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Case-based complexity: within-case time variation and temporal casing

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We observe that time is central to most social dynamics and yet remains poorly understood. The complexity sciences have contributed a wide range of concepts and tools to investigate and recast time in social systems. However, the dominant focus on quantitative models and quantification of data in the complexity sciences also prohibits a deeper understanding of time. As such, there is a need to fuse alternative notions of time with how it is commonly understood and measured in the complexity sciences. To this end, we juxtapose diverse notions of time from the social sciences and comment upon how this contrasts with notions in the complexity sciences. We will demonstrate how (qualitative) temporal casing can more appropriately capture social and causal complexity through within-case time variation. We use examples from research into megaprojects to demonstrate how temporal casing plays out in empirical analysis.

Keywords: time; case study research; methods; complex causality

1 On time and case-based complexity

It is one thing to say that social reality is complex. It is, however, quite another to pinpoint said complexity in such a way that it can be conceptually articulated and mapped in empirical social research. For social science, it is in the probabilistic following-up of events through time that complex causality becomes apparent as multiple and inherently uncertain future directions for observations or cases (Prigogine, 1997; for a re-elaboration, see Gerrits & Pagliarin, 2020). In other words, the future is highly unpredictable because every event can be followed by several possible subsequent events with a different degree of plausibility.

Hence, it comes without a surprise that early scholars cast minds to the question of how to deal with time as the locus of causal and social complexity. Compte conceptualised social change in terms of evolutionary stages centred on the specific development of Western countries, while Simmel's analysis of modern urban life highlighted the differences between the non-urban, pre-modern ordinary man and the typical *homme blasé* of the "metropolis" (Simmel, 1903 ed. 1995). Many scholars have found ways to express time in their research, primarily through quantification, distribution of phenomena over regular intervals, additional narratives, and through abstract conceptualisations. Yet, "time" manages to elude social scientists when it comes to ontology, epistemology, and research methods: fixed time points may fail to capture shifts or the clustering of events in episodes. Alternatively, stages may feel arbitrary, while quantification tends to black box considerable social complexity, and qualitative approximations of change and stability seem clumsy and lack the rigour needed to move beyond truisms.

The challenges and limitations for achieving conceptual dexterity in accounting for time in social research might never have a final and uncontested answer, but this should not discourage scholars from engaging with the topic. Rather, we might find a range of theoretical concepts in the complexity sciences that enhance our understanding of time in the social realm, including emergence, non-linearity, tipping points and punctuated equilibrium – as phenomena playing out over time and to be understood only through time. These concepts also highlight the irregular, multifinal, subjective, and volatile nature of time.

There is no doubt that the complexity sciences continue to enrich the conceptual toolkit of the social sciences. However, and inevitably, they are limited in some respects. As complexity relies predominantly on quantification and systems of equations, there is still much work to do in accounting

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for the qualitative aspects of time, which characterise social research. The goal of this paper is to propose a case-based conceptualisation of time that acknowledges the irregularity and equifinality of durations as units of time. To this end, we juxtapose diverse notions of time from the social sciences and comment upon the limitations of how time is understood in the complexity sciences. This sets up explications for how case-based research can more appropriately capture social and causal complexity through within-case time variation. This is achieved via temporal casing. We will identify various methodological operations to guide empirical research by re-elaborating on a well-known analysis in megaprojects management (Flyvbjerg, Bruzelius, and Rothengatter 2003). We believe there is much to be gained from the dialogue between case-based research and complexity and will derive methodological implications from such a dialogue.

In our analysis, we observe that time is usually treated as *sui generis* or as a given and uniform measure—structured and aligned with—but external to social processes (Elchardus, 1988). Some accounts skirt temporal dimensions via other concepts such as structure (Nowotny, 1992). Many, if not most approaches to time, rest on conventional measurements rather than on following the dynamics of how time passes. These conventions are deeply ingrained in the practice of research, for example the use of clock time or calendar time to structure narratives or to distribute panel data, as well as simulations that use iterations spaced on a uniform timescale (e.g., one day or month's "time ticks"). Conventions exist for a reason: that is, they serve as workable proxies to account for time in empirical research. As they stem from a more or less stable consensus within academic communities in different fields, these conventions also impose a regimentation on data. Nevertheless, such conventions may not reflect the actual nature of social processes that data supposedly represent.

What is needed, then, is greater reflexivity in how researchers address time in their work (Adam 2003). In view of this, we argue for an understanding of temporal units as embedded in social processes; these units of time reflect irregularity in duration and equifinality (see Ragin, 2008). This approach to understanding and analysing time has implications on the comparative study of sequences of events and phenomena; it also opens the possibility to conceptualise time that is made, not only given. We root these claims in the critical examination of how time is structured and set in empirical research. Instances of these include how specific temporal horizons and norms define the research question at hand, as well as a reconsideration of the methods used (Altomonte, 2016; Aeon & Aguinis, 2017).

The kind of processes we focus on can be studied in their own right—e.g., via process tracing (Beach & Pedersen, 2013) and event-sequence analysis (see Abbott, 1995) or comparatively (Bengtsson & Ruonavaara, 2011; Pagliarin & Gerrits, 2020; Ragin, 2008). Of key importance here is the notion that complex systems nest within other systems, and have systems nested within them (Byrne, 1998). This perspective implies that any case takes place within a variable context, thus explaining why a casual observation in one context does not necessarily hold in another. It then appears methodologically plausible that empirical research may also adopt a case-based approach to explain and differentiate between contexts. Beyond the differentiation (and at times, opposition) between methodological standpoints (i.e., the focus on rich individual histories of within-case research and on general patterns of cross-case research), we claim that within-case complexity of social processes can be an entry point to reach cross-case complexity. An essential dimension of this complexity is time and how it is methodologically characterised; the subsequent sections will address. We first present an overview of some of the main scholarly alternatives to time and space, which is followed by a discussion on how time and space are accounted for in the complexity sciences. Next, we present the main properties of temporal casing to account for within-case variation. We then re-cast the notion of temporal casing in the context of managing megaprojects to demonstrate how such a refocusing alters the ways in which the complexity of developments may be understood. This paper does not present a conventional case study but rather opens a conversation about time and complexity.

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2.1 Conceptualisations of space and time

2.1.1 A brief incursion into the debates about space

The claim that "we must get to know [...] invisible time and recognise its fundamental role in the constitution of the lives and institutions of those we study" (Adam, 1995, pp.41–42) marks the starting point for our argument. In developing this argument, we first look to the critical re-considering of space and its units of analysis. Surprising as this may seem, it shows how researchers' choices socially construct definitions of space, which may aggregate as consensus and reify as conventions. This may inspire a shift in how we currently conceptualise and account for time. It also compels us to take stock of the various ways through which time is considered in social reality by examining the transition from a pre-industrial to an industrial society. This transition introduced not only the clock, but also technological and social standardisation as well as systematisation; these processes have since imposed a regime on the social world—irrespective of its appropriateness. Time zones or standard working hours are examples of and outcomes from such standardisations and systematisations. The ones mentioned here are but a few key developments that have left us unwittingly inattentive to considering time beyond notions of linearity or regularities.

