Exogenous Shocks in Leadership and Management Research: Types and Challenges for Empirical Strategy

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Abstract

Empirical strategies leveraging exogenous shocks have substantial value, but they can be challenging to design and evaluate. One of the main reasons — at least in leadership and management studies — is the variance in how scholars think and use exogenous shocks. This work has a twofold objective. First, it aims to clarify the boundaries and nature of the exogenous shock concept. Second, it aspires to create a taxonomy that helps authors and reviewers reason how core empirical strategy issues change across various types exogenous shocks.

Keywords: exogenous shocks, causality, observational data, natural experiments, empirical strategy.

1 Introduction

Exogenous shocks have started to play an increasingly central role in the agenda of leadership and management researchers. On the one hand, the COVID-19 pandemic has called attention to the consequences of major environmental shifts for organizations (Kniffin et al. 2021) and markets (Zhang, Hu, and Ji 2020). On the other hand, the ecological favor towards causal evidence has further stressed that exogenous shocks are an integral part of 'smart' empirical strategies (Angrist 2022).[1]

Our work elaborates on two analytically distinct but interrelated observations. First, the extant literature conveys different views on exogenous shocks. Second, such a diversity of views appears to jeopardize the evaluation of empirical strategies drawing on exogenous shocks. Hence, we raise the following research questions: *What is an exogenous shock? How can we harness exogenous shocks to achieve valid empirical strategies?*

To address the first research question, we highlight the angle of the 'natural experimentalist' — say Nobel laureate Professor Joshua Angrist — according to which exogenous shocks are vital sources of randomization to carry out causal inference with observational data. Then, we review the literature to uncover how leadership and management scholars think and use exogenous shocks.

We address the second research question by proposing an original taxonomy of exogenous shocks that expands on three elements: (i) the extent of the intervention[2] emerging from an exogenous shock, which ranges between one or few units and the totality of a population's units; (ii) the timescale of the intervention, namely, the amount of time necessary for an exogenous shock to become relevant *vis á vis* the research question at hand; (iii) the granularity of the intervention, which can either split the units into a control and a treatment groups or affect units with different degrees or intensity. We posit that specific combinations of these elements reveal types of exogenous shocks that present particular empirical strategy issues.

Our work provides a twofold contribution. We clarify the concept of exogenous shock by considering its ontological status. Our point is that exogenous shocks are unobservable. In other words, they 'exist' in the nexus of naturally occurring events (e.g., the sudden death of an executive) and 'concrete' theoretical or empirical problems (e.g., do social connections affect an executive team's decision quality?). We also help authors and reviewers appreciate an exogenous shock's key features and reason about how these features might threaten the validity of an empirical strategy aiming at inferring causal effects with observational data. Section 2 succinctly illustrates how exogenous shocks are conceptualized and used in natural experiments and leadership and management literature. Section 3 introduces our novel taxonomy of exogenous shocks. Section 4 describes how one can use our taxonomy to harness exogenous shocks.

1. An empirical strategy is a consistent configuration encompassing three elements: (i) empirical identification; (ii) data; and (iii) statistical estimator. Exogenous shocks influence (i) and (ii) and tend to associate with certain estimators, such as Difference-in-Difference or Abadie's Synthetic Control Method.

2. Throughout the various sections of the document, we will use the terms intervention and treatment interchangeably.

Finally, section 5 wraps up around the major points we raise and suggests further methodological research avenues regarding the role of exogenous shocks in leadership and management research.

2 What Is an Exogenous Shock?

2.1 Exogenous shocks in the literature on natural experiments

The literature on natural experiments offers several elements to appreciate the concept of 'exogenous shock' (for an overview of the natural experiment design, see Craig et al. 2017; Dunning 2012; Keele and Titiunik 2016; Withers and Li 2021; for a review of the application of this design, see Rosenzweig and Wolpin 2000; Sekhon and Titiunik 2012; Sieweke and Santoni 2020). Mainly, the extant studies draw a line between the categories of 'exogenous shock' and 'naturally occurring event.' While one can observe diplomatic crises, institutional reforms, or terrorist attacks, exogenous shocks are situated in abstract models that illustrate how economic and social formations work in the real world (Morgan 2012). In other words, impactful naturally occurring events, such as the COVID-19 pandemic, could be challenging to fit within a model of interest and, therefore, do not lead to any exogenous shock. At the same time, a particular event could provide multiple models with an exogenous shock. For example, the reunification of Eastern Germany and Western Germany has been exploited to address diverse research questions, including the impact of income on health (e.g., Frijters, Haisken-DeNew, and Shields 2004), the transmission of preferences for entrepreneurship from parents to children (e.g., Wyrwich 2015), or the legitimation of inequality (e.g., Haack and Sieweke 2018).

Figure 1 illustrates the idea that exogenous shocks emerge from purposive associations of naturally occurring events and research questions. The quality of these associations can be substantive — when the environmental variation becomes an integral part of a study's theorizing —, empirical — if one exploits the environmental variation to deal with endogeneity concerns — or comprise substantive and empirical elements.

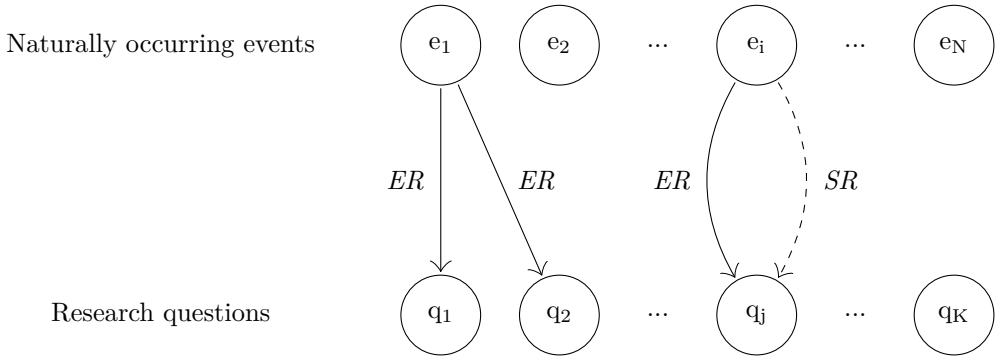

FIG. 1. — Exogenous shocks map naturally occurring events onto research questions via empirical and substantive relevance relationships. Notes. — The labels *ER* and *SR*, reported around the arrows connecting events to research questions, denote the empirical relevance and substantive relevance relationships; a naturally occurring event can be associated with one or multiple research questions or be isolated.

The lack of *substantive relevance* is one of the most common concerns when using nat-

urally occurring events as sources of randomization. For instance, in his critical analysis of Instrumental Variable (IV) applications, [3] Deaton (2009) observes that

> *"[omitted] randomized evaluations of projects are useful for obtaining a convincing estimate of the average effect of a program or project. The price for this success is a focus that is too narrow to tell us 'what works' in development, to design policy, or to advance scientific knowledge about development processes."* (page 3)

Hence, he argues

> *"[omitted] the analysis of programs or project needs to be refocused towards the investigation of potentially generalizable mechanisms that explain why and in what contexts projects can be expected to work. The best of the experimental work in development economics already does so, because its practitioners are too talented to be bound by their own methodological prescriptions. Yet there would be much to be said for doing so more openly. I concur with the general message in Pawson and Tilley (1997), who argue that thirty years of project evaluation in sociology, education and criminology was largely unsuccessful because it focused on whether projects work instead of on why they work."* (page 4)

Coming from an econometric background, Heckaman and Urzua (2010) share Deaton's concerns about the IV design as a lever to approximate the experimental ideal

> *"The problem that plagues the IV approach is that the questions it answers are usually defined as probability limits of estimators and not by well-formulated economic problems. Unspecified 'effects' replace clearly defined economic parameters as the objects of empirical interest."* (page 28)

In his comprehensive work on natural experiments, Dunning (2012) points out

> *"[omitted] the causes that Nature deigns to assign at random may not always be the most important causal variables for social scientists. For some observers, the proliferation of natural experiments therefore implies the narrowing of research agendas to focus on substantively uninteresting or theoretically irrelevant topics."* (page 3)

A positive example of turning a naturally occurring event into a shock with substantive relevance is Miguel, Satyanath, and Sergenti's (2004) study of the effect of economic growth

3. It is commonly accepted that natural experiments comprise the 'Instrumental Variable' design along with the 'Standard Natural Experiment' and 'Regression Discontinuity Design' (Dunning 2012; Sieweke and Santoni 2020).

on civil wars in Africa. Thanks to the ingenious choice to consider rainfall data, the authors broaden the conversation on institutions and economic growth. Notably, the variation in rainfall levels facilitates an IV design that copes with longstanding endogeneity issues regarding the co-evolution of institutions and macroeconomic factors. Hence, the authors can empirically investigate a new and essential theoretical relationship, namely, the effect of economic growth on the likelihood of civil war.

Regarding the *empirical relevance* of a naturally occurring event, the literature on natural experiments shows a strict view: an event qualifies as an exogenous shock if and only if it allows operating an empirical strategy with a control group (Cook, Campbell, and Shadish 2004). In other words, there should be an adequate window[4] in which the intervention T emerging from the exogenous shock exclusively affects a fraction of a population's units only. Such a condition is the *sine qua non* to evaluate the impact of the intervention using Neyman's potential outcome framework (1923 (1990)), an unbiased estimator of the average causal effect $T - C$ that based on three quantities: (1) $\widehat{T}$, the average response if all subjects were assigned to treatment; (2) $\widehat{C}$, the average response if all subjects were assigned to control; and (3) the difference $\hat{T} - \widehat{C}$.

