



Trajectory-based Qualitative Comparative Analysis: Accounting for case-based time dynamics

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Abstract

Qualitative comparative analysis was initially time-agnostic, but efforts to make the method more time-sensitive have been made since the mid-2000s. These attempts mainly focus on cross-case differences, accounting for change over time at the level of attributes or conditions. While useful, they cannot account for the fact that individual cases also develop over time. As such, strategies regarding ‘within-case’ development have remained under-theorized in qualitative comparative analysis (QCA). To address this gap, we propose trajectory-based qualitative comparative analysis (TJ-QCA) building on the logic of the diversity-oriented approach: meaningful within-case change is carefully defined in terms of development stages that capture qualitative case-based change patterns. We conceptualize configurations dynamically so that they express different development stages. Theoretically, our method is rooted in a complexity-informed understanding of cases describing trajectories through the property space. Trajectory-based qualitative comparative analysis works with both numerical and qualitative data. We will illustrate the method empirically by re-elaborating a well-known published time-sensitive qualitative comparative analysis study.

Keywords

Trajectory, complexity, configurations, longitudinal, time-series, qualitative methods

Introduction

Qualitative comparative analysis (hereafter, QCA) is a set-theoretic method and research approach for systematic cross- and within-case comparison introduced by Charles C. Ragin (1987). At the cross-case level, a given number of attributes, called conditions, form configurations. Types of cases associate with different configurations, leading to the presence or absence (in kind or degree) of an outcome. QCA is hence an outcome-driven method, where different configurations can explain different types of cases (equifinality; Ragin, 2008). Configurations also capture qualitative within-case differences: the focus on types of cases is grounded on the ‘diversity-oriented logic’ underlying QCA (Ragin, 2000). Configurations are instrumental in merging case-based research and in-depth case narratives with the generality sought for in variable-oriented approaches (Byrne, 2005; Byrne and Ragin, 2009).

The rising popularity of the method comes with rapid theoretical and methodological advancements, branching out in many directions and adding layers of complexity to the original version. Different types of QCA (crisp-set, fuzzy-set,

multi-value) have been established and applied in a variety of disciplines (Rihoux et al., 2013) and empirical applications expanded from small/intermediate-n (<70 cases) to large-n datasets (Greckhamer et al., 2013).¹

Despite the widespread acknowledgement of the dynamic unfolding of social processes, ‘time’ has proven elusive within QCA. Initially, it did not account for the fact that conditions may be distributed across time. Later, Caren and Panofsky (2005), and then Ragin and Strand (2008; see also Schneider and Wagemann, 2012: ch. 10), introduced time-QCA (TQCA) to represent the chronological order of events at the level of conditions (cross-case level). Simultaneously, insights from statistical cross-sectional and time-series analysis (time-series QCA TS/QCA, Hino, 2009) and strategies

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Table 1. Different options to integrate time into QCA.

Qualitative comparative analysis (QCA) and time	Cross-case level (temporal order of conditions; sequences of events)		
		No	Yes
Within-case level (time variation in cases)	No	Conventional/Pooled QCA (crisp-set, fuzzy-set, multi-value)	TQCA (Caren and Panofsky, 2005; Ragin and Strand, 2008); two-step QCA (Schneider and Wagemann, 2012: ch. 10)
	Yes	Time-series QCA (TS/QCA) (Hino, 2009); Panel data QCA (PD-QCA) (Garcia-Castro and Ariño, 2013)	Trajectory-based QCA (TJ-QCA)

for the treatment of longitudinal/panel datasets (Garcia-Castro and Ariño, 2013, panel data or PD-QCA) have been integrated into QCA at the level of time variation in cases (within-case level; see Table 1 above).

While these contributions have been key in making QCA more time-sensitive, their focus rests primarily on the time variation of attributes across cases (cross-case level). Consequently, the complexity of individual cases remains unexplored, which is discordant with the diversity-oriented approach to cases as outlined above (Byrne, 2005; Ragin, 2000; Byrne and Ragin, 2009). Arguably, within-case time variation has so far not been considered at both the conceptual and at the technical level, that is, there is no established strategy in QCA accounting for the fact that individual cases can change, or remain stable, over time (see Schneider and Wagemann, 2012: 256). The evolution of particular cases is usually accounted for through thick case descriptions, for example, to substantiate the assignment of a particular set-membership score (i.e. calibration) or to explain a certain finding by ‘going back to cases’ (De Meur et al., 2009: 155–161). However, structural mapping and comparison of within-case development is not yet available.

This article has two goals: (1) to provide an overview of the different ways in which time is conceptualized in current QCA approaches; and (2) to present a novel way to account for within-case time variation in QCA, called trajectory-based QCA (TJ-QCA). This novel approach hinges on the argument that, if configurations can capture cases as wholes by accounting for their differences (i.e. their variation both in kind and degree; ‘one case, one configuration’), configurations should be equally fit to capture the evolution of single cases when developing over time (‘one case, multiple configurations’). In this light, configurations may represent the qualitative variation ‘inside’ single cases over time (within-case time variation). Case development can thus be represented by multiple configurations, each configuration corresponding to a specific development stage of a certain case. These configurations together represent the sequential movement over time in the property space, that is, a trajectory. Trajectories can be applied in actual empirical research to both quantitative and qualitative information.

