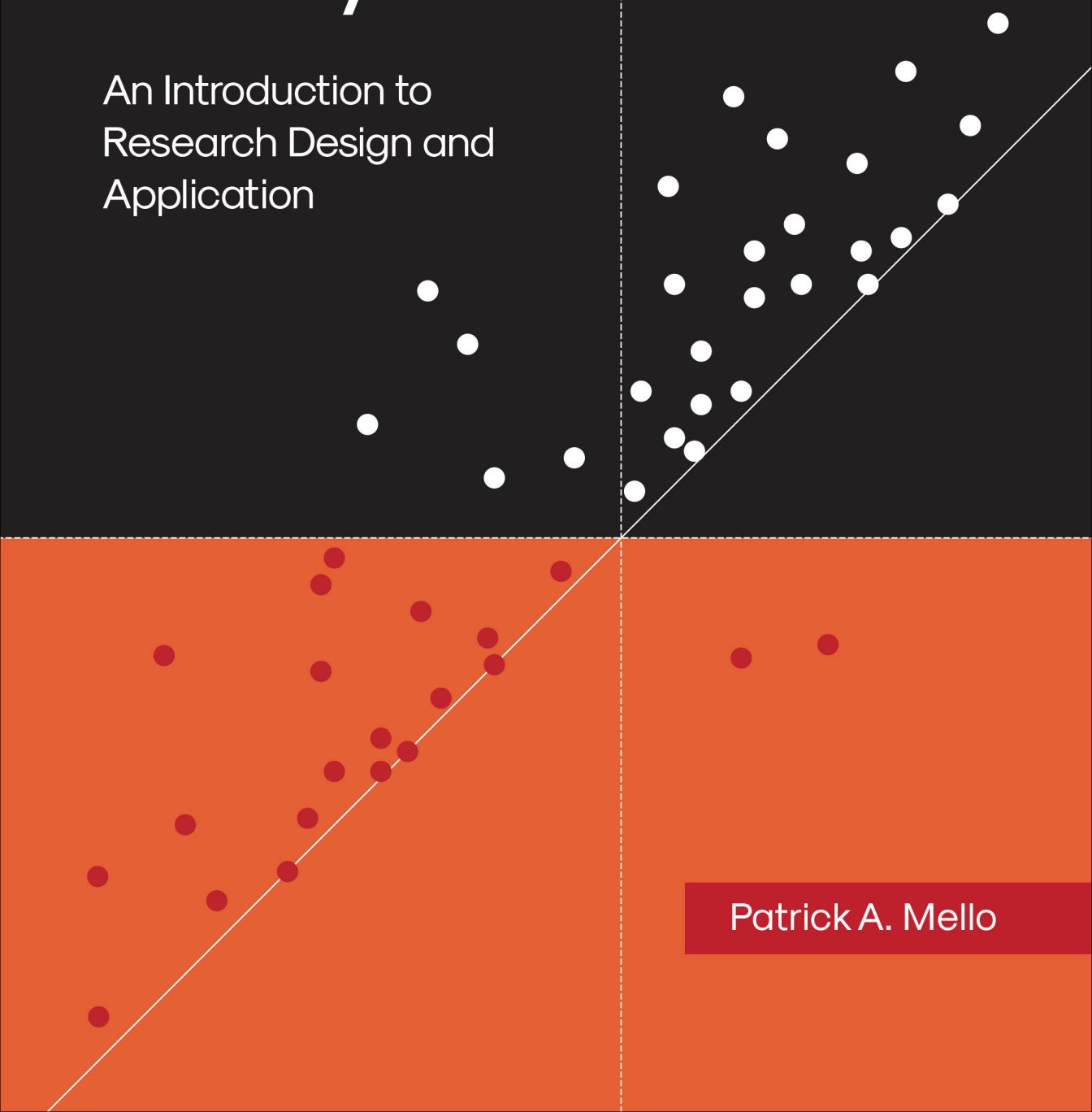
Qualitative Comparative Analysis

An Introduction to Research Design and Application



Patrick A. Mello

Qualitative Comparative Analysis: An Introduction to Research Design and Application

Patrick A. Mello

Front matter, table of contents, and chapter 1

This file contains the cover, title page, copyright page, table of contents and chapter 1 of the published book. The complete book is available from the publisher in hardcover, paperback and e-book formats.

Cite as

Mello, Patrick A. 2021. *Qualitative Comparative Analysis: An Introduction to Research Design and Application*. Washington, DC: Georgetown University Press. ISBN 9781647121440 (hardcover), 9781647121457 (paperback), 9781647121464 (e-book).

About the book

Social phenomena can rarely be attributed to single causes. Instead, they typically stem from a myriad of interwoven factors that are often difficult to untangle. Drawing on set theory and the language of necessary and sufficient conditions, Qualitative Comparative Analysis (QCA) is ideally suited to capturing this causal complexity. A case-based research method, QCA regards cases as combinations of conditions and compares the conditions of each case in a structured way to identify the necessary and sufficient conditions for an outcome.