In parallel, the conceptualisation and measurement of spatial units has engaged scholars of diverse backgrounds, ranging from statisticians and geographers to economists and sociologists. From their engagement grows increasing acceptance and awareness for how spatial units and spatial representation influence findings on spatial phenomena (Kitchin & Dodge, 2007). International comparative research showed the fallacy of using similar statistical classifications (often based on conventional administrative units) in different contexts. Spatial units may be called the same term but represent quite differently when comparing countries. For instance, the definition of what a village, a town, or a city means varies substantially across European countries (Le Gléau, Pumain, and Saint-Julien 1997). Also, data comparability across the different classifications of urban areas around the globe (e.g., between Europe and Africa) can call into question the current rhetoric of the "urban age" as a key characteristic of the 21st century (Brenner & Schmid, 2014).

As a result, the definition (epistemology) and measurement (methodology) of spatial phenomena have crucial consequences for the way space is represented and understood. Both definitions and measurements rest on conventions and consensus among scholars. More importantly, researchers inform conventions and consensus through the choices they make regarding their focus of analysis. Again, by referring to Le Gléau et al. (1997) to illustrate this point, the delimitation of comparable metropolitan areas in Europe has resulted in *two* different spatial units (through consensus) by combining the approaches (through conventions) of the French statistical institute (INSEE) and the US Census. The latter follows the application of functional urban regions (FURs) proposed by Hall and Hay (1980). As approximations of reality, spatial units can be multiple and equally correct. The consequence of their consensual and conventional character is that scholars change, update[1], and continuously open the definition of spatial units for debate (see Roca Cladera, 2003) as alternative classifications are proposed—e.g., the complexity-based, fractal approach to the delimitation of metropolitan areas as proposed by (Tannier & Thomas, 2013). In this regard, researchers need to ask themselves: which "space" is their "area of interest"? Which scale(s) best represents spatial phenomena? Or, to what extent are administrative boundaries sufficient in capturing spatial relations and processes?

Spatial measurements and maps, which are "a subset of all potential mappings" (Kitchin & Dodge, 2007, p. 337), result from socially constructed processes composed by a diverse set of practices. In sum, defining spatial units is an epistemological process enabling us to represent spatial phenomena, which

[1] The two spatial units for metropolitan areas identified by Le Gléau et al. (1997) have been discontinued and have been replaced by the Nomenclature of territorial units for statistics (NUTS) and by the Urban Atlas classification (Eurostat 2020).

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relies on methodological choices regarding the measurement and selection of several indicators (e.g., population), including temporal data that can be either static (one time point) or dynamic (multiple time points, e.g., commuting flows, see below).

2.1.2 Various conceptualisations of time

This brief discussion of the ambiguity that comes with delineating something as ostensibly clear as a physical space shows that spatial units are, even at best, provisional results of epistemological and methodological processes within the scientific community (see e.g. Latour, 1987). Further, researchers' practices have brought conventions and consensus to bear on these processes. Comprehending this compels scholars to interrogate their own ideas and practices that delineate (spatial and temporal) units of analysis as the basis of their investigations. By translating these epistemological and methodological observations on how we conceptualise space to how we conceptualise time, we can also reasonably ask, "*Which 'time' is this case?"*

To structure our response to this question, we first discus the historic process that encouraged unmindful and continued repackaging of temporal qualities and patterns. Following this, we turn to scholarship from sociology, geography, anthropology, philosophy, economics, and psychology that have progressed methods and theories to account for time or temporality in society. Investigations on time have moved from initially interrogating the social use of time, to focusing on the disparity between how we relate temporal meanings to social reality and history (see Table 1). These strands have developed independently from each other and consider time primarily in axiomatic manners (Adam, 2003; Elchardus, 1988).

We begin with Durkheim—a deliberator of things social, including the nature of time (Bergmann, 1992; Cheng, 2017; Zerubavel, 1985). According to Zerubavel (1985), Durkheim's pioneering and sociological impressions on religion uncovered foundational devices and behaviors that gave rise to, and institutionalised temporal regularity. The linear, progressive, non-repeatable idea of time developed by modern societies, typically represented by an arrow, emerged in opposition to the circular and cyclical conceptualisation of time from pre-modern societies (Eliade, 1965). The calendar, together with the clock (Simmel, 1903 ed. 1995), has become the epitomical technology anchoring a "time grid" in Western societies' understanding of time (Adam 1995, p. 20).

Permeating studies of time that underline unidirectional orientations towards the futures, linear and regimented conceptualisation of time highlight irreversible and path-dependent events, upon which we rely to track and study time (Bergmann, 1992; van Tienoven, 2019). In essence, our understanding of time implies a constant motion for which there is no obvious finality, albeit pressed on by present perceptions and continuous emergence of temporal realities (van Tienoven, 2019). As already highlighted by Simmel (1903 ed. 1995), modern time technologies have been key in supporting this directed conceptualisation of time. Modern time technologies are functional to the planning and controlling of time and thus essential for how we fundamentally understand time and its flows (Adam, 2006). Put differently, these technologies are at the crux of societies' continuous desire for, and ability to track, measure, anticipate and influence how other social processes engage with, or occupy time or "reckon" time (Adam, 1995, p. 26). As an example, time geographic heuristics show that the representation of individual paths by line are shaped by technologies as coupling constraints or by spatialised forces (authority constraints; see (Hägerstrand, 1970; Ellegård, 2018). While time geographic heuristics make the abstract conceptualisation of time through space possible (e.g., measuring individual paths through points representing spaces), it also reproduces conventional ways of thinking about time and space. Namely, as linear patterns that representing time as intervals of movement in space or as durational points of activity in place.

An outcome of these developments is an "artefactual" sense of time, which "constitutes our most taken-for-granted reality" (Adam, 1995 pp. 25–26). This sense of time departs in a "direction of ever greater

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abstraction, emancipating itself from local particularities." Durkheim (1915) highlighted this as embodied in local and religious sovereignty through his work. , This departure and change in understanding time initiated the naturalisation of a limited way to account for time—reinforcing linear and regulated conceptualisations of time and time-based institutions; these have further enforced temporal conventions "as given and unalterable" (Adam, 2003, p.60; Van Tienoven, 2019).

Our abilities to investigate and explicitly articulate considerations of time could be considered modern but are far from sophisticated. From a bird's eye perspective, it appears that current and conventional ways to account for time are a part of "social time" rooted in religious developments that created and ingrained an "impersonal set of indispensable guidelines for daily life that transcend the individual" (van Tienoven 2019, p. 976). This impersonal and collective conceptualisation of time has then provided the background for conceiving time in (post-)industrial societies.

