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Methods and lessons for business resilience and recovery surveys

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ABSTRACT

Surveys are important tools in business resilience and recovery research because of their ability to capture disaggregated economic information; however, they can be difficult and costly due to business operational dynamics and the larger challenges of disaster research. The COVID-19 pandemic serves as a recent example where demand for business data was high across both research and practice. Yet, the methods and modes for collecting data were limited due to safety, health, and ethical concerns. This research seeks to address the lack of tailored guidance for conducting business resilience and recovery surveys by collecting and synthesizing instruments and best practices from previous survey efforts. These previous surveys were undertaken by a diverse group of organizations with varied research questions, objectives, and hazard events of interest. This paper discusses six broad lessons: clearly define purpose, objectives, and concepts; recognize that response rates will be low, consider disaster dynamics in the research design, address bias that can be exacerbated by disasters, take care to acknowledge the unique ethical considerations of disaster resilience surveys in the business and economic context, and verify and validate data at all stages of the survey process. These lessons, in addition to the published instruments themselves, support researchers or practitioners who wish to conduct their own business resilience and recovery surveys in the future.

1. Introduction

Resilient businesses are a crucial component of community resilience and provide the goods, services, wages, and profits needed for disaster recovery and economic stability [1–3]. A disaster such as an earthquake, hurricane, wildfire, or flood, however, can affect businesses both directly and indirectly [4,5]. Direct impacts include damages to buildings, contents, and inventory [6], transportation, telecommunications, and utility service outages [7,8], and direct business interruption losses by businesses physically damaged or cut off from their infrastructure services [9]. Indirect impacts include disruptions to downstream businesses in supply chains [10], damages to neighborhoods and safety perceptions that deter customers [11–13], socioeconomic status of customers [14], and staff is-

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sues [15,16]. Generally, how well and for how long a business can withstand, carry-on, and bounce back or adapt in the face of these interruptions is the focus of practitioners and researchers interested in the resilience and recovery of businesses.

Business resilience and recovery surveys are valuable tools towards that end. Surveys can be used in research to inform the characterization of the functional recovery of buildings, provide economic recovery model assumptions and parameterization, perform verification and validation of mathematical models, and test or develop theory at the micro- and macro-scales. For practitioners, surveys can help gather data to monitor the direct and indirect impacts of businesses, identify unmet needs, and structure policy. Surveys are versatile in that they can capture data that may otherwise be unavailable and can be tailored to the particular research or practical need. For example, business data is often aggregated spatially, which could miss some of the dynamics at the individual firm level in terms of business births and deaths and how those are distributed across firm types and business districts. Many economic indicators are reported annually or quarterly, which could miss immediate impacts and losses [17]. Similarly, business decision-making and adaptation is a critical factor in their resilience and recovery [18], but this information is rarely collected outside of surveys and interviews.

When done well, surveys are a powerful tool in social inquiry and survey studies can achieve validity in their conclusions through good research design principles. However, there are many challenges and costs to launching a survey effort that could affect research validity, many of which can be exacerbated by the disaster context. The survey may not yield enough responses or adequate information for analysis and generalization, it could introduce bias in the responses, or even compound recovery challenges faced by disaster survivors if the survey response burden is particularly high. The COVID-19 pandemic serves as a recent example of the importance of business survey efforts as well as the challenges those efforts can face. The scale and novelty of the event led to several new research questions for academics studying the impact of, resilience to, and recovery from other types of hazards [19], and governments across the world were seeking information on the status of their business communities to guide policy design and to provide assistance. Surveys allowed for both academics and practitioners to capture timely data in the context of the pandemic's uncertainty, changing regulations, and enduring supply and demand disruptions facing businesses. Yet public health and cost restrictions often necessitated web-based surveys, which can present unique challenges for sampling and survey design [85]; preliminary evidence has also suggested an increase in survey fatigue during the pandemic that may have affected response rates [138]. These issues could potentially affect the validity of the survey responses at a time when information was valuable for multiple organizations interested in business resilience and recovery.

This paper contributes to this field of research by offering guidance and best practices learned through the experiences of previous business survey efforts. We draw from cross-sectional and longitudinal research conducted across several countries after hurricanes, fires, earthquakes, floods, and during COVID-19. These surveys were conducted by a diverse group of organizations with a range of research questions and objectives. The paper begins by establishing the empirical and theoretical motivations for conducting business surveys through a review of the business resilience and recovery literature and outlines the methodology used to generate our lessons learned. We then discuss six lessons for future business survey methodologies: 1) Clearly define purpose, objectives, and concepts; 2) Consider disaster dynamics in the research design; 3) Response rates can be low; 4) Understand the risk of bias in a survey; 5) Verify and validate data at all stages of the survey process; and 6) Address the unique ethical considerations of disaster surveys. We then conclude with future extensions and applications of business surveys. Appendices A and B of business survey instruments and metadata are included to further the utility of this research.

2. Theoretical foundations for resilience and recovery surveys

Many definitions of recovery and resilience have been developed over the years and these concepts are highly related. Recovery definitions can range anywhere from the return to the pre-disaster baseline to more sophisticated reference points that account for future growth expectations, building back better (i.e. greater resilience to future shocks), or considerations of a "new normal" if economic conditions or business practices have changed irreversibly [4,17,129,20]. Resilience definitions can include recovery, particularly in terms of the time taken to return to a recovered state, but also the ability to absorb or withstand the initial disruption (see Ref. [21] for a review). Though they can vary, these definitions will ultimately underpin any business resilience or recovery survey effort and can be linked to discipline-specific theories. In this section we offer examples of economic and other social science theories and definitions used in surveys developed by the authors. Though far from comprehensive, the definitions help to illustrate the range of framing approaches in the literature.