Qualitative Comparative Analysis: An Introduction to Research Design and Application is a comprehensive guide to QCA. As QCA becomes increasingly popular across the social sciences, this textbook teaches students, scholars, and self-learners the fundamentals of the method, research design, interpretation of results, and how to communicate findings. Following an ideal-typical research cycle, the book's ten chapters cover the methodological basis and analytical routine of QCA, as well as matters of research design, causation and causal complexity, QCA variants, and the method's reception in the social sciences. A comprehensive glossary helps to clarify the meaning of frequently used terms. The book is complemented by an accessible online R manual to help new users practice QCA's analytical steps on sample data and then implement them with their own findings.

Links

Publisher: https://press.georgetown.edu/Book/Qualitative-Comparative-Analysis
Book page and resources: https://patrickmello.com/qca-research-design-application/
R Manual for QCA (version 4.2): https://patrickmello.com/qca/r-manual/ and https://doi.org/10.7910/DVN/KYF7VJ
Japanese edition: Chikura Publishing, 2023, ISBN 9784805113042

A second edition is under contract with Georgetown University Press.

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Patrick A. Mello

Georgetown University Press / Washington, DC

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Library of Congress Cataloging-in-Publication Data

Names: Mello, Patrick A., author.
Title: Qualitative comparative analysis : an introduction to research design and application / Patrick A. Mello.
Description: Washington, DC : Georgetown University Press, 2021. | Includes bibliographical references and index.
Identifiers: LCCN 2021004429 | ISBN 9781647121440 (hardcover) | ISBN 9781647121457 (paperback) | ISBN 9781647121464 (ebook)
Subjects: LCSH: Social sciences—Research—Methodology. | Social sciences—Statistical methods.
Classification: LCC H62 .M38 2022 | DDC 300.72/1—dc23
LC record available at https://lccn.loc.gov/2021004429

∞ This paper meets the requirements of ANSI/NISO Z39.48-1992 (Permanence of Paper).

22 21 9 8 7 6 5 4 3 2 First printing

Printed in the United States of America

Cover design by Martha Madrid
Interior design by BookComp, Inc.

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1 • Qualitative Comparative Analysis in the Social Sciences

The causal relationships on which scholars now focus
are different from those posited two decades ago,
and many acknowledge forms of multicausality
that previous work ignored.

—PETER A. HALL

Social phenomena can rarely be attributed to individual causes. Instead, what social scientists observe is often the result of a combination of several factors. For instance, how to explain the global rise of populism? Depending on who you ask, different accounts are suggested. But many observers agree that important drivers are the socioeconomic effects of globalization and a general increase in uncertainty, which often boils down to questions of identity and meaning. To account for the electoral success of populist parties, either of these factors may need to be present. Moreover, multiple pathways may lead to the same outcome. Although the United States, Turkey, Bolivia, and Venezuela all saw the emergence of populist leaders, these countries' socioeconomic conditions are quite different, suggesting the existence of different trajectories toward populism. To complicate things further, the explanation for the positive outcome may not provide an explanation for the negative outcome. And though we may have empirically identified socioeconomic grievances as a cause of the electoral success of populist leaders, this does not allow us to say that the absence of such grievances means that populists will not be electorally successful.

Together, the concepts of conjunctural causation (combinations of conditions), equifinality (multiple pathways), and causal asymmetry (outcome and nonoutcome may require different explanations) constitute the core of *causal complexity*, a defining characteristic of Qualitative Comparative Analysis (QCA; Ragin 2008b; Rihoux and Ragin 2009; Schneider and Wagemann 2012). Drawing on set theory and the language

of necessary and sufficient conditions, QCA is a case-based comparative research method that is ideally suited to capture causal complexity.

This chapter introduces readers to QCA, and to the approach to exploring it that is taken in this book. After a general overview on the method and the substantive research areas where it has been applied in the social sciences, I sketch the QCA research cycle that informs the book's chapter structure. This is followed by a brief history of the method and its development, a look into publication trends in various disciplines over the past decades, and a chapter-by-chapter discussion of the book's outline.

WHAT IS QUALITATIVE COMPARATIVE ANALYSIS?

Originated by Charles Ragin (1987) in his seminal book *The Comparative Method*, QCA was conceived as a case-based method for "comparing wholes as configurations of parts" (Ragin 1987, 84). Although there is undoubtedly more to QCA, this concise definition captures the essence of what the method is about. It is a comparative method that regards cases as combinations of conditions. The emphasis on cases and their complexities also reflects QCA's roots as a qualitative method. What is left out in this definition is that QCA compares cases to identify necessary and sufficient conditions for an outcome. This is done through a structured analytical procedure and a software-based algorithm—all of which are introduced in stepwise fashion in this book.

