Course title
SB104. Qualitative Comparative Analysis and Fuzzy Sets

Instructor details
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Short Bio
Carsten Q. Schneider is Head of the Department of Political Science at Central European University, Budapest. His research focuses on regime transitions, the consolidation and qualities of democracy, and measuring political regimes. His book The Consolidation of Democracy in Europe and Latin America has been published with Routledge in 2009. His second field of interest consists in methodology, especially set-theoretic methods, with a focus on Qualitative Comparative Analysis (QCA). He has published in Sociological Methods and Research, European Journal of Political Research, Political Research Quarterly, Socio-Economic Review, and others. His book Set-Theoretic Methods for the Social Science, co-authored with Claudius Wagemann, has been published with Cambridge University Press in 2012.

Instructor details
First name, last name: Patrick A. Mello
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Institution: Chair of International Politics
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Short Bio
Patrick A. Mello is a research associate and lecturer at the Chair of International Politics, Technische Universität Dresden (Germany). His substantive research focuses on matters of international relations theory, international security, and foreign policy analysis. His methodological research interests evolve around comparative and case study approaches, with an emphasis on fuzzy-set Qualitative Comparative Analysis. He has recently published in the European Journal of International Relations and the Journal of International Relations and Development. His book Democratic Participation in

Disclaimer: the information contained in this course description form may be subject to subsequent adaptations (e.g. taking into account new developments in the field, specific participant demands, group size etc.). Registered participants will be informed in due time in case of adaptations.
Prerequisite knowledge
Students are not required to have any prior knowledge of QCA or the R software environment and its QCA package. However, they are strongly encouraged to familiarize themselves with the basic principles of the method in advance by reading the recommended literature as specified in the reading list. A previous introduction to the basic functions of R and RStudio will be useful to start working with the software from day 1.

Short outline
This course introduces participants to set-theoretic methods and their application in the social sciences with an emphasis on Qualitative Comparative Analysis. The introductory course is complemented by an advanced course that is taught during the ECPR Winter School in Bamberg. The course starts out by familiarising students with the basic concepts of the underlying methodological perspective, among them the central notions of necessity and sufficiency, formal logic and Boolean algebra. From there, we move to the logic and analysis of truth tables and discuss the most important problems that emerge when this analytic tool is used for analysing social science data. All analytical issues will be introduced on crisp sets and later expanded to fuzzy sets. Right from the beginning, students will be exposed to performing set-theoretic analyses using the relevant R software packages. When discussing set-theoretic methods, in-class debates will further engage on broad, general comparative social research issues, such as case selection principles, concept formation, questions of data aggregation and the treatment of causally relevant notions of time. Real-life published applications are used throughout the course. Participants are encouraged to bring their own data for in-class exercises and assignments, if available. To get the most out of the course, participants would profit from some basic empirical-comparative training and an introduction to the R environment (e.g., Refresher Course), but these are no prerequisites in a strict sense.

Long outline
The central aim of week 1 (P. Mello) is to familiarise the participants with the formal logic of set-theoretic methods and to introduce QCA as an approach, its main assumptions, the technical environment (software) and the standard procedures and operations. The course begins with applications of crisp-set QCA (csQCA), before moving on to multi-value QCA (mvQCA) and fuzzy-set QCA (fsQCA) once the fundamentals are in place. Particular emphasis is put on a thorough understanding of the notions of necessity and sufficiency, as they are the nuts and bolts of QCA that set it apart from the majority of other available cross-case comparative techniques.

