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To cite this article:

Henrich R. Greve (2025) Airline Responses to the COVID-19 Collapse: Applying Learning to an Unprecedented Crisis. *Strategy Science* 10(1):48-67. <https://doi.org/10.1287/stsc.2023.0083>

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Airline Responses to the COVID-19 Collapse: Applying Learning to an Unprecedented Crisis

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Received: August 8, 2023

Revised: October 31, 2023; February 14, 2024; April 17, 2024


Accepted: April 30, 2024

Published Online in Articles in Advance: July 22, 2024

<https://doi.org/10.1287/stsc.2023.0083>

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Abstract. Organizational learning is a result of knowledge creation, retention, and transfer. An unanswered question in learning theory is whether learning occurs when firms face an unprecedented and urgent crisis as such events leave little time for knowledge creation, and they complicate knowledge transfer and retention. The COVID-19 pandemic is an example because it saddled firms with consequences ranging from liquidity crises to worsened strategic position, and it required urgent responses. Operational and strategic responses had to be made without recent experience from similar situations and with high uncertainty about the duration and severity of the crisis. This paper extends learning theory by developing an argument that such extreme events allow knowledge transfer and retention that current learning theory would not predict. The new predictions are tested on the airline industry, which was severely affected by the mobility restrictions imposed by states. The findings show organizational learning even when facing an unprecedented crisis, but different learning rules were used for reversible and irreversible actions, suggesting that decision makers search for adaptive choices and are mindful of their strategic consequences.

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Funding: This research received funding from the Hoffman Global Institute for Business and Society.

Supplemental Material: The online appendix is available at <https://doi.org/10.1287/stsc.2023.0083>.

Keywords: [organizational learning](#) • [environmental shock](#) • [strategic position](#) • [knowledge construction](#) • [behavioral strategy](#)

Introduction

Organizational learning theory has since its inception emphasized that learning is “routine-based, history-dependent, and target-oriented” (Levitt and March 1988, p. 319). Consistent with this view, it emphasizes how learning through repeated execution of routines increases efficiency and yields competitive advantage (Argote 1999). This research on organizational routine development has been expanded to include examination of “search, knowledge creation, knowledge retention, and knowledge transfer” processes (Argote et al. 2021, p. 5399). Research on these processes has produced a solid foundation for examining how a firm can improve its efficiency (Dutton and Thomas 1984) and alter its strategy and operations (Greve 2003b), but also, it has shown that retention of knowledge is problematic even after short interruptions in operations (e.g., Darr et al. 1995, Benkard 2000). Learning from repeated events provides advantages, but it leaves open the question of whether learning theory can help in understanding organizational responses to unexpected events.

This question is important because firms are sometimes faced with crises that are unprecedented, are economically threatening, and require urgent responses. The COVID-19 pandemic is a good example. The 1917–1918 Spanish Flu is the most severe pandemic in recent history, with approximately 25 million deaths and 500 million infected, but COVID-19 led to nearly 10 million deaths and more than 700 million infected. The social and economic effects of the COVID-19 pandemic have been significant for many firms, especially those in industries affected by mobility restrictions. For airlines, it quickly became clear that the industry would face losses on a scale of 100 billion dollars (Jasper 2021). The challenges facing learning theory in understanding such events stem from its focus on knowledge creation and retention from similar events and on organizations using the consequences of actions to guide whether to repeat them unchanged, alter them, or search for new actions (Haunschild and Sullivan 2002, Greve 2003b, Rhee and Kim 2015). COVID-19 was a crisis with no similar event, and it unfolded so

quickly that decisions were made without knowledge of the consequences.

There have been efforts to extend learning theory into the study of rare events that originate in a focal firm (Rerup 2009, Rerup and Zbaracki 2021) but are not environmental crises that envelop an entire industry. Research has revealed that lack of knowledge about a situation by strategic decision makers reduces the value of the responses (see especially Decreton et al. 2023, Kim et al. 2023). This research has not addressed the situation of an entire industry facing an urgent and unprecedented crisis, and as of now, learning theory does not appear to offer predictions of how firms respond to such crises. This is problematic because many firms in crisis conditions have difficulty discontinuing activities and shedding assets, even though the capability to make termination decisions is known to improve performance (Guler 2018). Thus, the magnitude and severity of the COVID-19 pandemic give the investigation of firm responses to it significant theoretical and empirical interest.