Throughout the past three decades, QCA has undergone a dynamic evolution. Although some of its early applications were still carried out by hand, where researchers manually filled out spreadsheets, the method nowadays draws on a reliable spectrum of software-based solutions that reflect a high level of methodological sophistication and refinement. Moreover, scholars have developed a broad repertoire of QCA variants to address specific needs and formulated sets of best practices to guide applied research.

The evolution of QCA went hand in hand with its spread across the social sciences, including the fields of sociology, political science, international relations, economics and management, public policy, political geography, legal studies, criminology, public health, evaluation studies, and many other areas of research.[1] Many early QCA applications were macrocomparative studies of welfare state formation in liberal democracies (e.g., Hicks, Misra, and Ng 1995). Nowadays there are applications at all levels of analysis. Besides the country level, studies have selected units of analysis ("cases"), such as regional parliaments (Buzogány and Häsing 2018), government cabinets (Vis 2010), national elections (Fernández-García and Luengo 2019), internet regulators (Ewert, Kaufmann, and Maggetti 2020), medical schools (Williams et al. 2018), project ventures (Bakker et al. 2011), communities (Kane et al. 2016), business firms (García-Castro, Aguilera, and Ariño 2013), civil society organizations (Durán Mogollón, Eisele, and Paschou 2020), peacekeeping missions (Gromes 2019),

investment decisions (Berger, Wenzel, and Wohlgemuth 2018), and food safety inspectors (Thomann, Hupe, and Sager 2018).

Likewise, empirical studies have covered a wide range of substantive issue areas, including norm promotion (Schimmelfennig 2005), allocation of government ministries (Oppermann and Brummer 2020), compensation inequality (Greckhamer 2011), national convergence of EU law (Goanta and Siems 2019), stem cell regulation (Engeli and Rothmayr Allison 2013), sanctions effectiveness (Boogaerts and Drieskens 2020), authoritarian persistence (Grauvogel and von Soest 2014), labor market policies (Vis 2011), partisanship and policy change (Hörisch and Wurster 2019), environmental peacekeeping (Ide 2018), trade relations (Gansemans et al. 2017), postconflict democratization (Mross 2019), weight management interventions (Melendez-Torres et al. 2018), state collapse (Johais, Bayer, and Lambach 2020), democratic war involvement (Mello 2014), and the role of junior partners in coalition warfare (Schmitt 2018).

Methodology textbooks show that QCA has been widely acknowledged as a method that can have unique benefits for comparative research and multimethod research designs (Beach and Pedersen 2019; Blatter and Haverland 2012; Gerring 2012b, 2017, 2020; Goertz and Mahoney 2012; Moses and Knutsen 2019; Rihoux and Grimm 2006; Rohlfing 2012; Toshkov 2016). Unlike conventional statistical methods that focus on the "average effects of independent variables" (Mahoney 2010, 132), QCA explores the specific conditions under which outcomes of interest occur. Therefore, causal relationships are expressed in the set-theoretic terminology of *necessary and sufficient conditions*, a perspective that is "increasingly viewed as substantively important" in social science research (Collier et al. 2010a, 147). In a nutshell, necessity means that a condition is always present when the outcome occurs, whereas sufficiency indicates that whenever a condition appears, so does the outcome.

Although QCA has been recognized as a valuable addition to the social-scientific toolbox, the method's analytical protocol, available software, and standards required for peer-reviewed publications have gradually become more sophisticated. Clearly, these are welcome developments. But the methodological refinement has also created barriers for new users. For example, consider the R software environment, which has become the new standard for conducting QCA studies (Duşa 2019b; Oana, Schneider, and Thomann 2021).[2] Though R provides a powerful platform of boundless possibilities, it can also be forbidding and frustrating, even for people with a background in computational analysis.[3] This poses an even bigger hurdle for those without any prior knowledge of R, who are considering using QCA for a project. Others might be uncertain about whether QCA is a suitable method for their own research and the kind of data they have collected. Still others might have read a critique of QCA and are now unsure if the method can be fruitfully applied in their own project (critiques are discussed in chapter 9).

This book seeks to overcome such barriers and address conceivable concerns by providing a step-by-step introduction to QCA that emphasizes research design, practical

application, and real-life examples from published studies. The book's online R Manual aims at new users who are not yet familiar with R (instructions are provided in the appendix). Beginners are taken through each step in the research process so that the method can swiftly be applied to individual projects. Experienced users will refresh their knowledge of QCA, learning about recent developments and new ways to apply the method, including up-to-date discussions of best practices. Both groups will profit from many illustrated examples from published studies, and a compendium of suggestions to improve QCA research design, the interpretation of findings, and the graphical presentation of results.