Post-industrialisation, urbanisation, globalisation, and even climate change are contexts through which we are developing finer-grained temporal awareness (Adam, 2003; Pahl, Sheppard, Boomsma, and Groves,. 2014). Studies in the aforementioned contexts slowly patch the pre-existing and historically accepted understandings of time that distanced and numbed personal as well as complex accounts for time. Recall how processes of industrialisation administered and streamed collective and eventually conventional understandings of time. These effects were most keenly perceived through Fordism and Taylorism, which standardised concepts for how we structure(d) labour time; currently these dominating conventions are subject to increasing changes in valuation and structuration as a result of post-Fordism and networked flexibilisation of time and activities (Adam, 1995, 2003). In regulating how societies have measured time, these processes not only created clear structuring devices (shifts, work periods etc.), they were key in the systematisation and universalisation of temporal conventions (Madanipour, 2017). How else could we now have need for time zones and Daylight savings time, if not to accommodate the expansion and coordination required for the innovations of industrialisation? Not only did these layered developments scaffold the means to track time cycles—both social and natural (such as those governing agricultural seasons and natural biorhythms), but they also bolstered a quantitative subdivision of time (i.e. hours, minutes, and seconds, etc.) that has become unquestionably superimposed onto phenomena (Madanipour, 2017). Through this mechanistic lens, even understandings for natural cycles have become amounts and rates, for which the full effects of these changes are still unclear or unpredictable (Adam, 1995).

In sketching out this legacy in accounting for time, we root our disagreements in the enduring preferences to *quantify* time, which most notably sprung from the chronological ordering or sequencing of time to support production-line processes. While initial interests were for efficiency and control, this capacity has shifted focus to leverage the exchange value of time for labour; put simply, time is no longer about labour but has become a commodity (Adam, 1995, pp. 25–26). With the aims to mark uniform units of work represented by shifts or interrupted by pauses, we have come to receive time as an almost prescriptive framework of "temporal norms" assumed through economically set tempos, sequences, and durations. Clear illustrations of the extent for which social lives are regimented by "clock-like" time are the strictly punctuated activities that not only follow a certain order, but also produce inescapable routines (Goffman, 1961 ed. 2007). Time regimentation also pervades the quintessential form of work-free time: the holiday. For example, Minca (2009) examines the paradox of regulated activities and routines that characterise leisure time in some of the most common spaces for leisure, such as cruises, campsites, holiday villages, and hotels.

Less so appreciated are the naturally rooted understandings of time governed by biological or environmental cycles of time-keeping (Elchardus, 1988). Indeed, social time contours and possibly constrains a fully objective understanding and study of time beyond our collective and internalised experiences with time (Zerubavel, 1982). In transport and mobility studies, scholars differentiate between perceived and objective measures of travel time. As self-reported trip duration constitutes the main data source for surveys and travel diaries, scholars are however aware that such data are based on travelers'

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memories and perceptions (perceived measure) that might not correspond to the real duration of travel time (objective measure (Delclòs-Alió, Marquet, and Miralles-Guasch 2017)). The increasing availability and pervasiveness of smartphones with built-in GPS-tracking greatly helps us to estimate time misperceptions while also identifying possible factors that generate discrepancies. For instance, Delclòs-Alió et al. (2017) showed that longer trips do not only present greater misperceptions, but also an underperceived travel time. Kolarova et al. (2019) investigated how the subjective perception of travel time changes as an effect of the multiple ways through which digitalisation and automation of private mobility decreased the need for active driving while, at the same time, increased the potential for performing other activities while travelling. Millonig et al. (2012) explored the influence of different entertainment offerings on the perception of waiting times at transit stations among a sample of public transport passengers.

The difference between perceived and objective measures of time relates to another more subtle quality of time: range in velocity. Tempos are particularly slow for when we wait (Wexler 2015) or are perceived to progress faster when time is commodified or tightly structured as has been the case after the industrial revolution (Rosen, 2012). In short, we are increasingly competent at distinguishing comparable regularity in duration and interval (rhythm), synchronicity (attunement), or simultaneity (density) of how events and phenomenon flow in time (Levine, 2006). Moreover, we are also progressively reliant on the "temporal location" of events that we infer through other event-based markers (Provonost, 1989; Zerubavel, 1985). Again, time geographic heuristics such as the bundling of individual and linear paths emphasise how we sequentially anchor or mark spatial and temporal locations in relation to each other (Ellegård , 2018, p. 7.

Put differently, sometimes it is not so much that time comes to an end for an activity (intrinsic/intentional delimiting of duration) as it is that the time for another event is beginning (external/inflicted foreclosing of duration). For instance, the blurred boundaries that many experience in working from home are disadvantageous for those who operate better with external markers or sources of timing embodied as "Zeitgebern or time-givers" (Parkes & Thrift, 1979, p.356). When individuals have a weak sense of temporal awareness or do not have to self-regulate time, then a stronger reliance develops through which necessary activities, such as the transition of a commute to an office building, help dictate when certain rituals, such as morning preparations, conclude while others, such as work, begin. These illustrate concatenation of activities or fluid temporal boundaries.

All this underlines the prevalence of certain conceptualisations of time that also feedback into and shape our experiences of time. The independent development of time conceptualisations (Elchardus, 1988; Adam, 2003) on the social use of time (linearity, clock-time, global time coordination, regimentation of work and leisure time) and the subjective perceptions of time (meanings related to time according to specific activities) have effects that ripple and swell through all manners of practices. These practices include those involved in epistemological and methodological processes, which produce unquestioned definitions and measurements of time. These practices, in aggregate and particularly in research, also leave us with convenient consensus and less than accurate conventions that the predominantly positivist worldview only reinforces. By allowing science to lean on particular understandings of time, we are also yoking scientific investigation and reporting to structures we must remember not to take for granted.

A key illustration of our argument can be found in time series analysis. This form of analysis deals with the application of statistical methods to data whose observations are not independent and identically distributed, but that are autocorrelated and covary as they are a sample of adjacent points in time (Shumway & Stoffer, 2017). A time series is formed by a collection of assumed random variables (columns) indexed according to the order in which they are obtained in time and labelled as t=1,2, … *n*, where each observation (rows) is conceptualised as an array of time points. Key concepts in time series analysis are sampling length and rate. On the one hand, particular discipline-specific time intervals (sampling length) often define time points. Time intervals can be, for instance, expressed in years and quarters (e.g., economics), days or hours (e.g., finance), or seconds or decimals of seconds (e.g., speech analysis), but also through cycles or periodic behaviour (e.g., annual or multiple-year cycles in climate research) or as

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specified in experimental settings (e.g., stimulus given every period of x seconds or minutes). On the other hand, sampling rate refers to the frequency of data sampling within a specific time interval (sampling length), for instance 20 observations every quarter, 5 observations every hour, or a single observation every 3 seconds. Time series data can be continuous or composed of discrete parameters depending on whether the sampling rate is higher or lower. The point is that the conceptualisation and assessment of time in certain disciplines must draw and construct its definition from external and social conventions.

Broadly speaking, even in the highly formalised approach to time series analysis, time is not given, but is "constructed": it needs to be adapted in terms of sampling length and rate to the phenomenon at hand in order for researchers identify patterns. In time series analysis too, we can recognise conventions, consensus, and research practices because the definition of sampling length and rate can vary and is discipline specific.

