University of Bamberg

Introduction to Qualitative Comparative Analysis (QCA)

Morning Session: The Basics of QCA as an Approach

IUSF-TIAS Autumn School on 'Concepts, Frameworks and Methods for the Comparative Analysis of Water Governance'

Jülich, Germany, November 3rd, 2015

What is Qualitative Comparative Analysis?

"QCA is both a research approach and a data analysis technique"…

> "The plausibility of findings from a QCA *as a technique* much depends on the quality of the work done before and after the analysis, i.e., QCA *as a research approach*"

(Schneider and Wagemann, 2012, p.13).

QCA as a Research Approach

Qualitative Comparative Analysis as an approach is…

- Case-based/oriented
- Comparative
- Set-theoretic

QCA as a Research Approach

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It strives to

"gather in-depth insight in the different cases and capturing the complexity of the cases"

(Rihoux and Lobe, 2009)

QCA as a Research Approach

Qualitative Comparative Analysis as an approach is…

- Case-based/oriented
- Comparative
- Set-theoretic

It strives to

> "gather in-depth insight in the different cases and capturing the complexity of the cases"

and to

> "produce some level of generalization"

(Rihoux and Lobe, 2009)

QCA as a Research Approach

Qualitative Comparative Analysis as an approach is…

- Case-based/oriented
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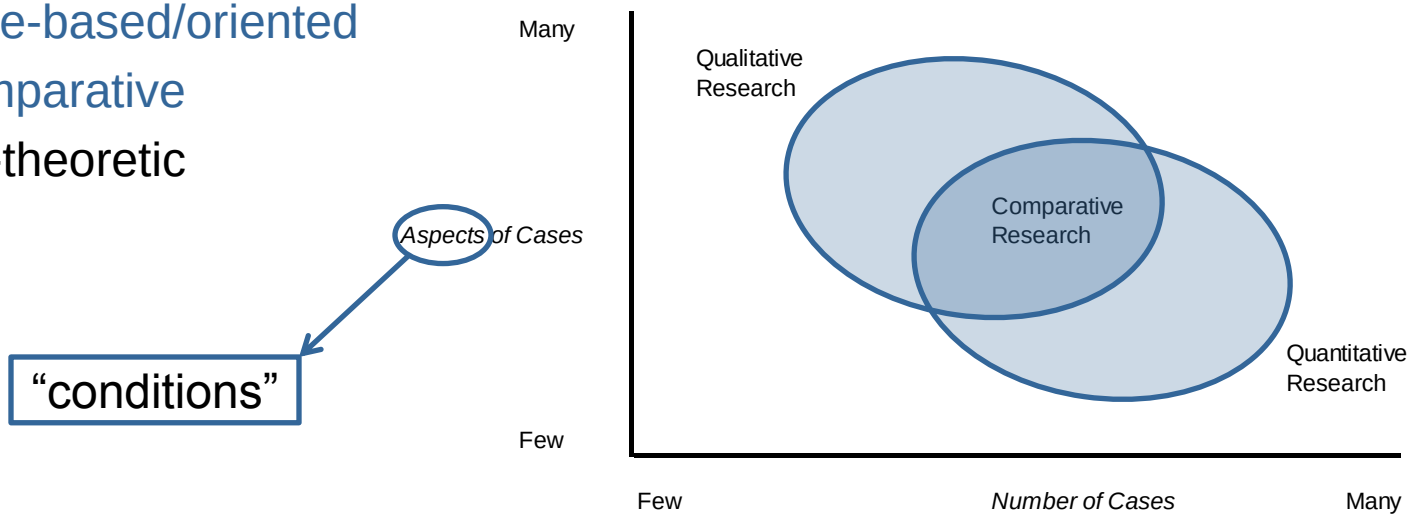
- Set-theoretic



Graph: Adapted From Ragin (1994) Constructing Social Research

QCA as a Research Approach

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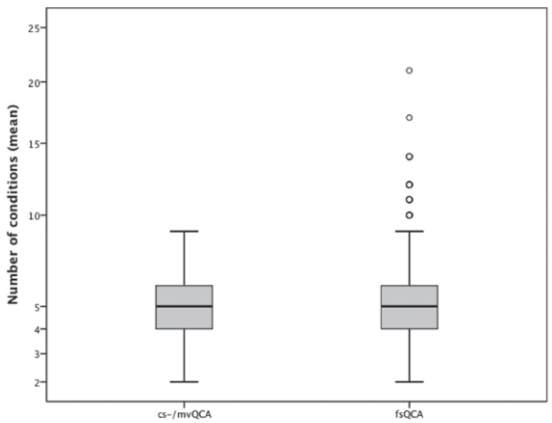
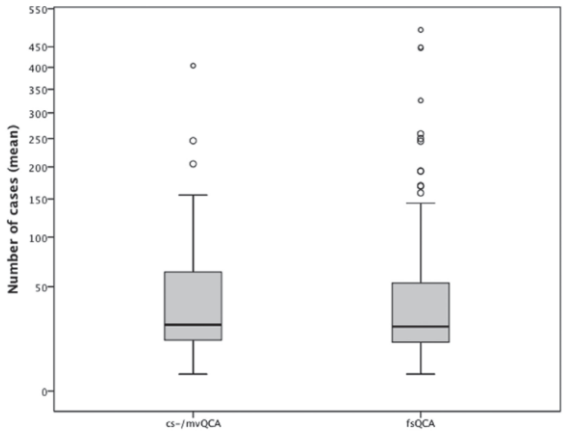
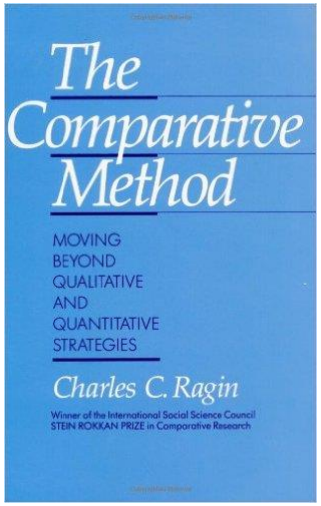




Graphs: Rihoux et al. (2013) in 'Political Research Quarterly'

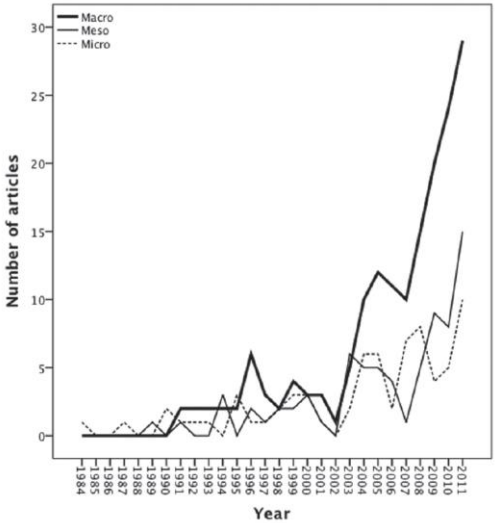
QCA as a Research Approach



"QCA was mostly developed for applications in political science (…) and historical sociology (…)" where "the maximum number of [such] cases is of necessity limited."

(Berg-Schlosser et al., 2009, p.2-3)

- Macro-, meso-, and micro-level



Graph: Rihoux et al. (2013) in 'Political Research Quarterly'
Book: Ragin (1987) The Comparative Method: Moving Beyond Qualitative and Quantitative Strategies

QCA as a Research Approach

QCA formalizes and systematizes case comparison, and this has a huge advantage:

> "The problem is that, when it comes to comparing more than, say, two or three cases, *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 (…)."

(Rihoux and Lobe, 2009)

QCA as a Research Approach

Jonathan Aus even put it like this:

> "There can be no doubt that 'thick descriptions', as for instance employed in anthropology, may contribute to a better understanding of human behavior in specific social contexts. Yet the interpretation of data gathered in a theoretical vacuum remains largely intuitive (…). Nevertheless, most case studies (…) could maliciously be qualified as atheoretical '*data dumps*'."

(Aus, 2009, p.175)

QCA as a Research Approach

However,

> "*The empirical argument must be subordinated to the theoretical argument*. Even if researchers are confronted with a medium-N dataset, *the use of QCA would not be appropriate if there are no explicit expectations about set relations*.
>
> Likewise, the use of QCA would be appropriate even if the N is large if, and only if, researchers are interested in set relations rather than correlations."

(Schneider and Wagemann, 2012, p.13).

QCA as a Research Approach

QCA is fundamentally different from regressional analytical methods. Inter alia,

Causal inference in regressional analytic methods, e.g.:

The more of *X*, the more of *Y*

The less of *X*, the less of *Y*

Causal inference in QCA, inter alia:

If *X{1}*, then *Y{1}* $X\{1\} \Rightarrow Y\{1\}$

Only if *X{1}*, then *Y{1}* $X\{1\} \Leftarrow Y\{1\}$

See for the full argument: Thiem, Baumgartner, and Bol (2015) in 'Comparative Political Studies'

QCA as a Research Approach

Qualitative Comparative Analysis as an approach is…

- Case-based/oriented
- Comparative
- Set-theoretic

"Set-theoretic methods operate on membership scores of elements in sets; causal relations are modeled as subset or superset relations; *necessity* and *sufficiency* or *INUS* (…) are at the center of attention.
The use of set theory focusses attention on unraveling causally complex patterns in terms of *equifinality*, *conjunctural causation*, and *asymmetry*."