HOW TO USE THIS BOOK

This book provides a hands-on introduction to QCA. Because the chapters follow an ideal-typical research process, beginners should read the chapters in sequence. Experienced users who are interested in specific issues can directly move to the respective chapter or section, as highlighted in the table of contents and the index. Key terms are

Table 1.1 Overview of This Book's Infoboxes

Variant	Box	Field	Topic	Study
Multimethod QCA	2.1	Political geography	Environmental cooperation and peacemaking	Ide (2018)
Fuzzy-set QCA	2.2	Sociology	Biological attributions of mental illness	Andersson and Harkness (2018)
Fuzzy-set QCA	5.1	Political science	Leaders' economic beliefs	Swinkels (2020a)
Fuzzy-set QCA	5.2	Public policy	Climate change policy	Giordono, Boudet, and Gard-Murray (2020)
Multivalue QCA	8.1	Law	Judicial independence	Castillo-Ortiz (2017)
Two-step QCA	8.2	Environmental governance	Policies against deforestation	Brockhaus et al. (2017)
Crisp-set QCA, MDSO-MSDO	8.3	International relations	EU military operations	Haesebrouck (2017)

summarized in the book's glossary. The book is written for anyone interested in learning about QCA, how to use it properly, and how to make the most of their analytical findings. The book equally speaks to beginners, who may have heard about the method and want to understand its basics, as well as experienced users who are familiar with QCA but want to learn more about seizing its potential. There are no prerequisites, and the technical discussion is kept to a necessary minimum. To enable readers to engage in a seamless application of the QCA procedure, the R Manual provides a hands-on guide on how to install the software, how to prepare the data, and how to conduct the main analytical steps in R. This is complemented by an R script that users can customize for their own research needs.

A unique feature of this book is that the substantive chapters are complemented by seven infoboxes from authors of published QCA studies, who revisit their personal experiences with QCA and the decisions they faced when they conducted their study. The selected examples represent a diverse range of applications across the social sciences, including political science, sociology, law, public policy, environmental governance, political geography, and international relations. The infoboxes further draw on six different QCA variants and approaches, to document the full spectrum of empirical applications. The unique authors' perspectives allow readers a look "behind the scaffolding" of published studies, which rarely make such decisions explicit. Table 1.1 lists the contributions from various scholars found in this book, their QCA variant, field of study, and topic of application.

THE QCA RESEARCH CYCLE

The chapter outline of this book follows an ideal-typical QCA research cycle, as shown in figure 1.1. Typically, the starting point for a new project is the definition of a research problem, which is narrowed down to a focused research question in the next step. Potential answers for the research question are found in theory, whether as broad conjectures or formal hypotheses. The first stage is complete when theory is linked to empirical observations, in the form of cases and conditions selected for study. The issues that arise during this stage are discussed in chapter 2 on research design. The second stage begins with data gathering and the calibration of sets, to prepare for the QCA analysis. The foundation of set theory is provided in chapter 3. Chapter 4 considers causation and causal complexity, which equally inform the initial stages of research and the substantive interpretation of the findings. Calibration techniques and examples are introduced in chapter 5.

The core of the analytical procedure begins with the construction of the truth table and the analysis of necessary and sufficient conditions. Measures of fit, as a required background to make sense of the analytical results and to interpret empirical patterns are discussed in chapter 6, while the set-theoretic analysis as the core of QCA is the

