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BREAKING NEW PATHS: THEORY AND METHOD IN PATH DEPENDENCE RESEARCH**

ABSTRACT

We argue that the main reason for the prevailing dissent in path dependence research methods is the futile attempt to capture “path dependence as a whole” within either a single-method research design or a single all-encompassing theoretical mechanism. By delineating two conceptual building blocks, path creation/emergence and positive feedback/lock-in, which rest on different epistemological foundations, we advocate for the application of complementary methods. We further refine our argument by proposing a general axiomatic structure for path dependence as a theoretical concept, which allows us to derive more specific methodological suggestions.

JEL Classification: B40, B52, D02, M10.

Keywords: Contingency; Methodology; Path Dependence; Positive feedback; Testability.

1 INTRODUCTION

As a theoretical concept, path dependence was originally developed and discussed within different streams of economic thought by researchers such as David (1985), Arthur (1989), North (1990), and Witt (1997). Recently, it has attracted a growing interest in the field of organization and management studies (see Garud and Karnoe (2001); Schreyögg and Kliesch-Eberl (2007); Sydow, Schreyögg, and Koch (2009); and Vergne and Durand (2010)). However, despite several conceptual adaptations for its application within the organizational realm (see, for example, Koch (2008, 2011)), some of the most fundamental and still unresolved controversies have been imported from economics into organizational research. Among these aspects, the question of how

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to empirically validate the central claims of path dependence research is particularly prominent (Kay (2006)).

To us it seems that a lack of conceptual clarity in path dependence research leads to confusion on methodological issues in general and the issue of testability in particular. This need for clarification is especially obvious in a recent dispute on the methodology of, and testability in, path dependence research (Vergne and Durand (2010); Garud, Kumaraswamy, and Karnøe (2010)): in discussing the “missing link between theory and empirics of path dependence”, Vergne and Durand, who note a lack of both conceptual clarity and testability, very often refer to the mainstream economic critiques by Liebowitz and Margolis (1990, 1994, 1995). Vergne and Durand’s “narrow definition” of path dependence, which is similar to the three-phases model put forward by Sydow et al. (2009), distinguishes contingency, self-reinforcement, and lock-in as the major components of path dependence. In contrast to Sydow et al. (2009) a definition leads them to suggest that simulations, experiments, and counterfactual models are the appropriate tools for investigating path dependence. In their reply to these methodological claims, Garud et al. (2010) argue for a slightly different theoretical concept and advocate for a case study method in general and their narrative approach in particular for researching path dependence. This view is again in conflict with the methodical suggestions provided by Sydow et al. (2009), who emphasize the role of patterns of behavioral practices as an empirical anchor for analyzing path dependence. Sydow et al. (2009) explicitly differentiate this perspective from older process studies that have a strong narrative component. Thus, we have three recent articles, all of which have been published in leading academic journals, each of which advocates a very different methodological prescription, but all of which refer to a common theoretical framework.

A review of this debate shows that the current discourse lacks a clear discussion of the relevant theoretical mechanisms or propositions, and further, that it is driven by a debate on concrete methods while the more fundamental questions on the epistemological nature and the axiomatic structure of path dependence remain diffuse. Hence, such an approach does not advance a rigorous discussion on “testability” since both conceptual clarity for the alleged mechanisms and a pedantic analysis of these mechanisms are necessary preconditions for evaluating the empirical content of a certain theoretical concept. Moreover, the axiomatic structure of a given theory is also the most promising starting point for developing concise methodological suggestions.

By taking the current debate as an example of epistemological problems in path dependence research, we build on the basic observation that there are still substantial epistemological and methodological differences on how path dependence should be properly implemented in empirical testing. From our point of view, the main reason for the prevailing dissent is the futile attempt to capture “path dependence as a whole” either in one generalized all-encompassing theoretical mechanism, or within a single-method research design. Both Vergne and Durand (2010) and Garud et al. (2010) engage in searching for a single best method for addressing path dependence.

By embodying a more pragmatic approach to this issue, we avoid this specific pitfall. Hence, our paper addresses three basic research questions:

- (1) Can we isolate common mechanisms that are conventionally subsumed under the label of path dependence and formulate appropriate hypothetical statements?
- (2) Can these common mechanisms be embedded in an axiomatic structure, one which qualifies that structure to be called a “theory”?
- (3) Can we find ways to test the central propositions embedded in this axiomatic structure, and if so, determine which methods are most appropriate?

The paper proceeds as follows: In section 2 we provide some preliminary epistemological remarks. In section 3 we address the first question by presenting an argument on theoretical convergence in path dependence research. In section 4 to address question 2 we present a suggestion for a unifying axiomatic structure that exhibits testable implications. In section 5 we offer a more rigorous assessment of possible methodological strategies related to research in path dependence to answer question 3. Section 6 concludes.

2 MECHANISMS, DESCRIPTIONS, AND THE TESTING OF THEORIES

Within a social science context not all uses of the words „path“ or „path dependence“ refer to the narrow theoretical concept that we deal with in this paper. Many researchers use these words to metaphorically describe historical contingency and the conditionality of certain events or institutional configurations (see Goldstone (1998) for an example of this type of usage). However, the researchers who intentionally use “path dependence” as a theoretical concept, in contrast to a metaphorical or heuristic understanding, often base their work in the tradition of David (1985, 2001) and Arthur (1989, 1994).

Such a theoretical perspective implicitly accepts the idea of nomothetical knowledge, even for the realm of the social sciences. In this context, *nomothetical* implies that knowledge takes the form of theoretical mechanisms or propositions (i.e., mechanisms expressed in law-like statements – see Bunge (1997) or Mayntz (2004)). The major issue with such theoretical propositions is whether they are able to inform about empirical relations. If they can do so, then they carry *explanatory power* or (equivalently) *empirical content* (see Bunge (1996); and Popper (1969)). In this paper we refer to single law-like statements, as “theoretical propositions” or “hypothetical statements”. We define *theories* as being normally composed of a set of such theoretical propositions in conjunction with a less obliging additional set of possible auxiliary hypotheses (Bunge (1967)). The function of these auxiliary hypotheses is twofold. They concretize the more general laws for special cases, thereby allowing for testable empirical predictions, and they also restrict the scope or domain of the derived statement. This understanding implies that different applications might require different compositions of auxiliary hypotheses. Although both, auxiliary hypotheses and theoretical propositions, can be perceived as theory-specific assumptions, the latter exhibit a specific structure, that is:

For all x holds: if there is A , there is B , too (or formally: $G:(x) (Ax \rightarrow Bx)$)

Statements of this kind contain general terms (A, B, x) in conjunction with some proposed necessity (if-then; i.e., \rightarrow). As indicated above, theoretical propositions of this form often cannot be tested directly but require the specification of additional auxiliary hypotheses in order to bear testable implications. (This restriction even holds for well-established theories such as classical mechanics; see: Bunge (1967).) In sum, *if path dependence is to be considered a theory, then it should contain at least one such theoretical proposition*. This statement should be testable if some assumptions are added to it.