The conceptual and methodological originality of our approach is grounded in a case-based understanding of time: instead of considering time as being distributed across clock time (i.e. at fixed intervals determined by time such as hours, days, years), time is demarcated by the researcher who identifies the various developmental stages of individual cases. Our approach hence innovatively proposes a time-sensitive re-definition of cases. This way, the qualitative narratives about the evolution of cases are explicitly accounted for by means of multiple configurations. Not only is this in line with the outcome-centeredness and diversity-oriented approach of QCA (Ragin, 2000) but also in line with, for example, Abbott (1992, 2001) and Abell (Abbott, 1993), who locate the driving factors in social processes in sequences of events (see also Gerrits and Pagliarin, 2020). We call the set of multiple configurations that *together* represent the time-bound development stages of a *single* case, a ‘trajectory’, hence ‘trajectory-based QCA’ (TJ-QCA).

We proceed with a short overview of existing main techniques to account for time in QCA. Next, we discuss the concept of trajectory in more detail. Subsequently, we first critically examine the well-known TS/QCA by Hino (2009) and propose an improvement by using relative variations. In the final step, we use Hino’s study and dataset to demonstrate how TJ-QCA can effectively be applied to his analysis and other empirical research. We provide some critical insights to our approach and outline avenues for further research.

Different approaches to account for time in QCA

Conventionally, QCA considers configurations as static ‘snapshots’ of cases where the interdependence of conditions is considered, but not their chronological or ordered unfolding over time (see Gerrits and Verweij, 2018: ch. 5). Caren and Panofsky (2005) proposed temporal QCA (TQCA), where temporal order is accounted for by including all the possible sequences in which conditions could occur. Consequently, the number of possible configurations increases substantially ($k! \cdot 2^k$). However, not all possible configurations are empirically observed and sequence of events only matter in specific cases. Therefore, Caren and Panofsky recommend appropriate

strategies to restrict the number of possible configurations. In response, Ragin and Strand (2008) modified TQCA by including, if theoretically and empirically relevant, temporally ordered conditions as new conditions in the dataset (e.g. 'B before A' will be rendered as condition 'D'). Therefore, the number of possible combinations of conditions is reduced $((k*(k-1))/2)$ as compared to Caren and Panofsky's (2005) version. Despite these possibilities, to our knowledge, TQCA is seldom used in empirical research.

In an attempt to keep the number of conditions to a workable limit for empirical research, Schneider and Wagemann (2012: ch. 10) developed two-step QCA. The authors differentiate between 'remote' and 'proximate' conditions according to the 'causal closeness' to the outcome that conditions are assumed to have. Remote conditions are factors 'relatively stable over time', while proximate conditions 'vary over time and originate not so far back in the past' (Schneider and Wagemann, 2012: 253). Remoteness and proximity can also be interpreted in terms of space, making two-step QCA a tempo-spatial-sensitive approach. Recently, Schneider (2019) expanded the conceptualization of remote and proximate conditions to account for 'structure' and 'agency'.

In these approaches, the conceptualization of time corresponds to temporal order and sequence of events at the level of conditions (cross-case). In contrast, Hino (2009) introduced TS/QCA as a first formalized contribution shifting the focus from cross-case time variation to within-case level. Hino defines three subtypes of TS/QCA: 'pooled', 'fixed effects' and 'time-differencing' QCA. 'Pooled QCA' is the standard time-insensitive QCA (see Table 1), where cases across different time points and spatial units are considered homogeneous, and where set-membership values are assigned uniformly. In 'fixed effect' QCA, the values at different time points ($t_0, t_1, t_2, \dots, t_n$) available per each case (e.g. a country) are averaged, and the average (or median) is used as cut-off point to define set-membership separately for each case. Therefore, the within-case values at time points $t_0, t_1, t_2, \dots, t_n$ per each case become the cases. Hino (2009: 257) argues that fixed effect QCA is most appropriate when different time points t_n for each ('fixed') spatial unit are available (e.g. several time points per country) and when the focus is on their variation over time ('effects').

In 'time differencing' QCA, the temporally ordered values available for each case at t_0 and t_1 (e.g. in 1980 and 1990) are subtracted (i.e. the 'time difference'). Although t_n time points might be available for each case, Hino (2009: 256) specifies that subtraction is performed between values at two given time points, that is, the earliest and more recent ones for each case. The resulting difference is then calibrated in set-membership inclusion or exclusion, for example, if the result of the subtraction is below 0, the membership score will be coded as 'fully out' or exclusion. Time differencing QCA is best employed when the researchers' focus is on the increase and decrease of values in each case. In Hino's perspective, this facilitates the assignment of 'fully-in' and

'fully-out' set-membership scores to cases for performing QCA. Therefore, Hino emphasizes the advantages of time differencing QCA as compared to fixed effects QCA.²

However, in our view, time differencing QCA 'levels out' the within-case (intragroup) information available for each case: as simple subtractions between values at two time points are calculated per each case, the result is only one value (from initial two) for each case (see also subsection 'A critical assessment to Hino's (2009) time differencing QCA and a proposal for improvement using relative variations' below). In turn, intragroup heterogeneity is better retained in fixed effects QCA because all the information for each time point $t_0, t_1, t_2, \dots, t_n$ is used.