- On day 1, participants will be introduced to the course topic, the content and sequence of the course sessions, as well as the course resources. We will also touch upon the basics of set-theoretic methods, the epistemology of QCA, its different variants, and how it compares to other standard qualitative and quantitative social scientific research designs. The centrepiece of the first session will be a demonstration of QCA on the basis of a recently published study.
- On day 2, we turn to the methodological foundations of QCA including a thorough discussion of the basic mathematical concepts of QCA, which are derived from set theory. The session begins by with an outline of sets and set membership, including the notion of fuzzy sets as opposed to crisp sets. Once these essentials are in place, we turn to Boolean and fuzzy algebra, formal logic and operations on complex expressions.
- On day 3, we will address the question of how to prepare observational data to perform QCA, i.e. how to calibrate. In doing so, we will cover various modes of calibrating raw data for crisp-set, multi-value and fuzzy-set QCA. We will go through various calibration techniques using R and discuss the consequences of different calibration decisions.
On day 4, we will define the notion of a truth table in crisp-set and fuzzy-set QCA and how it differs from a data matrix. We will show how to analyse truth tables with respect to necessary and sufficient conditions in order to derive solution formulas. This includes the Quine-McCluskey Algorithm for the logical minimization of the sufficiency statements in a truth table.

On day 5, we will turn to the so-called parameters of fit that are central to any QCA study, i.e. the measures of consistency and coverage for necessary and sufficient conditions. We will further discuss some methodological issues that are related to the parameters of fit. The first week will be concluded with an informal course evaluation and a consideration of topics that the participants would like to see covered in more depth in week 2.

The purpose of week 2 (C. Schneider) is fourfold: (1) to re-visit the core points of QCA addressed in week 1 (calibration, tests of necessity and sufficiency, truth tables, parameters of fit); (2) to elaborate on further issues that arise when neat formal logical tools and concepts, such as necessity, sufficiency, and truth tables, are applied to social science data (mainly the issues of limited diversity and the challenge to make good counterfactuals on so-called logical remainders); (3) to get better acquainted with the standards of good practice, both in its fundamental aspects and in using the relevant software programmes; (4) to discuss general methodological issues such as robustness and theory evaluation from a set-theoretic point of view.

On day 6, we will start by briefly reviewing what we learned in week 1, above all with regard to the basics of the analysis of necessary and sufficient conditions and how truth tables are used to reveal the latter. Putting everything together, we explain how the Truth Table algorithm, the standard mode for analysing crisp and fuzzy sets in QCA, works. We will recap the notions of parameters of fit, problematize some of their properties, and elaborate on potential improvements of these formulas. Since several of the problems have their roots in what could be called skewed set membership scores, we will be looking into this issue more closely.

On day 7, we will discuss the second problem of incomplete truth tables: logical remainder rows. We will explain how this phenomenon of limited diversity arises and which basic strategies are at the researcher’s disposal to mitigate its impact on drawing inferences. Above all, we will show how counterfactual thinking can be used to resolve problems of limited diversity. This leads to the development of “intermediate solutions” in a so-called standard analysis.

On day 8, we continue with the issue of limited diversity and introduce several amendments to the standard analysis. In addition to distinguishing between easy and difficult counterfactuals, we introduce the notion of tenable and untenable assumptions on remainders.

On day 9, we put together the material of the entire course by spelling out the Truth Table algorithm, i.e. the process from turning the data matrix into a truth table, then logically minimizing the table, allowing for different strategies vis-à-vis the logical remainders, and calculating the parameters of fit for each solution formula. During this day, participants are asked to apply their knowledge gained during the course to different published data sets and/or their own data.

Day 10 will be devoted to deepening our knowledge on how to perform a QCA. In addition, we spell out the principles of set-theoretic Multi-Method Research, that is, which cases to choose for process tracing on the basis of a QCA.

In all sessions, we will analyse fake (mostly week 1) and real data (week 2) in the computer lab, using the most important software packages R and fsQCA. During the computer lab sessions, students will be able to choose whether to follow the software instructions for the fsQCA program or for R. In addition to the prepared datasets, participants are encouraged to bring their own data (even if this
data is still tentative), which they may use during the lab hours and project work. The instructors and TAs will be available for appointments (individual counselling) to discuss personal research projects, “formatting” of own data to be compatible with QCA, etc.