Furthermore, the sampling rate is particularly important in time series because data behaviour can appear completely different if different sampling rates are used. Timeseries scholars know that one- vs. six-month sampling rates can show different patterns (e.g., peaks) or dynamics (e.g., seasonality). An inappropriate sampling rate is associated with the serious problem of "aliasing," meaning that the phenomenon under analysis is falsely represented (see Lentz, 1990). To avoid this, adequate sampling in time series involves both time intervals with a sufficient length and an appropriate amount of data points (sampling rate). Again, what "sufficient" and "appropriate" mean depends on the conventions, consensus and research practices related to a certain object of analysis. We can, however, recognise a certain degree of "qualitative" reasoning that characterises time series analysis beyond its "objective" definition and measurement of time.

Naturally, and by carefully avoiding postmodernist drifts, we are not the first to question such conventions. Conventions, consensus, and research practices are not inherently wrong, but they have to be acknowledged as characteristics of epistemology and methodology as processes of "doing science" (Latour, 1987). As we have seen from the conceptualisations of space, debates about the epistemology and methodology of time open up a healthy dialogue among scholars by revealing limitations or gaps between theoretical and empirical work and alternative conceptualisations (Cheng, 2017). Time geographers already explicitly acknowledge the lack of analytical rigor in addressing time, particularly with capacities to measure, compute, and compare data coming out of innovations such as location-aware technologies or location-based services (Miller, 2005). They also highlighted the selective tendencies to make use of approaches that are incongruent with, and amplify analytical conventions (Shen, Chai, and Kwan, 2015, p.90; Ellegård, 2018, pp.7–8). These inclinations reinforce how researchers characterise time by delineating movements or boundaries in space. Those delineations are essentially steps of casing (Ragin & Becker, 1992) to which we will return to further below. First, we need to turn our attention to the complexity sciences and the ways it attempts to deal with time.

2.2 The complexity sciences and time

With roots in the so-called "hard" sciences, the complexity sciences have clear positivist and modernist roots. Yet, complexity science, because of its anti-reductionist stance, has burned some holes in the modernist regimentation of time, as discussed above. The latter resonated in the social sciences (Reed & Harvey, 1992) and led some scholars to call the complexity sciences as a post-Newtonian science (Adam, 1992; Heylighen, Cilliers, and Gershenson 2006).

However, the complexity sciences are anything but a coherent body of knowledge—more a patchwork of ideas than one school of thought—although there are some common themes. Non-linearity is mentioned frequently, and there are several strands focused on phase shifts and hysteresis (Isaac, 1994; see also Elster, 1976). These common aspects in the complexity sciences revolve around the irreversibility of time, as discussed by Harvey (2009). Irreversibility, here, implies that there is asymmetry between past and future because of the occurrence chance and systemic interactions (Prigogine & Stengers, 1984;

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Prigogine 1997; Harvey 2009). More importantly, the recurring theme is that complexity comes from, and can only be understood through, time.

While the complexity sciences may stem from the hard sciences and are primarily concerned with the physical, natural world and its development over time, social time may differ in terms of duration and temporal pace, and in the experience of time (Newton, 2003), as mentioned above. To the natural scientist, ultimately concerned with finding fundamental natural laws and necessity, the social experience of time is not very relevant because it is seen as a stratum upon fundamental time that obscures rather than clarifies how things play out over time. As much as complexity scientists from the natural sciences make observations fitting to a post-Newtonian worldview, they still usually default to strict time regimes as the structuring device for their findings and simulations. More specifically, non-linearity, phase shifts and hysteresis are found as a rate over uniform intervals, and simulations run by uniform ticks.

We observe very little—if any—cross-fertilisation between the complexity sciences and the alternative conceptualisations of time as discussed in this paper. This is unfortunate, as the complexity sciences could benefit from those advanced time conceptualisations as much as the social sciences could take advantages of the numerous time-related discoveries coming from the complexity sciences. A deeper and broader engagement with time can awaken the complexity sciences to how various forms or qualities of time enhance one's understanding of social complexity.

As a step in this direction, Table 1 presents an initial review of the multiple and diverse alternative conceptualisations of time. These indicate the reinforced and functional conventions of cutting up time in equal durations: granular, specific units that can be ordered sequentially with (in)variance. These various conceptualisations also reveal repeated practices in the social sciences, which study overwhelmingly outcomes of invariance embodied in routines for instance (Cullen & Godson, 1975). Some scholarship emphasises the multiplicity and diversity of ways to consider time. These highlight how different individual and collective perspectives can be objective (Chronos), subjective (Kairos), both run in parallel or imagined as layered flows (Barabara, 2014).

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Conceptual Orientation	**Key Contributors**	**Temporal Casing**
Plural and simultaneous modalities or structures	Mead (1932), Gurvitch (1964;1973), Luhmann (1982), Bergmann (1992), Cheng (2017)	Socially interpreted time-systems frame perspectives on time as modalities or scales. For the former, phenomenological references to the present differentiate horizons (both past and future) and thus stages that can be analysed. For the latter, hierarchical strata add a vertical dimension to temporal analysis.
Regularities and rhythms	Zerubavel (1982), Sorokin and Merton (1937), Lefebvre (1985),	Structuring of activity or temporal location and markers (time-budget, schedules) as well as rates of recurrence, rhythmicity (repetition, sequence, frequency, tempo, synchronisation), or *rhythmanalysis*.
Space through concept of *Time-geography*	Hägerstrand (1967; 1970)	Spatial interpretations of time through individuals' and activity paths as represented through the *prism* (this can be aggregated or transposed to other social units), *place* (pockets of local order), and *projects* (activities of individuals and groups that are constrained by rules).
Multiplicity of times in relation to spaces. A critique of time-space binaries through concept of *TimeSpace*	Thrift (2005, 2006), May & Thrift (2003)	Does not subscribe to specific temporal casing but draws on other conceptual orientations and their analytical devices (phenomenology, time-geography, rhythms, cycles, tempo, duration, etc.) to facilitate critiques of time-space dualities.
Processes, structured in event-sequences and sub-sequences	Heise (1993), Abell (2004), Abbott (1983; 1995),	Sequences of events and sub-sequences that run in parallel or are a subset of main sequences together form the case. There is no strict delineation of the case in time or space, it could be a series of personal events of an individual but also the sequences of events leading to a global outcome (such as the outbreak of WWI).
Valuation	Bourdieu (1963), Rezsohazy (1970), Pahl (2010; 2014), Whillans (2020)	Individuals' sense of proximity or orientation to events (distant versus close events affect memory and cognitive processing) and their value associated with temporal durations and horizons. Temporal casing expresses valuation through economic productivity or holistic well-being.
Perceived and objective measures of time	Millonig et al. (2012); Delclòs-Alió et al. (2017); Kolarova et al. (2019)	Self-reported trip duration in surveys and travel diaries, perceived time different from real or clock time, GPS-tracking, different travel perceptions based on different activities.
Sample of adjacent points in time at t=1,2, … *n*	Lentz (1990); Shumway and Stoffer (2017)	Time series data are a sample of adjacent points in time at t=1,2, … n and are formed by a collection of random variables. Time intervals/cycles (sampling length), sampling rate of autocorrelated time points. Overall, regularity of patterns is assumed.