Quote: Schneider and Wagemann (2012, p.8)

Set-Theory and Complex Causality

QCA is set-theoretic and geared to analyzing complex causality

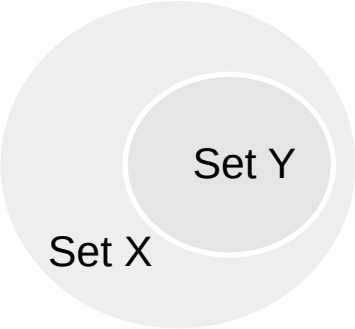
- Necessity
- Sufficiency
- INUS

The condition *X* has to be present for the outcome *Y* to occur; without *X*, *Y* cannot occur

Only if *X{1}*, then *Y{1}*

This means that *Y* <u>implies</u> *X*

$$X\{1\} \Leftarrow Y\{1\}$$



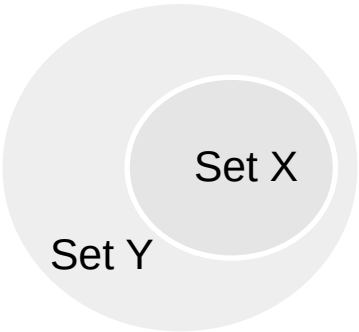
The outcome *Y* is a subset of the condition *X*

Set-Theory and Complex Causality

QCA is set-theoretic and geared to analyzing complex causality

- Necessity
- Sufficiency
- INUS

The condition *X* can produce the outcome *Y* by itself; with *X*, *Y* can occur



If *X{1}*, then *Y{1}*

This means that *X* <u>implies</u> *Y*

$$X\{1\} \Rightarrow Y\{1\}$$

The condition *X* is a subset of the outcome *Y*

Set-Theory and Complex Causality

QCA is set-theoretic and geared to analyzing complex causality

- Necessity and
- Sufficiency
- INUS

Y cannot occur without *X*, and only *X* can produce *Y*

This means that *X* implies *Y* and *Y* implies *X*

$$X\{1\} \Leftrightarrow Y\{1\}$$

The condition set *X* and the outcome set *Y* perfectly overlap

Set-Theory and Complex Causality

QCA is set-theoretic and geared to analyzing complex causality

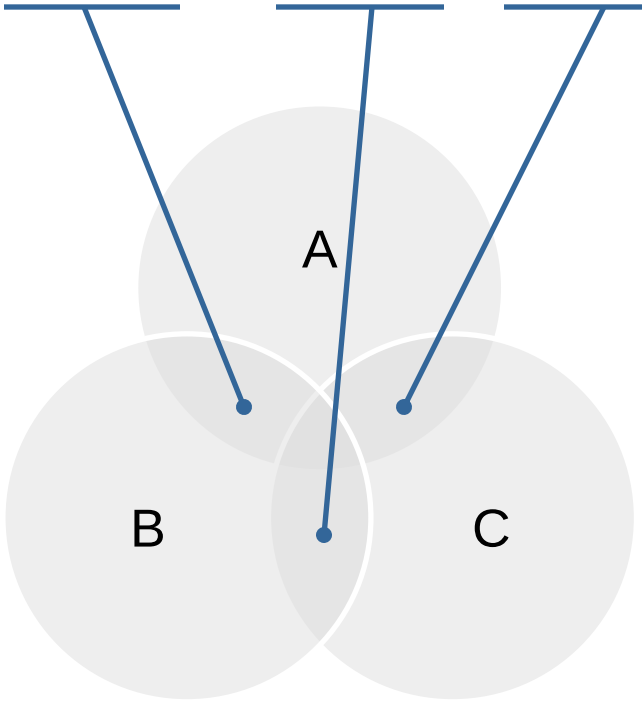
- Necessity
- Sufficiency
- INUS

A condition is INUS if it is insufficient for producing the outcome on its own, but a necessary part of a conjunction that is unnecessary but sufficient for producing the outcome

- For example: A*B*~C + ~A*B*C + A*~B*C $\Rightarrow$ Y

Set-Theory and Complex Causality

$$A*B*{\sim}C + {\sim}A*B*C + A*{\sim}B*C \Rightarrow Y$$



Equifinality [Logical OR]

Multiple conditions (or ‘paths’ / configurations) can produce the outcome

Conjunctural causation [Logical AND]

Combinations of conditions produce an outcome

Asymmetry

Presence of a condition for Y does not imply absence of that condition for ~Y

QCA as a Research Approach

To recap, Qualitative Comparative Analysis as an approach is…

- Case-based/oriented
- Comparative
- Set-theoretic

The latter implies understanding causality as being complex in terms of:

- Equifinality
- Conjunctural causation
- Asymmetry

QCA as a Research Approach

So, how does a QCA research process look like?

> "In the process of configurational comparative analysis, the researcher engages in a dialogue between cases and relevant theories."
>
> (Berg-Schlosser et al., 2009, p.6)

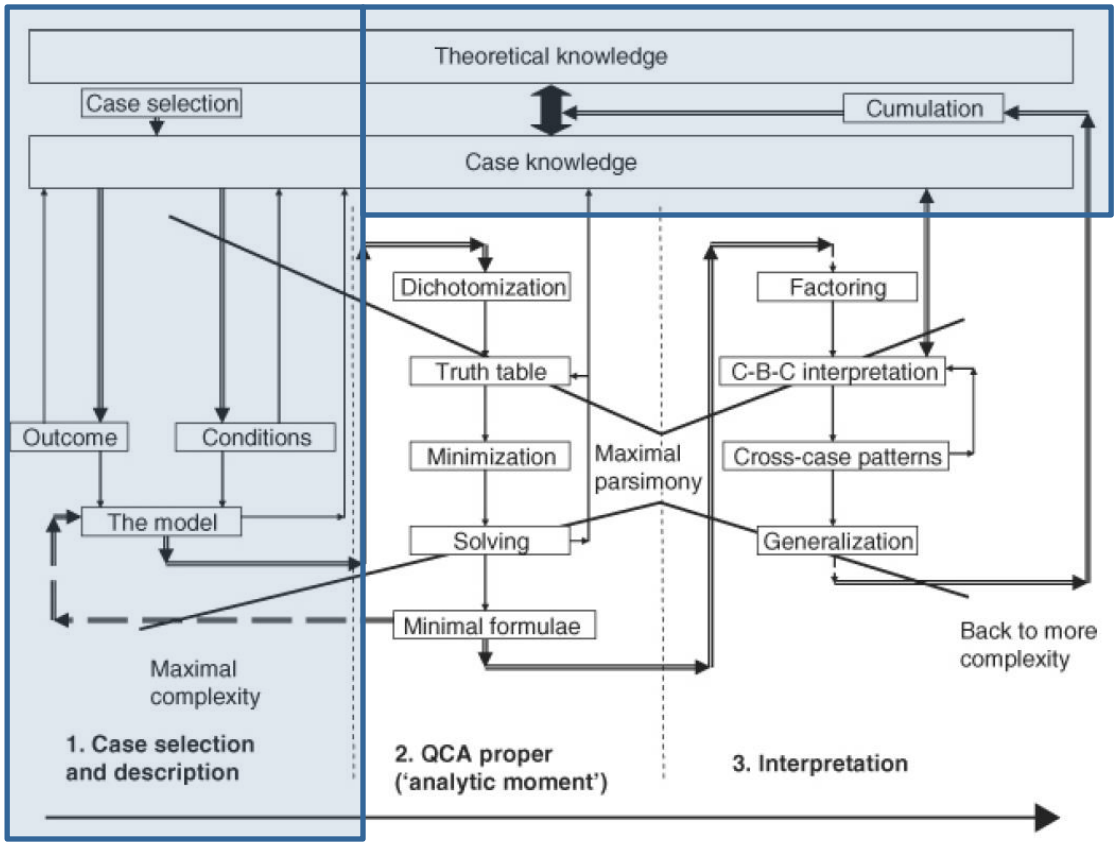
Put differently:

> "…a dialogue between evidence and ideas."
>
> (Ragin, 1987)

Or:

> "…iterative movements between induction and deduction…"
>
> (Gerrits and Verweij, 2013, p.176)

QCA as a Research Approach



Graph: Rihoux and Lobe (2009) in Byrne and Ragin (2009)

Source: Verweij et al. (2013) in 'Public Administration'

Example 1

1. We formulated a research question…
2. Drafted a theoretical framework and operationalized our conditions…
3. Selected our cases, and collected and coded our data…
4. Constructed a data matrix and analyzed the matrix with QCA techniques and software…
5. Interpreted the results of our analysis...

public administration

doi: 10.1111/padm.12007

WHAT MAKES GOVERNANCE NETWORKS WORK? A FUZZY SET QUALITATIVE COMPARATIVE ANALYSIS OF 14 DUTCH SPATIAL PLANNING PROJECTS

STEFAN VERWEIJ, ERIK-HANS KLIJN, JURIAN EDELENBOS AND ARWIN VAN BUUREN

Many studies have been conducted to determine the conditions that contribute to the satisfactory outcome of decision-making processes in governance networks. In this article, we explore how the interaction of three such conditions – network complexity, network management, and stakeholder involvement – results in stakeholder satisfaction. We use fuzzy set qualitative comparative analysis – a relatively new approach in public administration research – to systematically compare the decision-making processes and outcomes of 14 Dutch spatial planning projects. Our analysis points to three combinations that result in stakeholder satisfaction: network complexity combined with adaptive management; stakeholder involvement combined with adaptive management; and low complexity combined with both limited stakeholder involvement and closed network management.