Before we go further, we wish to clarify how we see the role of hypothetical statements in the context of path dependence research. Even though we believe that path dependence as a *theoretical* concept does contain such hypothetical statements (in what follows we show that it even qualifies to be called a “theory”), we argue that practical research in path dependence cannot be exhaustively described by a set of theoretical propositions. Such research also deals with historical phenomena from an ideographic viewpoint, i.e., it is intended to supply good descriptions of specific situations or processes. Also we do not imply, by our insistence on the possibility of nomothetic knowledge, that ideographic descriptions are per se of lesser scientific merit. Quite to the contrary, all sorts of topics may be empirically investigated by ideographic approaches whose application is often a methodological necessity, for example, when the phenomena of interest constitute unique events. It would be absurd to claim that such unique events are not of scientific interest: just think of World War I, the oil shock or floodwater prevention at a river.

However, most ideographic approaches also make use of known or assumed regularities (that is, *mechanisms*), even though the point is to give an ideographic account. Conversely, every experiment implemented to test a specific mechanism requires using one of the archetypes of ideographic research, a *protocol*. These examples clearly indicate the major shortcoming of the nomothetic-ideographic divide: all kinds of (empirical) scientific fields, regardless of whether they are commonly located in the natural, social, or cultural sciences, use both methods of inquiry. Although these modes of thought cooperate to varying degrees and with varying relative importance across disciplines, their productive interaction shows that nomothetic and ideographic elements do not necessarily represent inherently antagonistic ontologies (as alleged by Garud et al. (2010)) but may instead be *complementary* modes of scientific inquiry.

This issue is important, since conceiving science as either purely nomothetic, i.e., only accessible in terms of regularities (“laws”), or as purely ideographic, i.e., only accessible in terms of scrupulous descriptions, lies at the heart of the current debate on path dependence. We illustrate this dichotomy by the following quotations:

“Methodologically, our path creation perspective suggests that it is important for a researcher to study processes in ‘real time’, i.e., place oneself at the time that events occurred even if one were looking at data gathered in the past. [...] It is equally important for a researcher to ‘follow the actors’ to study how actions become possible through entanglements.” (Garud et al. (2010))

“The bottom line is: organization scholars will not be able to verify path dependence empirically if their argument relies on the *ex post* demonstration that something did happen contingently.” (Vergne and Durand (2010))

Vergne and Durand (2010) appear to be convinced that contingent events, where the application of theoretical propositions is strongly restricted, are never a legitimate part of science. They emphasize the nomothetic aspect of science, i.e., the idea that science is either only, or primarily, characterized by the search for regularities in society and nature. But Garud et al. (2010) refer to social constructivism and urge us to observe the idiosyncratic processes of a given case, which represents either the only, or perhaps the primary, way to deepen our understanding of path dependence. From such a viewpoint, careful descriptive research is a necessity, and simplistic mechanisms are either superficial or misleading.

This debate thus resembles the classic dichotomy between a purely nomothetic and a purely ideographic approach, which is shown in many cases in the history of philosophy and science. The most famous case may be the German *Methodenstreit* between the German Historical School and the early proponents of Austrian Economics (see (Hodgson (2001))). An example for a dichotomic understanding of the ideographic-nomothetic distinction within organizational research is provided by Burrell and Morgan (1979), who label it the “subjective-objective” divide and present it as a “meta-theoretical assumption” that precedes any concrete research activity (Burrell and Morgan (1979)). In contrast to these conflicting approaches, we propose a more pragmatic viewpoint, one that is rooted in current developments in the philosophy of science. In this approach, the traditional nomothetic-ideographic dichotomy is deemed to be a philosophical chimera, which we believe is as wrong as it is common among empirical researchers:

“To sum up, the nomothetic/ideographic dichotomy is a philosophical artefact, for every science is both nomothetic and ideographic.” (Bunge (1999))

As discussed above, we argue that from both a philosophical viewpoint and in actual research practice, ideographic and hypothetical concepts are much more closely intertwined than most people would expect. Hence, it is easy to see that “mixing ontologies”, as criticized by Garud et al. (2010), can indeed be desirable. As we have seen, this differentiation is not a matter of “consistency,” but should instead be determined by the problem or question at hand. Thus, ideographic purism is not of much help. Nevertheless, Vergne and Durand (2010) commit the mirror fallacy by proposing to reduce the amount of ideographic case-study research and to perceive the initial conditions of a path dependent process as either unimportant, if initial conditions are weak, or problematic, if initial conditions are strong. In doing so, they try to define away the most controversial component of path dependence from a purist nomothetic perspective: the series of unique events that take place before positive feedback effects kick in.

3 PATH DEPENDENCE THEORY: COMMON GROUND

First, and despite the appropriateness of the complaints about the absence of conceptual clarity (see, for example, Mahoney (2000)), we argue that actually, a kind of *theoretical convergence* has happened over the past decade. We have observed a growing consensus across disciplines and analytical levels on the question of what path dependence is or should be. In this context positive feedback effects are of central importance, since they link initial contingencies with an eventual state of hyperstability called “lock-in”. Hence, path dependence is located in the realm of *mechanism-based theorizing*, which explains social phenomena by identifying the processes through which they are generated (Davis and Marquis (2005)). On this level of abstraction, path dependence is a theoretical umbrella term that covers various processual empirical phenomena that are related to different social standards in form of technologies or institutions. Thus, it is comparable to similar terms commonly used in management and organization studies such as “absorptive capacity” (Cohen and Levinthal (1990)), “core competences” (Prahalad and Hamel (1990)), or “dynamic capabilities” (Teece, Pisano, and Shuen (1997)). The important question is whether this emerging consensus can be framed within a common axiomatic structure.