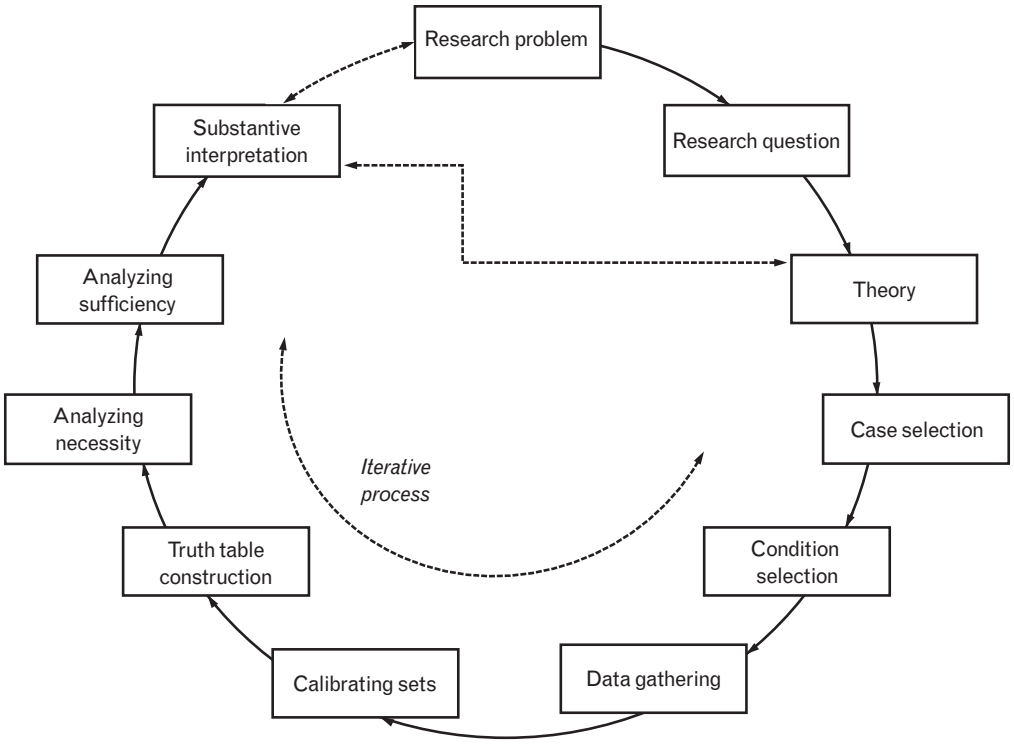


Figure 1.1 The QCA Research Cycle

topic of chapter 7. What remains is the substantive interpretation of the analytical results. It is important to underline that set-theoretic analysis is meant to be an *iterative process*—a "back-and-forth" between theory and evidence (Ragin 2000). Hence, initial results often lead to an adaptation of the theory, case selection, or other aspects of the research design, until a satisfactory explanatory model is found.

A BRIEF HISTORY OF QCA

At 30 years of age, QCA may still be considered a novel approach, at least when compared with statistical methods and historically informed case studies, each of which can trace their lineage to the eighteenth century (Moses and Knutsen 2019). Yet the method has undergone a substantial evolution since its inception by Charles Ragin in 1987. At its core, QCA is grounded in the algebra of George Boole, a nineteenth-century British mathematician and logician. Boolean algebra uses variables that occur in only two states: *true* (present) or *false* (absent). This conception proved central, for instance, to the development of electronic switching circuits, and Boolean algebra

was soon widely used across the applied sciences (Whitesitt 2010). What is important for the aims of qualitative comparison is that Boolean algebra allows for set-theoretic operations, the construction of truth tables, and their minimization to derive solution terms—essential parts of QCA that are covered throughout this book.

Naturally, the Boolean use of binary categories meant that QCA was limited to working with *crisp sets*, where 1 indicated the presence of a condition and 0 indicated its absence. This drawback was overcome with the introduction of *fuzzy sets* (Ragin 2000), which allowed for graded set membership (any scores from 0 to 1). Fuzzy logic was developed by the mathematician Lotfi Zadeh (1965), who conceived of it as an extension of traditional set theory to tackle the problem of complex and imprecise concepts. Zadeh's work sparked a revolution in computer technology, which was narrated in the account by Daniel McNeill and Paul Freiberger (1993), and fuzzy sets have also made their way into the social sciences (Smithson and Verkuilen 2006), including linguistics (Lakoff 1973) and many other areas of application.

Another step in the refinement of QCA was the introduction of *measures of fit* to assess the strength of the empirical support for set-theoretic relationships of necessity and sufficiency (Ragin 2006b). The measure of set-theoretic *consistency* indicates the extent to which cases that share a specific combination of conditions also show the outcome of interest. In turn, set-theoretic *coverage* reflects "how much" a condition or combination of conditions accounts for the occurrence of the outcome. These measures introduced straightforward indicators to evaluate the analytical results of QCA, which are similar to the concepts of significance and strength in statistical analyses (Ragin 2008b, 45). Later, these were complemented by additional measures of fit, including *proportional reduction in inconsistency* (Mendel and Ragin 2011) and *relevance of necessity* (Schneider and Wagemann 2012). Chapter 6 develops these and additional metrics and illustrates them with empirical examples.

Evidently, the comparative logic of QCA was inspired by John Stuart Mill's well-known methods of scientific inquiry, which he put forth in *A System of Logic*, first published in 1843 (Mill 2006, book 3, chapter 8). His methods include the method of agreement and method of difference, as well as the lesser-known method of residues and method of concomitant variations. But Mill (2006, 388–406) also devised a joint method of agreement and difference. In some ways, QCA can be seen as a systematic application of the joint method, which Mill already regarded as an improvement over his more basic approaches (Mill 2006, 396).

However, it is important to note that QCA goes beyond Mill's methods in many respects. First, whereas Mill focused on individual variables to identify a single cause for an observed phenomenon, QCA explicitly considers equifinality and conjunctural causation. Second, Mill's methods cannot account for the phenomenon of limited diversity, but this is systematically addressed in QCA's truth table procedure, which identifies all logically possible combinations of conditions and enables researchers to deal with so-called logical remainders (combinations without empirical cases). Third,

the advent of fuzzy sets meant that graded set membership became feasible and measures of fit gave researchers ways to assess the strength of set-theoretic relationships. Both features are missing from Mill's methods.[4] Finally, Boolean logic and minimization allow for a systematic comparative procedure and inferential analysis that is not found in Mill's methods.