The study of John Snow of London's cholera outbreak of 1853-54[5] emphasizes the importance of using exogenous shocks that heterogeneously affect the units of a population. In 1852, the Lambeth Waterworks company — one of the major utility companies supplying water to several parts of the city — relocated their waterworks from Hungerford Market to fifteen miles upstream in the Thames, thereby *"obtaining a supply of water quite free from the sewage of London"* (Snow, 1855 (1965), page 68). Contrarily, Southwark & Vauxhall, a company competing with Lambeth Waterworks in several districts of London, left its intake pipe downstream in the Thames at Battersea. Snow obtained records on cholera deaths in households throughout London, as well as information on the company that provided water to each household and the total number of houses served by each company. Figure 2 reports one of the most compelling pieces of empirical evidence included in the study: fatal attacks are compared before and after the exogenous shock — namely, Lambeth Waterworks moving their intake pipelines in 1952 — and by water supply (see the column reported on the far-right hand section of the table). Consistently with Neyman's model, the analyses of Snow disentangle the 'true' effect of the exogenous shock on cholera communication from time-invariant attributes regarding the households served by different water suppliers and, perhaps more importantly, from the time-variant factors such as the state of the cholera outbreak at other points in time. Should the naturally occurring event have affected the totality of households in London, unlikely Snow's work would have addressed the problem of confounders convincingly.

A related but distinct aspect of *empirical relevance* concerns the 'exogenous' nature of the naturally occurring variation. The literature on natural experiments emphasizes that relevant

4. We discuss the temporal aspects of exogenous shocks' effects in Section 3 and Section 4.

5. The project of Snow — aiming to prove that cholera did not transmit through the air, the so-called 'miasma hypothesis'— developed along two arms: he used geospatial visualizations to show that attacks clustered around Broad Street water pump in London's Soho district; then, he conducted the standard natural experiment briefly summarized in the main text.

TABLE XII.

Sub-Districts.	Deaths from Cholera in 1849.	Deaths from Cholera in 1854.	Water Supply.
St. Saviour, Southwark .	283	371	
St. Olave . . .	157	161	
St. John, Horsleydown .	192	148	
St. James, Bermondsey .	249	362	
St. Mary Magdalen .	259	244	
Leather Market . .	226	237	
Rotherhithe* . .	352	282	Southwark & Vauxhall Company only.
Wandsworth . . .	97	59	
Battersea . . .	111	171	
Putney	8	9	
Camberwell . . .	235	240	
Peckham . . .	92	174	
Christchurch, Southwark	256	113	
Kent Road . . .	267	174	
Borough Road . .	312	270	
London Road . .	257	93	
Trinity, Newington .	318	210	
St. Peter, Walworth .	446	388	Lambeth Company, and Southwark and Vauxhall Compy.
St. Mary, Newington .	143	92	
Waterloo Road (1st) .	193	58	
Waterloo Road (2nd) .	243	117	
Lambeth Church (1st) .	215	49	
Lambeth Church (2nd) .	544	193	
Kennington (1st) . .	187	303	
Kennington (2nd) .	153	142	
Brixton . . .	81	48	
Clapham . . .	114	165	
St. George, Camberwell	176	132	
Norwood . . .	2	10	
Streatham . . .	154	15	Lambeth Company only.
Dulwich . . .	1	—	
Sydenham . . .	5	12	
First 12 sub-districts .	2261	2458	Southwk. & Vauxhall.
Next 16 sub-districts .	3905	2547	Both Companies.
Last 4 sub-districts .	162	37	Lambeth Company.

FIG. 2. — An extract of the statistical analyses reported in the study of John Snow 'On the mode of communication of cholera' (1855 (1965)). Notes. — The table, reported on page 90, considers both pretest and posttest data points (Lambeth Waterworks moved their intake pipes in 1952) for treated and control households.

events are not necessarily sudden, such as the death of a business leader because of heart attack (e.g., Nguyen and Nielsen 2010),[6] uncontrollable, such as earthquakes (e.g., Belloc, Drago, and Galbiati 2016), or random, such as lotteries (e.g., Poulos 2019). The extant studies show that legal changes and policy interventions can be purposefully used as exogenous shocks to address particular research questions (e.g., Beaman et al. 2012; Chauchard 2014; Matsa and Miller 2013). Dunning (2012, page 236) advances a three-step procedure to assess whether a naturally occurring event can be plausibly considered exogenous or 'as-if random.' First, researchers should investigate whether units had information that they would or would not receive the treatment. Second, researchers need to check whether units had incentives to self-select into the treatment or control group. Finally, researchers should analyze whether units had incentives and the capacity to self-select into a treatment status. For the assessment, Dunning (2012) suggests using both qualitative evidence (e.g., documents, interviews) and quantitative evidence (e.g., balance tests).

For example, Snow (1855 (1965)) presented various sorts of evidence to establish the pre-treatment equivalence of the houses that were exposed to pure and contaminated sources of water supply

> *"The mixing of the (water) supply is of the most intimate kind. The pipes of each Company go down all the streets, and into nearly all the courts and alleys. A few houses are supplied by one Company and a few by the other, according to the decision of the owner or occupier at that time when the Water Companies were in active competition. In many cases a single house has a supply different from that on either side. Each company supplies both rich and poor, both large houses and small; there is no difference either in the condition or occupation of the persons receiving the water of the different Companies... It is obvious that no experiment could have been devised which would more thoroughly test the effect of water supply on the progress of cholera than this."* (pages 74 - 75)

At the same time, qualitative information on the context and the process of determining the water-supply source was also essential for Snow. For instance, he emphasized that absentee landlords decided which competing water companies would have served a particular address. Thus, many residents had limited opportunities to 'self-select' into a source of water supply — that is, confounding characteristics of residents appeared unlikely to explain the significant differences in death rates across the two suppliers (see Figure 2). Moreover, the Lambeth company committed to moving their intake pipe upstream on the Thames before the cholera outbreak of 1853-54, when existing scientific knowledge did not link water sources to cholera

6. The identification of sudden deaths poses definition issues (e.g., Azoulay, Graff Zivin, and Wang 2010; Oettl 2012). In the interest of consistency, Nguyen and Nielsen (2010) report they *"rely on the medical literature, which defines sudden death as an unexpected and non-traumatic death that occurs instantaneously or within a few hours of an abrupt change in the person's previous clinical state."* The causes of sudden deaths they consider are 'heart attack,' 'stroke,' and 'accident or murder.' In addition to such deaths, they also consider *"accidental and traumatic deaths that are unanticipated by the stock market and unrelated to firm conditions"* (page 553).

risk. Such a supply choice implied that more than 300,000 people of all ages and social strata were

> *"divided into two groups without their choice, and, in most cases, without their knowledge; one group being supplied with water containing the sewage of London, and, amongst it, whatever might have come from the cholera patients, the other group having water quite free from such impurity."* (Snow, 1855 (1965), pages 74-75)

Drawing on the methodological insights included in Snow's study, Figure 3 illustrates that both events that are unknown/unknowable to units and events that are known to units can provide scholars with an exogenous variation suited to address the research question at hand. However, 'known events' may raise endogeneity concerns regarding the possibility of a unit affecting the direction and magnitude of a naturally occurring variation and self-select into the treatment or control group.

2.2 Exogenous shocks in leadership and management research

To understand how leadership and management scholars conceptualize and use exogenous shocks, we reviewed the literature. Specifically, we focused on the studies that assign the 'exogenous shock' concept to a core narrative role by placing it in the paper's title or abstract.[7] Consistently with recently published reviews (e.g., Gonzalez-Mulé and Aguinis 2018; Rindova et al. 2018), we restricted our search to a selection of prominent journals such as Academy of Management Journal, Administrative Science Quarterly, Entrepreneurship Theory and Practice, Journal of Applied Psychology, Journal of Business Ethics, Journal of Business Venturing, Journal of Management, Journal of Management Studies, The Leadership Quarterly, Management Science, Organizational Behavior and Human Decision Processes, Organization Science, Organization Studies, Personnel Psychology, Research Policy, Strategic Entrepreneurship Journal, Strategic Management Journal, Strategic Organization. Using Scopus, we retrieved 58 articles published up until or available online on December 22, 2022, presenting the bi-gram 'exogenous shock*,' in the title, abstract, *or* set of author's generated keywords.

Considering the full manuscript of each retrieved article, we discarded 18 articles that did not fall within the reviews' remit. We excluded from the sample two studies in which the search token appears once and does not focus on or use the conceptual category of 'exogenous shock' (Kriauciunas and Kale 2006; Uzzi 1997); one work focusing on managers' cognitive representation of a shock (Barreto and Patient 2013); four non-empirical papers (e.g., McSweeney 2009); two qualitative studies (Glynn and Lounsbury 2005; Jenkins 2010); one field experiment (Cui, Zhang, and Bassamboo 2019); eleven Management Science articles dealing with finance, marketing, or operations subjects (e.g., Tham, Sojli, and Skjeltorp 2018). Figure 4 illustrates the distribution of sample studies across journals.

7. Our purpose is not to provide a systematic review of the literature on the role of exogenous shocks for empirical identification (see Sieweke and Santoni 2020). Instead, we aim to uncover the views and uses of the exogenous shock concept. Retrieving the studies in which the bigram 'exogenous shock' appears once or a few times in the full text of the paper would have little value for us.