One example of a theoretical basis for business resilience and recovery surveys is economic production theory [3,22], an established body of thought for more than 100 years (see e.g., Ref. [23]). The economic production function embodies the ways that a firm combines inputs with a given "technology" (a way of doing things) to produce one or more outputs. The most basic version is to consider output as produced by a combination of primary factors of production: labor, capital and sometimes land (or more broadly natural resources). In some cases, intermediate goods (commodities used to produce other commodities) are included. Production functions can be expanded, however, to cover a broader range of inputs, including capacity, inventories, management details, and location, in order to cover the full range of ways firms cope with input disruptions [24]. They are well-suited to evaluate how those relationships change in the presence of shocks or disruptions, including those that result from disasters. Most disasters represent an external shock that results in a disruption of an input into the firm's production process: destruction of built or natural capital, death/injury leading to inaccessibility of labor, interruption of infrastructure services, or disruption of intermediate inputs (supply-chain effects). Businesses can cope by utilizing or enhancing resilience in place ahead of the disaster (*inherent resilience* such as stockpiling critical

materials or purchasing emergency electricity generators) or improvising once it strikes (*adaptive resilience* such as innovative ways to conserve or modifying technology) [25,26].¹

Other surveys have used theories from social science literature, viewing businesses as social as well as economic units within a community [1,27]. This literature explores the idea that the effects of disasters are not uniform across population groups and that disasters exacerbate existing societal inequalities [28,29]. The social vulnerability perspective argues that the social characteristics of a person or group of persons can influence how they “anticipate, cope with, resist, and recover from the impacts of a natural hazard” [30]; p. 9). Research has shown that racial minority individuals and communities are often stuck in the recovery phase disproportionately longer compared to their white counterparts [29] and have less access to recovery resources [31,32]. Together these generate long-term racial inequalities within communities affected by hazards [33].

Consequently, business surveys using this perspective will be concerned with how individuals within the business experience unequal impacts of disasters and how that in turn can affect the recovery of the business. For example, owners or managers belonging to a minority group may be less likely to have a prior bank loan given histories of discriminatory lending policy and redlining [34], which in turn could affect their ability to qualify for loan-based recovery resources. Minority owners, managers, and employees may experience more severe personal impacts due to differences in infrastructure [35] which can disrupt business operations and prolong a return to pre-disaster levels. These surveys may ask questions on the market area of the business, given that social vulnerability can vary geographically (Van Zandt et al., 2012), potentially leading to differences in demand and purchasing power of customers [36].

These two different approaches, as well as other theoretical foundations, may be blended in some survey designs. Questions on access to inputs or labor or on changing production timing or practices may inform the economic definitions of resilience, while questions on sources of recovery financing or interactions with community organizations may provide an understanding of the role the social setting plays in recovery. Given the limited definitions presented here, we anticipate that future survey developers will have their own definitions from which to build upon. With this in mind, the authors took a broad and inclusive approach to the concepts of resilience and recovery when collecting surveys and generating lessons for the paper. Researchers may use either or both terms to motivate their study design and may draw from different definitions and operationalizations of these concepts. In some cases, the use of resilience or recovery may affect the lessons in the paper and the survey challenges researchers might expect. For example, including the concept of recovery situates the survey in a post-disaster context, which presents unique methodological challenges. Arguably, resilience surveys can be carried out without connection to a particular event, focusing on hypothetical scenarios or looking at resilience attributes or indicators. Recovery surveys may include resilience—surveys may ask questions about how businesses have adapted after an event to reduce their future risk—or they may just want to know how businesses are doing after an event and look at purely recovery metrics. Both terminologies are therefore used throughout the paper. Survey developers can consider these definitions and how they might translate across and apply to the proposed survey's theoretical or policy questions, as well as the lessons of this paper. More discussion on different survey objectives follows in the next section.

3. Empirical foundations for business surveys

There have been many business surveys over the last few decades carried out for a range of different purposes. In a review of post-disaster recovery assessments, Stevenson et al. [37] identify three key objectives of business studies:

1. To identify characteristics, actions, or external assistance that affect recovery;
2. To understand the business recovery process and outcomes;
3. To analyze business recovery as part of community recovery.

For example, the first objective requires collection of a set of ordinal classifications that can be used to compare the recovery outcomes of different businesses. These can include business structural or managerial demographic information, preparedness measures, impacts sustained, and post-disaster actions and adaptations. This objective primarily lends itself to comparative analysis of organizations, to understand the factors that most influence disaster recovery outcomes. A broad range of survey respondents would be required to represent the full range of variables being studied. The survey could be done at any point in time, as long as it was consistent amongst participants.

Many business surveys fall under this objective. Previous studies have found differences in recovery and resilience by business age, sector, number of employees, ownership type, and pre-disaster profitability [3,7,12,38–42] and the types of pre-event planning, mitigation, and preparedness activities taken by the business [38,43,44]. The effects of physical damage, utility dependence and disruption, and customer loss and demand changes have also been the topic of business survey studies, with both indirect and direct losses affecting recovery [45–48]. Disaster aid, insurance, relocation, and innovation are all post-disaster resources and actions that have had effects on recovery and future business resilience [18,49–54].

The second objective is primarily concerned with the longitudinal observations of organizations and observing how recovery evolves through time, for example studies done by Chang [55] and Stewart [56]. This type of assessment could potentially be carried out on a relatively narrow group of businesses but would likely need to be carried out over a long period of time. Some business surveys have done this, though relatively fewer of them [14,57,58]. These surveys have illuminated how the factors identified through

¹ The production function is especially adept at yielding insights into the effects of tactics such as conservation, substitution of scarce resources, or other changes in technology. These responses can be expanded if the production function is enhanced to reflect real-world considerations relevant to disasters, such as those associated with excess capacity, inventories, location, management effectiveness and inter-firm sharing of resources. It can also be bifurcated to distinguish between tactics implemented pre- and post-disaster, as described here.

Objective 1 evolve through time. Whereas some factors are associated with initial re-opening, other sets of factors may be associated with long-term survival and resilience.

The third objective focuses on the state of business recovery in the context of community recovery at a point in time. Often these studies are aimed at understanding the aggregate performance of businesses relative to some pre-disaster measure or how business recovery affects or is affected by broader recovery trends in the community. Kroll et al. [59], for example, used surveys to compare small business impacts to regional economic performance after the Loma Prieta Earthquake and Xiao and Van Zandt [2] used a business survey in tandem with a household survey to examine re-opening and return decisions in the Galveston community after Hurricane Ike. Torres, Marshall, and Sydnor [60] found that businesses that are more connected with their communities were in turn more resilient to disasters, connecting back to Objective 1. In some instances, these surveys will be designed to support response and recovery activities in real time, for example studies done by Liu and Plyer [62] and Pearson, Hickman, and Lawrence [63] examining indicators and rates of recovery after Hurricane Katrina.