In TS/QCA, both fixed effect and time differencing QCA work at the within-case level or intragroup. Instead, the retention of both intragroup and intergroup information by case over time is currently best achieved in PD-QCA. Introduced by Garcia-Castro and Ariño (2013), PD-QCA is specifically targeted at the treatment of panel/longitudinal data in large- n QCA. Similar to Hino's (2009) pooled QCA, it considers all the cases composing the longitudinal or panel dataset across all the different time points ($t_0, t_1, t_2, \dots, t_n$). The result is 'pooled consistency' (POCONS), that is, 'the overall consistency observed in the sample when time and individual effects are not taken into account' (Garcia-Castro and Ariño, 2013: 65). Pooled consistency is the 'strength' (or consistency) of sufficient relations between configurations and the outcome (i.e. a configuration as subset of the outcome) of standard QCA. Cases, that is, panel data observations in PD-QCA, are treated uniformly regardless of their multiple time points (T, or intragroup variation) and group nestedness (N, or intergroup variation).

Garcia-Castro and Ariño (2013) then introduce 'between consistency' (BECONS), corresponding to the strength of subset relations for all the individual cases at one time point, or 'cross-sectional consistency for each year t in the panel' (p. 65). If panel data are available for 1980, 1990 and 2000, consistency is calculated across all cases but separately for each 'time group' (intergroup or between variation) composing T (the time dimension) of the longitudinal or panel dataset. Similarly, 'within consistency' (WICONS) is calculated as the strength of subset relations between configurations and outcome for each individual case across multiple time points (intragroup or within variation), that is, 'the longitudinal consistency of the set-subset connection for each individual i in the panel over time' (Garcia-Castro and Ariño, 2013). As there are multiple time points observed per each case, these form a group (the N dimension of the longitudinal or panel dataset). As stated by the authors (Garcia-Castro and Ariño, 2013: 65), '[i]n any real panel data there are T different BECONS, N different WICONS and one single POCONS'. They note that, even if a high POCONS is found between a set of configurations and the outcome, this consistency can be 'unpacked' by looking at the relative contribution to consistency produced at the different time points (T

dimension, intergroup variation or BECONS) and within the different individual cases across time (N dimension, intragroup variation or WICONS). If detected, the distinctive contribution of BECONS and WICONS to the overall POCONS will signal a panel structure and is calculated by means of difference (i.e. Euclidean distance) between the obtained values (see their Table 1 on p. 65 and section 2.2). For example, if all three BECONS for years 1980, 1990 and 2000 are 0.8, the calculated distance is zero and therefore no time effect on the relationship between the causal condition(s) or overall solution and the outcome (POCONS) is observed.

The difference among the n WICONS can also be calculated: researchers check which group(s) (i.e. groups of multiple time observations per each case, e.g. by firms) in the N dimension of the longitudinal or panel data differently, and distinctively, contributes to the overall POCONS.³ The authors state that a high WICONS indicates that groups are not homogeneous in the population, as some contribute more to the POCONS calculated for the entire panel. Garcia-Castro and Ariño (2013) proceed in the same way for calculating pooled (POCOV), between (BECOV) and within (WICOV) coverage.

PD-QCA is innovative because it bridges panel data with set-theoretic methods. As the most refined QCA time-sensitive approach currently available, the main aim in PD-QCA is to identify the inter- (BECONS) and intragroup (WICONS) temporal structure in the panel. Garcia-Castro and Ariño (2013) also define a protocol (p. 69) for assessing the different types of consistency to exploit at best the potential of panel data.

However, PD-QCA might easily become rather computing-intensive. Although this is not a problem per sé, in their paper the authors illustrate their approach by computing the pooled, between and within consistency of one condition to the outcome. In empirical research, sufficient conditions (i.e. single conditions) are rarely found; therefore, the three different consistencies (POCONS, BECONS and WICONS) and coverages (POCOV, BECOV and WICOV) have to be calculated (1) for the overall solution and (2) for each of the paths composing the overall solution. At the very least, a researcher is required to perform nine different analyses of sufficiency when the overall solution is composed of two paths only. In addition, the adjusted Euclidean distances of the obtained results for BECONS, WICONS, BECOV and WICOV have to be calculated for (1) and (2), too.

More importantly, we find that, as PD-QCA targets panel data, it remains anchored to a statistical cross-sectional time-series (CSTS) perspective: the refined treatment of within-case time variation drifts apart from in-depth knowledge of cases. If a high BECONS (i.e. time substantially affects overall pooled consistency) or a high WICONS (i.e. groups are highly heterogeneous) are found, we still do not know why this occurs. This is a common issue in large- n QCA and not necessarily a disadvantage (see Greckhamer et al., 2013: 57ff; Thomann and Maggetti, 2020). A (mixed-method) post-QCA (Oana and Schneider, 2018) could be performed

to identify the typical (i.e. most consistent) and deviant (i.e. less consistent) cases in terms of BECONS and WICONS.