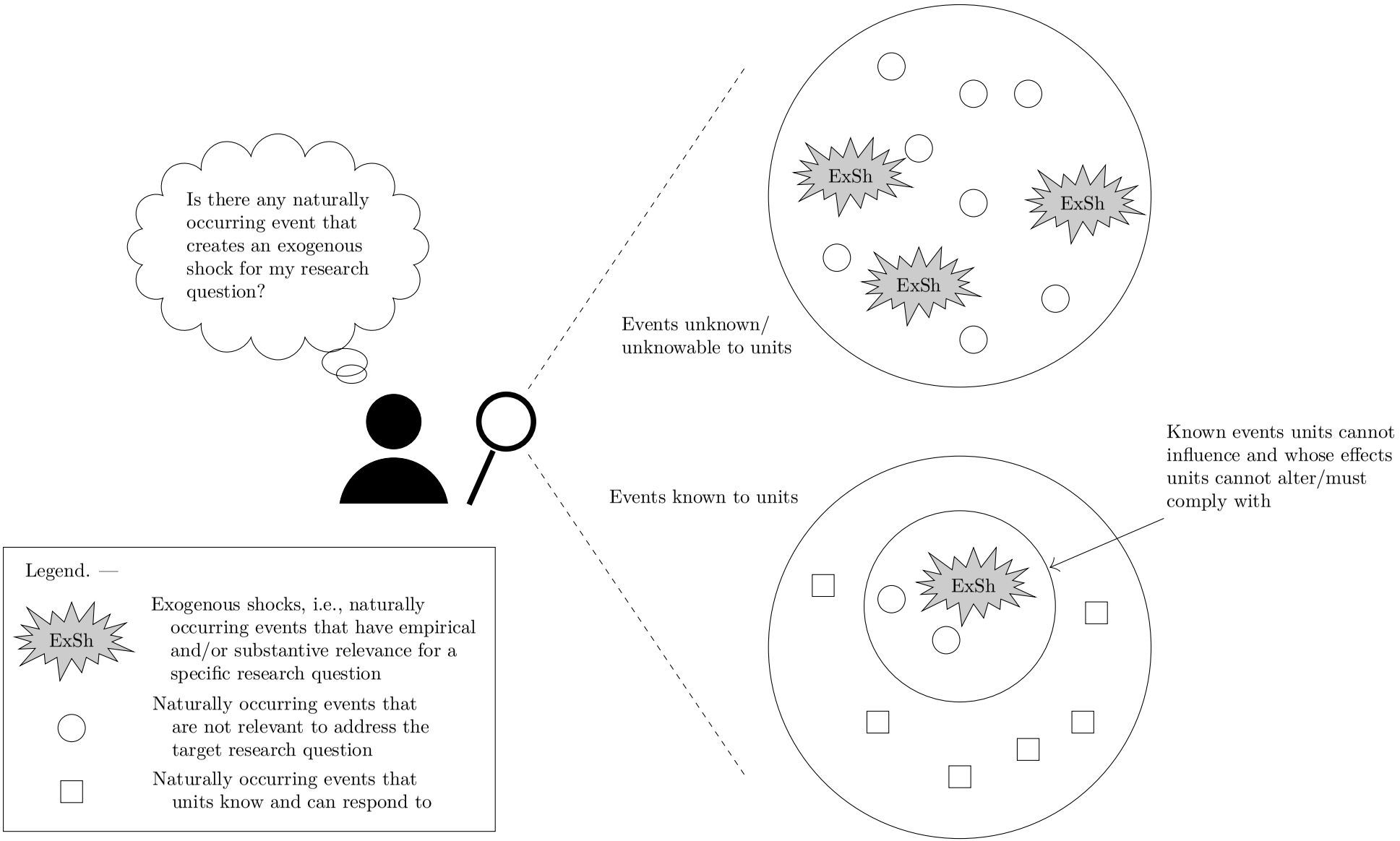

FIG. 3. — The interpretation of a naturally occurring event as an exogenous shock is contingent on the research question one wants to address and the intrinsic attributes of the event.

FIG. 4. — Distribution of exogenous shock studies across journals. Notes. — N = 37; in the interest of consistency, we excluded 'exogenous shock' studies published in Management Science addressing finance, marketing, or operations subjects.

The two authors independently coded the retained studies against the dimensions included in Figure 1,that is, (1) the exploited naturally occurring event (e.g., 9/11, Sarbane-Oxley Act); (2) the leading research question (e.g., 'how do changes in an employee's relational capital influence mobility and entrepreneurship decisions?'); and (3) the relationship between (1) and (2), which can be substantive — when the exogenous shock is an integral part of the research question/plays a key role for theorizing — or empirical — when a study's authors claim to leverage a naturally occurring event to cope with the problem of confounders — or both. Having completed the independent analysis of sample studies, the two authors of this work merged their coding choices and reconciled their different views regarding the role of exogenous shocks in four papers.[8] Table I reports the outcome of our coding, including a summary of how the naturally occurring event qualifies as an exogenous shock (see the column 'Summary,' reported on the right-hand side of the table).

Regarding the first dimension of our coding, the most popular categories of events are 'legal change' (N = 12) and 'turnover' (N = 7) (see Figure 5). Concerning 'legal change,' scholars have relied on events such as the staggered passage of anti-takeover laws (Cabral, Francis, and Kumar 2021; Wang, Zhao, and He 2016), change in immigration rules (Choudhury and Kim 2019), the Garn-St. Germain Act (Haveman, Russo, and Meyer 2001), the Sarbane-Oxley Act (Gupta et al. 2020), SEC's regulation change (Jia, Gao, and Julian 2020), the change of inheritance, gift, and estate taxes (Kang and Kim 2020), the staggered adoption of the Inevitable Disclosure Doctrine in U.S. (Kang and Kim 2020), a revision of U.S. Higher Education Amendments (Krishnan and Wang 2019), reductions in import tariffs (Li and Zhan 2019), demonetization measures (Natarajan, Mahmood, and Mitchell 2019). Turnover events comprise sick leave episodes of key employees (Chen and Garg 2018; Chown and Liu 2015; Drexler and Schoar 2014), political leadership churn (Byun, Raffiee, and Ganco 2019; Gedefaw Birhanu and Wezel 2020), and executives' sudden death (He 2022; Ke et al. 2019) and retirement (He 2022). Other recurrent events include terrorist attacks (Bastardoz, Jacquart, and Antonakis, in

8. The coding spreadsheet is publicly available at: https://www.dropbox.com/.../coded_studies.xlsx?dl=0.

press; Corbo, Corrado, and Ferriani 2016; Li and Zhan 2019; Vergne 2012), scandals (Cai and Shi 2019; Hilary and Huang 2021), change in financial analysts' coverage (Chatterji and Toffel 2010; Qian, Lu, and Yu 2019), and pandemics (Garretsen et al., in press. Jo, Harrison, and Gray 2021).

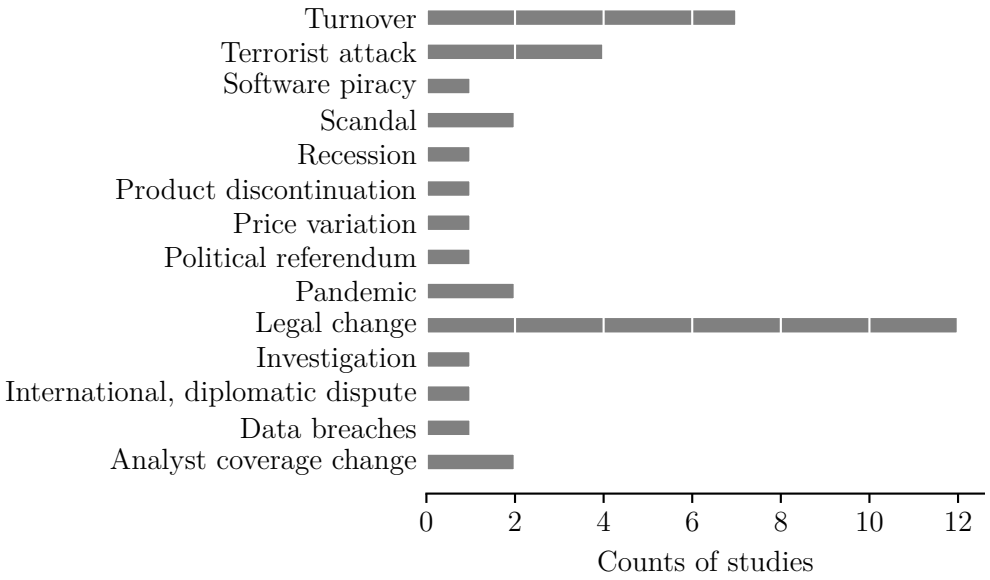

FIG. 5. — Classes of naturally occurring events presumed to create an exogenous shock. Notes. — N = 37.

As shown in the Venn diagram in Figure 6, circa three cases out of four (N = 27) claim to use exogenous shocks with an empirical role. For instance, Krishnan and Wang (2019) use Survey of Consumer Finances data to address the research question 'does student debt influence the propensity to start a firm?' The concept of exogenous shock is not essential for the scope of their work and does not inform the proposed theorizing. Still, one may study the relationship between student debt and business creation using a correlational approach. However, the authors are concerned about the causal interpretation of their empirical estimates

> *"there may be unobserved characteristics that may drive our results. For instance, individuals with wealthier families may have lower student debt as well as the financial means to start a firm. Such unobservable family effects may explain the negative relation between student debt and entrepreneurship. Alternatively, individuals from wealthier families may borrow more if they expect to be able to pay back the loans easily (and such individuals are more likely to be entrepreneurs)."* (page 4528)

Hence, they use a legal change as an exogenous shock to the cost of business failures for individuals with greater levels of student loans

> *"To address endogeneity concerns, we utilize the Higher Education Amendments (HEA) of 1998, which effectively rendered student loans completely non-dischargeable.*

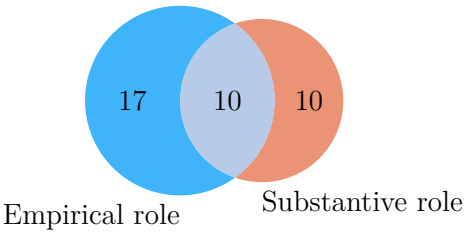

FIG. 6. — Role of the naturally occurring events presumed to create an exogenous shock.

> *We find that students that were already in four-year college at the time of this regulation and had significant student debt were less likely to start a firm. This test considers only individuals who were enrolled prior to the year of regulation (i.e., prior to 1998) in a four-year college. The idea is that, for the group of individuals who are already enrolled in college, the regulatory change is clearly exogenous, in the sense that it does not drive their choice to enter college. "* (page 4532)

About half of the studies (N = 20) assign a substantive role to exogenous shocks. For example, Haveman, Russo, and Meyer (2001) articulate a framework that links organizations' responses to discontinuous industry-level regulatory change. The theoretical section of the study maps the phenomenon of regulatory change onto the General Punctuated Equilibrium Model and provides expectations about the multiple consequences of regulatory change for individual organizations. The substantive role of the shock is self-evident in the formulation of the hypotheses, e.g.

> *"Immediately following any regulatory punctuation, CEO succession rates will not rise; instead, CEO succession rates will rise gradually as time passes."* (page 259)

It is worth notice the authors emphasize the 'exogenous' nature of the Garn-St. Germain Act — the example of regulatory change at the center of the paper —, but they do not discuss what it means for the study's empirical strategy, especially in terms of empirical identification.