Depending on their objective, empirical studies may seek to generalize the conclusions drawn from their sample to a broader population. For Objective 3, for example, it is likely these surveys would need to capture a sample that is representative of the population of businesses in the study region and would be carried out at a specific point in time, linking aggregate impacts to the individual businesses in the sample. Similarly, with Objective 1, generalizability may be useful to know whether recovery policies might be successful in other communities after different events. In these studies, findings may be used for reporting generalized percentages, formulating and fitting regression models, or informing the types of control variables and survey sections that need to be included in future work. However, in some cases generalizability may not be the goal of the researcher and surveys may be constructed with more qualitative aims. For example, surveys supporting Objective 2 might be designed with more open-ended questions or used to support a case study methodology of in-depth experiences of businesses or business owners in context. Regardless of whether the surveys are grounded in more quantitative or qualitative traditions, previous empirical studies can offer a long history of worked examples of how validity is considered and included in business disaster research. The survey instruments and methods referenced in this paper are indebted to these previous business resilience and recovery survey efforts.

4. Methodology: synthesis approach and scope

This paper is a collaboration of authors who have conducted business resilience and/or recovery surveys, broadly defined above, that have resulted in some publication of findings. The paper synthesizes the collective lessons learned from these survey efforts in the context of the broader body of literature on business disaster surveys. Rather than focusing on the survey findings, this paper discusses the *process* of survey development and data collection.

A team implementing a survey in the midst of a disaster faces unique challenges, therefore, this paper draws on the experience of the authors who have conducted surveys in several countries over the last ten years, often as part of larger, interdisciplinary teams. These surveys and research efforts have been deployed after events such as earthquakes, hurricanes, floods, and COVID-19. The authors represent a range of disciplines and have conducted these efforts from both research and practice, often drawing on their own experiences with other types of surveys (not necessarily business-focused or disaster-based). More detail on the business surveys referenced in the paper, including sample information, research questions, findings, and context, is included as metadata in Appendix B. As established in Section 3, these surveys have built on many years of business surveys and this survey collection is meant to be illustrative rather than comprehensive. Rather, the authors see this as an effort to highlight the practicalities of launching a survey of businesses following a major disruption. The surveys analyzed have all been published on publicly available websites or data repositories for modification and use; not all have gone through an academic peer review process.

To create the series of survey “lessons” the authors have learned about conducting business surveys during and after disasters, the group began by writing individual summaries of their experiences and their takeaways. These summaries were then combined and organized under larger themes across all the surveys which became the basis for the initial lessons. The group met bi-weekly, discussing the lessons and iteratively modifying the larger themes. These themes were also compared to the larger body of literature on business surveys (see Section 3) as well as broader research design principles. This iterative discussion allowed information to emerge that would not be gleaned from the literature review alone. Many of the lessons learned were somewhat specific, and although common across our experiences, were not necessarily things that would go into a traditional methodology section. Although sampling, response rates, and metrics may be more commonly reported, procedural and survey administration decisions and tradeoffs, business reactions outside formal data collection, and ethical discussions are perhaps less likely to be reported. This paper allows for an extension of the traditional methodology section to capture more of the challenges and solutions the authors have found.

5. Lessons for business resilience and recovery surveys

5.1. Clearly define purpose, objectives, and concepts

Ultimately, surveys are tools to answer research questions. Therefore, clearly defining the objective of the survey and its theoretical foundations, as outlined in Section 2 and 3, is critical in ensuring the survey will have measurement validity in support of the research question [64]. Research questions include key concepts, such as business resilience and/or recovery that can be broken down into indicators or metrics. Building on Section 2 there are multiple metrics that could be used for each definition of recovery. For example, recovery in relation to financial performance could be measured using revenue, profit, debt and/or capital value. These metrics can be objective or subjective. Subjective measures are useful where relative measures will suffice, as when doing comparative studies or examining what influences recovery. Subjective measures provide flexibility for businesses to self-define their recovery

state, taking into account values that are important to them [65]. For example, a question might ask, “With the disaster in mind, is your organization: significantly better off; slightly better off; the same; slightly worse off; or significantly worse off?”

Quantifiable objective measures are particularly useful if you are wanting to inform modeling or evaluate policy effectiveness. For example, a complex concept like avoided losses, once gathered, can be mapped to a theoretical construct such as a production function (see Section 2).² This allows for the empirical estimation of explicit relationships among inputs, such as substitution relationships between labor and capital when employees are restricted from coming to work. However, these types of questions might be more challenging for participants, and difficult concepts will need to be conveyed to a diverse sample of respondents in an accessible way. Businesses may also be more hesitant to answer questions on objective measures: for example, a business may not be comfortable sharing the exact dollar amount of their revenue losses but might be more willing to answer whether their revenue was higher, lower, or the same as it was prior to the disaster.

A number of authors have argued for consistency across disaster recovery studies to enable comparison between different events (different hazard types and/or across different community contexts) [20,37,61]. Marshall and Schrank [61] propose a standardized vocabulary for business recovery in the near aftermath of a disruptive event (operating, not operating) and at any time following the immediate aftermath of the disaster (demised, survived, recovered, resilient). Stevenson et al. [37] suggest that a single definition of recovery is not appropriate given the different objectives of post-disaster business studies (see Section 3) and instead suggest a range of recovery metrics divided into three categories: Financial performance, Operational capacity, and Overall organizational health.

Common across all metrics, however, is the idea that recovery (the prefix ‘re-’ meaning ‘again’ or ‘back’) is generally a measure relative to another state. In a post-disaster context this will primarily be relative to a pre-disaster state or some counterfactual state, that is, the assumed state of a business had the disaster not occurred. Therefore, defining a metric or metrics that describe the state of business recovery is arguably the most critical part of post-disaster survey design. To illustrate Stevenson et al. [37], use results from a survey of business following the 2010–2011 Canterbury, New Zealand earthquake sequence including the moment magnitude (Mw) 7.1 Darfield earthquake and Mw 6.2, 6.0, 5.9, and 5.8 aftershocks to demonstrate that conclusions on recovery progress and relative recovery of different interest groups (in this case tenants versus property owners) can be quite different depending on the measure used.

As described in Section 3, the purpose and objective of disaster recovery surveys can vary significantly. This section has covered the key considerations when determining key survey metrics. The selection of the metrics comes down to the individual researcher and the study purpose, while ensuring that the survey questions a) are readily answerable (qualitative vs quantitative data), b) provide the level of data needed (relative vs absolute data), and c) measure the relevant aspect of business recovery (financial, operational or overall health).