In short, while TS/QCA and PD-QCA are advanced ways towards integrating within-case time variation into QCA, they nevertheless move away from the attention to qualitative differences across and within cases that lies at the heart of a diversity-oriented approach (Ragin, 2000). In other words, they lack case-orientedness (see Rihoux, 2013). The CSTS framework characterizing both TS/QCA and PD-QCA is both an advantage (multiple time observations per individual cases can be accounted for) and a disadvantage (it underexposes the evolution of social processes and downplays the qualitative aspect of QCA). Departing from a CSTS position, both techniques consider time as a given: time points are fixed according to the data at hand and locked to clock time. Consequently, TS/QCA, and especially PD-QCA, can primarily work only if numerical information is available: values need to be quantifiable to calculate averages and differences.

The TJ-QCA we propose below addresses this gap and resounds with the diversity-oriented approach that focuses on the qualitative differences between types of cases. TJ-QCA starts from the in-depth knowledge of cases and considers within-case time variation not as fixed to clock time, but rather as structured in sequences of events. These are trajectories. Table 1 lists current time-sensitive QCA approaches as discussed above and shows how TJ-QCA integrates case-based time dynamics with ordered sequences of events as conditions.

A prior proposal approximating ours can be found in Schneider and Wagemann (2012: 256). They argue for a qualitative understanding of within-case time variation. Development over time is understood as a case-specific mechanism embedded in the in-depth knowledge of cases' histories. This constitutes essential information to assigning set-membership values to cases and to the interpretation of cross-case comparison (De Meur et al., 2009: 162). In empirical research, we noted researchers constructing 'new' cases by performing a qualitative segmentation in time periods of cases' histories, either based on their in-depth case knowledge (Pagliarin et al., 2019; Rihoux, 2006) or on pre-defined phases (Vis, 2009).

A trajectory-based approach to integrate within-case time into QCA

In structuring TJ-QCA, we build on these previous efforts but add a dynamic conceptualization of configurations: not only can the evolution of one case be described via multiple configurations, but these are also temporally linked as development stages forming the case trajectory. Trajectories, hence, capture qualitative case-based patterns of change. What is also new in our approach is that we formally integrate trajectories in the standard workings of QCA. We first discuss the conceptual background, then focus on the nuts and bolts of the proposed approach.

A brief discussion of the conceptual background is necessary because it shows the foundations of our approach, which extends beyond a simple rearranging of existing QCA routines to add some dynamism. Indeed, TJ-QCA starts from a strong conceptual understanding of how social reality plays out. It hinges on the axiom that social reality is structured by sequences of events (of any kind) that form processes. Such processes play out over time. Three points are important here. First, processes alternate between stability and change (e.g. Abbott, 2001; Gerrits, 2012; Gerrits and Verweij, 2018; Byrne and Callaghan, 2013; Castellani and Hafferty, 2009; Kiel and Elliott, 2005; Reed and Harvey, 1992); second, the periods of stability and change are not neatly structured by clock time (Adam, 1990, 1992); and third, processes are not necessarily moving towards one single end-state (equifinality and multifinality, Ragin, 1987, 2000, 2008). The question then is under what conditions a process moves into a particular direction. These three points require that one examines social reality as something that emerges over time, and that one does so comparatively in order to discern the conditions that coincide with changes in direction.

A social process is represented as a sequence of n states. In TJ-QCA, these states are expressed through configurations of conditions. The range of possible states at any given point in time is not infinite but limited to all plausible states, as social reality is historically determined (Ragin, 1987). Exactly which state is actualized, that is, which state represents social reality at a certain point in time of the social process, is associated with a specific configuration of conditions at that particular point in time (Byrne, 2005). A configuration then sets the space for new adjacent possibilities (Kauffman, 1993; Kiblinger, 2007). The collection of all possible configurations of conditions (i.e. configurations, 2^k) identified by the researcher as potentially sufficient to produce the outcome forms a multidimensional vector space, called the property space (Ragin 2000:76; see also Schneider and Wagemann, 2012: 98). Each particular configuration of conditions occupies a specific location in the vector space. As changes in social processes are expressed as a series of different configurations (i.e. the n states), the collection of subsequent configurations is called a trajectory,⁴ hence the titular trajectory-based qualitative comparative analysis (TJ-QCA).

The development of a case can be thought of as a process and therefore as a trajectory through the property space. Hence, a case can feature different set-membership scores to the conditions composing the configurations at different points in time. If each configuration captures a particular stage of a case, multiple configurations represent different states or development stages of a case through time (within-case time variation). Therefore, n configurations distinguish and delineate multiple time-bounded *kinds* of (within-)cases along the evolution of a *single* case, that is, n states. A trajectory is thus the set of *multiple* temporally bounded configurations representing how the *same* case evolves over time. In conceptually

grounding TJ-QCA, our understanding of social reality is deeply informed by the school of critical realism (Archer, 1998; Bhaskar, 2008; Gorski, 2013), which sits comfortably with case-based research (e.g. Byrne, 2009; Easton, 2010; Harvey, 2009; Mjøset, 2009) in general, and QCA in particular (e.g. Gerrits and Verweij, 2013; Verweij and Gerrits, 2018; Jopke and Gerrits, 2019). From this ontology, it makes much sense to focus on understanding which (configurations) of conditions relate to the actualization of trajectories.

A trajectory distinguishes *kinds* of cases within the evolution of a *single* case because each of the configurations accounts for a different state in the development of a single case. In the next session, we elaborate Hino's (2009) analysis to illustrate how TJ-QCA works in practice.