To prepare some common theoretical ground, we analytically disassemble path dependence into three parts or phases, all of which can be found in most of its recent applications (see, for example, Sydow et al. (2009); and Vergne and Durand (2010)). Thus, our focus on “contingency” and “self-reinforcement” is compatible even with researchers such as Garud et al. (2010), who are skeptical about phase models of path dependence but acknowledge that these two building blocks “have been shaping the very use (or misuse) of this concept over time.”

3.1 CONTINGENCY: PATH EMERGENCE AND CREATION

At the beginning of path dependent processes there is contingency. It is at this stage that historical peculiarities – what Arthur (1989) calls the “small events” – matter most. For Arthur (1989) these small events are important, because on the one hand, they “are not averaged away and ‘forgotten’ by the dynamics – they may decide the outcome” but on the other hand, they “are outside the ex-ante knowledge of the observer – beyond the resolving power of his ‘model’ or abstraction of the situation”. The latter is what makes small events responsible for the non-ergodicity of path dependent processes. In phase models of path dependence such as those developed by Sydow et al. (2009), the period of contingency lasts until a “critical juncture” (Mahoney (2000)) is reached and positive feedback kicks in.

Consistent with Arthur’s (1989) definition of small events are thus both “unpredictable, non-purposive, and somewhat random events” (Vergne and Durand (2010)) and actors that are “...able to improvise and bricolage their ways through an emergent process” (Garud et al. (2010)). This observation is not only true from a researcher’s perspective, but also for the actors involved in the process. What appears as purely random for one observer may be attributed causally to intentional actions by another one.

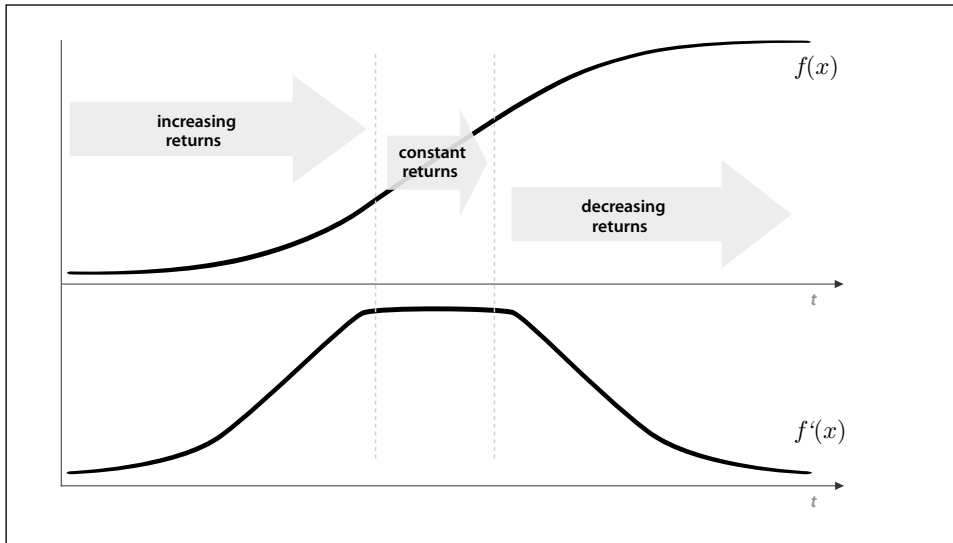
In terms of investigative methods, the contingent phase of path emergence and creation is always subject to historical explanation. From this perspective it is not surprising that Garud et al. (2010), whose concept of “path creation” clearly focuses on this phase, favor narrative approaches.

3.2 SELF-REINFORCEMENT: POSITIVE FEEDBACK

The research that examines positive feedback as a basic element of path dependent processes differs in wording and categorizing, but not in essence. Saxenian (1999) even states that “...path dependency without a mechanism is nothing more than a recognition that history matters.” Consequently, scholars who use path dependence in the tradition of David (1985) and Arthur (1989) prominently feature concepts such as “self-reinforcement” (Arthur (1994); Vergne and Durand (2010)), “positive feedback” (David (2001); Sydow et al. (2009)), and “increasing returns” (Arthur (1989); Pierson (2000); Campbell-Kelly (2001); Kay (2006); see also Arthur (1994) pointing to a variety of further labels). The notion of “increasing returns” has especially inspired criticism (Arrow (2000)) and is prone to misunderstandings, as its clear-cut mathematical meaning interferes with its metaphorical usage, mainly in the field of political science (see, for example, Pierson (2000); Thelen (2003); and Kay (2006)).

Thus, while we contend that most of the different labels for positive feedback could be used interchangeably, we nevertheless suggest that researchers abstain from using the term “increasing returns” unless it is exactly specified. The reason for this choice of wording is that although positive feedback effects may come with increasing returns, they need not. Such effects are also possible with constant or even decreasing returns, which is not to be confused with negative feedback. Even with decreasing returns, there might still be an increase in the variable under question. This phenomenon can be seen in the most classic example for path dependence: the standard S-curve of technology diffusion is the result of ongoing positive feedback, but shows all three possible kinds of return structures at different points in time (see also *Figure 1*).

The second difference lies in the growing number of attempts to categorize different causes for positive feedback. For example, Sydow et al. (2009) list coordination, complementarity, learning, and adaptive expectation effects, each of which comprises several different types of positive feedback that can be found elsewhere in the path dependence literature. Among those types of mechanisms are direct and indirect network effects/externalities (Katz and Shapiro (1985); Liebowitz and Margolis (1994); Shapiro and Varian (1999)), dynamic capability development (Leonard-Barton (1992); Teece et al. (1997); Schreyögg and Kliesch-Eberl (2007)), and certain types of strategic co-evolution (Burgelman (2002, 2009); Koch (2008)).

Figure 1: Returns Structure(s) of a Standard S-Curve Technology Diffusion Process

However, from the perspective of methodology, all these categorizations should not obscure the common conceptual core: positive feedback. The identification and investigation of particular positive feedback effects and their impact on the overall development is in turn an empirical task, one that even allows for applying a broad repertoire of methods.

3.3 STABLE OUTCOME: LOCK-IN

In a nutshell, lock-in is a situation in which there is no viable switching effort that can be used as an alternative to a given social standard. Referencing Giddens (1984) and Sydow et al. (2009) argue that a lock-in may be predominantly cognitive, normative, or resource-based and become a de facto irreversible state. For the organizational realm, Sydow et al. (2009) "...suggest conceptualizing the final stage of a path dependent process in a less restrictive way – as a predominant social influence, leaving some scope for variation." Using different sets of auxiliary hypotheses can accommodate these slight differences in interpretation.