5.2. Consider disaster dynamics in the research design

In addition to measurement validity, the literature has identified several characteristics of disasters that cut across different case studies that will similarly affect the generalizability or transferability of research in this context: 1) disasters exacerbate and hasten pre-existing business trends [20,66], 2) there can be disaster-induced “winners and losers” [36,67], and 3) businesses can adapt and use a common set of actions (tactics) to recover amid community and economic changes [3,18,24]. Many of the ways to account for these disaster dynamics will overlap with clearly establishing and defining metrics and objectives (see Section 5.1) and controlling for key variables identified in other empirical work (see Section 2). However, these dynamics occur not only within the business population of interest, but across the community as a whole and at different rates. Survey timing and geographic distribution of the sample are important factors that can add “when?” and “in what context?” to study objectives.

For example, in understanding external assistance that affects recovery (Section 3.1, Objective 1), resource injections are likely to vary in their effectiveness based on these time and space dynamics [18,68]. Assistance for physical repairs that is disbursed after a business has already cleaned up its premises is likely to have a lesser impact, but if a business waits on assistance to re-open it may miss out on early demand surges for food, repairs, and replacement goods [18,69]. This demand can also vary spatially, with higher demand occurring in areas outside and close to the impacted area [36] so assistance provisions that “tie aid to place” and prevent businesses from adapting will also be less effective [68]. Although Objective 2 relates to process and is ideally done longitudinally, cross sectional surveys in other objectives can capture these dynamics as well. In this particular example, designing post-event survey questions to be able to incorporate time as much as possible (e.g. “what resources did you receive in recovery?” versus “when did you receive resources for recovery?”) can help create a richer picture. This can also apply to questions on resilience tactics, infrastructure restoration, and other topics.

Questions on “when?” and “in what context?” will also have implications for Objective 3 in that it can help illuminate what areas in the community are recovering, how quickly, and how businesses are contributing to that process. However, it is also important to note although there are commonalities across disaster events, there are likely to be unique circumstances and stories within broader themes. Disasters vary in their severity and typology and communities are also unique in their populations, histories, and development patterns. Practically, this can mean survey questions might need to modify types of damage states that are included (e.g. wind versus flood descriptions based on event type), the types of resources that businesses might have access to, and the types of organizations that might be involved in the recovery process. Conceptually, it might mean that business resilience/recovery may look different from community economic resilience/recovery or individual resilience/recovery. For example, a business might be resilient if it

² For example, survey questions arising from production theory aim to develop metrics such as the ratio of business interruption avoided by implementation of a given tactic divided by the business interruption that would have ensued had the tactic not been implemented [24], or a benefit-cost ratio, where the first metric would appear in the numerator and the cost of implementing it would appear in the denominator (Dormady et al., 2019).

moves to another city in the face of increased flooding, but that could affect the recovery of the community it leaves behind. An individual owner may choose to retire and close their business, which could be defined as a business failure, even if it was a personal adaptation to changing market conditions. This highlights the importance of diversification in quantitative, qualitative and mixed methods approaches in surveys. Even conducting in-person surveys has the added benefit of allowing the survey to be more conversational outside of the formal questions. The authors have gathered much important contextual information from the side comments during the survey—businesses will elaborate on their answers, which can help design better surveys in the future, note topical areas that might need to be revisited during interviews, or allow researchers to better represent businesses when presenting the research findings. For mailing surveys, the questionnaire can include optional comment boxes periodically or after major sections.

To summarize, overall, disaster dynamics can be accounted for in survey design through careful inclusion of time bounded questions, and mechanisms for analyzing spatial patterns in data (e.g. address data or location questions) or supplementary questions categorizing the specific characteristics of the business and impacts experienced (disaster impact, neighborhood damage, customer disruption etc). Freedom also can be given to participants to add additional context to responses to account for the unique characteristics of each event.

5.3. Response rates can be low

Further threats to the generalizability of survey research can result from non-response of survey participants that can be particularly challenging to address in the context of these disaster dynamics. Business resilience surveys can face obstacles when it comes to garnering responses and response rates for these types of surveys, including those conducted by the authors, can range anywhere from six percent to close to fifty percent. Table 1 provides a summary of the response rates of previous business survey efforts and their methodological and geographical contexts. Broadly, response rates can be affected by the nature of disaster research, timing, and mode choice. Business resilience and recovery surveys can be difficult simply due to challenges associated with businesses as a sampling unit. Many commercial or public datasets used for generating sample frames have information on the business operating location or storefront rather than contact information for business owners or managers. Surveys are therefore often administered or dropped off at the place of business during normal operating hours, which can lead to conflicts when the business is still expected to respond to customers and service requests or when the owner or manager is focused on critical actions such as building repair or inventory rescue. The manager with the most recovery knowledge might not be working when the first visit is made. Coastal areas, which are often the subject of resilience surveys due to their risk, are also likely to specialize in tourism; this can make surveys challenging in the summer and during holidays—when many academic and professional schedules allow for data collection—due to the increase in demand and foot traffic in the business. Other sectors will require similar considerations. Tax preparation businesses will be less accessible during filing season, restaurants will be busy during meal times, and many specialty boutiques may not be open the full business week. Businesses that do not rely on walk-in customers may be less distracted by customer service duties but face their own unique challenges. Conducting in-person surveys with manufacturing businesses, for example, may be less feasible due to the type of building (sometimes no “front” door) and on-site safety considerations due to the presence of heavy machinery. If the business is not locally owned, there may be further challenges to identifying the right respondent for the business, and local managers may face company restrictions to answering questions.

Table 1
Response rates of recent business surveys.