Trajectories at work: replicating and re-elaborating Hino's (2009) analysis

This section shows how TJ-QCA works in practice. We first replicate (section 'A critical assessment to Hino's (2009) time differencing QCA and a proposal for improvement using relative variations') and then re-elaborate (section 'Applying TJ-QCA to Hino's (2009) dataset') Hino's (2009) TS/QCA on extreme-right parties in Western European elections in 1980s and 1990s.⁵

A critical assessment to Hino's (2009) time differencing QCA and a proposal for improvement using relative variations

Before showing how TJ-QCA can be applied to Hino's study, we first examine his analysis by focussing on time differencing QCA. We identified five critical aspects. First, part of the within-case time variation is lost when calculating the difference, since from two time points per each of the 15 considered countries, only one value per country results. Second, the subtraction of absolute values does not consider the potentially relevant *qualitative* difference between cases, which is an information typically considered of great value in QCA. For instance, the difference between the demographic proportion of foreigners (condition FOREIGN) in Austria between the 1980s and the 1990s is 4.5 (calculated as 8.05–3.6), while for Belgium, is only 0.1 (=8.97–8.87). Third, in Ireland, the variation in the percentage of FOREIGN has been 0.6 (=2.9–2.3) that, while higher, is calculated on approximately one-third of the absolute values of foreign population in Belgium. Fourth, Hino's calibration strategy for crisp-set QCA uses 0 as the cut-off point to distinguish between inclusion or exclusion of cases to the conditions and the outcome, but this choice is not sufficiently justified. Using Austria and Belgium as examples, one wonders if the condition FOREIGN should be considered present in both cases, or if a different conceptualization of the condition is needed. These issues extend to the other conditions and outcome in Hino's dataset.

Being aware of possible criticism, Hino (2009) states that ‘[a]lthough the difference can be fairly small in some instances, the conceptualization of “increase” or “decrease” is at least clearer and more straightforward’ (p. 262). Therefore, calculating the difference between absolute values facilitates calibration into set-membership scores (i.e. increase: fully in; decrease: fully out). However, and as a fifth critical remark, calibration appears to be a sort of statistical coding (specifically: dichotomization), instead of stimulating researchers to investigate kind of cases, and which ‘part’ of the variation within the data can and has to be meaningfully differentiated for assigning set-membership values. A similar comment can be extended to Hino’s pooled and fixed effects QCA, because mean and median are used as anchor points for calibration that, although not incorrect, are usually critically queried by QCA researchers as they might not meaningfully capture the *qualitative* difference-in-kind among cases.

In our view, Hino’s analysis would better retain the within-case information of the two time points per case (1980 and 1990) if the relative variation⁶ is used instead of the subtraction (or delta) of absolute values (see the results made available in the Supplementary materials). The result is a percentage of change that also considers the initial value, which is an improvement. To illustrate, Austria has seen a 123.6% increase in the percentage of foreign population between the 1980s and the 1990s, while in Belgium, it has only been 1.13%. Therefore, relative variations can express more clearly and in a more relevant way how strong the increase has been, and can guide calibration of cases more precisely.

Applying TJ-QCA to Hino’s (2009) dataset

To illustrate how TJ-QCA works, we used Hino’s (2009) original ‘raw’ dataset (shown in Table 1 in his study) and calibrated it differently. We used different thresholds⁷ and crafted a ‘trajectory-based’ dataset sensitive to within-case time variation. To achieve this, we maintained the two time points available for the initial 30 cases and calibrated each of the 30 cases individually. This highlighted that not all information is relevant: 14 of the 30 calibrated cases (IC80, IC90, IR80, IR90, IT80, IT90, L80, L90, SWE80, SWE90, SWI80, SWI90, UK80, UK90) display the same within-case time information, that is, they did not change over time; hence, showing the same configuration and outcome for 1980 and 1990. This information, if retained, would add redundant data when performing QCA. Therefore, seven of these cases were kept by merging the information into one case for both time points (e.g. IC80 and IC90 become ‘IC80_90’).

The new dataset is composed of 23 cases in total: seven cases combine information on two time points (i.e. no within-case time variation), while eight cases show different configurations and/or outcome in the two time points (i.e. relevant within-case time variation); hence, two configurations per case are needed.

In performing QCA with this newly calibrated dataset on 23 cases, we found that, first, PRES80s appears to be a relevant necessary condition (consistency: 1.00; relevance of necessity: 0.64; coverage: 0.75).⁸ This means that the existence in the 1980s of an extreme right-wing party is necessary for the outcome. Second, we created the truth table of the dataset with 23 cases by using 0.80 as consistency cut-off value for sufficiency (Table 2). Following one of the recommended strategies to deal with true logical contradictions (TLCs) (Rihoux and De Meur, 2009: 48–49), and considering the illustrative purposes of this analysis, we deleted the case of The Netherlands in both time points (NT80 and NT90) because it is a TLC in the configuration in rows 4 and 8. This might suggest that The Netherlands requires a separate case analysis.⁹ Belgium also presents a TLC: Belgium in the 1980s (B80) is associated with the absence of the outcome, while in the 1990s to its presence (B90). Because of the presence in row 16 of all conditions, which are assumed to produce the outcome, we decided to keep B90 as positive instance of the outcome, thus deleting B80.