Table 1. Various alternative time and space conceptualisations that may be used in conjunction with the complexity sciences.

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As shown in Table 1, we have multiple conceptualisations of time that span from the subjective perception of time to its fragmentation into milliseconds, as discussed in Section 2.1. On the one hand, time, as commonly conceived in the complexity sciences, appears to feature few traces of the alternatives presented in Table 1, perhaps except for time series analysis approaches that also incorporate objective forms of time measurement, and the idea that certain empirical phenomenon can play out over different but parallel time scales. On the other hand, conventions about how to conceptualise time and space in the social sciences are the result of a historic process also affected by technological trends and devices, like clocks, calendars, and GPS tracing, as discussed in Section 2.1.2.

Overall, we observe the prevalence for systematic and uniform measures of time as linear and regular, and specifically represented as durations and intervals. We contend that these conventions, despite their utility, also convey a questionable sense of certitude and regularity in the practices of research. This is the result of how they distance us from the actual whimsical nature of time, even in the realm of the complexity sciences. This paper is an attempt to reveal the analytical blinders we may have created for ourselves; more importantly, it sets the stage for a necessary debate about how the social sciences account for time. Instead of limiting ourselves to certain comfortable and consensually accepted conventions of durations and boundaries, let us consider an alternative way to account for time. Temporal casing forms a conduit to achieve that goal.

3.1 Temporal casing

In temporal casing, we suggest that one can approximate the complexities of time by acknowledging within-case variation as time that is segmented (sampling length) from processes according to specific time points/events (sampling rate). Within-case variation concerns the temporal changes and logic that is internal to a particular case. Time is qualitative and reflecting not uniformity but diversity (characterised by context, interpretation, layered processes, etc.). This also could be conceived methodologically not only through sampling but in temporal casing.

"Cases" are a core aspect of every social scientific research. Indeed, the difference between case study research and non-case study research is an artificial one; all phenomena in the social sciences are cases (Gerring, 2004). Cases are as ubiquitous as they are ambiguous in how they are defined and handled (Lund 2014). A bare-bones definition of cases conceives of them as an in-depth examination of an instance of some phenomenon of interest (Babbie, 2013; Gerring, 2004). However, stemming from this is a diversity of perspectives (see Ragin & Becker, 1992). A case can be anything from a person in psychology and medicine to a decision-making process in public administration to a neighbourhood in urban planning. It can be "a single phenomenon, a narrative unit, an instantiation of a class of events" (Dumez, 2015, p.127). Cases may be delineated by researchers in time, space, size, number, topic, and many other ways—some of which logically incompatible (Gerring, 2004). By definition, they are situated within a context to which they are open, reflecting some of the context's properties. As such, there is a constant blurring of the boundaries between the case and its context (Yin 1994).

Among others, Harvey (2009), Carter & Sealey (2009), Castellani & Hafferty (2009), and Castellani et al. (2016) note the correspondence between the properties of complex systems and the properties assigned to cases as in the literature cited above: developmentally open and with permeable boundaries. Cases obtain their structure and processes in interaction with their contexts in very much the same way said structures emerge through the dissipative structure of complex social systems (Gerrits & Verweij, 2013; Gerrits & Pagliarin, 2020). The key point here is to accept a critical realist or complex realist (Harley, 2009; Gerrits & Verweij, 2013) ontology that foregrounds the difference between the case as object (intransitive domain, in which reside the cases' mechanisms, events, and experiences) as such and our knowledge of the case as obtained through the observations (made) available to us (transitive domain, in which reside our experiences of the case). The stratified take on reality as expressed in critical realism

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explains the experience of many researchers through which they learn that there the many ways in which one can approximate the same object.

The boundaries of any complex system are as much a property of the case as it is of the act of describing and defining it by researchers. As much as researchers may look for commonalities between cases, as if they are disembodied and decontextualised units, it is their diversity that forms the biggest empirical puzzle. Naturally, similar and stable cases in similar and stable contexts would come a long way towards generating predictions. However, the social scientist has to contend with the fact that case diversity as it develops over time leads to equifinality (Goertz & Mahoney 2009) and multifinality (George & Bennett, 2005). Enter the probabilistic and subjective nature of time, as discussed in the previous sections, and it becomes clear why cases are such ambiguous entities. Indeed, "… cases appear to be much more complicated than suggested by the rather clear and simple expression 'case study'" (Dumez, 2015, p.44; see also Carter & Sealey, 2009).

"Temporal casing" is the process of capturing the case as an object that evolves as precisely as possible through description and/or modelling. The case representing a dissipative structure will likely change in its structure and processes, i.e., the within-case variation discussed above. This calls for dynamic descriptions and models. Inevitably, details of the object will be overlooked, ignored, and lost, as no representation can be fully accurate. Contrary to social constructivists, however, there is a link between knowledge of the case and the actual object. This calls for a constant reflection that "[...] entails a methodological justification that openly appeals to social scientific criteria of consistency and appropriateness of the researcher's social categories to the task of explanation." (Carter & Sealey, 2009, p. 77). Temporal casing as an act on behalf of the researcher can't be separated from the case as object; interpretation or reading of the data creates additional data that then becomes part of the case study. This point of departure has the following epistemological implications for casing, which also reflect in the methodology of temporal casing:

1. *Context and history over similarity*. Cases should be understood as having a history, as following a trajectory through an n-dimensional property space (cf. attractor; see Byrne 2004, 2005; Gerrits & Pagliarin, 2020). While cases may certainly describe similar trajectories, similarities in case properties should not be the primary target of the analysis. Convergence and divergence of trajectories is inherent to the way complex systems evolve.
2. *Qualitative first, quantitative later*. As Chronos has limited meaning vis-à-vis the real world, it is through case-based qualitative data that one gets a first approximation of how time plays out as within-case variation. Interpretation and identification of meaningful time points characterizing a certain set of processes as experienced from within by analysing qualitative data.
3. *Endogenous time over exogenous time*. As each case follows its own contextual logic over time and across certain places, the research should follow the logic internal to the case instead of imposing an external regime such as clock time. Importantly, one should acknowledge that various aspects of cases can have their own spatio-temporal duration and frequency.
4. *Uniqueness and generality*. Cases are neither completely similar nor completely unique. Exactly what is idiosyncratic in cases and what is recurring can only be found through comparison.
5. *Stages instead of intervals*. As internal logic in qualitative terms describing context and history trumps external (quantified) time regimes, the focus should be on the developmental stages of varying length instead of on intervals.
6. *Boundaries*. Cases in categories such as organisations, cities, and neighbourhoods have contestable, permeable boundaries as they are approximations of the case as object. This implies that the process of setting boundaries must be a conscientious one (Cilliers 2001; Jessop et al., 2008).

We will now turn to the burgeoning body of knowledge of the governance of megaprojects to illustrate how alternative takes on time alter our understanding of such projects.