To preface the argument made here, it is still possible to apply learning theory to the study of such unprecedented crises, but doing so requires theoretical extensions. The first extension is to return to the emphasis on interpretation and memory in early learning theory (Levitt and March 1988, Walsh and Ungson 1991). Although an organization has no memory of the same event or its responses when facing an unprecedented crisis, the ambiguity introduced by the crisis allows for searching the organizational memory for crises that have some similarity and to draw lessons from actions taken by the focal firm or observed in peer firms.

The second extension is to complement the usual assumption that organizations learn mimetically from each other by copying the most frequent response of peer organizations. Although such mimetic learning will occur, an unprecedented crisis will also produce significant heterogeneity of responses, allowing examination of whether heterogeneous learning environments produce better understanding and responses, as some work has suggested (Schilling et al. 2003, Kim et al. 2009, Csaszar 2018). Examination of an unprecedented crisis is ideal for a rigorous test of these theoretical extensions. This test will also offer indications on the promise of a future research direction emphasizing the role of fast-changing environments and rapid obsolescence of organizational knowledge (Argote et al. 2021, p. 5421).

The theoretical contribution of this study is to apply learning theory to a type of context rarely examined because the theory appears to be a poor fit. The application involves theoretical extension because prior assumptions on knowledge creation and retention no longer hold when organizations are forced to respond to an unprecedented crisis, and the resulting heterogeneous

learning environment also allows for actions rarely seen from organizations operating in placid and homogeneous environments. These theoretical extensions will become more important to the extent that social and competitive environments are increasingly fast paced and unpredictable as has been suggested by the increase in natural and social disasters, such as climate change, armed conflict, and regionalization of global trade. The empirical contribution is to show support for some of these predictions but selective support that appears related to whether the response was primarily operational in nature or also strategic.

This study applies learning theory to a highly consequential and strategic set of actions. The COVID-19 pandemic forced airlines to deal with a series of significant decisions affecting the cost of owning and operating the aircraft fleet.¹ Such decisions are familiar because airlines do dispose of aircraft that have become expensive to maintain or less fuel efficient than recently launched models, so a potential response to this situation would be to make such aircraft disposals at a larger scale than usual. This means that key decisions included the following. (1) How many airplanes should be stored, which ones, and when? Storage is less costly than operation but still has some costs, and returning aircraft to service is also costly because stored aircraft need to be prepared for service. (2) How many aircraft should be disposed of? It was unknown how long the financial stresses from crisis would last and whether air passenger traffic would ever recover to past levels, so the best future fleet size was unknown. (3) Should the fleet be renewed? Older, less fuel-efficient aircraft could be replaced with modern aircraft. However, if the low demand for air travel lasted long, airlines renewing their fleets would experience a worsened liquidity crisis.

When the research question is how firms respond to an unprecedented crisis through adjusting their portfolio of production assets, it becomes clear that their responses to such a situation are not only rarely studied by learning theorists; they are also strategically important because firms rearrange assets in ways that make them forks in the road. Some decisions can set the firm onto a path toward competitive advantage; other decisions can place it on a path of decline. The findings are very informative about how strategic choices are made. Firms may apply learning responses when facing a crisis, even if the crisis is unlike anything they had seen before. Consequently, learning theory has lessons for strategic responses to severe environmental shocks, and these have applied value for firm decision makers.

Bounded Rationality and Crises

Consistent with Levitt and March (1988), the theory built here predicts organizational changes as a result of how each airline has learned from its own experience

and that of other airlines. Central to the theoretical modeling in experience-based models is how firms differ in their experience before the pandemic started and the information available to them during the pandemic. Before deriving these predictions, it is important to discuss why the decision making was difficult. As outlined by Simon (1955), decision makers need to consider (a) a set of alternative behaviors, (b) the potential consequences of each alternative, and (c) the value of each set of consequences.