From a methodological viewpoint, the state of lock-in is virtually inseparable from the previous stages of positive feedback and path creation/emergence: even the empirical question of whether positive feedback can still be found in situations of alleged lock-in requires identification and measurement of these very effects. There may be differences between the two phases, with regard to the stability of a given situation, the auxiliary hypotheses needed to test the postulated mechanism(s), or the latter's specific formulation, but their investigative core – a focus on mechanism testing – is basically equivalent (stochastic and

deterministic). The specific question of whether any other alternative standard would have been, or still was, viable or even superior compared to the dominant standard might in turn require ideographic reasoning similar to the issue of path creation/emergence.

4 THE AXIOMATIC STRUCTURE OF PATH DEPENDENCE: A SUGGESTION

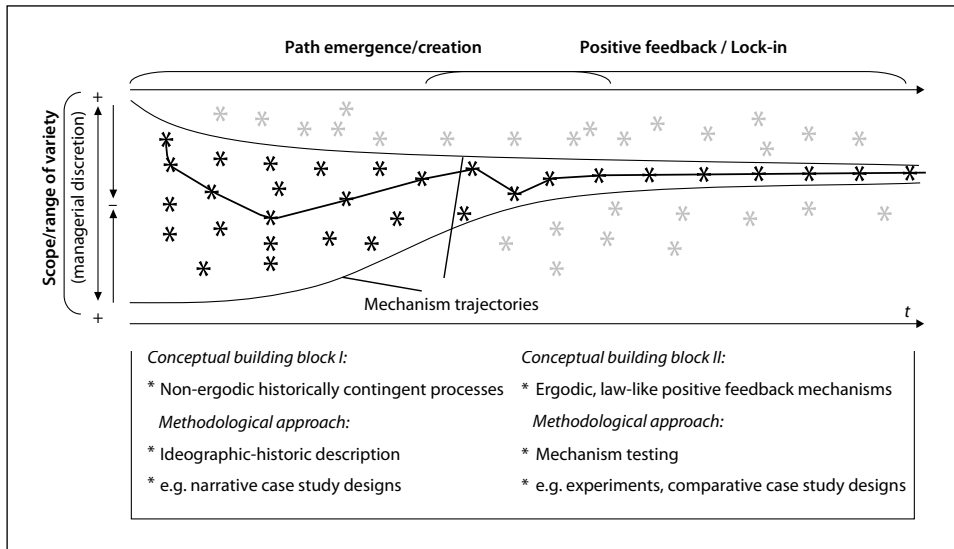
Although theoretically we have followed the common distinction between three consecutive phases of path dependence theory (Sydow et al. (2009)), in our methodology we differentiate two partially overlapping and reciprocally related conceptual building blocks (see *Figure 2*). The first building block deals with the emergent or intentional actions – historically contingent small (and not so small) events – that are responsible for initiating and directing a path dependent process. This building block requires approaches that are open for idiosyncrasies in historical chains of events, something Mahoney (2000) refers to as “reactive sequences”. As mentioned above, the narrative case study approach put forward by Garud et al. (2010) is perhaps the most prominent, but definitely not the only, approach for such an endeavour. Alternatively, the researcher could apply “contextualist analysis” (Pettigrew (1990)) or “systematic process analysis” (Hall (2003)). These analyses strive for generalization by identifying patterns while being responsive to historical idiosyncrasies (see also Bennett and Elman (2006)).

Several studies describing cases as path dependent apply such an ideographic approach. For example, Schreyögg, Sydow, and Holtmann (2011) use an entirely historical approach to describe the rise and decline of the Bertelsmann book club in Germany as a case of organizational path dependence. Also, several examples in the volume on path dependence and creation, edited by Garud and Karnoe (2001), pursue purely ideographic research methodologies (see, for instance, Kenney and von Burg (2001) or Porac et al. (2001)).

However, as in any historical analysis, ideographic descriptions of path emergence and creation processes cannot be tested in a narrow sense. They can only be contested by presenting additional (counter-)evidence and/or developing alternative explanations. Whether a particular case is one of path emergence or creation is an empirical question depending on, among other things, the agent(s) under study. Thus, it is difficult to tell whether disputes on path creation can ever be resolved (see the debate on the QWERTY-example in David (1985); Liebowitz and Margolis (1990); Frost and Egri (1991); David (2001)), since additional evidence might be added at almost any time to an established argument, thereby possibly changing its implications.

The second building block covers ergodic positive feedback mechanisms that can reduce the range of available alternatives and thus managerial discretion over time. On a general level, such mechanisms could be described as “sequences of causally linked events that occur repeatedly in reality if certain conditions are given” (Mayntz (2004)). Thus, they are recurring processes that account for how a set of specified initial conditions leads to a specific outcome. It is in this context that a more concise testing of path dependence becomes possible.

Figure 2: Conceptual Building Blocks and Methodological Approaches to Path Dependence Research



Note: inspired by Sydow et al. (2009).

Examples of studies trying to test positive feedback mechanisms within path dependent processes are Koch, Eisend, and Petermann (2009) and Blinn (2009). Koch et al. test the tendency of probands in a controlled experiment "...to neglect future developments at the expense of information on present situations" In their experiment, to compare the actual decision paths of the probands with a given optimal one, Koch et al. manipulate the complexity of a fictitious decision environment in a mobile service setting. Blinn (2009) demonstrates that mechanism testing need not be restricted to experimental research designs. By comparing the respective dynamics in different countries, he tests positive feedback mechanisms responsible for the persistence of dubbing in the film industry.

However, the approach of "mechanism testing" in building block 2 does not necessarily imply that ideographic descriptions as such are of no further importance. On the contrary, the unique facts they provide might be well-suited, or even necessary, for testing theoretical statements. So although they are still useful for path dependence research at this stage, they serve a different purpose: In the phase of contingent path creation or emergence (building block 1), their function is to supply precise descriptions of actual events, while in the context of mechanism testing (building block 2) their function is to evaluate theoretical claims. Therefore, this second building block demands a different case study design, one that establishes the idea of mechanism testing within case study research (see Gerring (2004) or Flyvberg (2006) for a comparison of different approaches). While such research strategies are often limited in their representativeness, they are still suitable for refuting theoretical claims, due to the asymmetry between verification and falsification.

Hence, if research designs are adequately specified and executed, then these approaches will in many cases allow for the testing of theoretical claims.