INTRODUCTION

Public administration-related decision-making often takes place in networks (Rittel and Webber 1973; Kickert *et al.* 1997; Agranoff and McGuire 2001; Mandell 2001; Provan *et al.* 2009; Turrini *et al.* 2010). These governance networks consist of interdependent actors with different values, interests, and strategies (Koppenjan and Klijn 2004) and collective decisions have to be achieved by coordinating the actions of these actors, who make their own strategic choices. The complexity of the endeavour raises the question of how governance networks can be controlled to realize satisfactory outcomes for all actors involved.

Various researchers have explored the conditions that influence decision-making in networks and contribute to the achievement of good outcomes. These factors include the management of processes (Meier and O'Toole 2001, 2007; Klijn *et al.* 2010a), the embeddedness of actors in networks (Huang and Provan 2007; Provan *et al.* 2009), stakeholder involvement (Edelenbos *et al.* 2010), and factors such as trust (Klijn *et al.* 2010b). In this article, we analyze a combination of three conditions that have been singled out as important factors that influence the outcome of decision-making processes in governance networks: (1) the complexity of the network; (2) stakeholder involvement; and (3) network management. We are interested in analyzing the *combined effect* of these conditions in producing stakeholder satisfaction in governance networks.

The literature on governance networks and processes suggests that outcomes are produced by multiple conditions. Single case or small-N studies (Le Galès 2001; Agranoff and McGuire 2003; Marcussen and Torfing 2007) are useful for studying the conditions that hold sway in the decision-making processes because they allow us to analyze the combined impact of various conditions. However, the explanatory power is limited to the cases studied. At the same time, quantitative studies with larger samples (Meier and O'Toole 2007; Edelenbos *et al.* 2010; Klijn *et al.* 2010a), that are more suitable for generalizability, are also limited because they cannot account for how the conditions

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Public Administration Vol. 91, No. 4, 2013 (1035–1055)

Source: Verweij et al. (2013) in 'Public Administration'

Example 1

After operationalization, case collection and coding of the data…

WHAT MAKES GOVERNA

TABLE 1 *The 14 cases and their key characteristics*

Case	Abbr.	Period	Main issues
Wieringerrandmeer	WIER	1998–2009	Creating a lake and dwellings to enhance tourism and create better economic conditions for the ar
Zuidplaspolder	ZUID	2001–to date	Redeveloping a *polder* finding space for ext dwellings, water storage, and glass houses.
Noordwaard	NOORD	2005–to date	Realizing water safety creating a retention while also pursuing agricultural, econom and ecological goals
Dijkteruglegging Lent	LENT	2005–to date	Water safety project combining urban development with w quality improvemen the city.
Waalblok	WAAL	2006–10	Realizing the water retention capacity ar reconstruction of greenhouse area.
Nieuwe Hollandse Waterlinie (Dieldijk)	DIEF	2007–11	Strengthening and restructuring a long whilst retaining its historical character.
Ijsseldelta Zuid	IJSS	2000–to date	Creating more space fo the river Ijssel, combined with natu development and ar expansion of dwellin in the city of Kampe
Perkpolder	PERK	1999–2009	Revitalizing an agricultural area, housing and nature development, and coastal reinforcemen

Public Administration Vol. 91, No. 4, 2013 (1038–1055)
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TABLE 6 *Raw data matrix*

	Conditions			Outcome
Case	C	I	M	O
WIER	0.67	0.33	0.00	0.33
ZUID	0.67	0.67	1.00	0.67
NOORD	0.67	1.00	1.00	0.67
LENT	0.67	0.67	0.00	0.67
WAAL	0.33	1.00	0.00	0.67
DIEF	0.00	0.33	0.00	0.67
IJSS	0.67	0.67	1.00	0.67
PERK	0.67	0.33	1.00	0.67
SIJT	0.67	0.67	1.00	1.00
SCHEL	0.67	0.67	0.33	0.33
DELFT	0.67	0.33	1.00	0.67
WEST	0.67	1.00	0.67	0.67
GOUW	0.33	0.67	0.00	0.33
BROEK	0.33	0.67	0.67	0.67

Notes: C = network complexity; I = stakeholder involvement; M = management; O = outcome stakeholder satisfaction.

SIJT	SCHEL	DELFT	WEST	GOUW	BROEK
1.00	0.67	0.67	0.67		
	0.67	0.67			
	0.33	1.00	0.67		
1.00	0.00	1.00	1.00	0.00	0.33
0.67	0.00			0.00	0.67
1.00	0.33	1.00	0.67	0.33	0.67
	0.00		0.00		0.67
1.00	1.00	1.00	1.00		
0.67	0.00	1.00	0.00		0.67
	0.00			1.00	
1.00		0.67			
	1.00	0.67	1.00		
0.89	0.37	0.83	0.57	0.44	0.59
1.00	0.33	0.67	0.67	0.33	0.67

eholders (excluding the managers of the case, see table A6)
0 is smaller (0.165) than that of the categories 0.33 and 0.67

WHAT MAKES GOVERNANCE NETWO

Source: Verweij (2015) Ph.D. Thesis, Erasmus University Rotterdam

Example 2

1. We formulated a research question…
3. Drafted a theoretical framework and operationalized our conditions…
2. Selected our cases, and collected and coded our data…
4. Constructed a data matrix and analyzed the matrix with QCA techniques and software…
5. Interpreted the results of our analysis...

Source: Verweij (2015) Ph.D. Thesis, Erasmus University Rotterdam

Table 5.1 Events in the A15 highway project (continued)

ID	Brief description
EXP	In a nearby project commissioned by the Municipality of Rotterdam, an explosives risk zone was discovered through a standard so-called NGE-investigation into unexploded WWII explosives. The results of the investigation contradicted the previous NGE-investigation for the A15 highway project. Consequently, owners of Pipeline Corridor-2 demanded additional NGE-investigations for the A15 highway project.
GRO	The ground conditions near Pipeline Corridor-1 appeared more problematic than expected. During the piling works, the ground moved thereby exerting too much pressure on the cables and pipelines in the corridor.
HBR1	It was agreed upon by RWS and the HbR that the latter would become the owner of the new to be built Oudeland Viaduct by A-Lanes. When A-Lanes finished the design according to the requirements in the contract with RWS, the HbR – backed-up by the Municipality of Rotterdam – demanded changes in it. They did not accept the design. Respondents felt that the HbR "find fault with everything" after the HBR3 case.
HBR2	When A-Lanes announced that it would start with reconstructing the Welplaatweg and Hartelkruis junctions, and simultaneously redirecting the hazardous substances route via the Welplaatweg, the HbR objected that the Welplaatweg could not be both reconstructed and serve as the reroute.
HBR3	Motivated by the contract to make a good pace, A-Lanes constructed a temporary road for transporting hazardous substances without coordinating the design with the HbR as they were required to by contract. Consequently, the HbR objected and did not give its approval for the road.
LEI	LSNed, the organization responsible for managing and maintaining the pipeline corridors, demanded changes in the design of the Pipeline Corridor-1 overarch. This was unexpected as RWS did not close an implementation agreement with LSNed.
MUN1	The Municipality of Rotterdam objected to the designs of Ramp700 (a land abutment for the Botlekbridge) as it would make future access to certain cables and pipelines impossible. The Municipality felt that the design did not meet the requirements agreed upon in the implementation agreement.
MUN2	The Municipality of Rotterdam repeatedly did not give its approval for the construction of the Botlekbridge pillars as it was unconvinced that the designed pillars were strong enough to carry the weight of the bridge decks.
PRO	After the contract award, ProRail reconsidered its implementation agreements with RWS. ProRail wished another technical rail system on the Botlekbridge than previously agreed upon, because the then foreseen novel system appeared more susceptible to interference than anticipated.
PRV1	The Province of South-Holland objected to the position of a particular cable near the Groene Kruisweg Viaduct as it would make it impossible for the Province to build a road parallel to the Groene Kruisweg in the future.
PRV2	After the deal with the Province was made about the solution of PRV1, a work foreman announced to the A-Lanes stakeholder manager that he would commence the implementation. When the stakeholder manager passed this to the Province, it objected because it first had to check and formally approve the solution, i.e., no permit was issued yet.
RWS1	The RWS Traffic and Water Management directorate (DVS) demanded changes in the design of the Portland traffic changeover as they thought the current design to be not safe enough.
RWS2	The RWS road district objected to the positioning of a site office by A-Lanes under a flyover near the Vaanplein junction for safety reasons (i.e., fire hazard) and wants the site office to be moved.