We also found that one study out of four (N = 10) claims to use an exogenous with empirical and substantive relevance. Byun, Raffaele, and Ganco (2019) propose a hypothesis set that connects 'discontinuous increases in the value of an employee's relational capital' with 'employee turnover' and 'spinout' formation. For example, their first hypothesis states

> *"Discontinuous increases in the value of an employee's relational capital will be positively related to employee exit."* (page 1371)

The authors can advance and test this and the other hypotheses thanks to naturally occurring events regarding the politicians connected to lobbyists (i.e., 'employees'). Here is the passage from the paper describing the independent variable of the study, 'discontinuous increases in the value of an employee's relational capital'

"We use appointments to committee chair and assignments to the four most powerful committees in Congress to capture connected politicians' power changes in the legislative process. Discontinuous increase is a binary variable coded '1' for the first year a politician connected to a lobbyist is selected to be a chair of a congressional committee or is assigned to one of the powerful committees in Congress and '0' otherwise." (page 1375)

The series of political appointment decisions also play an empirical role, the Byun and colleagues point out

"Our identifying assumption is consistent with prior work and rests on the notion that the temporal change in power of connected politicians is exogenous, conditional on the observable characteristics of the lobbyists and their firms [omitted]. For the power change of a connected politician to be plausibly exogenous, whether and when the connected politician will experience the advancement has to be difficult to predict by lobbyists and firms. In addition, the change in lobbyist's value creation due to a surge in the value of political connections should be uncorrelated with the accumulation of the lobbyist's expertise, conditional on observables. Given the complicated and uncertain political process of chair selection and committee assignment, scholars have argued that committee and chair assignment satisfies these conditions with respect to lobbyists [omitted]. In fact, others have gone as far as to argue that the timing and ascension of committee and chair appointments are exogenous even to the politician herself [omitted]. Thus, it is reasonable to believe that using the power change of a connected politician to capture discontinuous increases in the lobbyist's relational capital would alleviate identification concerns due to potential omitted variable biases." (page 1375)

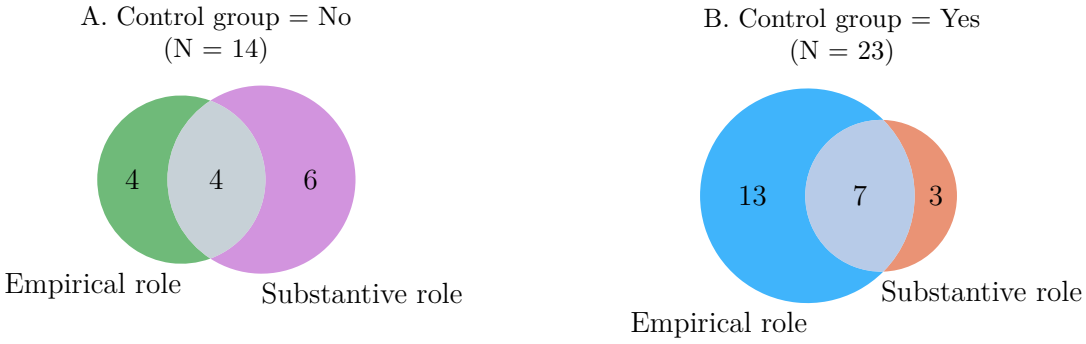

FIG. 7. — Distribution of studies across exogenous shocks' roles and empirical strategies (presence Vs. absence of a control group). Notes. — A design lacking a control group has a pretest and posttest observations for one group only; a design with a control group has pretest and posttest both for units that are affected by the exogenous shock and those that are not.

Figure 7 illustrates the distribution of sample studies across empirical strategies and exogenous shocks' roles. One article out of three (N = 14) operates an empirical strategy without a control group (see panel A.). Within this group, we found six articles that do not

use the shock for empirical identification purposes. For example, Corbo, Ferriani, and Corrado (2016) use 9/11 as a *"major environmental shock"* (page 323), affecting the logic that shapes the formation of alliances in the airline industry. The impact of 9/11 on aviation companies is so immediate and pervasive to impede the identification of units that can form a control group even for a limited period. Although such a naturally occurring variation does not help the authors in terms of empirical identification, it is relevant from a substantive standpoint. According to Corbo and his colleagues, 9/11 allows exploring novel theoretical intuitions regarding the change in interorganizational networks

> *"Our intuition is that patterns of interorganizational network ties provide a lens through which to view critical junctures that question extant logics and open prospects for change, enabling us to shed light on organizational responses to external events. To explore these ideas empirically and inform our understanding of the interorganizational dynamics characterizing fields that undergo cataclysmic upheavals, we focus on the global airline industry in the aftermath of the September 11, 2001 terrorist attacks (henceforth 9/11), which caused one of the most severe crises ever experienced by civil aviation worldwide. Given the exploratory, theory-building nature of the study we employ a hybrid empirical strategy that combines qualitative data analysis with quantitative social network analysis, enabling us to capture a more complete, holistic and contextual portrayal of the units under study [omitted]."* (page 325)

The remaining eight articles lacking a control group emphasize the empirical relevance of their naturally occurring events. Seebeck and Vetter (2022) investigate the relationship between gender board diversity and corporate risk disclosure. Their study uses the Brexit Referendum to create an intention-to-treat model (Angrist, Imbens, and Rubin 1996) where the future exit of the United Kingdom from the European Union is an exogenous shock on a firm's risk environment by which

> *"[omitted] all firms face similar and tremendous risks related to the Brexit that need to be considered by public firms when preparing their annual reports according to the Financial Reporting Council (FRC 2016a, b) as well as section 414c(2)(b) of the companies act and section 4 of the UK corporate governance code."* (page 396)

The authors claim to advance the literature on gender diversity and corporate governance by dealing with the endogeneity of a firm's risk reporting needs. Specifically, they assert their empirical strategy

> *"[omitted] is less likely to face the risk of omitted variables, allowing to provide more reliable evidence of an association between board gender diversity and corporate risk disclosure."* (page 396)

However, Seebeck and Vetter's article does not rely on Neyman Potential Outcome Framework because the study sample only includes UK (FTSE 350) companies, which are all affected by the exogenous shock associated with the Brexit referendum.

Similar to Seebeck and Vetter's work, the study of Bastardotz, Jacquart, and Antonakis (in press) uses a naturally occurring event with immediate and pervasive consequences on organizational and social formations. Specifically, the study considers 9/11 and the 2015 and 2016 terrorist attacks in France as exogenous shocks to assess the causal effect of crises on political leaders' charismatic rhetoric. To cope with the lack of a ground-truth control group — i.e., cross-sectional variance in the treatment across units — Bastardoz and colleagues use the Regression Discontinuity in Time (RDiT) estimator (Hausman and Rapson 2018), which they present as a model that

> *"[omitted] closely resembles event-studies or interrupted time series analyses in that they examine the effect of exogenous events on individual or organizational decisions. For instance, a researcher may be interested in studying how impromptu events such as the eruption of a Volcano or a ship being stuck in the Suez Canal affect global supply chains. Using time as a selection mechanism, researchers could estimate the effect of such events by considering the outcome of interest just before and just after the event, assuming the event is exogenous (i.e., unexpected)."* (page 2)

To attenuate the concern that the units (that is, political leaders' speeches) differ across the sides of the cutoff for reasons other than the exogenous shock, the authors perform a sensitivity analysis by re-estimating their RDiT mode.

> *"[omitted] using only half of the time window on each side of the cutoff, concentrating only on observations closest to the discontinuity. This reduced sample includes only 20 speeches pre-crisis (29 passages) and 18 speeches post-crisis (33 passages), ranging from 117 days before to 90 days after the 9/11 events. This reduced sample provided similar estimates of the treatment effect compared to the full sample [omitted]"* (page 10)

TABLE I
SUMMARY OF STUDY EVENTS, RESEARCH QUESTIONS, AND EXOGENOUS SHOCKS

Study	Event	Research question	Relevance of the event		Summary
			Empirical	Substantive	
Bastardotz et al. (in press)	9/11 and 2015 and 2016 terrorist attacks in France (i.e., Charlie Hebdo, Paris, and Nice attacks).	Does a (political) leader's charismatic rhetoric increase in the aftermath of a crisis?	✓	✓	Terrorist attacks are major exogenous crises that public leaders must cope with.
Birhanu & Wezel (2020) . . .	Government changes following Arab spring social movement.	How does group affiliation influence firm performance under weak market institutions?	✓	×	The use of sudden government change is presumed to affect executives' capacity to influence political leaders.
Byun et al. (2019)	Change in a politician's committee and/or committee chair assignments.	How do changes in an employee's relational capital influence mobility and entrepreneurship decisions?	✓	✓	Lobbyists may experience a discontinuous shift in the value associated with a connection, if there are changes to a politician's committee and/or committee chair assignments. Then, the authors can investigate empirically the consequences of social capital change on lobbyists' career.
Cabral et al. (2021)	Staggered passage of anti-takeover laws in U.S.	Does managerial job security affect the adoption of innovative practices and structures?	✓	✓	Adopting an anti-takeover statute is a proxy of managerial job security, which changes across states and within individual states over time, and it is supposed to affect the propensity to create a CVC program.

TABLE I (CONT'D)

Study	Event	Research question	Relevance of the event: Empirical	Relevance of the event: Substantive	Summary
Cai & Shi (2019)	The revelation of the sexual abuse of children by Catholic priests in U.S.	Does a firm's religious environment influence outside parties' perceptions in contracting with the firm?	✓	×	The revelation of the sexual abuse of children by Catholic priests is an exogenous shock to the religiosity of a region, which can influence the capital structure, credit rating, cost of debt, and covenants of local firms.
Chatterji & Fabrizio (2016)	Department of Justice investigation against the five largest U.S. orthopedic device makers.	How does an open innovation system affect the rate and direction of innovation?	✓	×	Department of Justice investigation increases the friction in the market for ideas by regulating the interactions between physicians and the medical device firms under investigation.
Chatterji & Toffel (2010)	Change in the scope of KLD Database, a prominent source of CSR ratings.	How do managers react to poor corporate environmental ratings?	✓	✓	The change in KLD's scope creates a subset of companies responding for the first time to a CSR rating, which allows the authors deal with mutual causality issues regarding a firm's CSR rating and CSR strategy.
Chen & Garg (2018)	Injuries occurred to star NBA players.	Does a star's temporary absence help the organization overcome myopia?	✓	✓	The absence of star players is presumed to impact the pattern of organizational routines at the team level.