The COVID-19 pandemic led to state-imposed mobility restrictions and individual reluctance to travel, which produced severe cash outflows for the airlines. It was uncertain how long the cash outflows would last because the pandemic development was unpredictable, and so were state and individual responses to it. The decision makers needed to (a) focus on a subset of alternative behaviors because the set of all possible responses was too large to consider, (b) make guesses on the consequences because the crisis could change over time, and (c) assess the various losses that could happen against each other. Chief among these were cash losses from operating unneeded activities, loss of personnel who were laid off and could find work elsewhere, costs of idling equipment, and loss of market position if they reduced their supply and competitors did not. These assessments are the bare minimum necessary to do boundedly rational decision making, but even they involved so much guesswork that decision makers were likely to make shortcuts by searching for potential actions based on their interpretation of the crisis.

Predicting responses to an unprecedented crisis requires theory that differs from a theoretical approach that examines learning from experience. This approach involves significant streams of research on refining routines (Argote 1999), observing peers (Kraatz 1998),

resolving goal shortfalls (Greve 2003a), and directing attention (Ocasio 1997). It also differs from an approach that examines interpretations of rare events (Rerup 2009) and an approach examining forward-looking learning through cognitive representations (Gavetti and Levinthal 2000) and analogies (Gavetti et al. 2005). Table 1 illustrates these differences. Each theoretical approach contains a diverse set of research efforts, but the table indicates the main theoretical arguments and contexts in which they have been applied so far. As shown in the table, learning theory has distinct approaches for the repeated tasks dealt with in learning from experience, differentiated interpretation in learning from rare events, resolution of uncertainty in forward-looking learning, and recall and solution generation when responding to unprecedented crises. Each approach has a primary context in which it is applied, but there are also extensions to other contexts.

Learning from Own Simplified Experiences

Theory on responses to an unprecedented crisis should begin with the realization that decision makers understand that they are facing a situation with no direct precedent. An unprecedented crisis requires problemistic search but one that differs from the usual because of its urgency and because the common heuristics of search in the vicinity of the problem and current solutions (e.g., Cyert and March 1963) are problematic; conventional solutions do not fit unique problems. Search can be conducted most rapidly by relying on organizational memory (Levitt and March 1988, Walsh and Ungson 1991) because responses to any similar situation in the past (and their consequences) can be used as a foundation for the next decision. Obviously, past responses to a similar crisis can be repeated if the consequences were favorable, but responses with poor outcomes can also help formulate a response through analyzing the

Table 1. Learning Approaches

Approach	Main application	Context and extensions
Experience-based learning		
Learning by doing	Repeated activities generate learning of routines	Relatively stable contexts with extensions to environmental changes
Learning by observing	Peer organizations inspire changes	
Performance feedback	Problemistic search and change follow low performance	
Attention-based view	Attention is directed by events	
Learning from rare events	Rare and harmful events lead to reconsideration of organizational processes	Events resulting from organizational production processes with extensions
Forward-looking learning	Resolution of uncertainty is done by imposing prior assumptions or analogies from similar contexts	Industry emergence or entry with potential extensions to technological discontinuities
Learning under unprecedented crises	Crises stimulate solutions based on organizational memory or observation of diverse peer responses	Negative environmental shocks with potential extensions to positive environmental shocks

reasons for failure and adjusting accordingly. The responses of peer organizations and their consequences may also be available in the organizational memory, and thus, they may be useful for formulating a response.

The two problems in drawing from organizational memory during the search process are that crises typically do not repeat, so no memory of the same crisis exists, and that even similar past crises may be so temporally distant that organizational memory has faded. Both problems are grounded in organizational learning theory, which emphasizes how knowledge creation requires repetition of the same action or a close variant of it and how knowledge retention over time is difficult, leading to the baseline expectation that organizational learning will not influence the responses to an unprecedented crisis (Argote et al. 2021). We treat this as a null hypothesis of no learning effects on the responses before discussing how the problems of crisis uniqueness and problem retentions may not prevent use of organizational memory to address a unique crisis.