Table 5.3 Responding to events

ID	EVENT	MANA	MANR	SATIS
CAB1	Physical	The focus of A-Lanes was on finding a technical solution to the problem that all stakeholders could agree with.	Their respective obligations to move cables and pipelines made RWS decide to combine the actions to be implemented, and to coordinate with stakeholders together.	This case was excluded from the requirements for the large multi-million payment, and a solution satisfactory to stakeholders was found.
CIT1	Social	A-Lanes decided to start actually measuring noise production to validate its model upon which it was basing its communication policy towards citizens.	As RWS is concerned with being a 'public-oriented network manager', the stakeholder manager started to renegotiate the 50 dB limit at which A-Lanes was required to inform citizens.	The 50 dB limit to inform citizens about construction works near the Botlekbridge was adjusted to 45 dB.
CIT2	Social	A-Lanes reconsidered its work plan which led to an approx. two-thirds reduction of nightly construction works. Additionally, it offered hotel stays to citizens that would be affected still.	There is no indication that RWS was involved in this particular case.	Only one or two complaints were received, and there were no problems with obtaining the needed permits.
CIT3	Social	The focus of A-Lanes was on choosing another method so as to continue construction.	There is no indication that RWS was involved in this particular case.	Construction was delayed for a week, extra costs were incurred, the media got wind of it, and RWS was dissatisfied with the situation.
CIT4A	Social	The focus of A-Lanes remained on achieving quick results, and not on high quality stakeholder informing through, inter alia, producing good permit applications.	RWS did not facilitate or cooperate at this point (but see CIT4B). It even said to the Barendrecht alderman to just reject the application.	RWS was dissatisfied with the situation, and the Municipality of Barendrecht rejected permit applications.
CIT4B	Social	The focus was still primarily on achieving results within time and budget; information about building activities came too late to be included in a newsletter.	RWS stepped forward, i.e., it gave A-Lanes a reprimand and started checking communication means by A-Lanes.	There was some progress regarding the Vaanplein case, but communication by A-Lanes remained an issue.
DOW	Physical	The focus of A-Lanes was on repairing the physical situation and on improving the collaboration between two sub joint-ventures.	There is no indication that RWS was involved in this particular case.	A hard shoulder had to be resurfaced.
EXP	Physical	The additional investigations were carried out by the Municipality of Rotterdam. A-Lanes had to redo its work preparation and increase working speed.	This was the contractor's risk; RWS was not involved in this case although A-Lanes did seek support.	Costs were incurred for the delay and hitherto RWS seemed unwilling to share (part of) the risks or costs.

QCA as a Research Approach

Gaining theoretical and case knowledge*

Case construction*

where the techniques come in

Raw data matrix

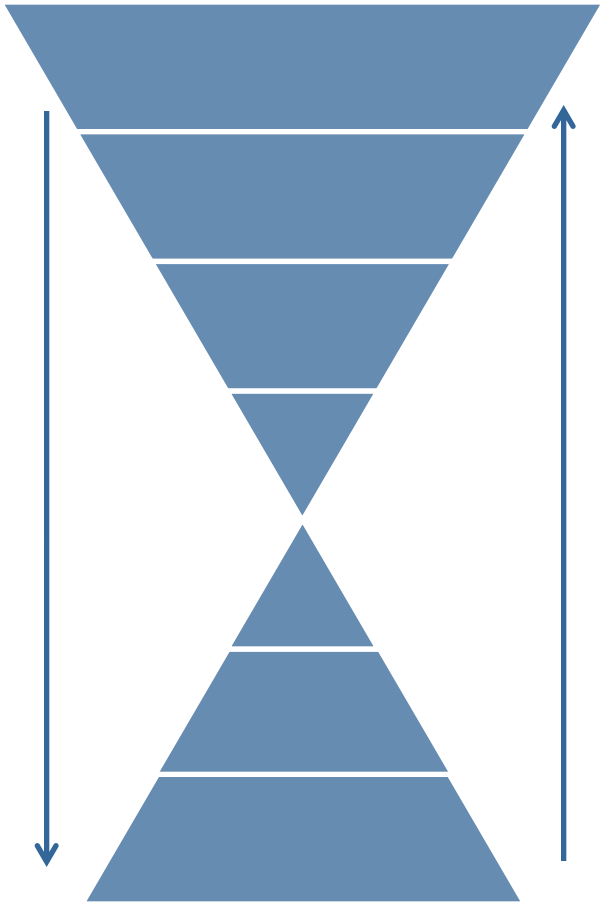
Truth table

Patterns

Interpretation

Return to the cases/theory

QCA is an iterative process

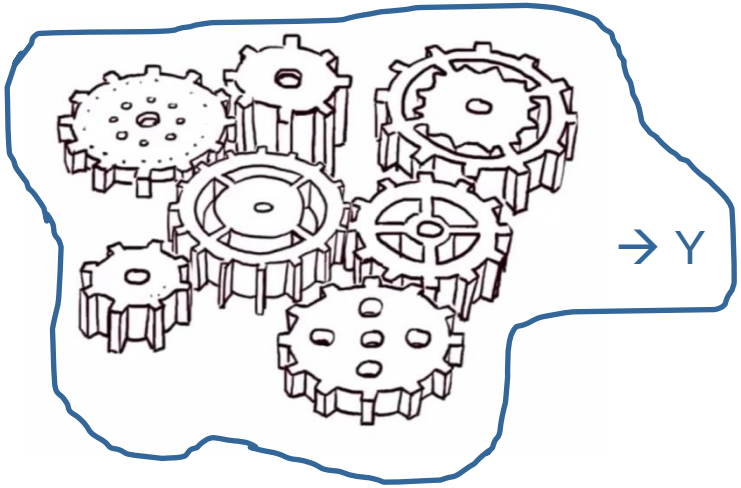


QCA as a Research Approach

- Before the ‘analytical moment’, the following tightly connected and often iterative research steps are important

- Research question
- Case selection
- Gaining case knowledge
- Defining the outcome of interest
- Selection of conditions
- Visualizing cases

A case = a configuration of conditions and the outcome



See: Rihoux and Lobe (2009) in Byrne and Ragin (2009)

QCA as a Research Approach

- Before the ‘analytical moment’, the following tightly connected and often iterative research steps are important

- Research question
- Case selection
- Gaining case knowledge
- Defining the outcome
- Selection of conditions
- Visualizing cases

The research question must fit QCA’s set-theoretical nature*

QCA can be used for multiple purposes, inter alia:

Summarizing data*
Testing hypotheses or theories
Pattern exploration*
Building new theories

Cf. Berg-Schlosser et al. (2009) in Rihoux and Ragin (2009)

QCA as a Research Approach

Examples of research questions from QCA-papers I reviewed…
Which ones are appropriate for QCA and which are not?

- "How and under what conditions do perceived integrity violations lead to organizational change?"
- "What are the characteristics of cities that make these changes more or less feasible?"
- "What configurations of organizational attributes are associated with high and low organizational capability (…)?"
- Which criteria in terms of (…) are associated with successful management in municipalities, and which of those principles are necessary or/and sufficient (…)?"
- "(…). What happens when these organizational attributes combine?"

QCA as a Research Approach

- Before the ‘analytical moment’, the following tightly connected and often iterative research steps are important

- Research question
- Case selection (1/3)
- Gaining case knowledge
- Defining the outcome
- Selection of conditions
- Visualizing cases

Remember:

A case = a configuration of conditions and the outcome

Cases can be ‘found’ or ‘produced’ during the research (i.a., more grounded approaches, pattern exploration) or cases can be ‘predefined’ prior to the research, based on existing theories (i.a., more deductive approaches, testing theories)

QCA as a Research Approach

- Before the ‘analytical moment’, the following tightly connected and often iterative research steps are important

- Research question
- Case selection (2/3)
- Gaining case knowledge
- Defining the outcome
- Selection of conditions
- Visualizing cases

Irrespectively, make sure that:

Cases share background characteristics… but within this ‘area of homogeneity’ the cases are heterogeneous

You allow flexibility: cases may be dropped or added

You justify your case selection

Cf. Berg-Schlosser et al. (2009) in Rihoux and Ragin (2009)

QCA as a Research Approach

- Before the ‘analytical moment’, the following tightly connected and often iterative research steps are important

- Research question
- Case selection (3/3)
- Gaining case knowledge
- Defining the outcome
- Selection of conditions
- Visualizing cases

Irrespectively, make sure that:

You have a clearly defined outcome that you want to explain

If possible, you include cases with the outcome and the non-outcome

Cf. Berg-Schlosser et al. (2009) in Rihoux and Ragin (2009)

QCA as a Research Approach

- Before the ‘analytical moment’, the following tightly connected and often iterative research steps are important

- Research question
- Case selection
- Gaining case knowledge
- Defining the outcome
- Selection of conditions
- Visualizing cases