TABLE I (CONT'D)

Study	Event	Research question	Relevance of the event: Empirical	Relevance of the event: Substantive	Summary
Chen et al. (2022)	Data breach events concerning publicly listed companies	Do managers increase the amount of cybersecurity risk factor disclosures after experiencing data breaches?	×	✓	Data breaches are exogenous shocks to managers' assessment of their firm's cybersecurity risks occur.
Choudhury & Kim (2019)	Change in U.S. H1B employment visas.	How do migrant inventors influence knowledge production and reuse?	✓	×	The H1B quota change exempted universities and a selected list of other entities, creating heterogeneous effects in terms of the supply of first-generation ethnic migrant inventors and the rate of codification of knowledge previously locked within migrant inventors' home countries.
Chown & Liu (2015).....	Turnover within U.S. Senate and 'iconoclastic' senators deviating from the institutionalized seating arrangement.	How does one's location in an organizational forum affect the likelihood of receiving peer support?	✓	×	Turnover within U.S. Senate and 'iconoclastic' senior senators create opportunities for freshman senators not to sit at the chamber's margins. These elements affect the dyadic distance between senators, a factor that is presumed to affect the likelihood of joint support.
Corbo et al. (2016).....	9/11.	Does a major environmental shock affect the social structure of an organizational field?	×	✓	9/11 is supposed to affect the organization and functioning of civil aviation, which allows the authors to assess the extent to which network mechanisms shape the alliances connecting airline companies under different contingencies.

TABLE I (CONT'D)

Study	Event	Research question	Relevance of the event: Empirical	Relevance of the event: Substantive	Summary
Drexler & Schoar (2014) . . .	Sick leave episodes among loan officers.	How (much) does employee turnover affect organizational performance?	✓	✓	Loan officers' sick leaves alter economic and social exchange between the firm and its clients.
Garretsen et al. (in press.) .	COVID-19 pandemic.	Does directive leadership behavior change in the aftermath of a major environmental crisis?	✓	✓	The variation in COVID-19 deaths across countries allows testing the threat-rigidity hypothesis by exposing leaders to threats of different magnitudes.
Gupta et al. (2020)	Sarbanes-Oxley Act (SOX) & Global Financial Crisis.	Does CFO gender influence the likelihood of financial misreporting?	✓	×	The authors expect: i) SOX to lead to a larger decrease in financial misreporting for male CFO firms than female-CFO firms; ii) firms to face greater pressure to report favorable earnings during crisis periods, which is more likely to influence male compared to female CFOs (based on the logic that female CFOs will be less likely to engage in fraud regardless of stakeholder pressure).
Haveman et al. (2019)	California Legislature enactment of the nation's first comprehensive managed competition program, and Garn-St. Germain Act	How do organizations respond to discontinuous industry-level change?	×	✓	The authors use a series of regulatory changes to investigate how organizations respond to punctuated changes in the environment and with what performance consequences.

TABLE I (CONT'D)

Study	Event	Research question	Relevance of the event: Empirical	Relevance of the event: Substantive	Summary
He (2022)	Exogenous turnover (i.e., deaths and retirements) of business leaders.	Are central business leaders more likely to engage in financial misreporting?	✓	×	Exogenous turnover at the upper echelon level can attenuate the 'firm-manager' matching may drive the effect of an executive's network centrality on the occurrence of financial misreporting.
Hilary & Huang (2021)	The revelation of the sexual abuse of children by Catholic priests in U.S.	Does generalized trust affect the power of CEO contracts?	✓	×	The revelation of the sexual abuse of children by Catholic priests reduces generalized trust for certain counties only, which helps to reveal the causal effect of generalized trust on the characteristics of executives' contracts.
Jia et al. (2020)	2005 Regulation SHO by which SEC removes the uptick restriction for a set of randomly selected pilot firms.	Do managers use CSR to insure against stock price risk?	✓	×	SEC program changes stock risk price for pilot firms only, which helps to assess whether firms invest in CSR in response to greater stock price risk, and whether such investments provide intended insurance-like benefits.
Jo et al. (2021)	COVID-19 pandemic	How do individuals recalibrate their social ties to cope with the uncertainty and anxiety introduced by the pandemic shock?	×	✓	COVID-19 is an exogenous stressor affecting interpersonal ties maintenance in the workplace, that is, optimal matching theory's focus.

TABLE I (CONT'D)

Study	Event	Research question	Relevance of the event: Empirical	Relevance of the event: Substantive	Summary
Kang & Kim (2020)	Staggered changes in inheritance, gift, and estate taxes in U.S. & sudden deaths of business owners.	Do family firms invest more in employee relations than non-family firms?	✓	×	Taxation changes provide family owners with incentives to continue their businesses, which helps to reveal the relationship between governance forms and investment in employee relations. The sudden death of family members alters a firm's status, which attenuates the concerns time-invariant characteristics jointly affect performance and the ability to implement employee-friendly policies.
Ke et al. (2019)	Sudden deaths and retirements of executives.	How do social connections among executive team members affect management forecast accuracy?	✓	×	Sudden turnover events alter the social connections within a team of executives, and, in turn, help to reveal the causal effect of social capital on decision-making quality.
Koh et al. (2018)	Staggered adoption of the Inevitable Disclosure Doctrine (IDD). in U.S.	Are confident CEOs more likely to report R&D expenditures than cautious CEOs?	✓	×	The staggered U.S. state courts' verdict on the IDD helps to reveal the relationship between CEO confidence and R&D disclosure by attenuating market competition.

TABLE I (CONT'D)

Study	Event	Research question	Relevance of the event: Empirical	Relevance of the event: Substantive	Summary
Krishnan & Wang (2019)	1992 and 1998 Higher Education Amendments (HEA)	How does student debt influence the propensity to start a firm?	✓	×	1998 HEA alters the cost of discharging student debt through bankruptcy — which increases the cost of entrepreneurship, that is, new venture failure — while it is unlikely to affect financing availability to start a venture. Hence, the authors can assess the causal relationship between student debt and the propensity to create a new venture. 1992 HEA affects the volume of student loans through the federal government. Students who spend more time in college during the post-1992 HEA regime will have more student loans. Hence, they will have a lower likelihood of starting a new venture.
Li & Tallman (2011)	9/11.	Does a sudden change in the environment influence the economic returns of international diversification?	×	✓	9/11 is a "reorienting disruptive change" that alters international business logic, particularly, the economic and finial returns of international diversification.
Li et al. (in press)	Terminal High Altitude Area Defense (THAAD) dispute between China and South Korea	Does country-of-origin agglomeration helo MNEs navigate an adverse institutional environment?	×	✓	THAAD increases the regulatory burden for South-Korean MNEs in the host country, namely, China.
Li & Zhan (2019)	Reductions in import tariffs initiated by U.S. authorities.	How do product market threats affect stock crash risk?	✓	×	Reduction in import tariffs increases competitive pressure, which aggravates executives' incentive to withhold negative information and increases and makes firms more prone to stock crashes.

TABLE I (CONT'D)

Study	Event	Research question	Relevance of the event		Summary
			Empirical	Substantive	
Mahmood et al. (2017)	Global Financial Crisis.	How does the centralization of intragroup equity ties affect the performance of group affiliates?	✓	✓	Global Financial Crisis creates environmental turbulence exogenously for Taiwanese firms, and, in turn, helps to appreciate the contingent role of equity tie centralization.
Natarjan et al. (2019) . .	Indian Government's demonetization measure.	How do middle managers influence resource allocation choices?	✓	×	The decision to withdraw almost 85% of banknotes in circulation (all 500-rupee and 1,000-rupee bills, the most common units of circulating currency) increased bank headquarters' control over ATM deployment, which resulted in tighter monitoring of middle managers' allocation decisions.
Qian et al. (2019)	Brokerage house mergers and closures in U.S.	How do financial analysts influence managers' choices to invest in CSR?	✓	✓	The closure or merger regarding a brokerage house reduces financial analyst coverage for some firms only, which allows the authors to assess the causal relationship between the (change in the) extent of analyst coverage and CSR.
Ramirez & (2018)	Price variation in the global copper industry.	How does the value appropriated by employees vary in response to an exogenous shock to the price of the firm's product?	✓	✓	Copper mines' size is homogeneous. Hence, price fluctuations in the global copper industry are exogenous variations for individual mines and can reveal the mechanisms behind value distribution within organizations.

TABLE I (CONT'D)

Study	Event	Research question	Relevance of the event: Empirical	Relevance of the event: Substantive	Summary
Seebeck & Vetter (2022)	Brexit Referendum.	Does board gender diversity affect corporate risk disclosure?	✓	✓	The outcome of the Brexit Referendum increases the risk for all UK-based companies, which attenuates reverse causality concerns regarding board gender diversity on corporate and risk disclosure.
Tan & Netessine (2014) .	Adoption of a new staffing system.	How does workload impact worker productivity?	✓	×	The staggered adoption of a new computer-based scheduling system prescribes different staffing levels from those that managers might suggest because it uses more historical sales data than a manager can handle. Hence, authors can make cross-restaurant comparisons involving similar servers experiencing different workload levels.
Vergne (2012).....	9/11.	Does straddling multiple product-market categories dilute stakeholder attention to the stigma of operating in the global army industry?	×	✓	Since attackers used commercial airlines hijacked by terrorists armed with kitchen knives, the definition of the weapons category was questioned in the post-9/11 period." Hence, 9/11 allows the author to test whether the salience of the category 'weapons' weakens 'the negative relationship between stigma dilution (i.e., the situation in which a diversified business also operates in a stigmatized sector, such as 'arms') and media disapproval.

TABLE I (CONT'D)

Study	Event	Research question	Relevance of the event: Empirical	Relevance of the event: Substantive	Summary
Wang et al. (2016).....	Delaware's 1996 ruling against hostile takeovers.	Do takeover threats affect a firm's knowledge structure?	✓	×	A series of law cases make takeover less favorable for target firms incorporated in Delaware, allowing the authors to assess the impact of (an increase in) takeover protection on firm-level knowledge production.
Zhang et al. (2020).....	iOS 7 jailbreak.	Does a lapse in gatekeeping reduce knowledge sharing among developers?	✓	✓	The event is an exogenous shock to Apple's gatekeeping policy, aiming to orchestrate developers' value-creation activities in the AppStore. That allows scholars to appreciate the impact of platform governance on knowledge sharing among developers.
Zheng & Wang (2020)..	2014 Google blockade in China.	How does Google's search engine influence the search process of inventors?	×	✓	The blockade of Google affects inventors' information processing and, in turn, innovation output.