**Day-to-day schedule**

**Week 1 (Patrick A. Mello)**

**Goals:**
- Address fundamental issues in comparative research
- Introduce set-theoretic principles and formal logic
- Present the main concepts of QCA approaches
- Introduce the main variants of QCA (crisp set, fuzzy set, multi-value)
- Become acquainted with the QCA software package for the R environment

<table>
<thead>
<tr>
<th>Lecture topic(s)</th>
<th>Lab session</th>
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<tr>
<td><strong>Day 1</strong>&lt;br&gt;Mon. 27 July&lt;br&gt;Course Introduction (90’)</td>
<td>Exercises (90’)&lt;br&gt;- Tour of QCA resources&lt;br&gt;- Introduction to the R environment and the QCA software package</td>
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<td>- Detailed course overview&lt;br&gt;- Set-theoretic methods&lt;br&gt;- Causal complexity&lt;br&gt;- Comparison of QCA and standard qualitative and quantitative research designs&lt;br&gt;- Empirical demonstration</td>
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<td><strong>Day 2</strong>&lt;br&gt;Tue. 28 July&lt;br&gt;Set Theory (90’)</td>
<td>Exercises (90’)&lt;br&gt;- Further introduction to R&lt;br&gt;- Calculation of Boolean operations&lt;br&gt;- Assessing necessity and sufficiency</td>
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<tr>
<td>- Methodological foundations: set theory, Boolean and fuzzy algebra, formal logic&lt;br&gt;- Set operations and set relations&lt;br&gt;- Forms of representation</td>
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<td><strong>Day 3</strong>&lt;br&gt;Wed. 29 July&lt;br&gt;Calibration (90’)</td>
<td>Exercises (90’)&lt;br&gt;- Calibrating fuzzy sets (participants are encouraged to bring their own data for this exercise!)</td>
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<td>- Measurement and calibration&lt;br&gt;- Calibration techniques&lt;br&gt;- Differences in calibration and their consequences</td>
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<td><strong>Day 4</strong>&lt;br&gt;Thur. 30 July&lt;br&gt;Truth Tables (90’)</td>
<td>Exercises (90’)&lt;br&gt;- Running the standard analysis&lt;br&gt;- Calculation of solution terms</td>
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<td>- From data matrix to truth table&lt;br&gt;- Analyzing truth tables&lt;br&gt;- Quine-McCluskey Algorithm</td>
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<td><strong>Day 5</strong>&lt;br&gt;Fri. 31 July&lt;br&gt;Parameters of Fit (90’)</td>
<td>Exercises (90’)&lt;br&gt;- Calculating parameters of fit&lt;br&gt;- Graphical tools for assessing consistency&lt;br&gt;- Informal evaluation of week 1</td>
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<td>- Consistency and coverage measures for necessary and sufficient conditions&lt;br&gt;- Issues related to the parameters of fit</td>
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**Week 2 (Carsten Q. Schneider)**

**Goals:**
- Deepen the skills and knowledge on QCA
- Apply QCA to real data and learn how to handle the most important challenges that typically arise in applied QCA
- Further acquaintance with standards of good practice
- Explore the limitations and pitfalls of set-theoretic methods