Citation	Event (year)	Sampling strategy	Survey method	Timing after event	Response rate
[45]	Flood in Pakistan (2010)	Quota sample	In-person	6–7 months	N/A
[12]	U.S. Nisqually Earthquake (2001)	Population in damaged city blocks	In-person	6–10 months	Nearly 100%
[70–72]	U.S. Hurricane Matthew (2016), U.S. Hurricane Florence (2018)	Stratified random sample	In-person	14 months, 7 months	43%, 49%
[73]	Covid-19 (2020-)	Convenience Sample (Alignable)	Online	March–April 2020	0.02%
[74]	Covid-19 (2020-)	Stratified random sample of research panel	Online	April–May 2020	24%
[75]	U.S. Hurricane Harvey (2017)	Convenience Sample	Online	6 months	N/A
[3]	U.S. Hurricane Sandy (2012), U.S. Hurricane Harvey (2017)	Stratified random sample of research panel	Online	60 months, 13 months	14%, 21%
[27]	U.S. Hurricane Sandy (2012)	Random sample in highly damaged zip codes	Mail	~12 months	4%
[2,43]	U.S. Hurricane Ike (2008)	Stratified random sample	Mail	7 months	6%
[40]	U.S. Northridge Earthquake (1994)	Stratified random sample	Mail	16 months	23%
[76]	2011 Great East Japan Earthquake	Random sample	Mail	8 months	16%
[44]	2003 Hypothetical Earthquake	Stratified random sample	Mail	N/A	15%
[7,46]	U.S. Loma Prieta Earthquake (1989), U.S. Hurricane Andrew (1992)	Random sample in damaged counties	Mail with phone follow-ups	8 years, 6 years	35%, 27%
[39,77, 131]	New Zealand Canterbury earthquakes (2010/2011)	Stratified random sample	Mail with phone follow-ups	3–6 months, 2 years	25%
[57,78]	U.S. Hurricane Katrina (2005)	Random sample	Phone	4 years	11%
[15,51]	U.S. Hurricane Katrina (2005)	Convenience sample	Phone, online, in-person	6–8 months	N/A

Response rates may also be affected by the perceived importance of research and/or challenges in the recovery process. Previous disaster exposure or experience increases the likelihood of business preparedness and mitigation for a future event [79,80] which might suggest that the perceived importance of disaster research might be higher after an event has already taken place. However, as illustrated by the literature on policy windows, the temporary, increased focus of attention on disaster issues can be fleeting and not always guaranteed [81,82]. Though it's difficult to ascertain true reasons for nonparticipation, this literature suggests that individuals might be less willing to respond if their perception of their current disaster risk is low and there is an unclear link between the survey and a benefit of participating. However, post-disaster surveys can present their own challenges. Businesses are more likely to have experienced multiple events given the increase in the frequency of disasters worldwide [83] and surveys can be emotionally taxing and traumatic for those still in the recovery or response phase. After large events, it's common for many organizations to be involved in data collection [84] and businesses may be recruited for several different surveys ranging from the local chamber of commerce to out-of-state universities as well as sector-specific surveys. The authors have also experienced similar issues from waiting too long to survey: some respondents will not want to revisit the event if they have personally moved on or if they have been oversaturated through media coverage or other reminders of the event (See section 5.6 on ethics for further discussion).

Addressing these issues can be done by combining general guidance on increasing response rates [85] with the disaster context in mind. In general, there are costs and benefits associated with different survey modes, some of which are exacerbated when conducting disaster research. For example, as shown in Table 1, in-person surveys can yield high response rates but are costly in terms of time and travel. These travel costs can be even higher when traveling to a disaster-affected area soon after the event, given supply chain and housing impacts (and some researchers may choose to commute from outside the area for ethical reasons). However, in-person surveys are hugely beneficial in building trust between the surveyor and respondent, can allow for validation and verification of the sample (see Section 5.5), and the authors have found that some businesses are more willing to participate when it feels like someone is listening to their story and experience. Other researchers have noted the importance of in-person surveys in gathering contextual information and feedback for future surveys and research questions [78].

By contrast, both mail and online surveys are less expensive and can be more flexible in terms of when the business owner or manager can respond, which can be an advantage given different sector and recovery challenges outlined above. Mail surveys do not require travel, but still incur costs from postage and assembling often thousands of survey packets over the course of multiple waves. Though common in business studies (see Table 1), response rates from this method can vary. Online surveys are relatively inexpensive to self-administer, but may be impersonal or more easily ignored compared to in-person or mail surveys. Purely telephone-based surveys are less common than other modes in business surveys—it can be challenging to build enough trust over the phone as telemarketing increases, especially when asking financial questions—but telephone surveys have been used as a supplement to other modes to add a human connection to mail surveys or follow-up with owners or managers that were unavailable during in-person field visits. Some researchers opt to pay for professional survey companies or research panels to improve response rates of mail and phone surveys.

Regardless of mode, keeping the survey short and streamlined in terms of concepts (as discussed in Section 5.1) will reduce the time-cost burden on participants. Also, identifying, communicating, and if possible, coordinating with any other organizations also launching surveys in the area can help to reduce survey burden. Working with and teaming up with local or representative organizations can help facilitate this as well as increase trust with affected businesses if the organization is seen as credible. Beyond survey administration, these partnerships can facilitate data sharing, validation, and comparison and, depending on timing and the type of partnership, can help to inform real-time policy making and advocacy.

5.4. Disasters can exacerbate the risk of bias in a survey

The benefits and costs of each survey mode will need to be weighed according to the research question and risk of bias, since bias extends beyond just issues of nonresponse. All survey methods, whether in-person, mail, online, or phone, can introduce bias and affect the validity of the research beyond just the issue of nonresponse. Bias can be defined as when “systematic error [is] introduced into sampling or testing by selecting or encouraging one outcome or answer over others” [86,87]. It is not practical to eliminate all sources of bias, but identifying likely sources aids with assessing its potential impact on the validity and generalizability of the results. Surveys themselves can be subject to more general issues of leading questions: vague or ambiguous question wording, or wording, expressions and framing that are relevant to the survey designer but not those being surveyed [88]. Business respondents' views on whether the survey is confidential or anonymous can also influence how they answer if the information is likely to be attributable to a specific business. These types of issues are all well set out in standard survey design guides [85] and there are disaster-specific resources aimed at reducing survey bias, as well [89–91]. For business resilience and recovery surveys in particular, we focus the discussion on how under-coverage and exclusion bias, survivorship bias, and self-selection bias may present challenges depending on sampling and survey administration.

Sampling can be a complex issue especially if a statistically representative sample with defined error bands is required, or when a variety of sub-groups need to be represented in a way that allows statistical analysis. Given how disaster can exacerbate inequalities (see Section 5.2), often the study is interested in people or businesses with specific characteristics, such as small businesses that were flooded in a particular event, locally owned and run enterprises and so on. Stratified random sampling can achieve a probability sample focused on an identified part of the population. These approaches generally minimize sampling bias and provide confidence that the results are representative of the population of interest. Market research companies can be used to identify people with specific attributes, such as female-headed businesses that were flooded, though may not result in a random sample and researchers will need to consider how research panels may differ from the broader population of interest. Sometimes, resources and other practicalities do not allow for such careful sampling and a convenience sample is used. Unless the population of interest is small, results are unlikely to be

representative and the research may be used as a pilot study. Regardless of sampling strategy, the representativeness of the sample can be checked against the characteristics of the population, through the original sample frame or aggregate data, for example the US Decennial Census and American Community Survey, the 3-year Census and Business Statistics New Zealand, or the 5-year Census in Australia.