3 How Do Exogenous Shocks Differ?

This section of the study introduces a taxonomy of exogenous shocks that help scholars evaluate a concrete shock's essential features and link them with salient empirical strategy challenges. In so doing, we take the relevance of a naturally occurring event 'for granted.' In other words, we assume the researcher has already proven the added value of the environmental variation in addressing a target research question.

As shown in Figure 8, the taxonomy builds on three dimensions of exogenous shocks: (1) the *extent of the intervention*, i.e., the fraction of a unit's population that is presumed to be treated; (2) the *the timescale of the intervention*, i.e., the amount of time an exogenous shock takes to treat units; (3) the *granularity of the intervention*, i.e., the different degrees with which an exogenous shock treats units.

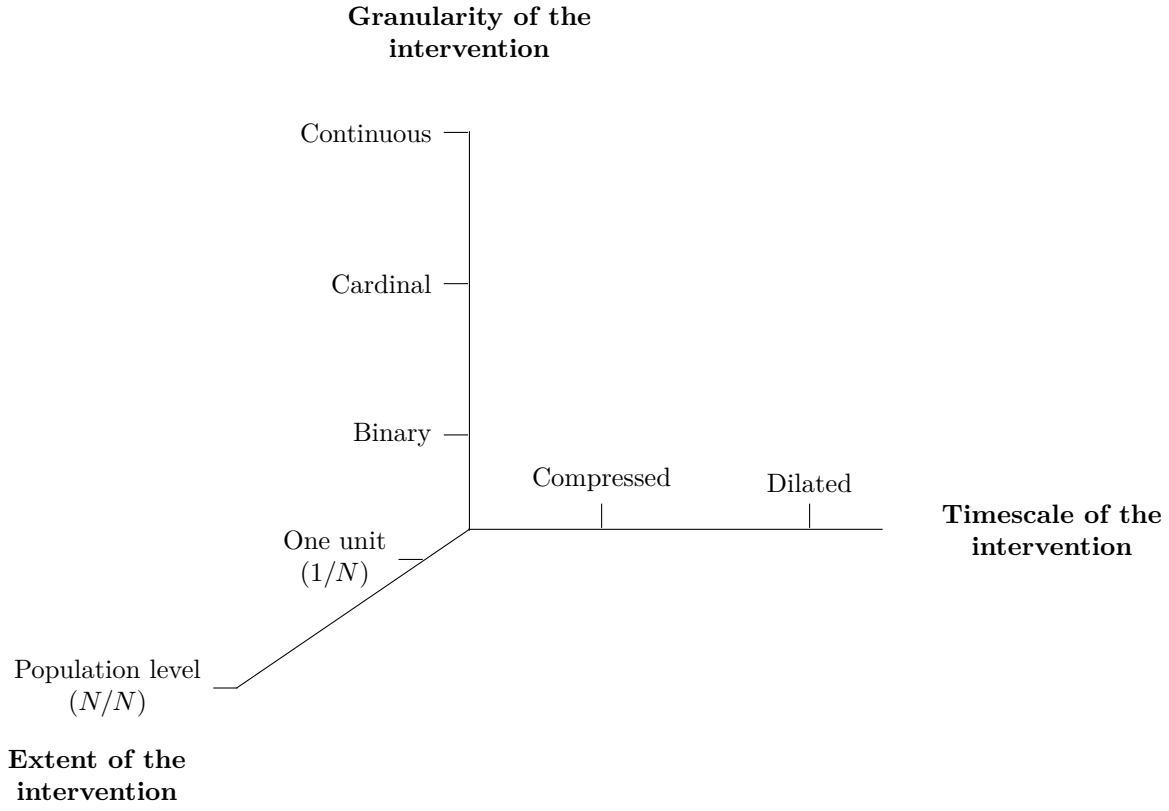

FIG. 8. — A taxonomy of exogenous shocks. Notes. — The 'timescale of the intervention' axis is a continuum, which we annotated with reference points in the interest of interpretability; N denotes the study's population size.

The literature shows considerable variations regarding the first dimension, an *exogenous shock's extent of intervention*. At one extreme of the gamut, there are cases such as pilot or unique policies and rare naturalistic or social events that affect one unit only. For instance, Nathan (2020) evaluates the causal impact of a flagship UK technology cluster program that carries out an original 'light-touch,' market-oriented intervention. The policy under investigation — which the author presents in as an as-if random variation[9] — regards one cluster London

9. Here is a passage from Nathan (2020) where the author describes the empirical identification strategy for

solely (that is, 'Tech City'). The study of Abadie and Gardeazabal (2003) is another example of an exogenous shock affecting one unit only. The authors use the terrorist conflict in the Basque Country as a case study to investigate the effect of conflict on regional GDP.

In other circumstances, exogenous shocks regard a fraction of the units included in the reference population. Typical cases are empirical strategies that consider the death of business or political leaders (e.g., Bennedsen et al. 2007; Brown et al. 2017; Iyer 2010; Johnson et al. 1985; Jones and Olken 2005; Kang and Kim 2020; Ke et al. 2019; Lee, Kim, and Bae 2020; Nguyen and Nielsen 2010, 2014; Quigley, Crossland, and Campbell 2017). For instance, Iyer (2010) uses the heirless death of princes in the 19^{th} century India as a random variate accounting for the transition of a district from the 'indirect rule' to the 'direct rule,' in which British administrators collected taxes and administered local governance themselves. The descriptive evidence reported in Iyer's work indicates twenty districts out of 181 experience heirless death.[10] One of the studies included in our review (Jia, Gao, and Julian 2020) takes advantage of SEC's pilot study consisting in the exclusion of designated securities from the operation of the 'tick' test of Rule 10a-1(a) and any short sale price test rule of any exchange or national securities association. Such a temporary intervention resulted in a stock price risk surge for 512 firms belonging to the Russell 3000 Index.

The other extreme of the gamut regards exogenous shocks that interest the whole population of units. That could happen for different reasons. Sometimes, governments introduce legal changes in a non-staggered manner, making new laws binding simultaneously for all firms in the country. An example is Norway's gender quota policy, the shock central to the work of Matsa and Miller (2013) on the implications of gender composition in executive teams. According to the policy — released in 2006 —, Norwegian public limited companies had two years to comply with the requirement of having at least 40 percent representation from each sex on their board. According to the descriptive evidence reported in the study, *"nearly all firms complied by February 2008, and all did by April 2008"* (page 140). Exogenous shocks affecting the reference population can also emerge from significant catastrophes, pandemics, recessions, or global-scale terrorist attacks. Examples are Corbo et al. (2016) and Vergne (2012), which rely on the variance created by 9/11 to investigate the change of the airline industry and the boundaries of the global arm sector, respectively, and Gupta et al. (2020), which draws on the Global Financial Crisis as a source of pressures for CFOs to report favorable results.

The second dimension of our topology — *the timescale of the intervention* — emphasizes the timing with which an exogenous shock is presumed to affect a relationship or mechanism of interest. To clarify this dimension, let us focus on one class of exogenous shocks: the death of individuals occupying prominent positions in organizations or fields. The finance literature includes studies using sudden deaths amongst upper echelons to address the overarching question

the paper: *"By 2010 Ministers were claiming 'something special' for the Inner East London cluster (Cameron, 2010; Osborne and Schmidt, 2012). Other accounts depict policy origins as chaotic (Butcher, 2013; Nathan et al., 2019), and thus as good as random"* (page 5).

10. Iyer considers the twelve-year timespan (1848 - 1856) where the Governor-General of India, Lord Dalhousie, enacted the Doctrine of Lapse, according to which annexation would result from the death of a ruler without a natural heir.

'how do executives matter?' (e.g., Cho et al. 2016; Dedman and Lin 2002; Duchin and Sosyura 2013; Faccio and Parsley 2009; Falato, Kadyrzhanova, and Lel 2014; Fee, Hadlock, and Pierce 2013; Fracassi and Tate 2012; Johnson et al. 1985; Nguyen and Nielsen 2010, 2014; Salas 2010). The intuition behind this body of work is that analyst and market reactions to unanticipated executive turnover reveal the 'net contribution' of business leaders to shareholder value. As Nguyen and colleagues (2014) note, stock price changes play a critical role as they

> *"reflect the expected incremental value of cash flows under the deceased executive net of this pay, relative to the expected incremental value of the replacement net of his pay."* (page 3000)

Since market expectations factor in broad arrays of time-variant elements (e.g., the search costs a firm may incur to fill in the vacancy), it is critically important to pick up an appropriate time window within which stock prices foster a *ceteris paribus*, pre-post shock comparison. Nguyen and colleagues (2014) evaluate the impact of executives' sudden death using

> *"daily returns from the Center for Research in Security Prices (CRSP) for an 11-trading-day period around the death. The event day is defined as the trading day of the executive's death, or the first trading day following the death if it occurred on a nontrading day."* (page 3000)

Such a strand of finance literature stresses two aspects. First, sudden executive deaths are essential sources of variance in estimating leaders' economic and financial impact. Second, and more importantly for our taxonomy, there is a relatively tight time frame where sudden executive deaths create exogenous shocks to address the question, 'how do executives matter?'