The advantage of restricting theory testing in a narrow sense to our second conceptual building block is best illustrated by the attempt of Vergne and Durand (2010) to formulate an "... all-encompassing" mechanism capturing "path dependence as a whole". These authors present the following two theoretical statements as a starting point for putting path dependence to a test:

"For any set of initial conditions, if contingent events put B far enough ahead of A, and the path is later reinforced, then the process is locked-in on B."

"By contraposition, for any set of initial conditions, if the process is not locked-in on B, then either contingent events did not put B far enough ahead, or self-reinforcement did not occur on path B (e.g., it was stronger for A)."

The inclusion of contingency in the *if* clause of these stylized mechanisms basically renders them nearly tautological. They lack empirical content and thus are basically untestable.¹ Taking into account the ideographic nature of contingent initial conditions for both statements, any empirical result may be attributed to the existence or absence of "contingent events", i.e., some "random factor". Our proposal to acknowledge in our methodology the ideographic nature of initial contingency and to preserve empirical testing in the aspect of self-reinforcement is particularly helpful to avoid such loopholes, which are based on the desire to test path dependence whole, but eventually and result in an immunization against critique.

4.1 AN AXIOMATIC STRUCTURE FOR PATH DEPENDENCE AS A THEORETICAL CONCEPT

Abstract theoretical mechanism categories such as coordination, complementarity, or learning effects (Sydow et al. (2009)) need to be linked to particular empirical phenomena. In such a scenario and in contrast to contingent actions and events prevailing in the first conceptual building block, mechanisms of positive feedback can be integrated in testable theoretical statements. However, although positive feedback effects are localized or analyzed in many applications, their presence as such is only rarely the controversial, i.e., the hypothetical, part of the argument. On the contrary, the typical conjecture in path dependence research is related to specific outcomes, because outcomes are determined or influenced by positive feedback effects. Moreover, the variety of objects tackled in the context of path dependence (technological standards, social norms, organizational

1 The only possible way to refute the Vergne and Durand (2010) hypotheses is to identify a situation in which self-reinforcement holds for B, but B is not locked in, *although contingent events have put B "far enough" ahead of A*. We suppose that this last condition related to contingent events is only accessible through ideographic-descriptive studies. The element of uncertainty associated with "contingent events" is redirected to the phrase "far enough ahead" in the above formulation. We cannot "measure" whether B has been put "far enough" ahead of A by contingent events if our only tools are descriptions of contingent events. As long as the answer to this question remains dubious the Vergne and Durand hypotheses lack testability.

routines, or more generally, social standards) hints at the diversity of processes, which exhibit positive feedback effects. How this diversity can be integrated into a single and consistent axiomatic structure is by no means clear and seems to have motivated much of Vergne and Durand's (2010) critique.

To fill this shortcoming in current conceptions of path dependence, we provide an axiomatic framework that takes into account a series of criteria that feature prominently throughout this paper. These criteria are mainly testability, consistency, and integrability, i.e., the ability to integrate superficially different research areas related to path dependence into a common structure. A fourth criterion is that an axiomatic framework should pose the same central questions as can be found in applied research on path dependence, i.e., it should resemble the focus on outcomes, since they are influenced by positive feedback effects.

Taking these criteria as fundamental to an axiomatic reconstruction of the theoretical arguments we provided in section 3, we arrive at the following *generic proposition*:

For all (x) holds CP: If “positive feedback” (PF) is at work and a series of competing and incommensurable social standards x are available, then one of these standards will tend to dominate.

This suggestion for a generic proposition resides in our second conceptual building block and has a series of features. First, it focuses on outcomes without claiming the suboptimality of outcomes. Thus, the latter is a possible, but not a necessary result of path dependent processes: If these processes are really non-ergodic, then there is no way to rule out this situation in which the “best” solution will succeed. Second, a generic proposition resembles a very basic claim often found in path dependence research, and one which is applicable to a variety of settings. Third, it incorporates a *ceteris paribus* clause (CP). Fourth, if some central terms, such as positive feedback or social standards, are appropriately defined, then we can test this conjecture. Such definitions normally take the form of auxiliary hypotheses. Moreover, a researcher can take advantage of the generic proposition by thinking of positive feedback in a very abstract way while clarifying different notions of positive feedback in a series of additional auxiliary hypotheses. Hence, we present the following four definitions, each of which addresses a different context out of which positive feedback effects allegedly arise:

PF_{external}: Whenever x_i is adopted by some adopter a_j , then x_i becomes more attractive for all adopters.

PF_{internal}: Whenever x_i is adopted by some adopter a_j , then x_i becomes more attractive for a_j in the future.

PF_{complementary}: If possible adopters want to utilize y and y can only be utilized in conjunction with x_i , then x_i becomes more attractive (for those adopters who want to utilize y).

PF_{expectational}: If possible adopters believe that x_i will dominate in the future, then x_i becomes more attractive in the present (for those adopters who believe that x_i will dominate).

These definitions make it possible for a variety of cases to be integrated in the generic proposition presented above. For example, *PF_{external}* is an abstract definition of coordina-

tion and network effects (e.g., Katz and Shapiro (1985); Shapiro and Varian (1999)) and $PF_{internal}$ is implicit in all instances of learning or habituation effects (see David (1985) or Eberl-Kliesch and Schreyögg (2007)). We note that the auxiliary character of these definitions specifies the generic proposition for a certain application, thereby restricting the domain of the derived statement. Thus, the crucial issue with these definitions is whether they actually apply to a given situation. Only if this is the case, it will make sense to test the derived statement. We also note that the definitions above are interchangeable and compatible with each other, which implies that two or more of these variations may apply to a given object. It also seems likely that some forms of positive feedback may regularly interact, for example, $PF_{expectational}$, $PF_{internal}$ and $PF_{complementary}$ in software markets (cf. *Table 1*, Shapiro and Varian (1999); and the related discussion on vapor-ware in Robertson, Eliashberg, and Rymon (1995); and Bayus, Jain, and Rao (2001)).

To complete our generic axiomatic structure for path dependence research we must still construct a definition for a social standard. We suggest a very broad, general definition, one which is still in line with the various applications found in the field of path dependence research:

Social Standard: A technology or rule informing human conduct, which can be replicated.