Although crisp-set and fuzzy-set QCA are the method's most popular variants, there are also several extensions and approaches aimed to overcome specific limitations of QCA. For instance, *multivalue QCA* (Cronqvist 2019; Cronqvist and Berg-Schlosser 2009) allows for nominal variables that entail three or more categories. This can be helpful where explanatory conditions cannot easily be dichotomized without losing important information. For example, instead of distinguishing between "employed" and "unemployed," you may want to introduce further categories like "part-time employed" and so forth. Another variant is *temporal QCA* (Caren and Panofsky 2005; Hino 2009; Ragin and Strand 2008), which aims to overcome the static nature of QCA comparisons by introducing notions of time and sequence. This is done via an additional operator that distinguishes whether a condition occurred before another condition (see also Pagliarin and Gerrits 2020). *Two-step QCA* (Schneider and Wagemann 2006) was developed to tackle the problem of limited diversity and having too many conditions. The approach distinguishes between remote and proximate explanatory conditions and conducts consecutive truth table procedures instead of just one. Finally, *fuzzy-set ideal type analysis* (Kvist 2007) aims to understand the constitution of cases (rather than explaining an outcome), which are compared against preconceived ideal types rooted in theory. Chapter 8 introduces these and other QCA variants with examples from applied research.

One of the most dynamic areas in QCA's evolution is software development. Although the first version of what later became the fs/QCA software was already introduced in 1986 (Drass and Ragin 1986), it was soon complemented by a range of different programs and packages for various platforms. And though there is a healthy stream of published studies using the fs/QCA and Tosmana programs, the most advanced software for QCA nowadays is based on the R environment. Among other advantages, R is platform independent, which means that it can be used on any computer system. Unlike many commercial statistical programs, R is free of cost and open source. Most important, rather than a click-and-point software with predefined functions, R and its code can be tailored for individual purposes. This means that besides the QCA procedure, one can visualize the data and analytical results within R and complement the analysis with further computational tests as needed.[5] Finally, R code can easily be made available as a complementary file, which enhances transparency and replicability. The R Manual that complements this book provides a concise introduction to R, its functions, and relevant packages for QCA analyses (see the appendix).

Since its founding, QCA has also spurred an array of critiques. One of the reasons for this may be the method's *hybrid* nature as an approach with both qualitative and quantitative elements—which propels criticism from scholars trained in statistical methods,

who usually work with hundreds or thousands of observations, as well as from those who conduct intensive studies on a handful of cases at most. Although not limited to a certain number of observations, QCA typically operates with 20 to 50 cases, which means that it is situated right between these camps. Chapter 9 reviews the criticism leveled against QCA and derives guidelines for how to respond to the arguments.

TRENDS IN QCA APPLICATIONS

The dynamic development of QCA is mirrored in the number of academic publications using this research method. Figure 1.2 displays the cumulative number of Web of Science journal articles between 1987 and 2020.[6] Growing slowly over the course of the 1990s, there has been an exponential increase in QCA studies since the late 2000s. The surge in QCA studies corresponds broadly to the publication of seminal textbooks that formalized the method and enhanced its widespread application, such as Ragin (2008b), Rihoux and Ragin (2009), and Schneider and Wagemann (2012).

As of 2020, the Social Sciences Citation Index (SSCI) of the Web of Science lists about 1,400 journal articles that referred to "qualitative comparative analysis" in one form or another. Although it should be noted that this number includes studies that use a broad understanding of the term or make only a passing reference to QCA, the complete number of empirical QCA applications and methodological articles is prone to be even higher because the SSCI covers only a part of all academic journals, and