Trade-off between

Gaining sufficient case knowledge (‘capturing the complexity of cases’)

And…

The number of cases you can study (‘striving for generalization’)

You may use a variety of data sources, both qualitative and quantitative

Cf. Berg-Schlosser et al. (2009) in Rihoux and Ragin (2009)

QCA as a Research Approach

- Before the ‘analytical moment’, the following tightly connected and often iterative research steps are important

- Research question
- Case selection
- Gaining case knowledge
- Defining the outcome
- Selection of conditions
- Visualizing cases

Make sure that:

You have a clear definition of the outcome you want to explain across the cases

You include cases with the outcome and the non-outcome

Cf. Berg-Schlosser et al. (2009) in Rihoux and Ragin (2009)

QCA as a Research Approach

- Before the ‘analytical moment’, the following tightly connected and often iterative research steps are important

- Research question
- Case selection
- Gaining case knowledge
- Defining the outcome
- Selection of conditions
- Visualizing cases

Make sure that:

The conditions vary across cases

The *n* of conditions is kept low

If theory permits it, expectations between conditions and the outcome are formulated

You justify your selections

Cf. Berg-Schlosser et al. (2009) in Rihoux and Ragin (2009)

QCA as a Research Approach

- Before the ‘analytical moment’, the following tightly connected and often iterative research steps are important

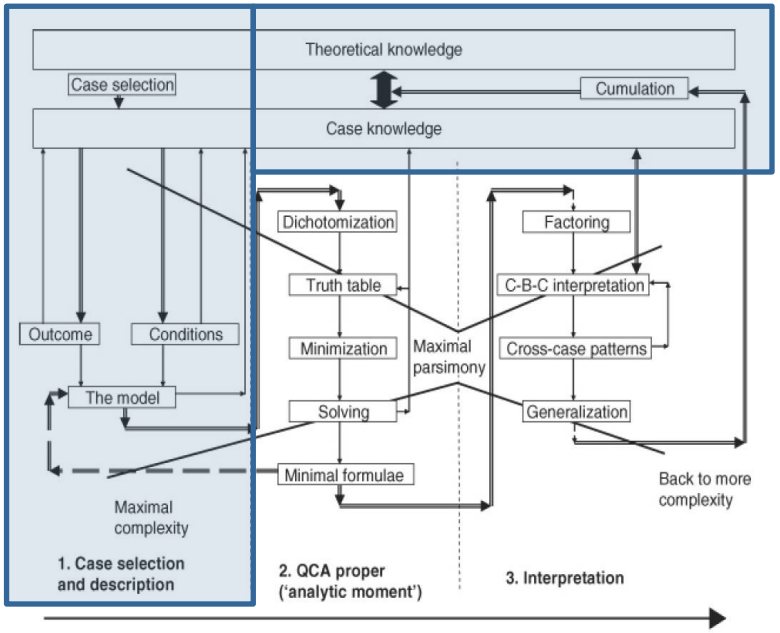
- Research question
- Case selection
- Gaining case knowledge
- Defining the outcome
- Selection of conditions
- Visualizing cases

As an interim complexity-reduction step between rich case material and the data matrix

Can be done in different ways (e.g., graphs, timelines, tables)

QCA as a Research Approach

The interim ‘product’ of your efforts so far: raw data matrix



Exercise for the morning:

Design your QCA research project, focusing on steps 1-4 in Rihoux and Lobe (2009)

Pay attention in particular to the fit between the research question/purpose, and the further design of the research

University of Bamberg

Introduction to Qualitative Comparative Analysis (QCA)

Afternoon Session: The Basics of QCA as a Set of Analytical Techniques

IUSF-TIAS Autumn School on 'Concepts, Frameworks and Methods for the Comparative Analysis of Water Governance'
Jülich, Germany, November 3rd, 2015

Recap of “The Basics of QCA as an Approach”

Gaining theoretical and case knowledge

Case construction

Raw data matrix

Truth table

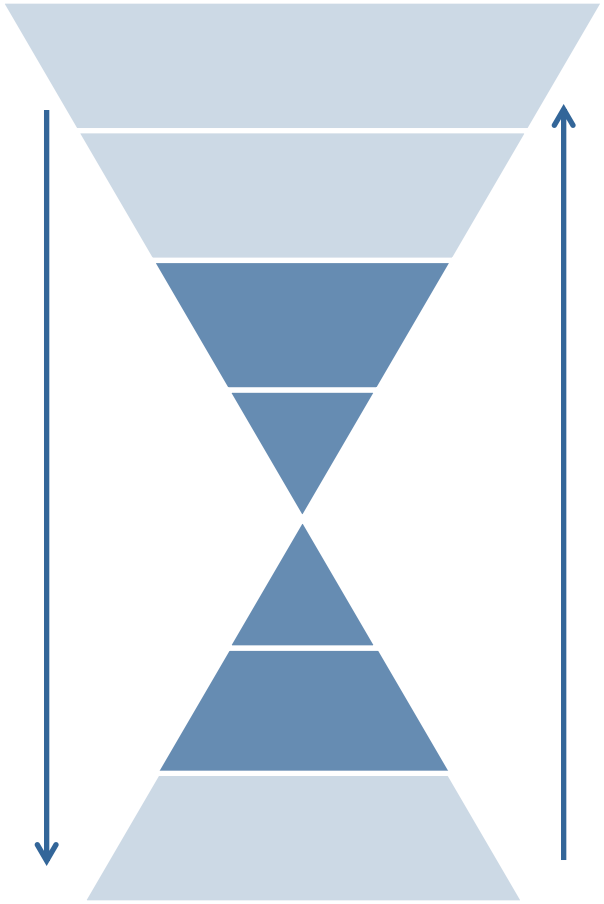
Patterns

Interpretation

Return to the cases/theory

where the techniques come in

QCA is an iterative process



Cf. Verweij (2015) Ph.D. Thesis, Erasmus University Rotterdam

The ‘Analytical Moment’ + Interpretation

This afternoon we will focus on the truth table analysis, that is, the *analysis of sufficiency**

1. Calibrating a data matrix
   - Crisp sets
   - Fuzzy sets
2. Constructing a truth table
3. Recognizing and solving contradictory truth table rows
4. Parameters of fit
   - Consistency
   - Coverage
5. Truth table minimization
   - Conservative solution
   - Intermediate solution
   - Parsimonious solution
6. Interpretation of results

Calibrating a Data Matrix

Calibration is:

> "The process of using empirical information on cases for assigning set membership to them (…)."

(Schneider and Wagemann, 2012, p.32).

Calibrating a Data Matrix

Cases have membership in sets (conditions and outcome = sets)

There are three important ‘anchor points’ in calibration

- 0.0 = full non-membership; the case is fully out of the set
- 0.5 = ambiguity; cross-over point
- 1.0 = full membership; the case is fully in the set

Basically, the result of calibration is the grouping of similar cases and the separating of different ones per condition/set

Calibrating a Data Matrix

CRISP VERSUS FUZZY SETS

Crisp set	Three-value fuzzy set	Four-value fuzzy set	Six-value fuzzy set	"Continuous" fuzzy set
1 = fully in	1 = fully in	1 = fully in	1 = fully in	1 = fully in
			.9 = mostly but not fully in	Degree of membership is more "in" than "out": $.5 < x_i < 1$
		.75 = more in than out	.7 = more or less in	
	.5 = neither fully in nor fully out			.5 = cross-over: neither in nor out
		.25 = more out than in	.3 = more or less out	Degree of membership is more "out" than "in": $0 < x_i < .5$
			.1 = mostly but not fully out	
0 = fully out	0 = fully out	0 = fully out	0 = fully out	0 = fully out

Differences in degree

Difference in kind

Differences in degree

Table: Ragin (2008) Redesigning Social Inquiry: Fuzzy Sets and Beyond

Calibrating a Data Matrix

Important things to take into account when calibrating

- Avoid calibrating cases as having 0.5 membership (i.e. maximum ambiguity)
- Use prior knowledge (theory) if possible to calibrate. Why?
  - Classifying cases based on, e.g., the mean or median produces categories that are void of any *substantive meaning* in terms of the concept being measured
    - Example: taking the mean of countries' GDP may classify certain countries as rich (set membership: 1.0) whilst we would actually consider them poor (set membership: 0.0)
- Allow yourself to recalibrate based on case knowledge

Calibrating a Data Matrix: Example

Table 2
Data matrix.