This definition differs from a more casual understanding of social standard in the sense of widely accepted social behavior, but serves as an umbrella term for potentially path dependent phenomena such as technological standards, social norms, or organizational trajectories. We note that this definition restricts the generic mechanism to matters of human conduct. To introduce more artificial, non-social variants of path dependence – the Polya Urn is a classic example – it is possible to replace the above definition with a more abstract variant. Such an abstract variant could then relate the aspect of replication directly to the formal properties of observed objects (e.g., red versus blue balls in a Polya Urn).

Taking our generic proposition along with the four basic definitions, we arrive at a roughly sketched axiomatic structure that satisfies the criteria laid out in the beginning of this section.

4.2 AUXILIARY HYPOTHESES AND CETERIS PARIBUS CLAUSES

Our conceptualization suggests that using a varying set of auxiliary hypotheses supports the great variety of topics commonly associated with path dependence research. Hence, the many applications of path dependence as a theoretical conception are due to the utilization of different, but compatible, auxiliary hypotheses that address different social patterns and subsume these distinct cases under a single theory. *Table 1* gives a stylized overview on how some prominent cases can be systematized within such a framework.

The many different problems tackled by path dependence as a theoretical concept not only allows for, but also demands, a certain degree of diversity in methods, since concrete methods always have to be tailored to the problem at hand.

Table 1: Systematizing Prominent Cases of Path Dependence within the Suggested Axiomatic Structure

<i>Generic Proposition: For all (x) holds CP: If "positive feedback" (PF) is at work and a series of competing and incommensurable (social) standards x is available, then one of these standards will tend to dominate.</i>				
Auxiliary hypothesis	PF _{external}	PF _{internal}	PF _{complementary}	PF _{expectational}
Exemplary case #1	Polya Urn (Arthur (1989))			
Exemplary case #2		QWERTY (David (1985))		
Exemplary case #3		Windows (Shapiro and Varian (1999))		

Contrary to auxiliary hypotheses, *ceteris paribus* clauses represent a general statement of caution. Such clauses say it might be possible that because of unforeseen exogenous forces, a theory or a specific proposition fails to produce the expected results. Generally, *ceteris paribus* clauses often restrict the testability of a given theory, but they seem to be a necessary evil (at least in the social sciences), this necessity is invoked by what is commonly referred to as the Duhem-Quine problem.²

An appropriate way to deal with *ceteris paribus* clauses is as follows: If a researcher who resorts to a *ceteris paribus* clause to defend a theoretical claim is confronted by conflicting empirical results, then we must not refer to the *ceteris paribus* clause in its general form, but to a specific exogenous factor located in the realm of the *ceteris paribus* clause. We may develop an additional auxiliary hypothesis (and add it to the theory as stated before the test), thereby enhancing the axiomatic structure of the theory in general. Such a procedure ensures that the *ceteris paribus* clause is not used as a vehicle for immunization against critique, but instead is utilized in a constructive way to extend the precision of the theory when viewed as a set of complementary statements.

An example is a case for which we assume three competing technologies (x_1, x_2, x_3) in a market associated with positive feedback effects. We further assume that the starting positions of these three technologies are that x_2 is widely used (say, roughly 70% of adopters use x_2), while the other two technologies play only a minor role. Given this information, we can conclude that it is most probable that x_2 will soon dominate the market. Now, we suppose that the government shows interest in regulating the market and finds that x_2 – in contrast to x_1 and x_3 – is in some way hazardous to the environment, and therefore

2 The Duhem-Quine problem basically asks whether we can expect axiomatic systems, i.e., our theories, to be exhaustive. The general answer, given by philosophers as well as social scientists, is that we cannot assure the completeness of theories. If this is indeed the case, then every theory has a *ceteris paribus* clause as a necessary element: It might always be the case that the supposed theoretical mechanisms are indeed correct, but the researcher has overlooked some decisive auxiliary hypothesis to adequately restrict the domain of a specific application.

bans x_2 completely. Although such a government ban is obviously an exogenous factor, only an auxiliary hypothesis that anticipates this governmental action upfront would have prevented the theory from being falsified by such an event. In such a case, we could resort to the *ceteris paribus* clause, which must be concretized in the form of a new and specific auxiliary hypothesis (e.g., “no government intervention in the market”). Via such an understanding, *ceteris paribus* clauses can help to refine and concretize theories by exposing new auxiliary hypotheses that restrict the domain of the theoretical proposition we would like to test.

4.3 FROM GENERIC TO MORE CONCRETE MECHANISMS

Above, we emphasize the necessity to concretize theories, i.e., to provide them with more precise formulations and more complete sets of statements that describe not only the proposed hypothetical mechanisms, but also the circumstances under which the respective propositions are expected to hold. Therefore, our generic account of path dependence as a theoretical concept needs further refinements. Hence, in *Table 2* we provide a short overview of the three phases and their relation to the two conceptual building blocks introduced earlier.

Table 2: Epistemological and Conceptual Differences between Different Phases of Path Dependence

Phases		Role of testable mechanisms	Degree of uncertainty	Conceptual building block	“What happens?”
Phase 1	Path-Creation/ Emergence	None (unidentifiable)	Contingent	Ideographic- explorative (building block I)	Distributing initial conditions
Phase 2	Positive Feedback	Probabilistic mechanism	Stochastic	Nomothetic- testing (building block II)	Law-like behavior and responsiveness to exogenous shocks
Phase 3	Lock-In	Non-Probabilistic mechanism	Deterministic	Nomothetic- testing (building block II)	Law-like behavior and low(er) responsiveness to exogenous shocks

Relating the conceptual differences depicted in *Table 2* to our generic proposition makes it possible for us to modify and concretize the latter with respect to the different phases of contemporary models of path dependence. While phase 1 is contingent and, thus, clearly falls in the domain of ideographic-descriptive methods, the stochastic nature of phase 2

demands a probabilistic mechanism. Consequently, the deterministic nature of phase three (after locking in a certain standard) demands a more traditional nonprobabilistic mechanism. We note that “deterministic” refers to the structural features of the general proposition, which is formulated in a non-probabilistic way. However, it does not imply that the development is determined by the core mechanism alone. The case-specific auxiliary hypotheses embodied in the respective formulation also play an equally decisive role. Keeping these qualifications in mind, we arrive at the following statements to describe the behavior of a given social standard in the context of positive feedback in phases two and three.

Phase 2: For all (x) holds *CP*: If *PF* is at work, some competing social standards x are available and the rate of adoption of x_i is higher than the rate of adoption of competing standards, then it is more probable that x_i will tend to dominate.