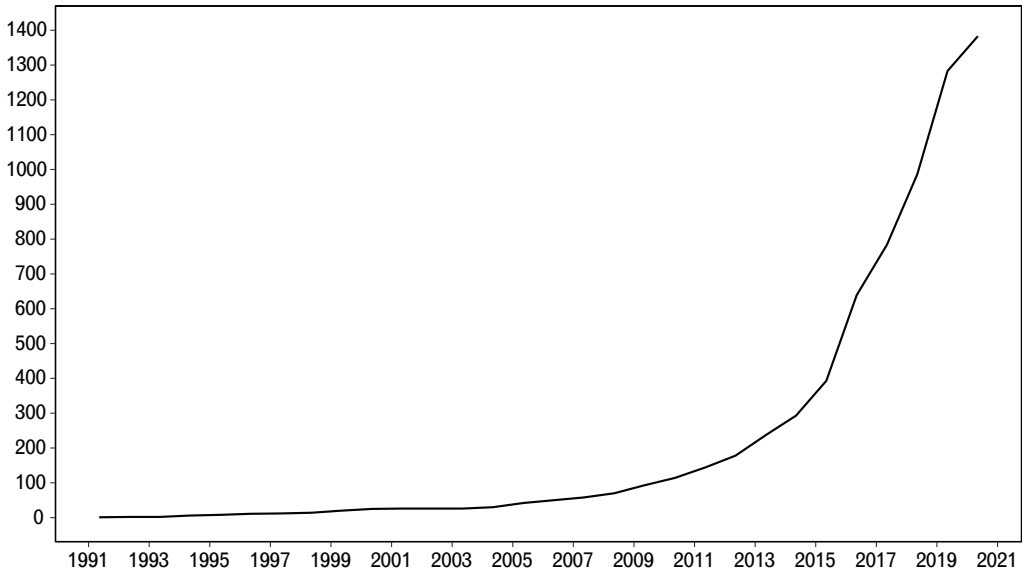


Figure 1.2 Cumulative Journal Articles on QCA, 1987–2020

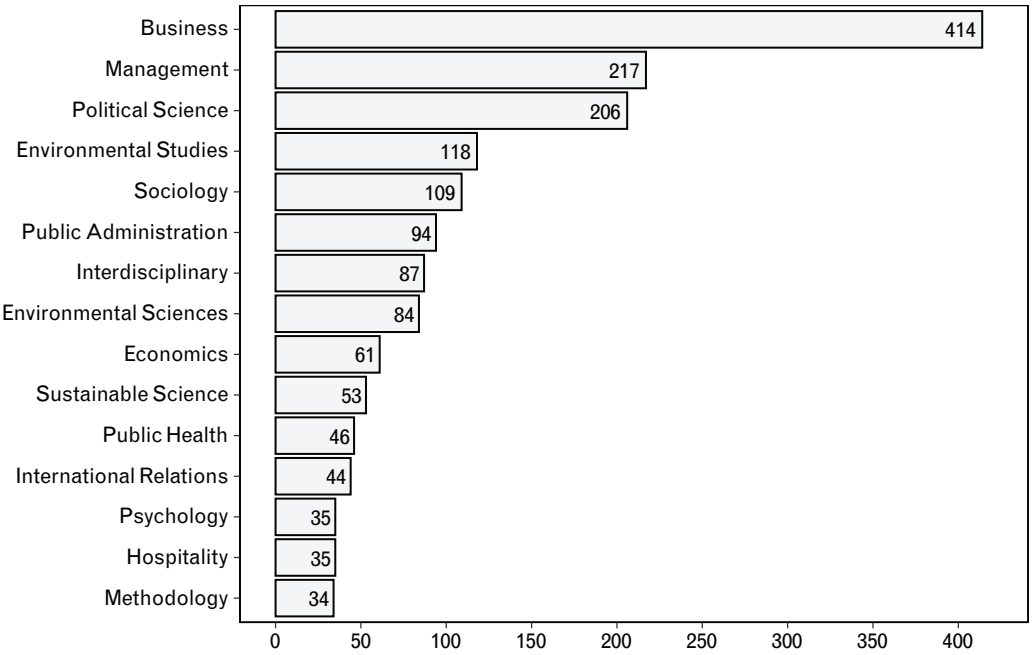


Figure 1.3 Journal Articles on QCA, 1987–2020, by Category

especially non-English publications are largely absent from its database. The growth of QCA also shows in the citation numbers for Ragin's (1987) *The Comparative Method*, which has accumulated about 10,800 citations on Google Scholar as of December 2020.

Which research fields of the social sciences contributed to this growth? Where is QCA most popular? Figure 1.3 differentiates the publication data from the Web of Science by research field for the top 15 categories in the SSCI. We can see that there are 10 substantive fields that each contain at least 50 articles on QCA in the years between 1987 and 2020. Business studies are out ahead, with 414 studies in the period. This is followed by the fields of management and political science, with more than 200 studies each; environmental studies and sociology, both with over 100 studies; and public administration, at just below that threshold. Overall, the Web of Science data differentiates more than a hundred different categories, with at least one study that mentions QCA (with an average of 20 and a median of 4 articles that refer to QCA).

To be sure, the Web of Science data do not differentiate by article length or publication output in a given field. Some fields have journals with a high volume of relatively short articles, which naturally drives up publication and citation numbers. Another caveat to the Web of Science data is that many journals are listed under more than one category, which leads to empirical overlap because the same journal article may be counted under several categories (on average, each of the 1,387 articles refers to 1.6 categories). However, these limitations notwithstanding, we can see that QCA as a

method is recognized across the entire spectrum of the social sciences and firmly established in a broad number of research fields.

OUTLINE OF THE BOOK

This book comprises 10 chapters. Its outline follows a typical research process, which means that new users will benefit from reading the chapters in sequence. But readers can also use the table of contents and index to navigate among issues, based on their own interests and backgrounds. Two caveats are in order. The first concerns the use of methodological jargon. In this book, I aim to give a thorough but approachable introduction to QCA. Hence, to the extent feasible, I have limited the usage of technical terms and acronyms. However, a number of terms are essential for understanding what the method is about and how to apply it correctly. These terms are introduced throughout the book and are defined in the book's glossary.

The second caveat relates to chapter sequence. Introducing a method like QCA poses a chicken-and-egg problem. Before we can move to set-theoretic analysis, we need to lay the groundwork, but some of this may only appear useful once later chapters are read. Hence the book begins with three general chapters—on research design, set theory, and causation and causal complexity—but their implications may only be clear when all elements of the analytical procedure have been presented.