Project	Data	CONT		SCOPE	SIZE		MAN	COOP	SATIS		Completeness
		Raw	Cal.		Raw (k€)	Cal.			Raw	Cal.	
P.0008	2013	D&C	1	0.33	278146	0.67	0.67	0.33	13.00	0.67	59%
P.0029	2013	D&C	1	0.00	274787	0.67	0.33	0.00	16.00	1.00	102%
P.0034	2013	D&C	1	1.00	620693	1.00	1.00	1.00	15.00	1.00	49%
P.0059	2011	D&C	1	0.33	114215	0.33	0.67	0.00	15.00	1.00	70%
P.0077	2012	D&C	1	0.67	276962	0.67	0.67	0.33	14.00	1.00	76%
P.0094	2013	D&C	1	1.00	319694	0.67	1.00	0.67	11.67	0.33	83%
P.0095	2012	D&C	1	0.00	97741	0.33	0.67	0.33	14.67	1.00	69%
P.0096	2011	D&C	1	0.00	103709	0.33	0.33	0.00	12.00	0.33	85%
P.0102	2011	D&C	1	0.00	48783	0.00	1.00	0.00	14.00	1.00	76%
P.0149	2013	D&C	1	0.67	686322	1.00	1.00	0.33	11.00	0.33	41%
P.0165	2011	D&C	1	0.33	211000	0.33	0.33	0.00	9.67	0.00	96%
P.0179	2013	D&C	1	0.00	121555	0.33	1.00	0.33	9.67	0.00	46%
P.0190	2013	DBFM	0	0.67	2268904	1.00	0.00	0.00	8.67	0.00	65%
P.0196	2012	D&C	1	0.67	127013	0.33	1.00	1.00	15.33	1.00	77%
P.0200	2011	D&C	1	0.00	55391	0.00	1.00	0.00	15.00	1.00	90%
P.0218	2012	DBFM	0	0.67	2187177	1.00	0.67	0.33	10.67	0.33	67%
P.0227	2013	D&C	1	0.67	300261	0.67	0.67	0.00	11.33	0.33	56%
P.0247	2012	DBFM	0	0.00	683008	1.00	1.00	1.00	16.00	1.00	89%
P.0272	2013	D&C	1	0.33	547430	0.67	0.67	0.67	14.67	1.00	74%
P.0319	2013	D&C	1	0.00	54750	0.00	0.33	0.00	15.00	1.00	89%
P.0351	2013	DBFM	0	0.00	332229	0.67	1.00	0.67	14.67	1.00	45%
P.0631	2013	D&C	1	0.00	9488	0.00	1.00	0.33	15.33	1.00	88%
P.0641	2012	D&C	1	0.00	163773	0.33	1.00	0.00	16.00	1.00	101%
P.0755	2013	D&C	1	0.00	159293	0.33	0.33	0.00	14.67	1.00	68%
P.1106	2013	D&C	1	0.33	21473	0.00	0.00	0.00	9.00	0.00	56%
P.2355	2012	D&C	1	0.00	42997	0.00	0.00	0.33	10.67	0.33	85%
P.2365	2012	D&C	1	0.00	320761	0.67	1.00	0.00	12.67	0.67	63%

Table: Verweij (2015) in 'International Journal of Project Management'

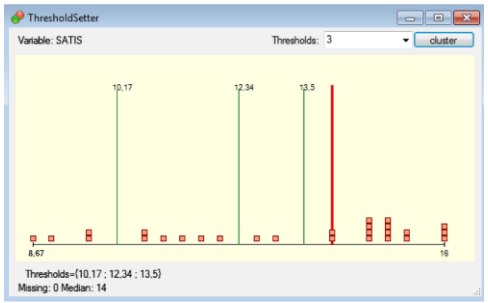
Contract type
- 0.00 = D&C
- 1.00 = DBFM

Scope
- 0.00 = road construction
- 0.33 = road & bridges
- 0.67 = road & bridges 'plus'
- 1.00 = integral projects

Contract size (cf. literature)
- Small, medium, large, very large projects

MAN & COOP (cf. literature)
- Internal – External
- Contractual – Cooperative

SATIS (no literature available)



From Data Matrix to Truth Table

In the calibrated data matrix, each row is a case…

…and in the truth table, you group similar cases as combinations of conditions, and each row is now a configuration

This means that the focus shifts from diversity between cases (data matrix) to similarities across cases (truth table)

Number of truth table rows = 2^k, where k is number of conditions

Each truth table row is a statement of sufficiency

From Data Matrix to Truth Table: Example

1. Order the cases over the logically possible configurations
2. Thereafter, based on case data, assign the outcome to each configuration

Table 3
Truth table.

No.	CONT	SCOPE	SIZE	MAN	COOP	SATIS	n	Cases
8	0	0	1	1	1	1	2	P.0247, P.0351
28	1	1	0	1	1	1	1	P.0196
21	1	0	1	0	0	1	1	P.0029
32	1	1	1	1	1	1	2	P.0034, P.0094
19	1	0	0	1	0	1	7	P.0059, P.0095, P.0102, P.0179, P.0200, P.0631, P.0641
23	1	0	1	1	0	1	2	P.0008, P.2365
24	1	0	1	1	1	1	1	P.0272
31	1	1	1	1	0	0	3	P.0077, P.0149, P.0227
17	1	0	0	0	0	0	6	P.0096, P.0165, P.0319, P.0755, P.1106, P.2355
15	0	1	1	1	0	0	1	P.0218
13	0	1	1	0	0	0	1	P.0190

Table: adapted from Verweij (2015) in 'International Journal of Project Management'

Truth Table Examination: Contradictory Rows

- Contradictory row = the same configuration produces the outcome in one case and the non-outcome in an other case
- Contradictions need to be solved as much as possible
- Low consistency scores (“incl.”) indicate ‘no sufficiency’

Table 3
Truth table.

No.	CONT	SCOPE	SIZE	MAN	COOP	SATIS	n	incl.	PRI	Cases
8	0	0	1	1	1	1	2	1.000	1.000	P.0247, P.0351
28	1	1	0	1	1	1	1	1.000	1.000	P.0196
21	1	0	1	0	0	1	1	0.909	0.875	P.0029
32	1	1	1	1	1	1	2	0.898	0.854	P.0034, P.0094
19	1	0	0	1	0	1	7	0.884	0.864	P.0059, P.0095, P.0102, P.0179, P.0200, P.0631, P.0641
23	1	0	1	1	0	1	2	0.875	0.819	P.0008, P.2365
24	1	0	1	1	1	1	1	0.875	0.834	P.0272
31	1	1	1	1	0	0	3	0.724	0.568	P.0077, P.0149, P.0227
17	1	0	0	0	0	0	6	0.681	0.597	P.0096, P.0165, P.0319, P.0755, P.1106, P.2355
15	0	1	1	1	0	0	1	0.493	0.000	P.0218
13	0	1	1	0	0	0	1	0.330	0.000	P.0190

Table: Verweij (2015) in ‘International Journal of Project Management’

Strategies for Dealing with Contradictions

1. Add an additional condition (model re-specification)
2. Replace a condition with another one (model re-specification)
3. Re-examine operationalization (re-calibration)
4. Reconsider the outcome condition (outcome re-definition)
5. Go back to the cases; gain additional case knowledge
6. Is the case really a case of your phenomenon being studied?
7. Recode contradictory cases as having the non-outcome
8. Use consistency and frequency criteria

Recall: QCA is iterative; dialogue between cases and theory

See: Rihoux and De Meur (2009) in Rihoux and Ragin (2009)

Strategies for Dealing with Contradictions

Strategies that I used in the example:

3. Re-examine operationalization (re-calibration)
4. Reconsider the outcome condition (outcome re-definition)
5. Go back to the cases; gain additional case knowledge
7. Recode contradictory cases as having the non-outcome
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23	1	0	1	1	0	1	2	0.875	0.819	P.0008, P.2365
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15	0	1	1	1	0	0	1	0.493	0.000	P.0218
13	0	1	1	0	0	0	1	0.330	0.000	P.0190

Parameters of Fit: Consistency

There are two basic parameters that aid in the analysis of the truth table and the interpretation of the results

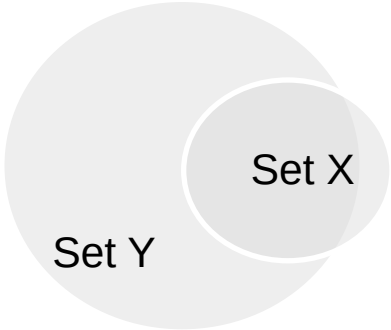
Consistency expresses "the degree to which empirical evidence supports the claim that a set-theoretic relationship [sufficiency] exists"

- As an aid in analysis: generally, low consistency rows in the truth table indicate a contradiction to the statement that 'this row is sufficient' – don't include it in the truth table minimization
- For interpreting results (i.e., after truth table minimization): higher consistency indicates more consistent statements of sufficiency

Parameters of Fit: Consistency (Crisp Sets)

Consistency of *X* as a sufficient condition for *Y* =

$$\frac{\text{Number of cases where } X = 1 \text{ and } Y = 1}{\text{Number of cases where } X = 1}$$



For example:

Row	A	B	C	Cases with Y	Cases with ~Y
1	1	1	0	31	2
…	…	…	…	…	…

Is configuration X sufficient for Y?