Regardless of the sampling strategy, non-response can undermine the generalizability of the results (see Section 5.3). Non-response rates for all kinds of survey research have been increasing steadily for many years in the U.S. and other countries [92]. Surveys intended to be representative of a business community could still exclude certain sectors or types of businesses, resulting in under-coverage bias. Sources of potential under-coverage and exclusion bias include (but are not limited to):

- Businesses without a storefront or website: many small and micro businesses lack a physical presence, which has historically made it difficult to include them in research. These operated out of homes, vehicles and other businesses, or used temporary facilities such as markets, and were often in the informal sector. Now, many such businesses will have websites making contact easier;
- Informal enterprises and activity: much of the work done by undocumented workers, domestic help, and seasonal work in rural areas and tourism and hospitality, construction, and maintenance sectors may be difficult to track, yet in some jurisdictions these can be a significant part of the local economy. There is literature on assessing the whole informal sector, but little on including local businesses [93,94].
- Less visible or socially acceptable enterprises (whether strictly legal or otherwise): research has found the sex industry, for example, to be challenging to include in survey research [95].

Survivorship bias can also result from non-response, and is a particular challenge for business surveys. Often surveys will reach only those businesses that have survived the event and businesses that have closed as a result of the disaster will not be captured. Similarly, those that are struggling or traumatized by the event might be less likely to participate and may not see any value in the research. The result is that only those businesses that survive or are doing reasonably well are likely to respond so biasing the conclusions. This can lead to serious errors when failures are ignored, especially if the results are being used to shape response policies. This issue can be exacerbated by a tendency across fields of research to publish only positive results [96]. Survivorship bias can also intersect with under-coverage bias. For example, businesses or sectors that are run by groups that are more likely to be discriminated against (and excluded from the sample during field work, for example), may also be more likely to fail after an event. For example, Black-owned businesses in the U.S. were much more likely to have closed as a result of COVID-19 and may be excluded depending on survey timing [78,97].

Verification (described in more detail in Section 5.5) through triangulating other data sources can help reduce under-coverage and survivorship bias [78]. There is broader survey guidance on reaching hard-to-reach populations that could also serve as business owners and managers [98,99]. Having local partnerships, as suggested previously, can also help identify subpopulations that may have been overlooked and connect researchers with outreach groups. With respect to closed businesses, asking surviving businesses, or local business associations, specifically about closed businesses may also lead to additional contact methods. Tax data (as applicable), social media posts, and news articles can be collected both to make sure the business actually closed and didn't just relocate, as well as to verify that the business closed after the disaster event rather than prior to it [78,100,101]. This exercise is important for calculating an accurate response rate, but is also important if the research is interested in the rate of business closure and whether the disaster triggered higher than normal business failures. Businesses close for many reasons, disaster-related or not, and often databases are slow to report these changes.

Lastly, there is a similar issue of bias with access to records, particularly for research that prioritizes more accessible data rather than representative data. Internet based surveys have many advantages in terms of lower cost, logistical ease and automatic analysis and production of graphics, however, they can have issues around representativeness and are prone to self-selection bias. Self-selection bias occurs when respondents decide for themselves whether to participate in the research, which can lead to those volunteering having characteristics that distinguish them from those not volunteering [102]. Yet, internet-based surveys may also enable access to "hard to reach" groups which might not be accessible through face-to-face or phone surveys [95]. Remunerations could be a way to overcome self-selection bias (or more generally bias due to selective non response) but it can also lead to its own biases. For future business resilience and recovery surveys, examination of bias is not a simple question of whether it is present or not, but also a question of degree, relevance and importance for the results at hand.

5.5. Verify and validate data at all stages of the survey process

Extending from the previous section and given that bias is a primary threat to the conclusions of the research, validation and verification (V&V) strategies should be implemented throughout the sampling, survey design, and data collection process. Incorporating the V&V process increases our confidence that we are meeting our study objectives, for example that we are observing a causal effect of recovery policies aimed at businesses, that we understand how recovery challenges might change through time, and how recovery experiences might vary across populations and communities.

First, validating the sample early on can save time and resources, particularly given challenges associated with business sample frames. Even business databases that are updated regularly may still include businesses that have closed or moved and may exclude newly established ones; especially if sole proprietors are included [103,104]. Some business surveys use lists from local business organizations—which utilize local knowledge and are likely to be updated regularly—however, those can bias the sample toward higher-resourced businesses.

Other survey frames are created through commercial databases with business records. Although these companies do practice some validation checks on their data, these are difficult to do on a national scale. In a study in Lumberton, NC, approximately 80 out of 460 (17%) ReferenceUSA sampled businesses were deemed ineligible due to being nonprofits, ATMs, vending machines, coin star machines, or businesses with a P.O. box (rather than a physical location) as their sole address [54]. These inaccuracies can also pertain to information fields within the database; a study in Galveston also found missing businesses in commercial databases, as well as inconsistencies in the reported sector and employment information [100, pp. 55–56].

To reduce this issue, the authors have employed strategies for validating before surveying. For in-person surveys, this involved driving through the sample checking for businesses that are no longer operating and those with incorrect addresses. If doing a mailing survey, begin with postcards with a digital information sheet and a link to the survey to be able to remove or substitute the returned mail before spending the more expensive postage for the physical surveys. For phone or online surveys, particularly during COVID-19, it was helpful to go through the sample finding their online presence (email and phone) and verifying their information. Large samples, however, could render this approach impractical. This approach can also be used after the survey, as well, to help determine rates of business closure and to help address issues of survivor bias. Schrank et al. [78] provide guidance on data sources and methodologies towards this end.