After this introductory chapter, chapter 2 opens with a guide to QCA *research design*, including the formulation of research questions, the different uses of QCA, and the selection of cases and conditions. The chapter closes with observations from a survey of recently published studies and recommendations for conducting multimethod research with QCA. Chapter 3, on *set theory*, lays out the distinctive characteristics of set-theoretic approaches. Starting with the distinction between crisp and fuzzy sets, the chapter introduces Boolean operations, formal notation, truth tables, and the concepts of necessary and sufficient conditions. The chapter concludes with a summary on how set relations can be identified in empirical data. Chapter 4 takes a step back to examine four major theories of *causation* in the philosophy of the social sciences. The second part of the chapter connects the discussion with an introduction to the concept of *causal complexity* and the prospects of *causal analysis* with QCA.

The subsequent three chapters develop the analytical core of the method. As a preliminary to set-theoretic analysis, chapter 5 discusses the *calibration* of crisp and fuzzy sets, including crucial differences in quantitative approaches to measurement. The chapter presents strategies to calibrate sets based on different kinds of qualitative and quantitative raw data, provides a guide to the mathematical transformation of raw data into calibrated scores, and introduces applied examples to underscore a range of different calibration approaches. Chapter 6 introduces *measures of fit*, which help to assess and interpret QCA results. Using empirical examples, the chapter explains how

set-theoretic consistency and coverage are calculated and how the resulting scores should be interpreted. The chapter closes with discussions of additional measures of fit. Chapter 7 presents set-theoretic analysis, starting with the analysis of *necessary conditions*, proceeding to the construction of the *truth table*, and concluding with the Boolean *minimization* to derive *solution terms*. Using empirical examples, the chapter illustrates how researchers' decisions have an impact on solution terms and closes with a discussion of *counterfactual analysis* and the treatment of *logical remainders*.

Although the book's emphasis rests on crisp and fuzzy-set QCA as the most popular variants, chapter 8 introduces QCA *variants*—namely, multivalue, temporal, and two-step QCA—as well as fuzzy-set ideal type analysis. The chapter discusses the advantages and requirements of each approach against the backdrop of empirical examples. Chapter 9 reviews the methodological debate on QCA's strengths and limitations, aiming to summarize the conversation for new users and to highlight how prior critiques have been addressed in the development of QCA. Chapter 10 summarizes the book's core points and derives guiding principles for good research practice. It also provides readers with directions for further developing their own applications. Conceived as a supplement, the appendix provides instructions for the online R Manual that summarizes the core R functions needed to conduct QCA, including reading and manipulating data, calibrating conditions, testing for necessary conditions, constructing a truth table, deriving solution terms, and visualizing results.

NOTES

Epigraph: Hall (2003, 383).

1. For a general overview of trends in applied QCA research, see Rihoux et al. (2013). For an introduction to QCA from an ethnographic and social movement perspective, see Kröger (2021). There are also reviews of QCA studies in specific fields, including comparative welfare state research (Emmenegger, Kvist, and Skaaning 2013), public policy (Hudson and Kühner 2013; Rihoux et al. 2011), public administration (Thomann and Ege 2020), sociology (Buche and Siewert 2015), business research (Wagemann, Buche, and Siewert 2016), public health (Palinkas, Mendson, and Hamilton 2019), entrepreneurship (Kraus, Ribeiro-Soriano, and Schüssler 2018), spatial planning (Verweij and Trell 2019), democratization (Møller and Skaaning 2019), and on the combination of QCA with statistical analyses (Meuer and Rupietta 2017).

2. As an indication of this, QCA summer school courses at the ECPR Summer School in Methods and Techniques, the ICPSR Summer Program in Quantitative Methods of Social Research, and the FORS Swiss Summer School in Social Science Methods now exclusively work with R and the packages "QCA" (Duşa 2019b) and "SetMethods" (Oana and Schneider 2018). The R software environment is freely available for all operating systems; see www.r-project.org/. The major alternatives to R include the "fs/QCA" (Ragin and Davey 2017) and "Tosmana" software (Cronqvist 2019). A comprehensive list of all available software, including further R packages, is maintained at the QCA community website: https://compasss.org/community/.

3. For a "survivor's guide" to R, see Gaubatz (2015).

4. To be fair, Mill's method of concomitant variations does allow for quantitative differences (Mill 2006, 403). For a discussion of Mill's methods in the context of modern quantitative approaches, see Sekhon (2008).

5. For example, the studies by Ide (2018) and Schneider and Makszin (2014) conduct statistical analyses before QCA, and Mello (2020) complements the set-theoretic analysis of necessity with statistical tests of association.

6. The database can be accessed at www.webofknowledge.com.

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Works cited in chapter 1. The complete list of references is on pages 211–34 of the book.

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