Phase 3: For all (x) holds *CP*: If *PF* is at work and a social standard x_i dominates, then x_i will stay dominant.

We note that this refinement leads to two different mechanisms, one probabilistic, one deterministic, which are most likely also accompanied by different, or at least slightly different, auxiliary hypotheses. We also note that both statements are framed as *ceteris paribus* laws, thus allowing for the creation of additional auxiliary hypotheses. We think a major task of empirical research related to path dependence is to elaborate and concretize these auxiliary hypotheses. Doing so is also relevant for differentiating the domains of these two hypothetical mechanisms.

However, distinguishing between probabilistic and deterministic mechanisms also involves another, more idiosyncratic empirical task, that of identifying the “critical junctures” (Mahoney (2000); Sydow et al. (2009)) that separate the different phases of path dependence in a certain empirical domain. Due to its idiosyncratic nature, this task requires an ideographic research method, thus strengthening our point that at least two different methodological approaches are necessary to capture path dependence as a whole.

5 DELINEATING METHODOLOGICAL SUGGESTIONS

The researcher might ask how the unified theoretical framework relates to the diversity of approaches and methods to be found in path dependence research (see Vergne and Durand (2010)). Paradoxically, we would argue, such a straitened account of different methodological building blocks in path dependence theory allows for productively and consistently applying a variety of methods. In this context, the two different investigative building blocks developed in section four are particularly helpful, since they separate two distinct types of problems – which mostly require different methods – without contrasting their distinctiveness. In this spirit, we base our suggestion on the general idea that the concrete research method has to be tailored to the problem at hand. To accomplish this task, distinguishing between two investigative building blocks guides a methodological division of labor and integration both within and between research projects.

However, such an approach would require us to abandon the prevalent competitive perspective on methodology that proclaims exclusivity of certain approaches and obstructs the more cooperative position we advocate here. Furthermore, our theoretical framework and its associated building blocks suggest perceiving methodological diversity not only as a complication, but above all as a practical necessity, one that is rooted in the complementarity of different investigative approaches. Consequently, in *Table 3* we give an overview of those approaches we deem both particularly relevant and promising for applying the theoretical framework developed above.

Table 3: Suggestions for Methodological Strategies in Path Dependence Research

Methodological Approach	Predominantly relevant in phase	Research strategy
(1) Narrative case-studies	<ul style="list-style-type: none"> ■ Path creation ■ junctures between different phases ■ Dissolution of path dependence ("path breaking") 	Provide descriptive accounts on the origins of certain paths or of decisive events leading to or breaking up lock-in.
(2) Comparative case-studies	Positive Feedback and Lock-In	Test theoretical propositions and evaluate the role of exogenous factors in real-world environments <i>ex-post</i> .
(3) Experiments	Positive Feedback and Lock-In	Test theoretical propositions in their allegedly „pure“ form by controlling exogenous factors in laboratory environments.
(4) Real-world prognoses	Positive Feedback and Lock-In	Test theoretical propositions and evaluate the role of exogenous factors in real-world environments via <i>ex-ante</i> predictions about future developments.
(5) Simulations	Positive Feedback and Lock-In	Explore the behavior of dynamic systems with varying model-specifications and parameter-settings (which exhibit positive feedback effects) and the weight different parameters acquire within such systems.

As far as case studies are concerned, we differentiate between *narrative* case studies, which are characterized by giving a detailed and illuminating ideographic description of a certain and decisive (series of) event(s), and *comparative* case studies, which are implemented to test the hypothetical claims in refined research strategies (see Gerring (2004); Flyvberg (2006); Ruddin (2006)). This definition implies that those studies, which compare different cases for primarily exploratory reasons, belong to the set of narrative case studies. Although such studies engage in some kind of comparison, the evaluation of theoretical claims is not their primary focus. Our theoretical analysis shows that both versions of case study research can be useful for path dependence as a theoretical concept, but each conception is useful in its own way.

Because of their ideographic orientation, narrative case study designs seem to be predominantly important in the phase of path creation/emergence. Moreover, narrative case studies are useful when the number of events is small and their importance for future development is high, since in such cases a detailed and thoughtful description of actual events is most illuminating. Such events might, but need not, be found at the edge between the different phases, especially to identify the point when positive feedback kicks in and when it effectively leads to lock-in. But narrative case studies or similarly ideographic approaches are also necessary to explain those cases in which the deterministic predictions of phase three did *not* hold, i.e., to decide whether we have a case of unlocking or path-breaking (e.g., Sydow et al. (2009)) or whether there was no path dependence in the first place. Generally speaking, the area of path creation and decisive events that reshape the role of positive feedback effects is where narrative case studies can contribute most to a profound understanding of path dependent processes and developments.

In contrast to narrative case studies, comparative case studies make it possible to integrate several different cases in a single research design, thereby also facilitating the potential refutation (i.e., the testing) of theoretical mechanisms. The general strategy of such approaches is to delineate theoretical predictions for a variety of cases, and in turn, to investigate whether the predicted differences or similarities between different cases do really hold. However, as mentioned above, many studies that are labeled “comparative” do not in fact follow this particular route. Instead, they have a more explorative character and therefore do not, despite the labeling, fall into this category. A main advantage of comparative case study designs in this specific sense is that they allow for mechanism testing in a messy real-world environment in which, in addition to positive feedback effects, intermediating and possibly conflicting forces are at work. Mainly for this reason comparative case study designs seem most promising for elaborating additional auxiliary hypotheses and thereby further clarifying the axiomatic structure of path dependence as a theoretical concept. The fuzziness inherent in comparative case studies provides the best first-hand knowledge on how to concretize the researcher’s *ceteris paribus* clause in the form of specific, but generally relevant, new auxiliary hypotheses (Ragin and Byrne (2008); Fiss (2009, 2011)).

Following Yin’s (1994) classical line of argument, for dealing with auxiliary hypotheses controlled (laboratory) experiments are somehow complementary to comparative case studies. Although comparative case studies have little control over the parameters that influence a certain development in addition to positive feedback, and thus have the potential to explore these additional factors, experiments are primarily useful for controlling such factors or keeping them constant. Due to this complementarity, experiments can be utilized to explore the effects of positive feedback in a much less fuzzy laboratory environment in which we can study positive feedback effects without needing to account for a variety of possible exogenous factors. In effect, experiments make it possible for us to study positive feedback in a pure form. We can abstract from the fuzzy and complicated nature of real-world developments in which positive feedback is just one parameter among a series of possibly relevant factors. In this context, the theoretical mechanisms proposed in the previous sections can be a useful guide for the design of such experiments.