Surveys, themselves, can incorporate V&V in their design to help with construct validity and internal consistency. Employing pre-survey screening or qualifier questions can determine whether the business was directly affected by the disaster for sampling purposes and can also ensure that respondents have sufficient knowledge for the survey. For example, questions can require the respondent to be actively involved in the financial decisions of the firm. Alternatively multiple respondents within the same firm can be used to avoid single source bias issues – although often this will not be practical. Particularly when counterfactuals are being elicited from respondents, internal validity checks within the survey can be useful. These can include pop-up windows to alert users to the internal consistency errors and allow corrections of prior responses. This serves to provide more internally consistent and reliable data, signals to the respondent the importance of the responses, and records of such errors can be utilized to rule out less reliable results during analysis. Survey firms can also put in place recontact mechanisms and provide financial incentives for credibly completed surveys (e.g., Ref. [3,107]), which can serve a dual ethical purpose of compensating respondents for a higher survey burden.

5.6. Address the unique ethical considerations of disaster surveys

Surveys related to disasters take place in difficult settings and situations. Potential respondents may be dealing with multiple crises as business owners, as individuals and family members, and as part of a severely disrupted community. The location may be inundated with outsiders wanting to help the community recover but also wanting to learn from their experience. The research team involved in the survey has the responsibility to avoid disrupting the recovery process and, if possible, to conduct work that can help in the recovery over time without distorting the objectivity of the work. In addition, the research team will need to consider whether their work complements or should be coordinated with activities of other groups involved in responding to the disaster. These ethical considerations should be considered before, during, and after the survey administration.

During the planning phase, surveyors should consider survey timing and inter-organization collaboration and ensure compliance with institutional and governmental regulation. It may seem important from a conceptual point of view to launch an initial survey quickly, while the experience is fresh in the minds of respondents and before businesses permanently close. However, there is a countervailing view that it is equally important to liaise with local organizations and emergency responders, who may also be launching surveys, to avoid survey fatigue on the part of the research subjects (as mentioned in Section 5.3). In Napa, for example, the city conducted a survey of the hospitality industry, but in retrospect would have welcomed collaboration with a team of researchers more experienced in business surveys. In Christchurch, a moratorium was placed on all social science research in the immediate aftermath of the earthquake, to give the victims time to address their own needs [84]. Some delay may also be important to give the survey subjects the time needed to assess the impact and their experience, particularly for research interested in the recovery process.

Delay might not only be ethical in some cases, but necessary. Many organizations like universities³ and governments⁴ have research protocols in place to ensure that the rights of persons being studied are respected and that the research burden is as minimal as possible. Fully adhering to the types of requirements described above can make it difficult to launch surveys early in a disaster as it may not be possible to plan in advance for this type of unexpected event. However, organizations regularly involved in disaster-related surveys may be able to hasten the approval process by obtaining approval for a general survey form that will be then tweaked to match the needs of a specific disaster. In collaborative work, an umbrella agreement or mechanism for sharing ethics review across different universities can also shorten and simplify an otherwise complex approval process [108].

³ In the U.S., the U.S. Office of Human Research Protections provides guidance on how to protect the rights of human subjects in research ranging from biomedical to behavioral research [125]. Research universities that receive funding from the U.S. government generally have their own internal procedures to ensure that research involving human subjects adheres to the U.S. guidelines initially spelled out in the Belmont Report [126]. International best practices are summarized in the Declaration of Helsinki, most recently updated in 2013 [127]. The time frame for reviewing some types of research may be expedited (and business surveys are likely to fall into this category) but even so, clearance for conducting a study can take a few months, and all researchers involved in data collection or analysis must have ethics training certifications.

⁴ For example, studies undertaken by U.S. Government agencies must also adhere to procedures defined by the Paperwork Reduction Act as administered by the Congressional Budget Office [128]. This adds a further level of review prior to launching a survey. The act applies to surveys that involve 10 or more members of the public (domestic or abroad) over a 12-month period. The clearance process involves time for public review and can take 6–9 months. However, for surveys, if a generic clearance of a survey design has already been approved (including specific types of questions), then the process can be fast tracked. NIST, for example, has an umbrella clearance that allows specific surveys to be approved in a month or less. There is also emergency clearance in specific cases that can happen in a few days. For longitudinal work, a lead Institutional Review Board can then cover follow-ups and the initial survey.

During survey administration, teams can be built strategically and surveyors can offer remuneration/incentives for surveys to help reduce the emotional, time, and cost burden of the survey, particularly when the survey is conducted during business hours. Remuneration and financial incentives can help compensate respondents for their time and effort and make them more likely to participate. However, care should be taken to balance compensation with risk of bias; financial incentives have faced criticism for causing “undue influence” on who responds or acting as a financial “coercion” towards participation [139]. Defining the level at which “remuneration” becomes “undue influence” is left to individual research boards, recognizing the wide range in variation in study design and process [109]. Another option to reduce survey burden is to consider whether a comprehensive or specialty survey is needed for the research question at hand. Comprehensive surveys, though longer, may be better if more general information is needed to capture the recovery and resilience of all types of businesses; however, if targeting particular subsets of businesses might suffice, the instrument can be both shorter and more specialized. Building from and publishing existing surveys can be useful for this effort.

Additionally, listening and informal conversations can be very informative—Reis and Sahibi [110] cite a single business to highlight a range of concerns over nonstructural losses and neighborhood effects in an article on mitigation investments—and, if done with sensitivity, allowing for these conversations can be less disruptive to the communities being studied while giving business respondents the opportunity to have their concerns heard. Even when studies are exempt from full review, researchers are expected to ensure that the subjects give informed consent, are aware that their participation is voluntary, and will not be put at risk of harm by participating in the study. In Christchurch, research teams went a step further by having someone from social services participate with surveys that took place [84].

Lastly, ethical concerns do not end once the data are collected, but also apply to how the information is used and the degree to which the findings are shared with respondents as the study proceeds. Confidentiality, if promised during survey recruitment, must be preserved in how the results are stored, coded, and analyzed. Publishing data can facilitate comparative research [134], and some hazards journals now encourage data availability statements in support of the re-use of data by other researchers (e.g. Refs. [135, 136]). If survey data are to be published, any Personally Identifiable Information (PII) and Business Identifiable Information (BII) would need to be removed. This includes names, addresses or spatial coordinates, telephone numbers, or email addresses, as well as any information that in combination might uniquely identify a participant (e.g. sector and number of employees). Researchers may also consider giving subjects the opportunity to review any illustrative stories that involve them that may be included in the write-up for accuracy and their comfort with how the situation has been portrayed [137]. Coordinating and engaging with local officials, people, and organizations can yield valuable feedback on the scope, interpretation, and recommendations of the research; in turn, by prioritizing the needs of local communities, research results may in support local responses to the crisis [117].

