

# Using multi-valued outcomes with MVQCA TOSMANA Technical Note #2

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## **Abstract**

The use of multi-valued outcomes with MVQCA has caused some confusion as these outcomes are used within MVQCA in a way which seems non-intuitive. This Technical Note explains how multi-valued outcomes are handled by the implementation of MVQCA in TOSMANA and shows how to use multi-valued outcomes correctly.

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## 1 Introduction

*MVQCA* (Multi-Value QCA) is an extension of *QCA* (Qualitative Comparative Analysis) first presented by Charles Ragin in his book “The Comparative Method” (Ragin, 1987). The main goal of *MVQCA* is to remove the compulsory use of dichotomous scores in *QCA* by incorporating the use of multi-valued conditions.<sup>1</sup>

While the (possible but not mandatory) use of multi-valued conditions (independent variables) is easy understandable for researchers aware of the main principles behind *QCA*, the possibility to use multi-valued outcomes in the *TOSMANA* software has caused some misunderstandings.

Although *TOSMANA* allows to work with outcomes based on multi-valued data, the outcomes of the logical configurations used to calculate the prime implicants are defined as in *QCA*. Before starting the calculation in the software, the researcher still has to explicitly define which outcome values should be reduced in the solution and which outcome values are to be excluded.<sup>2</sup>

In this technical note it will first be explained how multi valued outcomes are used during *MVQCA* calculations. In the second part of this note it will then be explained how multi-valued outcomes should be used within *TOSMANA* (Cronqvist, 2006) to ensure a intuitive use of these more fine scaled outcomes.

## 2 The Problem

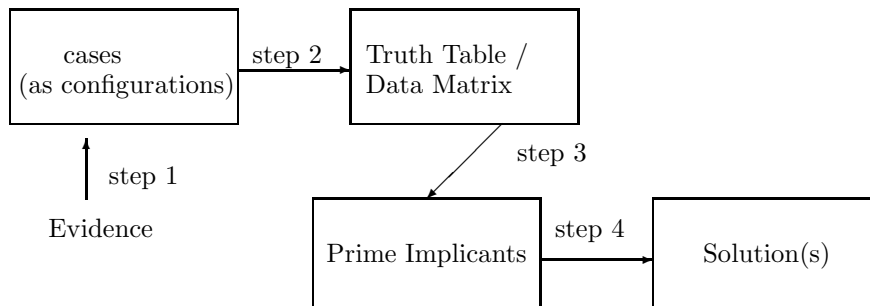
The problem caused by the use of multi-valued outcomes is rooted in the various steps performed while calculating the solutions of a (MV)QCA analysis. Based on the ideas of Quine (1952) and McCluskey (1956), prime implicants are extracted from the truth table (step 3 in Figure 1) and then combined to the shortest possible

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<sup>1</sup>A short introduction to *MVQCA* can be found in Cronqvist (2003) and Cronqvist (2005). The article of Berg-Schlosser and Cronqvist (2005) contrasts the use of *MVQCA* to *QCA* and diverse statistical procedures.

<sup>2</sup>Similar to *QCA*, it also has to be decided how logical remainders and contradictions are to be handled by the algorithm.

Table 1: Steps in a (MV)QCA analysis



solution(s) (step 4).

In QCA a truth table is created, grouping the prepared cases with the same values of the conditions and assigning these logical configurations an outcome value (step 2). If all cases with the same logical configuration do have the same value for the outcome, the outcome of the logical configuration corresponds to the observed outcome value of the cases. If cases with the same logical configuration do have contradicting outcomes, the outcome of the logical configuration is set to  $C$  (contradiction).<sup>3</sup>

The same steps are performed in MVQCA: First a data matrix is constructed grouping cases with the same configuration of conditions together.<sup>4</sup> To find the outcome value of a configuration, the same rule is applied as with QCA: If all cases in a logical configuration share the same outcome value, the outcome value of the configuration corresponds to the observed outcome value of the cases. If the outcomes differ, the outcome is set to  $C$  (contradiction).

For a multi-valued outcome the user has to specify with which outcome value(s) configurations in the data matrix are included in the result (*reduce* setting in TOSMANA) and for which outcome value(s) configurations are excluded (*exclude*). Also, it is possible

<sup>3</sup>If a case does not share its logical configuration with any other case, this case is found in a separate logical configuration. As “all” cases in this configuration have the same outcome, the outcome of the logical configuration is set to the outcome of the case.