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<tr>
<th>Day</th>
<th>Recap of Week 1; Alternative Parameters of Fit I (120')</th>
<th>Lab session on calibration (60'): Rehearsal of analytic procedures learned during week 1</th>
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<tbody>
<tr>
<td>Day 6</td>
<td>Rec of Week 1; Alternative Parameters of Fit I (120')</td>
<td>Lab session on calibration (60'): Rehearsal of analytic procedures learned during week 1</td>
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<tr>
<td>Mon. 3 Aug</td>
<td>- Calibration</td>
<td>Lab session on calibration (60'): Rehearsal of analytic procedures learned during week 1</td>
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<td>- Set relations</td>
<td>Lab session on calibration (60'): Rehearsal of analytic procedures learned during week 1</td>
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<td>- Truth Table analysis</td>
<td>Lab session on calibration (60'): Rehearsal of analytic procedures learned during week 1</td>
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<td>- Parameters of Fit</td>
<td>Lab session on calibration (60'): Rehearsal of analytic procedures learned during week 1</td>
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<td>- Skewed set membership scores</td>
<td>Lab session on calibration (60'): Rehearsal of analytic procedures learned during week 1</td>
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<tr>
<td>Day 7</td>
<td>Recap of Week 1; Alternative Parameters of Fit I (120')</td>
<td>Lab session on calibration (60'): Rehearsal of analytic procedures learned during week 1</td>
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<tr>
<td>Tue. 4 Aug</td>
<td>Limited Diversity I (90')</td>
<td>Lab session (90)': using the appropriate software package for producing the conservative, intermediate, and most parsimonious solution</td>
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<td>- Origins of remainders</td>
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<td>- The Standard Analysis</td>
<td>Lab session (90)': using the appropriate software package for producing the conservative, intermediate, and most parsimonious solution</td>
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<td>Day 8</td>
<td>Recap of Week 1; Alternative Parameters of Fit I (120')</td>
<td>Lab session on calibration (60'): Rehearsal of analytic procedures learned during week 1</td>
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<td>Wed. 5 Aug</td>
<td>Limited Diversity II (90')</td>
<td>Lab session on calibration (60'): Rehearsal of analytic procedures learned during week 1</td>
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<td>- Untenable versus tenable assumptions</td>
<td>Lab session on calibration (60'): Rehearsal of analytic procedures learned during week 1</td>
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<td>- Enhanced Standard Analysis</td>
<td>Lab session on calibration (60'): Rehearsal of analytic procedures learned during week 1</td>
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<td>Day 9</td>
<td>Recap of Week 1; Alternative Parameters of Fit I (120')</td>
<td>Lab session on calibration (60'): Rehearsal of analytic procedures learned during week 1</td>
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<td>Thur. 6 Aug</td>
<td>Limited Diversity II (90')</td>
<td>Lab session on calibration (60'): Rehearsal of analytic procedures learned during week 1</td>
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<tr>
<td>Day 10</td>
<td>Recap of Week 1; Alternative Parameters of Fit I (120')</td>
<td>Lab session on calibration (60'): Rehearsal of analytic procedures learned during week 1</td>
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<tr>
<td>Fri. 7 Aug</td>
<td>Deepening of Knowledge and Set-Theoretic Multi-Method Research (60')</td>
<td>Lab session on calibration (60'): Rehearsal of analytic procedures learned during week 1</td>
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<td>- Post-QCA case selection principles and practices</td>
<td>Lab session on calibration (60'): Rehearsal of analytic procedures learned during week 1</td>
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<td>- Conclusion/debriefing of course</td>
<td>Lab session on calibration (60'): Rehearsal of analytic procedures learned during week 1</td>
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(Day 11, Saturday, 8 August, 9:00-12:00: Exam)

**Day-to-day reading list**


Below, we specify for each day which chapter(s) from this book are to be read and which additional optional literature students may want to consult.

**Week 1 (Patrick Mello)**

*NB: The reading list is subject to minor changes in order to adapt to the quickly evolving field*

<table>
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<tr>
<th>Recommended readings (*compulsory text)</th>
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<td><strong>Day 1 Mon. 27 July</strong></td>
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<td><strong>Day 2 Tue. 28 July</strong></td>
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<td>Week 2 (Carsten Q. Schneider)</td>
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<tr>
<td><strong>Day 6 Mon. 4 August</strong></td>
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<tr>
<td><strong>Review of Week 1; Parameters of Fit II</strong></td>
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<td><strong>Day 7 Tue. 5 August</strong></td>
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<tr>
<td><strong>Limited Diversity I</strong></td>
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<td><strong>Day 8 Wed. 6 August</strong></td>
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<tr>
<td><strong>Limited Diversity II</strong></td>
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<td><strong>Day 9 Thur.</strong></td>
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Software and hardware requirements

Software programme
R, RStudio

Hardware requirements

Literature

a. Mandatory reading

b. Important books:


c. **General Background Readings (during and after the course):**


Wagemann, Claudius, and Carsten Q. Schneider (2010). "Qualitative Comparative Analysis (QCA) and Fuzzy-Sets: Agenda for a Research Approach and a Data Analysis Technique." *Comparative Sociology* 9 (3):376-96.


d. On Software


e. Applications (selection)

*NB: the most up-to-date list of QCA applications can be found at the Compasss website (compasss.org)*


**Lecture room requirement**
Seminar room, computer lab, TA room.