An unprecedented crisis presents the organization with a multidimensional problem in which each dimension provides information that could be useful for estimating the consequences of alternative actions. However, insufficient information on each dimension and the inability to estimate the consequences of each and integrate them across dimensions make fully rational decision making impossible (e.g., Simon 1955). Search for similar situations is still useful, however, and it can start by focusing on the dimension of the crisis that is most relevant to the decision making because it has the greatest economic consequences. Turning a multidimensional problem into a unidimensional one simplifies the search and decision making because it is easier to find similar problems when most dimensions are ignored, and it is easier to decide when only a single dimension is considered (Hodgkinson et al. 1999). For example, although important dimensions of the COVID-19 pandemic were its origin in a deadly disease and significant political controversy about the best policy response in some nations, the economically significant dimension for airlines was the abrupt and significant demand loss, which led to a liquidity crisis. Searching for past demand-loss events would be a reasonable use of organizational memory.

Locating a similar crisis and recalling the organizational responses to it are complex because organizational memory is dispersed across decision makers with familiarity with situations, written records, and stories interpreting past events (Walsh and Ungson 1991). Organizational memory has components that are distinctly different from the procedural memory that underlies the learning processes involved in the creation and retention of routines (Rowlinson et al. 2010). Of particular importance to search for temporally distant events is the retention of memory through narratives celebrating or

denigrating past events and actions (March et al. 1991). Narratives are typically drawn from consequential events in the past. They can be strategically used to construct a consistent view of the organization (Suddaby et al. 2010, Anteby and Molnár 2012, Ravasi et al. 2019), but they can also be contested because different organizational members view and retell narratives differently (Adorisio 2014, Dailey and Browning 2014).

Narratives of organizational history are important for understanding search in response to a crisis because narratives are retained over long time periods and are open to interpretation (Suddaby et al. 2010), creating rich and diverse experience that helps organizational responses (Haunschild and Sullivan 2002, Kim et al. 2009, Argote et al. 2021). Such search is particularly useful if it uncovers memory of the responses of the focal organization and its peers, as this provides more information relevant to the decision as well as greater opportunities to interpret the crisis in ways that facilitate decision making (Weick 1995). The degree to which the interpretation is factual or constructed is less important than its utility in extracting lessons for the current crisis because narratives built from the past of the organization are powerful guides to decision making (Suddaby et al. 2010).

This theory can be applied to our empirical context by considering that the most economically significant dimension for airlines was the demand loss, which decreased revenues and introduced the problem of how to best reduce the costs. With this simplification done, the novel situation of a worldwide pandemic became more familiar, and decision makers could look for past events that although different in their totality, also involved demand loss. For an airline facing demand loss because of the COVID-19 pandemic, the potential actions of aircraft storage, sales, and retirements are obvious, but how strongly to react is the crucial question. Airlines that were directly affected by similar demand-loss situations in the past could apply lessons from them and respond to the crisis with a greater reduction of their fleet.

Global air traffic statistics show that the two greatest demand-loss events in recorded history were those that followed the 9/11 terrorist attack in 2001 and the financial crisis in 2007/2008. These events had specific regional effects, however, so the potential for each airline to learn depends on its age and location. The 9/11 airline crisis was concentrated in the United States, with smaller effects in the rest of the world. In the United States, the impact was so severe that United Airlines, Delta Air Lines, and American Airlines filed for bankruptcy along with many smaller airlines, although the three majors (United, Delta, and American) were able to recover and continue operating. A federal bailout package (the Air Transport Stabilization Board) was assembled, and it supported seven airlines with loan

packages, four of which failed despite the support. In the rest of the world, only three airline bankruptcies are attributed to 9/11, so the effect was lower. If this event was particularly problematic and memorable for decision makers in U.S. airlines, it will be possible to distinguish their responses from those of airlines in other regions. The hypothesis is as follows.