The consistency is 31/33 = 0.939

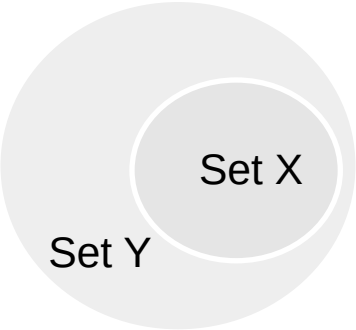
Yes, we can conclude this row in the truth table minimization

Source: Schneider and Wagemann (2012)

Parameters of Fit: Consistency (Fuzzy Sets)

Consistency of *X* as a sufficient condition for *Y* =

$$\frac{\Sigma(\min(X_i,Y_i))}{\Sigma(X_i)}$$



For example:

Case	A	B	C	Y
1	0	1	0.33	0.67
2	0.33	1	0.67	1

Is configuration (truth table row) A*B*~C sufficient for Y?

Membership case 1 in the configuration is 0
Membership case 2 in the configuration is 0.33
$\underline{\text{Min}(X_i,Y_i)}$ for the cases is 0 and 0.33, respectively
Thus: (0+0.33)/0.33 = 1.000
Yes, we can code row A*B*~C as Y{1} in the truth table

Truth Table Minimization

Once you have decided which truth table rows are consistent with (i.e. ‘true’) in supporting the statement of sufficiency, i.e., which truth table rows will be included in the minimization, the truth table can be minimized to produce a solution formula

The basic idea is:

> The pairwise comparison of configurations that have the same outcome but differ in one other condition

Truth Table Minimization: Example 1

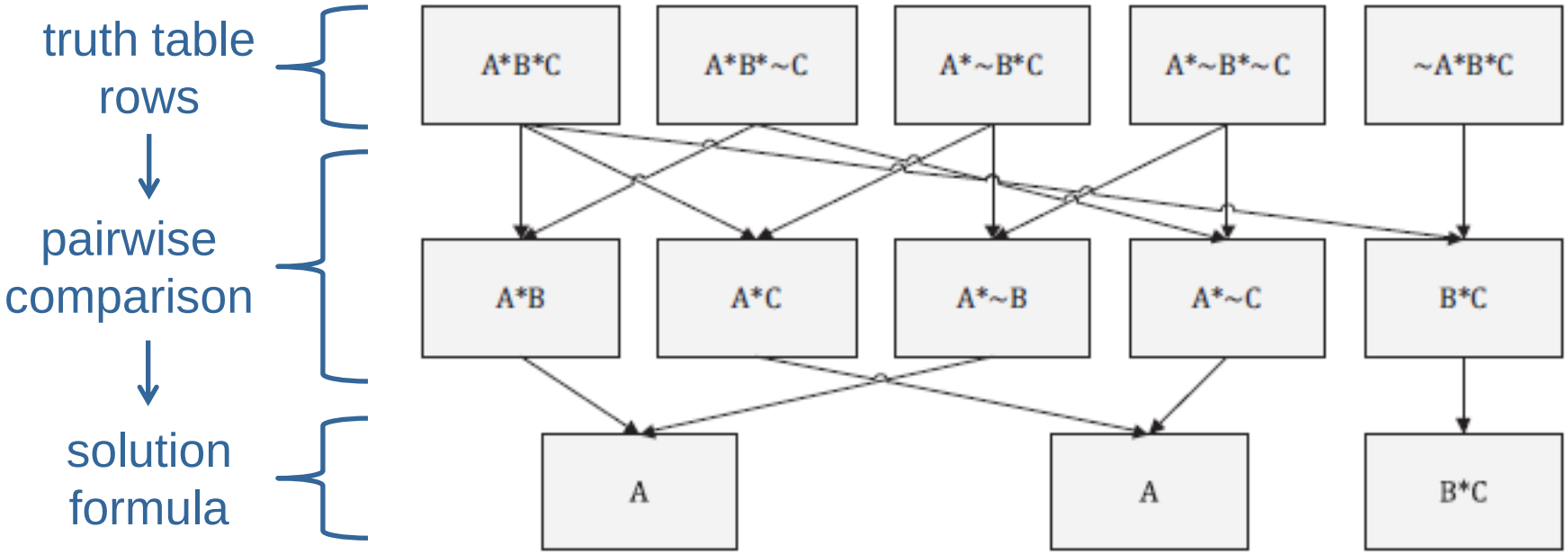
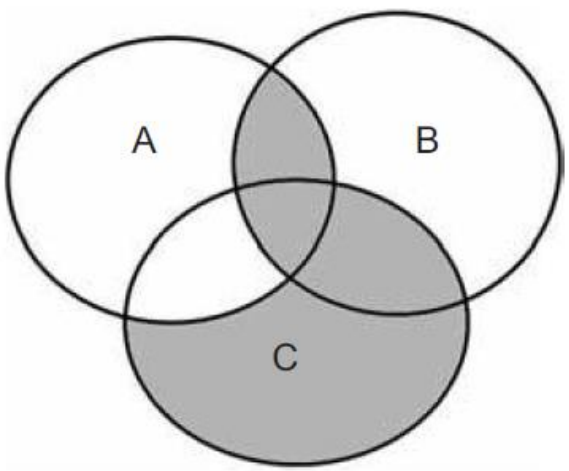


Figure: Verweij and Gerrits (2013) in 'Evaluation'

Truth Table Minimization: Example 2

Be aware!

Sometimes, the truth table algorithm in the QCA software obscures possible theoretically relevant models from your sight!



In this example, there are three sufficient minimized models that can explain the outcome

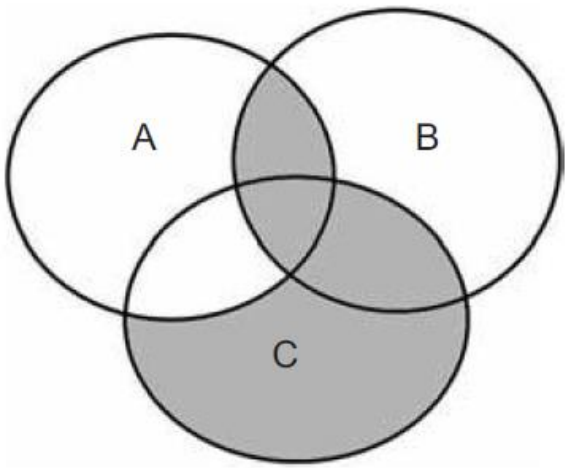
A*B*c
A*B*C
a*B*C
a*b*C

A*B
~~B*C~~
a*C

Truth Table Minimization: Example 2

Be aware!

Sometimes, the truth table algorithm in the QCA software obscures possible theoretically relevant models from your sight!

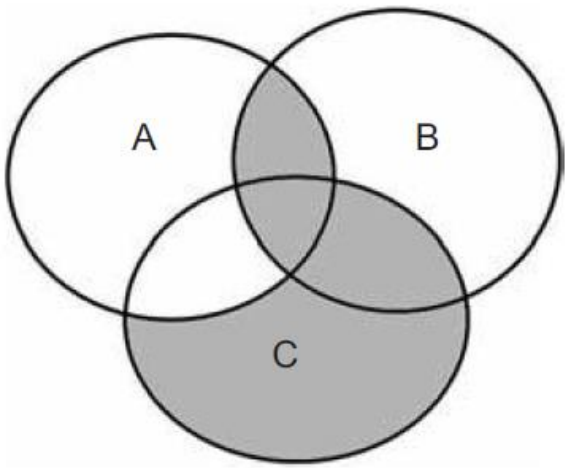


Sufficient configurations ▶ Prime implicants ▼	A*B*~C	A*B*C	~A*B*C	~A*~B*C
A*B	X	X		
B*C		X	X	
~A*C			X	X

Truth Table Minimization: Example 2

Be aware!

Sometimes, the truth table algorithm in the QCA software obscures possible theoretically relevant models from your sight!



AB + aC → Y

Sufficient configurations ▶ Prime implicants ▼	A*B*~C	A*B*C	~A*B*C	~A*~B*C
A*B	X	X		
~~B*C~~		~~X~~	~~X~~	
~A*C			X	X

Truth Table Minimization

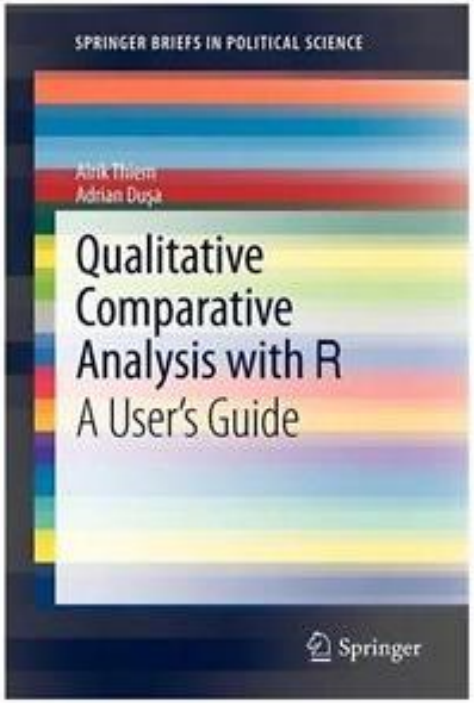
Be aware!

Sometimes, the truth table algorithm in the QCA software obscures possible theoretically relevant models from your sight!

The solution?