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3.2 A practical illustration of temporal casing in empirical research

Megaprojects concern construction projects[2] that are vast in scope, time, and budget. Exactly what can be considered a megaproject or what cannot, is not a given. As a rule of thumb, one could consider anything above a 1 billion euros or dollars a megaproject. Importantly, these projects are characterised by considerable complexity in various dimensions: technical (e.g., the use of novel construction techniques), societal (e.g., in the face of diverging societal voices, including protests), political (e.g., facing different coalitions in favour or against the project), physical locality (e.g., covering and linking various areas), scope (e.g., bundling various different subprojects), organisational (e.g., developed and built by a hybrid of public, private, and semi-public authorities), financial (e.g., financed through public-private partnerships), and more.

Megaprojects tend to be perpetually out of control, resulting in considerable budget overruns, delays, and faltering quality (Flyvbjerg et al., 2003). The evaluation of such projects has revealed recurring causes, including overly-ambitious politicians, inaccurate future projections, incentives to maximise budgets, and poor project control (Flyvbjerg, Skamris Holm, and Buhl 2005; Flyvbjerg, 2014). The findings in these studies derive primarily from statistical analysis, including cross-sectional data series, that subject the cases to uniformisation and regimentation across time and space.

We don't contest the soundness of those findings, but we also observe that individual case studies highlight considerable diversity that is not accounted for in said comparative research. For instance, while the Eurotunnel and the Øresund connection appear similar in many aspects, a complexity-informed, time-sensitive recasting in terms of temporal casing shows that the cases are more dissimilar than similar (Gerrits and Verweij 2018). This goes for many, if not most, other such projects. As spatial units, they range from being limited by clear boundaries (e.g., Elbphilharmonie, Germany) to sprawling programmes that cover large and diverse areas (e.g., Stuttgart21, Germany). Some of them can be considered as taking place in a green-fields (e.g., Hong Kong–Zhuhai–Macau Bridge, China), while others are fundamental conversions of existing built environments (e.g., Potzdammerplatz, Germany). There is a strong link between space and time. A sprawling redevelopment of a series of connected sites generates a different endogenous and dynamic temporality than a new development at a limited site.

Other differences between megaprojects also appear when one considers the time dimension. Obviously, megaprojects are delivered on different timescales: in some rare cases, megaprojects are completed as scheduled, while others are delivered decades later than originally planned (e.g., Berlin Brandenburg Airport). Following our argument, one should be less concerned about how those projects are tied to fixed timescales and more about how their endogenous time plays out. Some of them are dense with activities and are experienced as taking place at break-neck speed despite their longevity in calendar time (e.g., Noord-Zuidlijn, the Netherlands), while other projects that required an equal amount of calendar time feature stages during which very few activities take place (e.g., highspeed line Berlin–Erfurt–Bamberg, Germany). In a similar fashion, one can observe how the density of activities within cases varies wildly, with some showing very irregular patterns (e.g., HSL Zuid high-speed railway line, the Netherlands) and others having a more regular distribution.

Megaprojects hence, appear to offer a particularly appropriate illustration to show how temporal casing can concretely be performed in empirical research. We will focus on two European megaprojects: the Elbphilarmonie in Hamburg (Fiedler and Schuster 2016) and the Berlin Brandenburg Airport, Berlin (Fiedler & Wendler, 2016), both located in Germany. In what follows, we will make extensive reference to the work by Fiedler and Schuster (2016) and Fiedler and Alexander (2016). However, we will not summarise the content of their contributions. Instead, we will highlight where their analysis overlaps and differs in the approach of temporal casing compared to what we propose here. Our re-elaboration of both

[2] Arguably, technological projects such as the Apollo space program are also megaprojects. For the present purpose, we focus on projects that have a spatial component.

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megaprojects has two main goals: first, we will show how temporal casing is done in practice, by signalling (in italic) to readers the dimensions of temporal casing identified above in Section 3.1, and second, we hope to clarify to readers how temporal casing differs from other conceptualisations of time as previously discussed in the paper.

Boundaries: The Elbphilarmonie and the Berlin Brandenburg Airport (BER) are particularly appropriate for the purposes of our illustration because they have clear conceptual, temporal and spatial boundaries. Conceptually, the Elbphilarmonie and the BER are well-known European megaprojects that have been extensively covered in the literature on megaprojects and in the media. In terms of temporal boundaries, they both emerged after the German reunification in the early 1990s, and the planning and implementation of the BER covered over 25 years (mid-1990s to the opening of the airport in 2021), while the planning and implementation of the Elbphilarmonie spanned over approximately 17 years (2000-2017). In terms of spatial boundaries, because of the type of urban function they provide (cultural and tourist activities vs. transport and mobility), both megaprojects have clear spatial boundaries, as the BER is an airport and the Elbphilarmonie is a building.

However, their conceptual, temporal, and spatial boundaries could also be different: the BER could have larger spatial boundaries if the (city-wide or region-wide) transportation network and (global) mobility flows related to air traffic would be considered. The spatial boundaries of Elbphilarmonie could be enlarged by considering the entire area in which it is located (Hafencity). The Elbphilarmonie, hence would just be an element of a broader transformation occurring in Hamburg through the urban renewal of Hafencity; this demonstrates a widening of the conceptual and temporal boundaries of this megaproject. This means that, in temporal casing, the entire duration of a process is defined by the researcher (i.e., it is not a given). The definition of the whole duration of a process can be a starting point, but it can also be a later step of the analysis when the cases' development has been already reconstructed. This will become important for our discussion below on the "stages vs. intervals" as the key characterising feature of temporal casing.

Uniqueness and generality: Both megaprojects are similar and different to a certain degree. Conceptually, they are both megaprojects and can be analysed through the same analytical lenses, but their duration is different. They are also similarly located in Germany, and the formulation of both projects have emerged after the reunification of Germany. However, they are in different states (furthermore, Hamburg being a city state) and their spatial extents (both for the projects and of the cities in which they are located) are very different, as well as their demographic profile.

As outlined in the first paragraphs of this subsection, the list of similarities and differences could continue; differentiating between relevant and irrelevant similarities and differences is a key challenge in case research. Although we cannot address this issue in detail in the present paper (for a reference, see e.g. (Berg-Schlosser & De Meur, 2009; Ragin, 2000), we nevertheless want to stress that it is the researcher who has to argue for, and justify the ground for comparability across different cases. The grounds for justification relate back to the dimension of the conceptual, temporal, and spatial boundaries of cases discussed above. Noteworthy is that temporal casing is not solely tailored for comparative research, in this illustration we also show how temporal casing is particularly useful to compare the development of different cases characterised by different durations.

Context and history over similarity: To make the comparison across different cases possible, it is first necessary to examine the specific histories of individual cases (Byrne, 2005). This means that, even when the focus is on comparison, the in-depth analysis of individual cases must be rendered by as accurate of a "story" about the case as possible. Therefore, researchers have to develop an "intimacy" with their cases (Ragin, 2000) or, stated differently, they need to engage with cases' uniqueness before being able to provide a more synthetic representation of the development of each individual case through temporal casing. In both analyses of the Elbohilarmonie and the BER, the authors adopted a historical approach and reconstructed in detail the development of each project—from site identification, to plan formulation, to implementation phases.