6. Discussion and conclusion

These six lessons for business surveys draw from previous business and resilience survey efforts across different organizations. There will be challenges in applying these lessons. In concluding, we discuss how these challenges may shape survey practice following disasters, describe extensions to this work, and acknowledge limitations of these lessons given the scope of the surveys included.

6.1. Surveys in an increasingly complex environment

As the number of disasters and their severity rises [83,111], communities around the world are increasingly likely to have experienced multiple disasters, and many will have experienced a new disaster before fully recovering from the last. For example, just since 2018, St. Mary Parish on the U.S. Louisiana coast had disaster declarations for ten named hurricanes, Sonoma County in California suffered sequential Patrick, Tubbs, Nuns, Kincade, Glass, and LNU Lightning fires, and Florida's Bay County received disaster declarations for four hurricanes and two fires [112]. In Australia, the same areas that bore the brunt of the 2019 and 2020 bushfire season experienced severe flooding just one year later [113]. Each of these areas, like the rest of the world, also had to cope with the COVID-19 pandemic. Carefully measuring recovery in the context of multiple stressors, particularly for cross-sectional studies, helps to ensure valid data for use in analyses and policy-relevant recommendations.

Additionally, time profiles of disasters vary [19]. Pandemics, droughts, and financial crises can have a longer duration of impact compared to wildfires, earthquakes, floods and hurricanes. Therefore, impacts are not necessarily just incurred at the onset of the disaster, they emerge and change over time [14,61]. The structure of businesses may also change over time. The pandemic was the impetus for expanded telework – whether this will endure remains to be seen; however, early indications suggest that in some sectors employees are demanding this flexibility and employers are providing it to remain competitive [114,115]. Additional effort will be needed to incorporate telework into survey design and administration if its prevalence continues. Administration of the survey, sampling strategies, and defining how businesses relate to an overall community may need to be adapted. Future survey modifications could incorporate questions on the effects of telework on customer, employee, and community recovery and resilience, and how that in turn affects the recovery and resilience of the individual business.

In addition to modifications to question design and survey administration, these issues point to a growing importance of a longitudinal lens and data collection efforts that consider businesses within the context of long-term community resilience trajectories. Longitudinal studies, however, will need to be particularly cognizant of good survey design as decisions made in early waves can compound bias and issues like response rates through time. For example, future waves may need to consider incorporating additional questions, changing questions that respondents skipped or had difficulties with, or changing concepts and definitions in subsequent waves as new knowledge is collected. We believe the lessons in this paper can be useful towards this end, particularly in the initial survey design. Accounting for increasing complexity might require different definitions and theories to ground the research, but surveys can draw upon new conceptualizations as they emerge in the hazards field. For example, Pescaroli and Alexander [116] propose

a holistic framework that highlights the complementarities of four risk types (i.e., compound, interacting, interconnected and cascading risks), which could be useful in developing new metrics. In this case, teasing out or controlling for individual disaster effects may be less important in this framework that understands their cumulative impact. Similarly, this type of study might recognize a range of outcomes of interest that move beyond recovery as a state, for example whether the firm transformed in terms of type of products, location of operation, production process, or ownership structure.

6.2. Future extensions

This paper is motivated by the larger push in disaster studies towards interdisciplinary, transparency, and more ethical disaster research [117,118]. The goal was to share business resilience and recovery survey practices to facilitate more studies in this area and to encourage the publishing of past and future business surveys in open access repositories. This instrument and data sharing practice can allow for more cross-case comparison in the future. Similarly, this research can be extended through a deeper analysis of question formatting and survey concept mapping in the hope of creating more efficient survey designs. This will likely become more important as surveys will need to capture more complex information on compound, interacting, interconnected and cascading risks and how these multiple events increase the responsibility to reduce the response burden of those affected. In that sense, this paper was also motivated by the COVID-19 pandemic, since it embodies many of these future extensions. Given the timescale of the pandemic, longitudinal research can help to understand its effects through time as policy and conditions changed. Similarly, the nature of the pandemic raises considerations of survey burden and harm through the deployment of the surveys themselves. This also creates a challenge for researchers since remote surveys may face challenges with response rates and bias. Therefore, there is also space to explore further (novel) integrations between secondary data and survey data to further reduce survey length and burden and increase our understanding of available proxy measures. Though a few surveys referenced in this paper have incorporated the pandemic, there is much still to learn on how these lessons might be modified in this context.

6.3. Limitations, generalizability, and context

Lastly, although we aimed to be transparent in the scope of the survey efforts analyzed (see Appendices), we recognize that our conclusions are biased towards certain contexts. For example, many of the authors' surveys were conducted in North America and the global north (e.g., Australia and New Zealand with no representation of European-based collections), as opposed to the Global South. Further, most surveys referenced in this paper were conducted in English, which could lead to translation issues and are likely biased towards an Anglophone approach to research [119] and further constrains the representativeness of the garnered sample. Lastly, many of the lessons likely lean more towards a quantitative approach rather than a qualitative approach to survey design and implementation. However, given the discussion of disaster dynamics and the anticipation of increasing complexity in disaster research, qualitative approaches will be increasingly valuable going forward. For example, workforce well-being may be an understudied part of business recovery and resilience moving forward that would benefit from more open-ended and deeper examination of decision-making. For example, to what extent do businesses prioritize the health and well-being of their employees over financial metrics, what does that mean for business recovery, and what does that mean for broader community resilience?

There are surveys conducted in the Global South that often address welfare relevant to livelihoods (touching on businesses) and households' ability to cope (e.g., Ref. [120]). There is likely much to learn from these assessments, many of which have employed participatory games to address issues such as risk aversion (e.g., Refs. [121–123]). Furthermore, the World Bank conducted Business Pulse Surveys and Enterprise Surveys throughout the pandemic that have taken the "pulse" of firms across 76 countries and the impact of COVID 19 on their performance [124]. Lessons from this data collection and other data sources may help to inform our understanding of how firms around the globe cope and how to best address sectors with global supply and value chains.

Lastly, this first list of six lessons likely also misses some critical challenges that may be faced in other geographic locations and contexts. We offer this paper as the beginning of a conversation and await with interest additional articles that will expand on these experiences in different cultural and economic settings.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Co-author John Handmer is an editorial board member of the *International Journal of Disaster Risk Reduction*.

Data availability

No data was used for the research described in the article.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijdrr.2023.103743>.

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