The final dataset is composed of 20 cases and is analysed in the minimization process discussed below.

The truth table displayed in Table 2 allows to check ‘what changed’ within single cases over time. As a positive instance of the outcome, the Austria case shows that the vote for extreme right-wing parties was present in the 1980s without (A80: 0001, row 2) or with (A90: 1001, row 10) a high percentage of foreigners in the 1990s. In the property space, Austria changes coordinates from 0001 to 1001. This, then, represents a trajectory as defined above. The finding suggests that the success of extreme right-wing parties in Austria during elections is produced either with or without the increase of foreigner population in the country. Similarly, but as a negative instance of the outcome, Germany in the 1980s (G80) showed absence of all conditions (configuration 0000, row 1), while in the 1990s, a high percentage of foreign population is present (G90, configuration 1000, row 9). In the property space, Germany shifts from 0000 to 1000. This hints that the sequential order of these two configurations (0000 and 1000) specifically accounts for the individual trajectory of Germany in *not* being associated with the outcome.

Using TJ-QCA requires one to look at the truth table differently as compared to standard QCA: cases’ membership to truth table rows are understood dynamically and represent temporal patterns or cases’ movement in the property space. This is how a trajectory is formally integrated in the standard operations of QCA.

Following this trajectory-based reasoning, we also observe that Denmark shows a higher convergence between left- and right-wing parties in the 1980s (D80: 0011, row 4), but not in the 1990s (D90: 0001, row 2), delineating a trajectory where Denmark shifts in the property space from its coordinates representing the 1980s (0011) to the ones representing the 1990s (0001). The case of Norway shows a reverse movement. This means that, in both instances, we do not only have two

Table 2. Truth table of the recalibrated Hino's (2009) dataset by maintaining either two (16 cases) or one (7 cases) time points per cases, making 23 cases in total out of the original 30. Three cases generating true logical contradictions (TLCs) were deleted before minimization and are highlighted in bold.

Row	FOREIGN	UNEMP	CONVERG	PRES80 S	VOTE outcome	N	Consistency	PRI	Cases
2	0	0	0	1	1	3	1.00	1.00	A80, D90, NR80
10	1	0	0	1	1	1	1.00	1.00	A90
12	1	0	1	1	1	1	1.00	1.00	SWI80_90
8	0	1	1	1	0	4	0.75	0.75	FR90, IR80_90, IT80_90, NT80
4	0	0	1	1	0	3	0.67	0.67	D80, NT90, NR90
6	0	1	0	1	0	2	0.50	0.50	FR80, UK80_90
16	1	1	1	1	0	2	0.50	0.50	B80 , B90
1	0	0	0	0	0	4	0.00	0.00	F180, G80, IC80_90, SWE80_90
7	0	1	1	0	0	1	0.00	0.00	F190
9	1	0	0	0	0	1	0.00	0.00	G90
11	1	0	1	0	0	1	0.00	0.00	L80_90
3	0	0	1	0	?	0	–	–	
5	0	1	0	0	?	0	–	–	
13	1	1	0	0	?	0	–	–	
14	1	1	0	1	?	0	–	–	
15	1	1	1	0	?	0	–	–	

configurations (0001 and 0011) capturing two chronologically ordered development stages (from 1980s to 1990s) over time in the two cases, but we also learn that in the two countries the sequential order of these two configurations is reversed, despite both having the outcome present.

Therefore, trajectories not only identify different within-case development stages delineated by different configurations, but also specify which sequential order of within-case time variation is empirically observed in each case and is relevant for producing (or not) the outcome. We believe this is key information that needs to be retained in the dataset because it can qualitatively represent the empirical sequences producing the outcome through temporally ordered kinds of cases. The relevant within-case time variation is explicitly and formally preserved in the dataset for subsequent analysis.

The minimization of the truth table shown in Table 2 yielded to two paths in the conservative solution, as displayed in Table 3. PRES80S being a necessary condition, the solution can be factorized as $PRES80S * (unemp + CONVERG) \Rightarrow VOTE$ for the 11 positive cases. This new solution suggests that the combination of 'political' conditions ($CONVERG * PRES80s$, which is the same as the

parsimonious solution in Hino, 2009: 260), or the presence of extreme right-wing parties in the 1980s combined with high unemployment, are both sufficient 'recipes' for the outcome (rise of extreme-right parties in Western European elections). The added value of this new solution is that it also reveals patterns of change, as in the case of Denmark and Norway, whose two cases each shift from one path to the other.

Discussion

Re-elaborating Hino's analysis through TJ-QCA highlights the following discussion points. First, TJ-QCA appears to be more effective in identifying the relevant within-case time heterogeneity to be included in the dataset for subsequent QCA. As described above, we kept two time points per case only when the configurations and/or the outcome were different, while merging the two time points per case if they conveyed the same information for the configuration and the outcome (i.e. time invariance).

Second, as only two time points are given in Hino's dataset (1980s and 1990s), we are aware that the within-case time

Table 3. The conservative solution for the presence of the outcome with the newly calibrated dataset including trajectories; multiple covered cases (Denmark, Norway and Switzerland) are highlighted in italic.