Studies across the fields of economics of science and sociology of science highlight a different temporal pattern by which sudden deaths alter reference processes or mechanisms and, in turn, acquire relevance. Several articles (e.g., Aizenman and Kletzer 2011; Azoulay, Fons-Rosen, and Zivin 2019; Azoulay, Graff Zivin, and Wang 2010; Azoulay, Wahlen, and Sivan 2019; Khanna 2021; Oettl 2012) take advantage of the start scientists' premature death to estimate better the spill-overs that emanate from collaboration. The seminal study of Azoulay, Graff Zivin, and Wang (2010) quantifies these spill-overs in terms of a scientist's differential of publications and research grants when collaborative ties collapse because of the death of an alter star scientist. Unlike finance literature, where executive deaths can create 'instantaneous' change in expectations about a firm's future cash flows, Azoulay et al. (2010) consider a broad timespan to reveal the effect of exogenous shock. The rationale seems twofold. On the one hand, spillovers can 'roll over' after the death of a superstar collaborator. On the other hand, a scientist's research can take substantial time to change. These elements seem to guide the authors' choice to evaluate the effects of the shock in a fifteen-year time window (see Figure 9). At the same time, they also account for the intertemporal variation of the superstar extinction effect

"Following the superstar's death, the treatment effect increases monotonically in absolute value, becoming statistically significant three to four years after death. Two aspects of this result are worthy of note. First, we find no evidence of recovery — the effect of superstar extinction appears permanent. Though we will explore mechanisms in more detail below, this seems inconsistent with a bereavement-induced loss in productivity. Second, the delayed onset of the effect makes sense because it plausibly takes some time to exhaust the productive potential of the star's last scientific insights. In addition, the typical NIH grant cycle is three to five years, and the impact of a superstar's absence may not really be felt until it becomes time to apply for a new grant." (page 568)

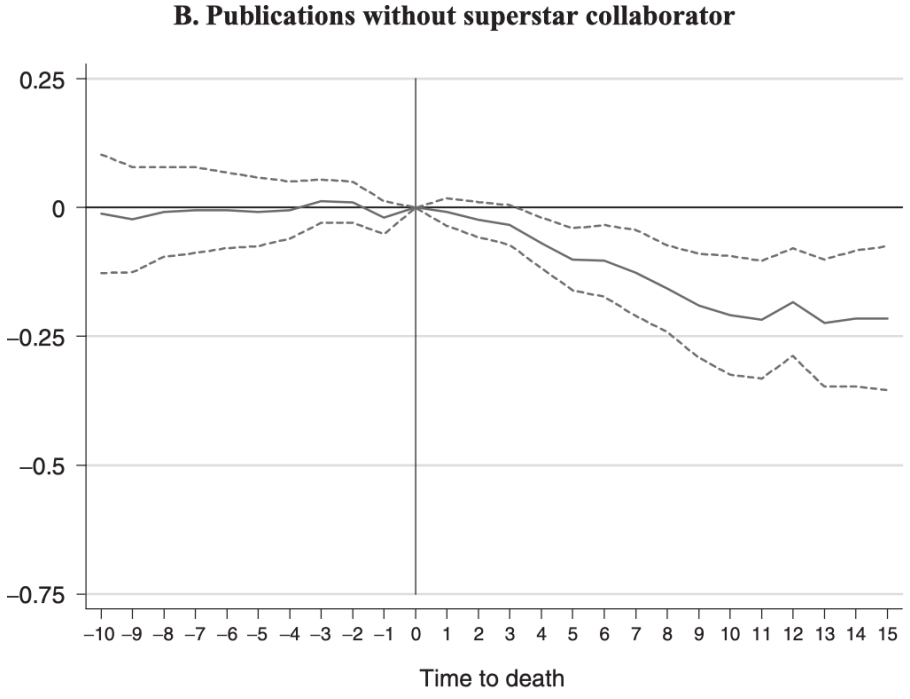

FIG. 9. — A visualization included in Azoulay et al. (2010) clarifying the timescale of the exogenous shock generated by the sudden death of a scientist's prominent collaborator. Notes. — The figure, titled 'Dynamics of Treatment Effects,' is reported a page 569; here is the note describing the key aspects of the figure: *"The solid lines in the above plots correspond to coefficient estimates of conditional fixed effects quasi-maximum likelihood Poisson specifications in which the weighted publication output of a collaborator is regressed onto year effects, seventeen indicator variables corresponding to different age brackets, and interactions of the treatment effect with 27 indicator variables corresponding to eleven years before the year of death and prior, ten years before the year of death, nine years before the year of death, . . . , fourteen years after the year of death, and fifteen years after the year of death and above (the indicator variable for treatment status interacted with the year of death is omitted)."*

The third element of our taxonomy regards the *granularity of the intervention* that stems from the exogenous shock. The minor granular intervention corresponds to a binary treatment that splits the statistical units into two experimental groups *á la* Snow (1855 (1965)). An intermediate level of granularity occurs when the exogenous shock is presumed to form more than two groups of units, each of which receives a certain amount of treatment. For instance, the study included in our review by Chen and Garg (2018) divides NBA teams into four strata:

those not affected by a superstar injury (the control group) and those affected by a superstar injury implying 'short,' 'medium,' and 'long' absence. Finally, an exogenous shock may create a continuous treatment. An example is Drago and Galbiati's (2012) paper on social influence and criminal activity. The authors use the Collective Clemency Bill, which the Italian Parliament approved in 2006, as an exogenous variation in the incentives to commit a crime:

> *"Upon approval of the bill, almost 22,000 inmates were released from Italian prisons. Of direct importance to the objective of this study, the bill stipulates that if a former inmate commits another crime within 5 years of their release from prison, they will be required to serve the residual sentence suspended by the pardon (varying from 1 to 36 months) in addition to the sentence for the new crime. In other words, the policy effectively transforms one month of an original sentence into an additional one month of sentence for future crimes committed at the individual level."* (page 200)

The shock does not originate from the new law for Drago and Galbiati (2012). Instead, it comes from the interaction between the application of the law — commuting actual sentences in expected sentences for forty percent of the Italian prison population — and a prisoner's residual sentence at the date of release. Thanks to such a creative empirical strategy, the authors can show

> *"Peers' residual sentences greatly impact individual recidivism. The estimated impact of the average residual sentence of the group (excluding the individual himself) is comparable to the direct effect of the individual residual sentence. In particular, an average residual sentence of one additional month decreases the probability of being rearrested by 0.16 percentage points. The considerable size of the indirect effects is consistent with a social multiplier of two in crime."* (page 200)

The study of Garretsen et al. (in press.) — dealing with the impact of crises on directive leadership — draws on the exogenous shock emerging from the interaction between the early stages of COVID-19 pandemic and the cross-country variation in the number of COVID-19 deaths. Below is the passage from the paper in which the authors explain how they fit a continuous treatment in a DID framework

> *"Since the COVID-19 crisis affects potentially all organizations and managers across the globe, a standard DID experiment with a treatment and control group is obviously not feasible. So, how to deal with global shocks like the COVID-19 crisis? In the framing of a DID-design — and hence instead of a standard treatment–control classification — the alternative strategy is to exploit the heterogeneity in the data, so as to come up with classi- fication of groups (in our case, groups of managers and their orga- nizations) that vary in the 'treatment intensity' of the shock."* (page 2)

4 Harnessing Exogenous Shocks: Empirical Strategy Challenges

This section emphasizes the empirical strategy challenges that are more likely to arise across exogenous shocks with different features. Mainly, we focus on three issues: (1) the scope of applicability of Neyman's Potential Outcome Framework; (2) the external validity of an average treatment effect; (3) interference between treated and control units, i.e., SUTVA violations. To do that, we map some ideal cases of exogenous shocks onto the taxonomy presented in the previous section (see Figure 10).

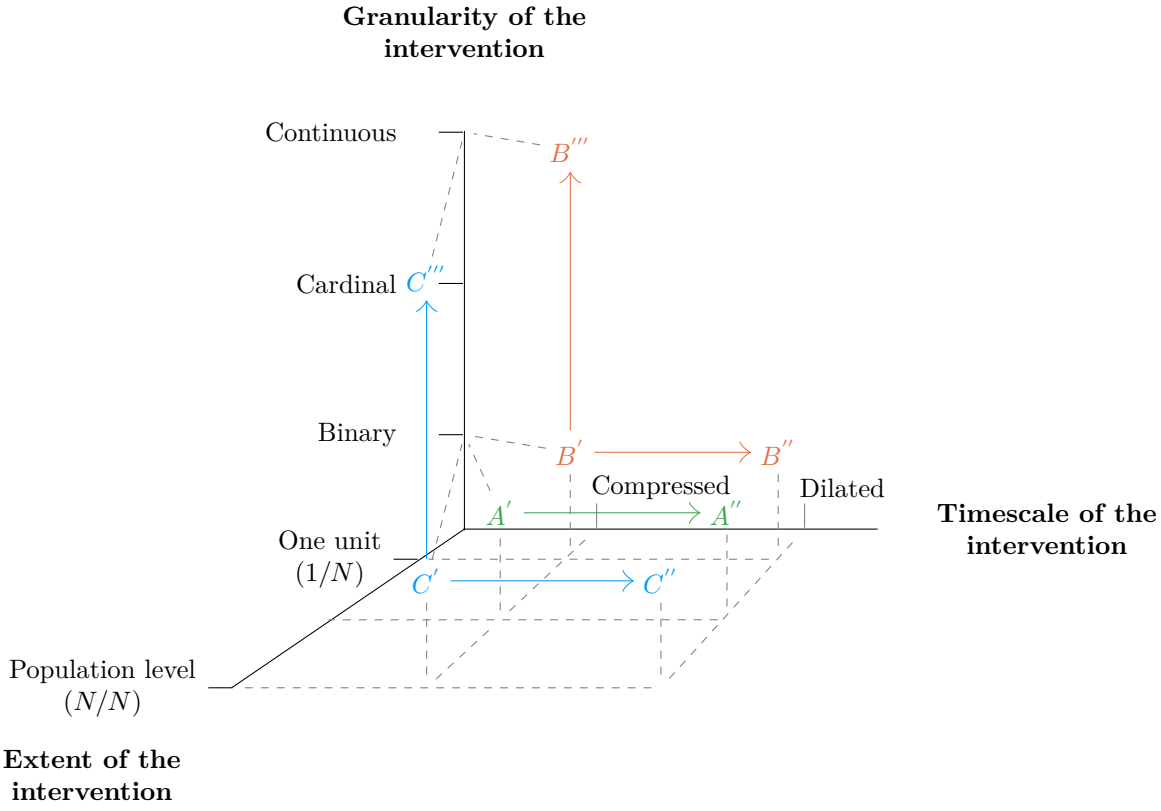

FIG. 10. — Comparative static comprising ideal cases of exogenous shocks. Notes. — The key idea is that different cases present diverse degrees of concern about (1) the scope of applicability of Neyman's Potential Outcome Framework; (2) the external validity of an average treatment effect; (3) interference between treated and control units.