Hypothesis 1a. *U.S. airlines that were in operation during the 9/11 crisis responded more strongly to the COVID-19 pandemic.*

The financial crisis in 2007/2008 is a worse match to the pandemic demand loss because the decline in air travel demand was slower and less severe, but empirically, it has the advantage of affecting different airlines. The financial crisis was felt across most nations with high Gross Domestic Product (GDP) per capita, with particularly strong effects in the United States and Europe (Dobruszkes and Van Hamme 2011). It coincided with high fuel prices and involved a reduction in travel on business class fares, which aggravated the economic effects and led to significant losses by airlines in the affected areas. If this event was particularly problematic and memorable for decision makers in high-GDP nations, it will be possible to distinguish their responses from those of airlines in other regions. The hypothesis is as follows.

Hypothesis 1b. *Airlines that were operating in high-GDP nations during the financial crisis responded more strongly to the COVID-19 pandemic.*

Learning from Others

Organizations learn from each other as well as from their own experience (Levitt and March 1988, Kraatz 1998), and they are especially likely to learn from others if they have little own experience (Henisz and Delios 2001, Chandler and Hwang 2015). The greater learning from others when organizations have little own experience makes this theory especially suitable for investigating responses to an unprecedented crisis. At the extreme, research on congenital learning in organizations has found that newly founded organizations incorporate lessons from nearby similar organizations (Baum and Ingram 1998, Bruneel et al. 2010). Organizations also imitate each other when adopting technological innovations or other practices that are consequential for their performance (Strang and Soule 1998, Naumovska et al. 2021a). As one may expect, this is shaped by the experience and capabilities of the organization that imitates (Dokko and Gaba 2012). Firms also learn from others if they have experience but are facing an environment with high uncertainty or actions of great consequence so that decision makers believe that the actions of others provide a guide to the best choice (Haunschild 1993, Davis and Greve 1997, Ahmadjian and Robinson

2001), as seen in the diffusion of innovations that are consequential for firm competitiveness (e.g., Greve 2009). The crisis responses of the airlines were not innovations but rather, actions taken regularly when economic conditions were poor, but it is still plausible that decision makers would learn about the actions of others to determine the strength of their response. Thus, imitation of the recent crisis responses of peer firms is likely. The hypothesis is as follows.

Hypothesis 2. *Airlines responded more strongly if many other airlines in nearby nations responded strongly.*

Learning from Context

Although imitation is a rapid form of learning that aggregates information from multiple peer firms, it can be flawed because the information revealed by the action of each peer is minor or even absent if the peer also imitates (Bikhchandani et al. 1992, Rao et al. 2001). This flaw can lead to disappointment in the adopted practice and end in abandonment by the firm (Burns and Wholey 1993, Greve 2011, Naumovska et al. 2021b). Because of the dominance of imitation as a form of learning from others in economics, management, and sociology (Bikhchandani et al. 1992, Strang and Soule 1998, Naumovska et al. 2021a), there has been less recognition that more sophisticated learning processes may also be used by firms. Such learning processes should be explored because the theory needs to recognize that decision makers considering imitating a peer firm are likely aware that this peer may also have imitated, and so, they may doubt whether the peer is as informed as the earlier action suggests. Although decision makers may trust peers for decisions like the adoption of a new technology, they understand that other decision makers have little relevant information about an unprecedented crisis, so imitation is not necessarily a good response.

Additional learning processes that hold promise for this investigation are known from research on firms that are newly founded or operating in environments with great uncertainty as such firms repeatedly encounter situations for which they lack experience. These firms learn through bricolage of actions based on observing peer actions, including unsuccessful actions, trying their own responses at a limited scale, and scaling up or down actions based on short-term feedback (Baker et al. 2003, Kim and Miner 2007, Kim et al. 2009). Central to this process is the development of mental representations of the industry and its participants (Csaszar 2018, Menon and Yao 2024). Consistent with this idea, abandonment decisions of nearby peers stop firms from adopting actions that are currently spreading (Greve 2011), suggesting that decision makers observe the context and learn through drawing from multiple information sources. Similarly, noisy failure signals drive learning (Maslach et al. 2018, Say and Vasudeva 2020),

and prior crisis exposure improves responses (Sharma et al. 2021). As in the development of Hypothesis 1a, the crucial step lies in recognizing that diverse information facilitates problem-solving (Suddaby et al. 2010, Argote et al. 2021).