		Consistency	PRI	Raw coverage	Unique coverage	Cases
1	<i>unemp*PRES80S</i>	1.00	1.00	0.58	0.33	A80, D90, NR80; <i>D80, NR90</i> ; A90; <i>SWI80_90</i>
2	<i>CONVERG*PRES80S</i>	1.00	1.00	0.58	0.33	<i>D80, NR90</i> ; FR90, IR80_90, IT80_90; <i>SWI80_90</i>
	Overall solution	1.00	1.00	0.92		

variation in our illustration of TJ-QCA is limited. In turn, TJ-QCA can also be employed with quantitative datasets where multiple time points ($t_0, t_1, t_2, \dots, t_n$) are available per case; each time point $t_0, t_1, t_2, \dots, t_n$ can potentially be represented by a different configuration. Moreover, TJ-QCA can also be applied by using qualitative in-depth narratives about cases, where multiple development stages are qualitatively defined by the researcher based on her case knowledge to describe case-based patterns of change. Either way, researchers have to select which within-case time variation is relevant to keep in the dataset for performing TJ-QCA. It is up to the researcher to determine the demarcations between time points as they are not dictated by clock time but by events that form major turning points, which requires a qualitative assessment of the data (see Abbott, 2001).

For instance, two development stages of one case (case a) can be identified by the researcher from 1995 to 2005 (case a.1) and from 2005 to 2010 (case a.2) because a specific event that occurred in 2005 differentiates the evolution of case a in two kinds of cases. In turn, for another case (case b), the development stages can span from 1975 to 1985 (case b.1), from 1985 to 2000 (case b.2) and from 2000 to 2010 (case b.3), because specific events occurred in 1985 and 2000 distinguish case b in three different kinds of cases. This is a rather common situation in empirical research, as shown for instance when analysing multi-decade large-scale development projects such as highways, bridges or waterfront redevelopments (Gerrits and Verweij, 2018; Pagliarin et al., 2019): different projects will be differentiated through different time-specific development stages.

Researchers should consider if the configurations representing the evolution of their selected cases over time are relevant for their analysis, that is, whether the multiple configurations describing a single case are capturing a difference in degree or a difference in kind. Ideally, case a.1 and case a.2 will be captured by two different configurations (and outcome); therefore, case a.1 and a.2 are different kinds of cases; similarly, cases b.1, b.2 and b.3 can be represented by three configurations. The multiple configurations per each case will form the case-based trajectories, that is, temporally linked within-case variation.

In constructing a dataset for TJ-QCA, researchers will have to qualitatively assess (1) which cases, and which within-case time variation, should be represented by multiple configurations and (2) which cases and within-case time variation can be represented by only one configuration. As we showed in the previous section, a typical TJ-QCA dataset will include cases both described by multiple (two or more) configurations, and also represented by only one configuration, as in conventional QCA.

Furthermore, it might well be the case that in TJ-QCA cases will share all or part of the configurations they are represented by. This is not different from conventional QCA, where different cases belong to the same configuration; what is different in TJ-QCA is that different cases might have all or

only part of their configurations in common with other cases. However, as the re-elaboration of Hino's (2009) analysis shows above, even if they share multiple configurations, they do not necessarily share the same trajectory: Denmark and Norway are represented by the same configurations, but their trajectory is reversed. Therefore, and in contrast to Schneider and Wagemann's (2012: 256) approach, in TJ-QCA, not only is within-case time variation qualitatively identified through non-fixed, but case-specific, development stages, but it is also formally, and not only interpretatively, integrated into QCA procedures. While accounting for within-case time in TJ-QCA requires processing more heterogeneous data from the part of the researcher, and does away with some of the assumptions about time-symmetry, it also provides two advantages. The first is that within-case time variation – which is a real property of social processes – is made explicit. The second one is that it can be formally accounted for in the analysis through the cases' movements in the property space along their individual trajectories. Regarding the latter, we would like to add that the cross-level treatment of time through ordered sequences of conditions as in TQCA (Caren and Panofsky, 2005; Ragin and Strand, 2008) could be further and formally complemented with TJ-QCA (e.g. including condition 'D' to indicate 'B occurs before A').

We would also like to emphasize that TJ-QCA is agnostic to the type of data used (see *supra*). However, we believe that TJ-QCA fits particularly well with qualitative data, even with data derived in a grounded manner (Jopke and Gerrits, 2019). Consequently, TJ-QCA targets, but is not limited to, QCA applications with small/intermediate-n. This is because multiple configurations for a single case do not necessarily correspond to fixed time points, which are to be defined qualitatively. Therefore, TJ-QCA appears to be particularly apt for QCA researchers rooting their calibration on qualitative empirical research.

Nevertheless, TJ-QCA can also be applied to datasets where quantitative information per case and on multiple time points ($t_0, t_1, t_2, \dots, t_n$) is available. Therefore, TJ-QCA can be used also with large-n datasets. However, as TJ-QCA is grounded on a qualitative interpretation of time variation of cases, how the latter are conceptualized ('casing') is different than the CSTS perspective as performed in TS/QCA and PD-QCA and more aligned with a diversity-oriented approach (Ragin, 2000).