Another methodological approach, one which is also connected to the idea of comparative case studies, but of a more longitudinal nature, is to state and assess real-world prognoses. In a real-world prognosis the researcher tests a given theoretical proposition in a very risky way by predicting real-world developments in a given market, institution, or industry. Some time later (e.g., a few months or years), the researcher re-evaluates this prediction by asking whether the hypothetical prediction of real-world developments has been corroborated or negated. The former case may represent a theoretical success, but in the latter case we must examine the historical developments to search for those factors or parameters that led to the failure of the prediction. In such a case, this research strategy will lead to a framework similar to that of comparative case study designs, which examine real-world processes for factors that disrupt the prevalence of positive feedback effects. Again, this approach might lead to the development of additional auxiliary hypotheses and contribute to a clearer axiomatic structure of path dependence as a theoretical concept. However, we note that there are still two important differences between comparative case study research and real-world-prognoses. While the former analyzes the development of a variety of cases ($N > 1$) ex post, the latter looks mostly at a single case ($N = 1$) and makes an ex ante prediction about some expected developments.

As a final investigative approach, simulations have a significant drawback: they are, strictly speaking, not an empirical method, but a way to examine the behavior of dynamic systems with respect to different parameter values. Hence, the connection between empirical phenomena and simulations is loose and mostly restricted to choosing or estimating plausible model specifications, initial conditions, and constants. Nonetheless, we believe that simulations can contribute to an enhanced understanding of path dependence as a theoretical concept. Simulations can do so by making possible the exploration of the weights of different parameters in dynamic processes, in which one of these parameters are positive feedback effects. In fact, many dynamic models exhibit notions of positive feedback. For instance, an iterative Prisoner's Dilemma game, where Tit-for-Tat is playing against Tit-for-Tat (see Axelrod (1984)), or simple predator-prey models can effectively be described as a sequence of positive and negative feedback loops (see Holling (1973)). Nevertheless, useful simulation results rest primarily on a careful formulation of the relevant axiomatic system, which acts as a blueprint for the setup of the associated dynamic systems. Therefore, it is no surprise that one of the most interesting applications of simulations in the realm of path dependence (Serman and Wittenberg (1999)) is connected to the Kuhnian concept of a scientific paradigm (Kuhn (1996)), in which a respectable set of hypothetical mechanisms and auxiliary hypothesis already exists. Hence, we think that simulations might be useful for gaining an impression of the weights of different parameters in real-world processes, when positive feedback effects constitute one of these parameters. However, in its current state, we think that the axiomatic structure of path dependence as a theoretical concept is too loose to successfully conduct simulation-based research. We believe that providing an avenue to clear-cut axiomatic foundations for such research in the future is one of our main contributions.

Although the investigative viability of simulation-based research is limited at the moment, the somewhat similar approach of using counterfactual models (such as the models in

economics by Vergne and Durand (2010)) is also found in research on path dependence (see the work on „history-friendly“ modelling, e.g., Malerba, Nelson, Orsenigo, and Winter (1999)). Hence, it seems unlikely that such models can be helpful for conducting empirical investigations, since the thought-experimental character of these models drastically reduces their empirical testability (see, e.g., Sugden (2000)). Indeed, many economic models are good examples for empirically irrelevant thought experiments. It is for this reason that we do not include counterfactual models as a suggestion for further improving empirical research.

6 CONCLUSIONS

We contribute to current path dependence research on three levels. First, we outline an axiomatic framework for path dependence as a theoretical concept that provides a workable framework for empirical research. Hence, we answer the question of what to test in empirical research on path dependence.

Second, we suggest a series of methods that may be useful, while also assigning a specific research purpose to these methods. Thus, we answer the question of which methods to choose in empirical research on path dependence with respect to the concrete questions or problems at hand.

Third, we show how to complementarily incorporate these methods in a common research program on path dependence. Thus, we answer the question of how to synthesize the observed methodological diversity by providing a general framework that relates a workable axiomatic structure to a set of promising methodical suggestions.

In our view, distinguishing, but not separating, two methodologically different conceptual building blocks, ideographic and nomothetic, in a theoretical concept of path dependence is compatible with the many topics and examples subsumed under the heading of path dependence. Although the theory is organized around the very general idea that positive feedback effects lead to some stable pattern despite the initially contingent events in the path creation/emergence phase, it basically places no restrictions on the potential contexts in which such a path dependent development might arise. From an epistemological viewpoint, applicability within a variety of settings is not a problem as such, but preferable to alternative situations in which no such setting exists (e.g., for many models in economics). Moreover, our analysis shows that the two conceptual building blocks we propose not only harmonize methodological diversity and a variety of distinct applications, but are also compatible with contemporary three phase-models of path dependence (e.g., Sydow et al. (2009); Vergne and Durand (2010)). Finally, we argue that such a view resolves, at least in part, the tensions normally associated with the nomothetic-ideographic divide in current debates on methodological issues.

We believe that it is important to note that the ergodic nature of positive feedback effects does not compensate for the non-ergodicity of path emergence and creation processes.

On the whole, path dependent phenomena are ex ante non-ergodic processes that require a combination of different methodologies for empirical investigation. Hence, we argue for using a variety of methods that are complementary rather than competitive. These methods should have distinct foci in terms of research strategy, as outlined in the previous section, to advance research on path dependence as a theoretical concept. Indeed, a rigorous understanding of non-ergodicity in path dependence inherently requires the methodological separation we suggest. If all theoretical propositions on path dependence contain the contingent factor associated with the path creation/emergence phase, their testability will be in constant doubt.

In this sense, our approach helps the researcher to avoid the confusion of contingent factors and law-like mechanisms, and allows for a harmonious division of labor between different methodologies. A recent example for the potential of integrating both methodological building blocks is the study by Blinn (2009), see also Schreyögg and Blinn (2008), on dubbing in the film industry. Blinn (2009) historically analyzes the idiosyncratic origins of dubbing in different countries and also tests mechanism-based explanations for its persistence against alternative explanations such as country size. However, such a methodological differentiation does not come without costs. It also demands a higher and more diversified level of methodological literacy among all scholars. If this requirement is not met, then increasing methodological diversity might easily lead to conceptual misunderstandings, mutual ignorance, or even heated controversies between those researchers who differ in terms of their preferences.

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