Use the QCA package in R as the preferred software for a QCA analysis

→ See www.compasss.org for more information



Book: Thiem and Duşa (2013)

Truth Table Minimization: Limited Diversity

Limited diversity occurs when many truth table rows are devoid of cases, with the consequence that no/few pairs can be compared

For example:

F_1	$\sim F_2$	F_3	M	$\Rightarrow$ Y
$\sim F_1$	F_2	F_3	M	$\Rightarrow$ Y
F_1	F_2	$\sim F_3$	M	$\Rightarrow$ Y
…	…	…	…	…
…	…	…	…	…

Number of conditions: 4

Number of logically possible configurations = $2^k = 2^4 = 16$

Empirically present configurations = 3

Logical remainders = 13

Problem: no minimization is possible

Truth Table Minimization: Limited Diversity

Where does limited diversity come from?

- The number of truth table rows outnumbers of the number of cases (‘arithmetic remainders’)
- Social reality tends to be structured in clusters of similar cases, so cases tend to be clustered in certain truth table rows (‘clustered remainders’)
- Conditions in a study could create configurations that are logically possible, but empirically impossible (‘impossible remainders’)

Source: Schneider and Wagemann (2012)

Dealing with Limited Diversity

How can we deal with limited diversity?

We could *add cases* and/or *drop conditions*
(iterative nature of QCA)

Or :

We can include logical remainders (empty truth table rows) in the minimization
(back to theory; ‘counterfactual analysis’)

Dealing with Limited Diversity

There are three options to minimize the truth table:

1. Conservative/complex solution

   Empty truth table rows are not included in the minimization

2. Parsimonious solution

   Simplifying empty truth table rows are included without any evaluation of their theoretical plausibility (‘difficult counterfactuals’)

3. Intermediate solution

   Only those simplifying empty truth table rows under (2) are included that are consistent with the researcher’s theoretical and substantive knowledge (‘easy counterfactuals’)

Dealing with Limited Diversity

The conservative/complex solution

- Pro: no assumptions are made about unobserved configurations
- Con: can yield complex results that are difficult to interpret

The parsimonious solution

- Pro: can yield results that are more parsimonious and easier to interpret
- Con: there is no evaluation of whether included unobserved configurations actually make sense

The intermediate solution: mitigates the respective cons

Dealing with Limited Diversity

The intermediate solution

- Only ‘easy counterfactuals’ (unobserved truth table rows ‘that make sense’) are included in the minimization
- Counterfactuals are based on directional expectations formulated earlier

Rule 1: no conditions can be dropped from the parsimonious solution term
Rule 2: conditions in line with directional expectations can be dropped from the conservative solution term

Example

This example: we expect the *presence* of all conditions (A-E) to contribute to the outcome
Therefore: ~A, ~C, and ~E could be dropped from the conservative solution term
However: ~C may not be dropped, so the intermediate solution is B* ~C*D

~A*B*~C*D*~E
(conservative solution term; subset)

B*~C*D
(intermediate solution term)

B*~C
(parsimonious solution term; superset)

Source: Schneider and Wagemann (2012)

Dealing with Limited Diversity

Important things to keep in mind in counterfactual analysis

- If you used a logical remainder for the truth table minimization for Y, then you cannot also use this logical remainder for the truth table minimization for ~Y ('contradictory simplifying assumption')

- Do not use 'impossible remainders' or 'implausible remainders' as counterfactuals

See more: Schneider and Wagemann (2012)

Table: Verweij et al. (2013) in 'Public Administration'

Interpretation of the Results

After you minimized the truth table, you interpret the results

- Identify necessity*, sufficiency, and INUS
  - Use the consistency and coverage measures to check the results

TABLE 8 *Complex solution from the fsQCA*

	Path 1	Path 2	Path 3
	C*M	I*M	~C*~I*~M →O
Cases	ZUID, NOORD, IJSS, PERK, SIJT, DELFT, WEST	ZUID, NOORD, IJSS, SIJT, WEST, BROEK	DIEF
Raw coverage	0.62	0.58	0.27
Unique coverage	0.08	0.04	0.19
Consistency	1.00	0.94	1.00
Solution coverage: 0.85			
Solution consistency: 0.96			

Interpretation of the Results

There are two basic parameters that aid in the interpretation of the results

Consistency expresses “the degree to which empirical evidence supports the claim that a set-theoretic relationship exists”

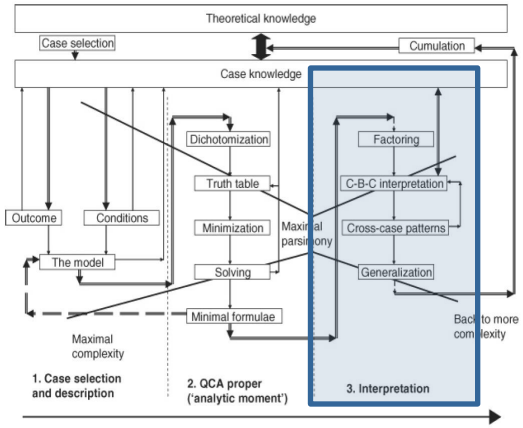
Coverage expresses “the way the respective terms of the minimal formulas ‘cover’ observed cases”

Quotes: Rihoux and Ragin (2009): Configurational Comparative Methods

Interpretation of the Results

After you minimized the truth table, you interpret the results

- Identify necessity*, sufficiency, and INUS
  - Use the consistency and coverage measures to check the results
- Interpret case-by-case (going back to the cases)
- Interpret cross-case patterns
- Beyond description: limited generalization (importance of ‘area of homogeneity’)
- Relate back to theoretical expectations



Graph: Rihoux and Lobe (2009) in Byrne and Ragin (2009)

QCA as a Research Approach

Gaining theoretical and case knowledge

Case construction

where the techniques come in

Raw data matrix

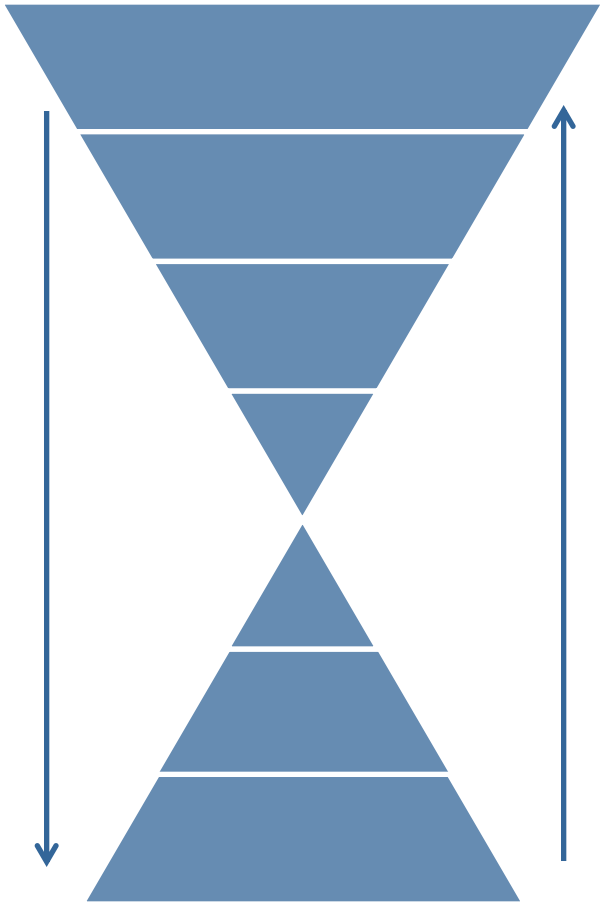
Truth table

Patterns

Interpretation

Return to the cases/theory

QCA is an iterative process



Final Notes: Some Good Practices

- Truth table is for analyzing sufficiency; analyze necessity separately
- Interpret the results by going back to the cases and theory
- Use computer software, but not mechanically
- Justify:
  - Chosen consistency levels
  - The treatment of contradictory rows
  - The treatment of empty truth table rows
- Always include and publish:
  - Raw data matrix, calibration rules, the truth table, the solution formulae, consistency and coverage numbers

See for elaborate overview: Schneider and Wagemann (2010) in 'Comparative Sociology'

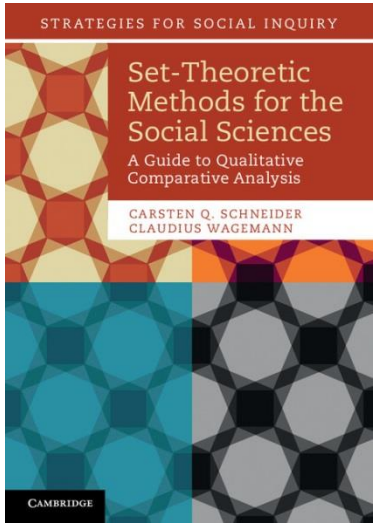
Final Notes

- Tip 1: buy & read Schneider and Wagemann (2012)

  See for a book review: Verweij (2013) in 'International Journal of Social Research Methodology'

- Tip 2: use QCA-package in *R* by Thiem and Duşa

- Tip 3: visit www.compasss.org for advanced material and courses on QCA



Thank You!

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