As a last point, we want to highlight that an extremely interesting situation can emerge when a certain case, represented, for instance, by two configurations, is associated with the outcome in one configuration and with its absence in the other one. This means that we do not only have configurations associated with the presence or absence of the outcome as in conventional QCA, but that in TJ-QCA, a single case can move from one configuration showing the outcome to another configuration not being associated with the outcome, or vice versa. Therefore, in the trajectory of such case, we do not only have a change in configurations, but

also a change in the outcome. It also implies that the association between configurations and the presence or absence of the outcome might not be the final one. If a case is represented by two configurations and presents the outcome in both, the further trajectory of the case might be represented by an additional configuration that does not produce the outcome. This implies that the expectations about the configurations considered to be associated with the outcome are essentially provisional working hypotheses that will have to be empirically tested when considering the dynamic development of cases over time in subsequent research. Consequently, middle-range generalizations (Befani, 2013) and results interpretation reveal not only 'recipes' to an outcome, but also patterns of change within and across cases.

Conclusion

We acknowledged that conventional approaches to QCA are essentially time-agnostic despite the fact that much of social reality plays out over time. To remedy this, we presented a new approach, TJ-QCA. Conceptually rooted in the idea of trajectories as sequences of states in the property space, TJ-QCA can be used to map under what conditions cases move or change direction. The qualitative changes in each case-based trajectory are represented by multiple and potentially different configurations. We showed how this specific conceptualization of within-case time variation can work in empirical research by re-elaborating Hino's (2009) dataset. We first showed how the use of relative variations instead of simple differences in time differencing QCA can enhance the retention of relevant within-case time variation, hence doing justice to the real complexity of social processes that QCA was expressly geared towards uncovering (Byrne and Ragin, 2009; Ragin, 1987, 1999; see also Gerrits, 2012; Gerrits and Verweij, 2018; Befani, 2013; Blackman et al., 2013; Cairns et al., 2017). Second, we applied TJ-QCA to Hino's data by retaining only the relevant information about within-case time variation to be included in the minimization process for QCA. Importantly, the demarcation of different stages concerns qualitative assessments of the within-case time variation of each case; therefore, TJ-QCA can formally handle a dataset constructed of cases presenting development stages/configurations with a different duration. Although TJ-QCA as a research approach and technique can be applied to quantitative datasets where multiple time points ($t_0, t_1, t_2, \dots, t_n$) per case are available, TJ-QCA appears particularly useful for QCA researchers using qualitative empirical strategies to calibrate their data, usually for subsequent application of QCA to small-/intermediate- n datasets.¹⁰

We conclude by emphasizing that, in presenting TJ-QCA, the QCA truth table becomes time-sensitive and time-heterogeneous, because it can contain cases represented either by one configuration or by two or more configurations. Therefore, TJ-QCA is an innovative, time-sensitive way to

understand truth tables in QCA. This also implies that, as cases develop over time and single cases may be represented by multiple and potentially different configurations, which are temporally linked, cases may move through the property space.

We hope that further research will apply TJ-QCA to a diversity of datasets (small/large- n , quantitative/qualitative data) across disciplines, and that visualization tools (e.g. showing how cases shift in a n -dimensional property space in a similar fashion as strange attractors are represented in models of dynamical systems) can be made available to QCA researchers taking the evolution of their cases at the heart of their research endeavours.

Authors' note

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Supplemental material

Supplemental material for this article is available online.

Notes

1. For more details on QCA as a research approach and technique, see Rihoux and Ragin (2009), Schneider and Wagemann (2012) and Gerrits and Verweij (2018).

2. For further details on Hino's (2009) analysis, see section 'Trajectories at work: replicating and re-elaborating Hino's (2009) analysis' of this article and the Supplementary online material.
3. Garcia-Castro and Ariño (2013: 66) standardize the Euclidean distance for BECONS and WICONS to obtain adjusted measures varying from 0 and 1 to facilitate interpretation.
4. We follow the definition of trajectories as derived from dynamical systems theory and its mathematics, not to be confused with ballistic trajectories. In dynamical systems theory, a trajectory is the set of sequential points in the property space that result from a given initial state. Over time, those trajectories will display typical behaviour, to be described via (strange) attractors (see Byrne, 1998; for a more detailed discussion).
5. See Supplementary online material for further details.
6. Relative variations are calculated as $x = [(value\ at\ t_1 - value\ at\ t_0) / value\ at\ t_0] * 100$.
7. We used the following anchor points: FOREIGN: 8; UNEMP: 8; DIVERT: 4; then transformed into its complementary set in CONVERG; PRES80 has not been changed from Hino's (2009) original calibration; VOTE (outcome): 3.5, capturing the general (i.e. Europe-wide) 'election threshold' for a party to enter Parliament. We performed the analysis in R by using Duşa (2019) QCA package and Oana and Schneider (2018) SetMethods package.
8. For further details, see the Supplementary online material.
9. Alternatively, NT80 could be kept in the dataset and 0.75 used as a consistency cut-off point for sufficiency. However, in our illustration, we aimed at obtaining a contradiction-free truth table.
10. We are aware that such a qualitative assessment was implicit in the re-elaboration of Hino's work. However, the purpose of the re-elaboration was to provide a proof-of-concept of TJ-QCA. Future research is needed to expand the method.

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