Let us consider case $A^{'}$, where a binary intervention influences a significant number of units by altering meaningful empirical relationships or theoretical mechanisms quickly. That would be the typical 'finance paper' drawing on the variance generated by the sudden death of executives. For instance, Nguyen and colleagues' (2014) paper considers 149 sudden death events whose effects are presumed to manifest in a relatively short period (i.e., eleven days). Such a case poses minimal concerns in terms of empirical strategy. First, the population of units contains a sufficient number of controls to approximate the unobservable counterfactual (e.g., how a stock price would have evolved absent the unanticipated executive turnover). Second, the binary intervention variable is 'well-behaved' and does not create range restriction issues threatening the external validity of the empirical estimates. Finally, the tight timescale of the intervention reduces the chances that control units will be unintentionally treated or affected by

treated units' course of actions (that would be a vacancy chain at the executive level involving both treated and control companies, which is unlikely in a timespan such as the one Nguyen and colleagues (2014) consider).

Case A'' differs from A' because of the timescale of the intervention, which has a temporally dilated impact on the empirical relationships and/or theoretical mechanisms at the center of the study. Azoulay and colleagues' (2010) paper on 'superstar extinction' and knowledge spill-overs is consistent with this case. The author's dataset contains 112 sudden, premature ends of elite life scientists, whose effects on circa five thousand collaborators are modeled empirically over a fifteen-year timespan (see Figure 9). Similarly to A', chances are significant the population will contain suited control cases, and external validity concerns will be least. However, interference issues may arise because of the persisting impact of the shock. For instance, the effects of super-star extinction events may propagate over time through the social structure of collaboration affecting treated units' collaborators who belong to the control group. Azoulay et al. (2010) propose supplemental analysis to deal with possible SUTVA violations, which they present in terms of the *"problem of leakage through the coauthorship network"* (page 579).

In general, relying on an exogenous shock such as B' poses external validity concerns. Plausible causes are generic range restriction issues — i.e., a treatment group with little variance — and/or the presence of treated units showing idiosyncratic features. The former may appear in studies with few treated units (e.g., Aizenman and Kletzer 2011). The latter is common when naturally occurring events regard complex systems such as regions/countries (e.g., Abadie and Gardeazabal 2003), business platforms (e.g., Zhang, Li, and Tong 2020), or industrial clusters (e.g., Nathan 2020). As the population contains comparable control units, an empirical strategy can still produce causal evidence in such a scenario. However, the estimated effect is a local average treatment effect (LATE) (Imbens 2010) since it *"it only characterizes causal parameters for particular units"* (Dunning 2012, page 290). A 'cautious,' LATE interpretation of empirical estimates is — if possible — even more critical in case B_2, where the increased granularity in the treatment may exacerbate range restriction issues.[11] Alternatively, the treated unit might lack a match in the control group. Then, 'Abadie's Comparative Case' method (Abadie 2021; Abadie, Diamond, and Hainmueller 2010, 2015; Abadie and Gardeazabal 2003) would be essential to create a synthetic counterfactual.[12]

Sometimes, a naturally occurring event's attributes and role *vis á vis* the target research question can impede the identification of a control group (see case C'). In our review, some studies take advantage of the variance created by 9/11 for theorizing (Corbo, Corrado, and Ferriani 2016) or measurement purposes (Vergne 2012). In contrast, none uses 9/11 to create an exogenous shock study in the sense of a natural experiment. In other circumstances, the existence of surrogate populations allows researchers to bypass the problem of a total-spectrum

11. The key idea is that the distribution of study variables conditional on a different level of the treatment may present significant sparsity.

12. As Abadie points out in his recent article (2021), the Synthetic Control Method was originally proposed *"with the aim to estimate the effects of aggregate interventions, that is, interventions that are implemented at an aggregate level affecting a small number of large units (such as cities, regions, or countries), on some aggregate outcome of interest" (page 392).*

exogenous shock. The gender quota study of Matsa and Miller (2013) is one of the most representative examples. The government of Norway applied the '40% policy' in a non-staggered manner and made it mandatory for all public companies. The authors bypass the lack of counterfactuals by adjusting their empirical strategy in two ways. First, they consider two surrogate populations, namely Norwegian private firms and public firms located in Scandinavian countries (*ex-ante*, similar to Norway in terms of culture and institutions). Second, they use a triple Difference-in-Difference estimator to create a composite counterfactual that considers factors specific to the Norwegian economy and comparable public companies. Compared with C', cases C'' and C''' pose fewer constraints when identifying a control group. Under C'', scholars can exploit the cross-section variance created by the staggered introduction of a new policy or law, for example; C''' is consistent with studies using the variance generated by global events that, at least temporarily, have heterogeneous effects across regions or countries (e.g., Garretsen et al., in press.). This case could become increasingly popular as scholars use the COVID-19 pandemic as a source of variance in organizational practices (e.g., work from home). In Figure 11, we use a decision tree to summarize the intuitions presented in this paper section.

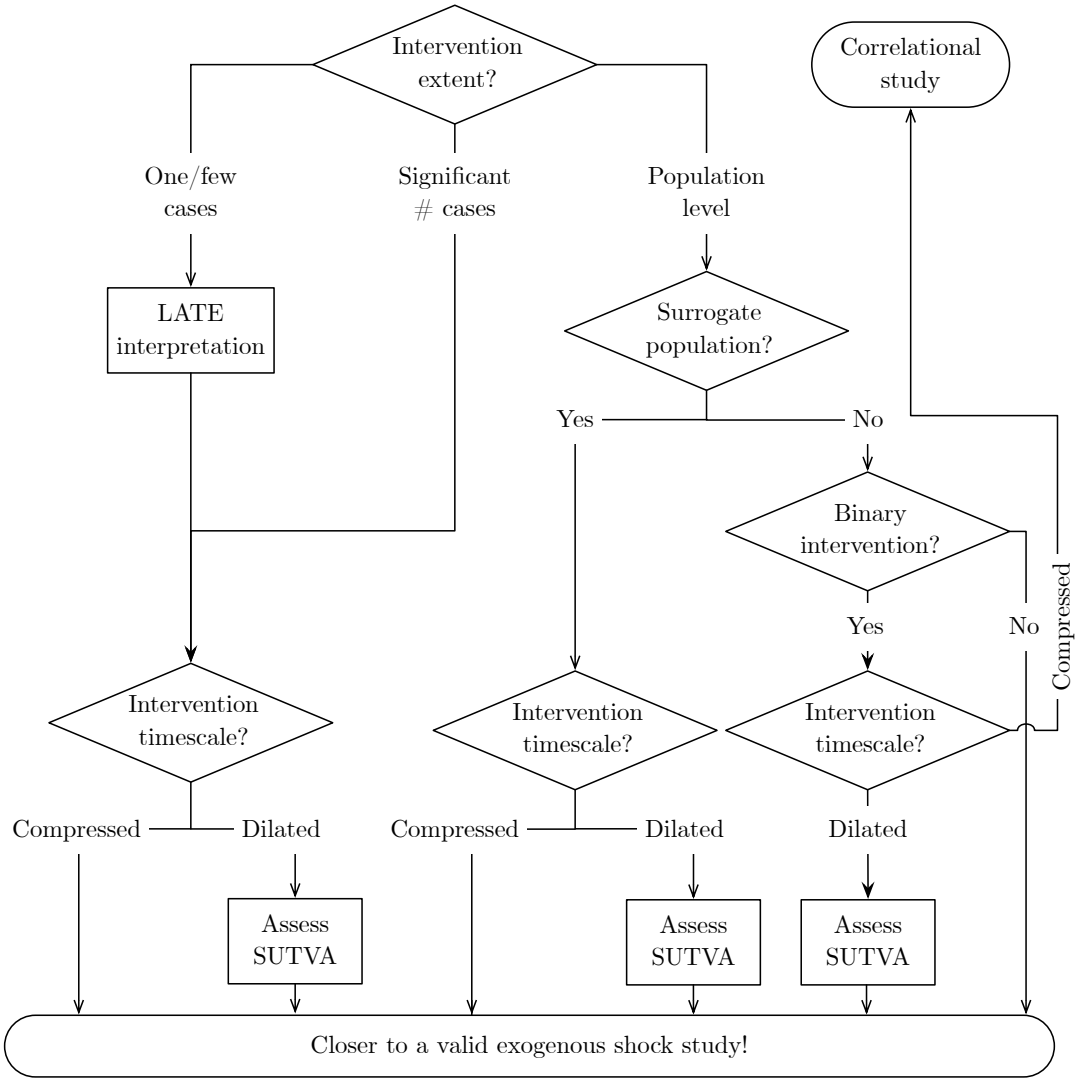

FIG. 11. — A decision tree to harness diverse exogenous shocks.

5 Coda

This paper aims to help authors and reviewers assess the validity of empirical strategies based on exogenous shocks. In the first arm of this project, we have clarified the exogenous shock concept's boundaries and ontological status. Mainly, we have stressed the idea that exogenous shocks do not exist in the real world. Rather, they emerge from the purposive association of naturally occurring events with concrete research questions. As a *corollary*, it is not the intrinsic characteristics of a naturally occurring event that make a powerful exogenous shock study. In other words, 'relevant events' are not necessarily sudden, such as the death of a business leader because of a heart attack, uncontrollable, such as earthquakes, or random, such as lotteries. Instead, the relevance of a naturally occurring event is contingent on the empirical and theoretical problems at hand.

In the second arm of the paper, we have argued that not all exogenous shocks are born equal. Our original taxonomy highlights three key features that differentiate exogenous shocks and help scholars anticipate which empirical strategy challenges are more likely to raise conditional on exogenous shock types. Primarily, we have focused on three issues that have received limited or no consideration at all amongst leadership and management studies: the scope of applicability of Neyman's Potential Outcome Framework; the external validity of the average treatment effect estimate — i.e., the 'LATE' interpretation of statistical estimates; the existence of treatment interference issues resulting in SUTVA violations.

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