<sup>4</sup>Strictly speaking, the term *truth table* can not be used in a multi value environment, as this term refers to a data matrix just consisting of Boolean values (every value is either *true* or *false*).

to define outcome values with which configurations are considered as don't cares (*include for reduction*). The prime implicants are then calculated by minimising all configurations with an outcome selected to be *in* the solution (including logical remainders if desired).

The problem which makes the search for prime implicants to appear non-intuitively is caused by the way in which the data matrix is calculated (step 2 in Figure 1). Logical configurations with cases sharing the same conditions but with different outcomes will be coded contradicting when creating the data matrix, even if the contradicting outcome values are all included for reduction.

While different outcome values predefined to be in the solution are all used to find prime implicants in step 3 of the MVQCA analysis, they do create a contradiction in step 2 if two (or more) cases with a different outcome value are found in cases with similar configurations while constructing the data matrix. This means that specific combinations are excluded from the analysis as they are (technically defined) contradictions, although they might be of substantial interest for the analysis.

An example should make this clear: Consider the data set in Table 2 with two dichotomous conditions ( $X, Y$ ) and one three stepped Outcome ( $O$ ) for which do want to calculate the solution explaining the values 0 and 1 for  $O$  excluding value 2.

Table 2: Example data set

case	$X$	$Y$	$O$
$a_1$	0	0	0
$a_2$	0	0	1
$a_3$	0	1	1
$a_4$	1	0	2
$a_5$	1	1	2

For this data set a data matrix of configurations as found in Table 3 is computed.

For the configuration  $X_0Y_0$  containing the cases  $a_1$  and  $a_2$  a contradiction is coded although the outcome values of both cases are to be included in the solution. The solution found is  $O_{0,1} = X_0Y_1$ .

Table 3: Data Matrix of configurations for the data in Table 2

cases	$X$	$Y$	$O$
$a_1, a_2$	0	0	<b>C</b>
$a_3$	0	1	1
$a_4$	1	0	2
$a_5$	1	1	2

Intuitively, it would have been appropriate to include the configuration  $X_0Y_0$  in the solution as all cases in this configuration do have outcome values included in the solution. This would have led to the solution  $O_{0,1} = X_0$ .

**Summary: The outcome of a logical configuration containing two or more cases is set to contradicting if the outcome values of the cases in this configuration are contradicting, even if these contradicting values of the outcome all are to be included in the solution.**

### 3 Recoding multi-valued outcomes

It should be noticed that the scenario sketched out above is not very likely to happen. Especially when using MVQCA with a larger number of conditions it is likely that a separate configuration is created for every case in the data matrix, which means that no contradictions can occur. But this does not entirely exclude the risk of such “unwanted” contradictions, and they are likely to occur with the use of fewer variables (as shown above).

The problem can be solved by explicitly recoding the outcome, assigning each case a new outcome value indicating if the case is to be included in the solution or not. If, for example, the outcomes 0 and 1 should be included in a solution for the data set found in Table 2, a new (dichotomous) variable  $O'$  should be added, assigning one value for  $O'$  (here: 0) to the cases with the values 0 and 1 of  $O$ , and assigning an other value (here: 1) for the value 2 of  $O$ . This would result in the extended data set found in Table 4.

Table 4: Extended example data set

case	$X$	$Y$	$O$	$O'$
$a_1$	0	0	0	0
$a_2$	0	0	1	0
$a_3$	0	1	1	0
$a_4$	1	0	2	1
$a_5$	1	1	2	1

Compiling the data set in Table 4 into a data matrix of configurations results in Table 5.

Table 5: Data Matrix of configurations for the data in Table 4

cases	$X$	$Y$	$O'$
$a_1, a_2$	0	0	<b>0</b>
$a_3$	0	1	1
$a_4$	1	0	2
$a_5$	1	1	2

The solution for the recoded outcome 0 (containing  $O$  values 0 and 1) is  $O'_0 = X_0$ .

**Summary: To avoid contradictions in configurations containing cases with outcome values which are all set to be covered by the solution, multi-valued outcome variables should be recoded to a dichotomous outcome explicit defining which outcome values to be reduced and which outcome values to be excluded.**

Two tools are included in the TOSMANA software to ease the recoding of data. If the multi-value outcome is scaled ordinal, the thresholdsetter can be applied to recode the outcome to a dichotomous variable. If the outcome is not scaled ordinal, and, for example, values 0 and 2 are included in a solution excluding outcome value 1, a new variable should be created using the *recode* facility of the TOSMANA software. Please refer to the TOSMANA manual found on the website [www.tosmana.net](http://www.tosmana.net) for details.

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