societies

Country	Weak class voting (**W**)	Affluent (**A**)	Income inequality (**I**)	Manufacturing (**M**)	Strong unions (**U**)
Australia	0.6	0.8	0.6	0.4	0.6
Belgium	0.6	0.6	0.2	0.2	0.8
Denmark	0.2	0.6	0.4	0.2	0.8
France	0.8	0.6	0.8	0.2	0.2
Germany	0.6	0.6	0.8	0.4	0.4
Ireland	0.8	0.2	0.6	0.8	0.8
Italy	0.6	0.4	0.8	0.2	0.6
Netherlands	0.8	0.6	0.4	0.2	0.4
Norway	0.2	0.6	0.4	0.6	0.8
Sweden	0.0	0.8	0.4	0.8	1.0
UK	0.4	0.6	0.6	0.8	0.6
US	1.0	1.0	0.8	0.4	0.2

Assessing the distribution of cases across combinations of causal conditions

Country	a.i.m.u	a.i.m.U	a.i.M.u	a.i.M.U	a.I.m.u	a.I.m.U	a.I.M.u	a.I.M.U	A.i.m.u	A.i.m.U	A.i.M.u	A.i.M.U	A.I.m.u	A.I.m.U	A.I.M.u	A.I.M.U
1.Australia	.200	.200	.200	.200	.200	.200	.200	.200	.400	.400	.400	.400	.400	.600	.400	.400
2.Belgium	.200	.400	.200	.200	.200	.200	.200	.200	.200	.600	.200	.200	.200	.200	.200	.200
3.Denmark	.200	.400	.200	.200	.200	.400	.200	.200	.200	.600	.200	.200	.200	.400	.200	.200
4.France	.200	.200	.200	.200	.400	.200	.200	.200	.200	.200	.200	.200	.600	.200	.200	.200
5.Germany	.200	.200	.200	.200	.400	.400	.400	.400	.200	.200	.200	.200	.600	.400	.400	.400
6.Ireland	.200	.200	.400	.400	.200	.200	.400	.600	.200	.200	.200	.200	.200	.200	.200	.200
7.Italy	.200	.200	.200	.200	.400	.600	.200	.200	.200	.200	.200	.200	.400	.400	.200	.200
8.Netherlands	.400	.400	.200	.200	.400	.400	.200	.200	.600	.400	.200	.200	.400	.400	.200	.200
9.Norway	.200	.400	.200	.400	.200	.400	.200	.400	.200	.400	.200	.600	.200	.400	.200	.400
10.Sweden	.000	.200	.000	.200	.000	.200	.000	.200	.000	.200	.000	.600	.000	.200	.000	.400
11.United Kingdom	.200	.200	.400	.400	.200	.200	.400	.400	.200	.200	.400	.400	.200	.200	.400	.600
12.United States	.000	.000	.000	.000	.000	.000	.000	.000	.200	.200	.200	.200	.600	.200	.400	.200
13.Number > 0.5	0	0	0	0	0	1	0	1	1	2	0	2	3	1	0	1

Plot of Weak Class Voting (W) Against Membership in A•I•m•u



Consistency = 1.0

(The X axis is degree of membership in A*I*m*u)

Assessing the consistency of causal combinations with the fuzzy subset relation

Affluence	Inequality	Manufacturing	Unions	Consistency	Outcome
1	0	0	0	1.00	1
1	1	0	0	1.00	1
0	1	1	1	0.87	0
1	1	0	1	0.84	0
0	1	0	1	0.82	0
1	0	0	1	0.79	0
1	1	1	1	0.78	0
1	0	1	1	0.72	0

The complex solution is A•~M•~U. The parsimonious solution is ~U.

Crisp-set data on class voting in the advanced industrial societies

Country	Weak class voting (**W**)	Affluent (**A**)	Income inequality (**I**)	Manufacturing (**M**)	Strong unions (**U**)
Australia	1	1	1	0	1
Belgium	1	1	0	0	1
Denmark	0	1	0	0	1
France	1	1	1	0	0
Germany	1	1	1	0	0
Ireland	1	0	1	1	1
Italy	1	0	1	0	1
Netherlands	1	1	0	0	0
Norway	0	1	0	1	1
Sweden	0	1	0	1	1
UK	0	1	1	1	1
US	1	1	1	0	0

The crisp-set solution is: ~U + ~A + I•~M