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Endogenous time over exogenous time: The historical reconstruction of the Elbphilarmonie and the BER is a description that allows us to identify the "temporal logic" characterising each case. This means that the case-specific development of each project is shown at the pace it unfolded. Endogenous time is typically examined through the identification of periods when the process accelerated or slowed down, or when a certain general event (e.g., financial crisis, Fall of the Berlin Wall) had specific consequences in one case but not in another because of the former's contextual characteristics.

Qualitative first, quantitative later: To perform this historical reconstruction on each of the megaprojects, different data sources have been used, from academic and non-academic outlets (e.g., newspaper articles, reports), to chronologically reconstruct the process through which each of the megaprojects emerged and developed.

By considering the above aspects together, it becomes clear that Fiedler and Schuster (2016) and Fiedler and Wendler (2016) reconstructed the complexity of both megaprojects by examining, over time, the intersection between actor governance and technical and technological aspects of megaprojects (co-evolution). For instance, the authors examine the role of the multiple actors involved (private and public actors, independent agencies, their "entrance" and "exit" during the "dramaturgical" development of both megaprojects) and the technical difficulties encountered in the planning and implementation of both megaprojects (e.g. the replacement of the fire alarm system in the case of BER, the problems in producing the individually unique glass windows of the Elbphilarmonie with novel production technologies). The authors also identify the main pitfalls of megaproject management (also with the advantage of hindsight) in terms of overoptimism, approximate planning, limited risk management, and vague cost estimation. To this historical and detailed, but necessarily simplified reconstructions of the complexity of actor governance, of technological development, and of (mega)project management, quantitative data can be integrated, for instance, by calculating the number of days, months, or years eventually needed to complete a specific task as compared to the estimated time or the estimated costs as compared to the actual cost of the entire megaproject.

However, the historical reconstruction by Fiedler and Schuster (2016) on the Elbphilarmonie and by Fiedler and Wendler (2016) on BER by using qualitative data is not only descriptive, but also analytical. Among the multiple actors involved, the key representatives are identified; among the many technical difficulties and production delays, focus is directed at the selection of main issues; among the complexity of megaproject management, certain key mistakes are subjects of study. Furthermore, the authors identify meaningful turning points along the process, for instance when governance arrangements or political scenarios changed, when the megaproject manager was replaced or when one of the main companies went bankrupt. This means that the authors have substantially interpreted the development of their cases.

This combination and balancing between empirical data and the authors analytical lenses about the complexity of governance, technology, and management of megaprojects is a characterising feature of qualitative research. Researchers perform in-depth analyses to provide thick descriptions of their cases, which are then interpreted and analysed based on the theories that grounded their examination in the first place for the goals of theory-testing or theory-building (broadly speaking).

Stages instead of intervals: So far, the conceptual and methodological approach adopted by Fiedler and Schuster (2016) and Fiedler and Wendler (2016) mostly overlaps with our own approach to temporal casing. What is different, potentially an added value or particularity of temporal casing (both conceptually and methodologically) is first, the connection to complexity-informed perspectives in the social sciences (see Abell, 2009; Uprichard & Byrne 2006), and second, the arrangement of the analysed empirical material into development stages.

First, narratives, such as collected qualitative data from interviews or chronologies of a certain process, can be systematised by identifying key actors, turning points, and ordered sequences of events that, together, describe the unfolding of a process as a story. Narratives are simplifications and abstractions, but they dialogue with complexity (or, at least, attempt to do it) because they are grounded in

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the indirect accounts (e.g., interviews to key informants, truly lived episodes of a specific event, newspaper articles, reports, academic articles) that actors provide about a certain process.

This means that by using narratives, complexity is approached through the agency of the actors involved in the process (Uprichard & Byrne, 2006). Narratives can represent the complexity of cases by showing the different meanings that actors involved in a process assigned to certain situations or events. Actors' interpretations, too, are part of the explanation linked to the occurrence of an event. Narratives, which are composed of both qualitative and quantitative information, can be systematised, for instance, into diagrams (qualitative modelling) and offer a route towards explanatory statements, such as limited generalisations of results, when narratives are compared across cases (Uprichard & Byrne, 2006).

It is probably Abell (2009) that, through his highly formalised conceptual framework on narratives, more clearly showed how explanatory statements can be derived from the analysis of action narrative paths. A detailed discussion of Abell's work is beyond the scope of our present article, but here it suffices to highlight, through Abell's framework, how researchers analyse and interpret narratives as an ordered sequence of events that can be formalised into diagrams composed of nodes and arcs. Actors' decisions and events, their duration and effects can be reconstructed through formalised diagrams that may also show "causal" links within a single case. This means that a narrative is not simply a story, but a "causal story" (p. 44) that provides an action path along which actors, their actions, the conditions for their acts, and the effects of those actions are connected and ordered by the researcher to derive causal statements. When narratives are compared, a common causal story might be identified.

Although Fiedler and Schuster (2016) and Fiedler and Wendler (2016) did not make a specific link with this complexity-informed approach to qualitative research, in this illustration we will consider their analyses as complexity-informed causal stories from which key actors, turning points and main effects can be identified (interpreted) to describe the planning and implementation process of the Elbphilarmonie and the BER. From this understanding of (mostly) qualitative (but also, quantitative) research, temporal casing comes fully into play when researchers subdivide these stories into stages. This means that key actors and turning points are used to identify where stages in a process "start" or "end" and that they, altogether, form an ordered sequence of events, or trajectory.

Below, we show how to practically perform temporal casing by using the BER and the Elbphilarmonie as examples. Given the purposes of our illustration, we reported only the main events and identified the main stages during the planning and implementation of both megaprojects. A much more detailed and complete account could hence be possible. We present both examples of temporal casing in tabular form (see Table 2) to show how stages are case-specific and how they can be used to describe at best what happened along the process. However, other visualisations are possible (see the qualitative modelling approach in Uprichard and Byrne, 2006, or the diagrams for action narrative paths as in Abell, 2009). We would also like to remind readers that, as stated above, stages are simplifications, and they are also an analytical lens to segment a complex process in manageable parts that compose the causal story of each case.

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Start/end	Berlin Brandenburg Airport	Stages	Start/end	Elbphilarmonie	Stages
1996	Consensus among relevant actors about the need for a new airport for Berlin	1			
1996-1999	Process for privatisation failed	1			
2000-2003	Public ownership of BER through FBB (*Flughafen Berlin Schönefeld GmbH*), appointment of general manager, but no general contractor and 100% risk of loans guaranteed by the public sector. Key management mistakes (optimistic time schedule, fragmented bidding process)	2	2000-2003	Consensus among relevant actors about the Elbphilarmonie as the new landmark of the City of Hamburg	1
2008-2011	Construction started, in parallel with the airport design	3	2004-2005	Set-up of governance arrangements ("slim" public agency ReGe—supporting the bidding process and appointment of one big contractor—Hochtief -)	2
2012-2013	New general manager appointed; re-building of fire safety alarm system given the new (but expected) regulations	4	2006 - 2013	Contract change to a forfeit model (higher costs for the public actor) and escalation of costs due to a "planning-by-doing" construction. Tension among actors and change in staff.	3
…	…		…	…	
…	…		2017	Opening	
2021	Opening				

Table 2. An illustration of temporal casing for the Berlin Brandenburg Airport (BER) and Elbphilarmonie, based on the analyses by Fiedler and Wendler (2016) and Fiedler and Schuster (2016), respectively. The book chapters have been published in 2016 so the analyses are not up-to-date, and we signalled missing information by using "….".

To conclude this section, we would like to discuss three main characteristics of the temporal casing as illustrated in Table 2. First, stages are topic-specific; in Table 2 we identified the main stages based on the megaprojects and spatial planning literature: site identification and plan formulation (stage 1), planning phase and governance set-up (stage 2), and implementation process (stage 3 and following). In other domains, stages have to resonate with the specific theories and knowledge developed in their

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respective research area (e.g., stages in the policy cycle). They should, however, not be followed slavishly but, as we discussed above, meaningfully capture the uniqueness of the cases' histories.

Second, the duration of stages is not defined by a fixed temporal unit (like one year, or 5 years), but it varies according to the focus of analysis. Moreover, as shown in Table 2, not only have stages a different duration within the same case (e.g., in the Elbphilarmonie, stage 1 has not the same duration as stage 2), but also across the cases (e.g., stage 2 in the Elbphilarmonie has not the same duration as stage 2 in BER). Furthermore, for stage 1 in BER, although we subdivided the processes between 1996 and 1999 into two items, we considered it as part of the same stage. Therefore, stages can also include multiple events, which might then be qualitatively grouped into one stage. It is always the job of the researcher to analyse the case-specific information and structure it into stages that can effectively (although never "perfectly") represent the case development. The latter is very important because stages will never satisfy the level of detail desired by researchers using either quantitative and qualitative approaches towards generalisation or case specifics.

The different duration of stages and the flexibility needed to identify them explains why we used the word "stages" and not "intervals," as the latter can suggest fixed time periods. On the other hand, although the word "stage" can imply a step along a pre-defined development path, the term stage is used to indicate a step in a periodisation (or "concatenation"; literally, "chain of events"). Temporal casing is not only a description of what happened but, more importantly, it is an analytical effort to systematise a process into an ordered sequence of events.

In temporal casing, the building blocks of this ordered sequence of events are (development) stages. Each of the stages has individual, case-specific characteristics in terms of content (what happened, where, and who was involved) and duration (how long) which, together, present, in Abbott's terms, a causal story (why). We restate that how exactly this is done depends on the focus of analysis (see above) and on the researcher(s)'s analytical and methodological strategy. There are no best ways to do this, but temporal casing is no mystery in this regard, as it is grounded on conventional qualitative research in the social sciences, so readers can refer to further resources on this domain.

Third, as it is the researcher who defines the stage-specific durations (see above) and the entire duration of a process (see above on boundaries), temporal casing allows for entire durations that are not only different, but that are also punctuated by a different number of stages with a different duration. Hence, temporal casing allows for variety (i.e., it is a diversity-oriented approach, see Ragin, 2000): regardless of their entire duration, some processes can be described and analysed by means of two stages, some others by four stages or more (and each of those stages will most likely have a different duration).

Furthermore, this means that temporal casing can also potentially (and partially) capture the rate of change of a certain process. Using a rough measure, which should be improved in the future, the case-based rate of change can be expressed as the ratio between the number of stages qualitatively identified and needed to describe a certain process and its total years of duration. For the stages we identified in Table 2, the rate of change would be 0.23 for both the BER (4 stages divided by 17 years) and the Elbphilarmonie (3 stages divided by 13 years). This suggests that, despite their different duration and number of stages, and the different durations of their stages, the two megaprojects are characterised by the same rate of change.

4 Conclusions

In this paper, we started from the observation that scientists continue to wrestle with notions of space and time. The complexity sciences focus on the topic, but with considerable limitations as empirical phenomena are subjected to the regimentation of calendar or clock time. Following an overview of alternative ways of understanding time (see Table 1), we outlined the properties of time-sensitive casing and revisited the research on megaprojects to highlight what would change had those projects been re-cast in a more time-sensitive manner. We argue that such a re-casting, which we label as temporal casing,

constitutes a difference in-kind instead of a difference in degree in research. Time and space are primarily endogenous to cases, so case-based research should follow that logic instead of subjecting the case to external logics conceptualising time as regular ticks.

However, we don't want to repeat the default argument that single, in-depth case studies would be better. Such studies can be helpful, too, just as a cross-sectional analysis can be. Nor is our intention to declare any of these approaches, or others, as obsolete. Rather, we observe a *faux* dichotomy between qualitative and quantitative approaches that misses the main point, namely that cases follow diverging and converging trajectories through the property space. These movements can only be found through structural comparison of the in-depth case materials that highlight the equifinal and multifinal nature of the cases (Gerrits and Pagliarin 2020).

In our empirical illustration, both the Elbphilarmonie and the BER feature many of the hallmarks as shown in Table 1. They are structured by time-space, contain multiple lineages of events and activities of a varying density, and have a different pacing from the perspective of the people involved. At the core of temporal casing lies the acknowledgement that time units and space units are not a natural given but should be redefined based on within-case variation as described here. In other words, a straightforward comparison between cases across calendar time is therefore not as informative as it seems at first sight but requires interpretation.

As we showed in section 3.2, most research practices in temporal casing can appear common sense because they are very much rooted in qualitative empirical research. However, we find these practices are rarely stated explicitly or highlighted by researchers. Hence, we identified and showed how the six main dimensions of temporal casing (see section 3.1: context and history over similarity; boundaries; endogenous time over exogenous time; uniqueness and generality; qualitative first, quantitative later; stages instead of intervals) work in practice in the two selected cases.

The result of temporal casing as time- and case-based research is rendered, in this paper, in tabular form as per Table 2. However, Table 2 is not simply a visual support to show how temporal casing works in practice. It is first and foremost an expression of the central effort towards formalisation that characterises temporal casing. The identification of *ordered* and numbered, development stages for each case not only means that stages can be captured, but also that they can be compared between different cases. Temporal casing aims at capturing *within-case* time variation, but also has the further goal to compare time variation, in the form or ordered stages, *across cases*. Such comparison can occur, for instance, by examining the rate of change of each case and by employing systematic comparative research methods such as qualitative comparative analysis (QCA) (Ragin, 2000, 2008). Temporal casing as a research approach and practice is therefore strongly rooted in configurational comparative methods.

In conclusion, we believe that capturing the within-case time variation through temporal casing would beneficially contribute to complexity-informed empirical research in the social sciences, as the power of methods is rendered void if the casing ignores the temporal specificities of social processes. In showing the diversity of ways to conceptualise time, we also highlighted their limits. We further demonstrated how, being rooted in qualitative, case-based research, temporal casing can partially address those limitations. Having also revealed the advantages of temporal casing, we hope that researchers will use it in the near future as a basis or groundwork for their own case-based and/or comparative research that aims to be sensitive to "the time of the case."

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