Learning from the context can help organizations that observe the same crisis nearby draw from the responses of their nearby peers, both successful and unsuccessful ones, and then, formulate their own responses. It is different from imitation because decision makers acting as bricoleurs will not necessarily pick the most frequent response, but instead, they will select from the many options chosen by similar firms that experience the same crisis. This form of learning is more effective for organizations experiencing a severe crisis because it allows for observation and comparison of a diverse set of responses. The hypothesis is as follows.

Hypothesis 3. *Airlines that observed more severe crises in nearby nations responded more strongly.*

Learning and Strategic Adaptation

Frequently, learning theory is applied empirically to answer questions about when and how firms make changes (Gavetti et al. 2012), and the question of whether these changes help the firm adapt to the environment is often left to simulation studies (Levinthal and March 1981, 1993; Gavetti and Levinthal 2000). There are good reasons for this division of labor as the assumptions of bounded rationality and incomplete information imply that any individual change has a highly uncertain outcome. It is only through repeated changes that the firm explores the environment sufficiently to adapt well. When forming theory of responses to an unprecedented crisis, there are even better reasons not to hypothesize that these changes will be adaptive because less is known about the environment. Still, even in a complex industry affected by such a crisis, some firms may have learned enough that they can make adaptive responses. For this reason, the tests of Hypotheses 1–3 will be followed by an analysis of whether these learning processes changed the firm adaptation to the environment along strategically important dimensions. This is a more cautious approach than analyzing outcomes, such as return on assets (ROA), as it examines how the decision making changes the firm rather than assumes that the actions have immediate performance consequences (March and Sutton 1997).

Airline Industry Crises

Airlines cost structures require close alignment of assets to demand because the costs of asset acquisition and maintenance are very high, leading to losses if assets are underutilized or prices are low. Even under normal conditions, profitability is difficult to reach for airlines (e.g., Scotti and Volta 2017), and crises leading to demand

loss make it even harder because airlines cannot easily adjust their assets. Airlines have been differentially affected by the major demand loss events. The 9/11 terrorist attack affected air traffic worldwide but with the strongest effects in the United States (Hätty and Hollmeier 2003, Alderighi and Cento 2004, Dobruszkes and Van Hamme 2011). The financial crisis in 2008/2009 reduced air traffic, especially in the developed world, but it had a more gradual demand loss than the 9/11 attack (Dobruszkes and Van Hamme 2011, Chi and Baek 2013). The COVID-19 crisis is the most severe yet, with year-on-year monthly air traffic reductions reaching 90% in many nations as early as April 2020. People's reluctance to travel as a result of a new contagious disease was known before the COVID-19 pandemic because the 2002 SARS epidemic also reduced air traffic demand but at a much lower scale (Chi and Baek 2013). Crisis response is important for airlines because the losses and recovery vary strongly by how well the scale of operations is adjusted to the demand loss (Rupp et al. 2005).

Inspection of airline responses by nation (figures are available from the author) shows some delays in airline responses to the state stringency mobility restrictions as well as varying response timing among airlines. The COVID-19 pandemic was severe and had an unpredictable time path, and airlines had difficulty calibrating their responses to it. Indeed, even popular culture has left behind traces of the difficulty in estimating of the pandemic duration, like the viral YouTube song with lyrics saying the pandemic might end as late as July—of 2020.²

The airline responses to this crisis obviously had to involve idling their aircraft, but it was far less obvious when and how to do this. Storage, retirement (scrapping), and sales of aircraft were potential responses, with different implications for the immediate costs and future capacity of each airline, and the degree to which each airline engaged in each of these is used to test the hypotheses. The scale of each option was consequential as large-scale storage (for example) quickly reduced costs, but it placed the airline at risk for losing revenue and market share when the pandemic ended. This consideration was critical because the worldwide storage demand hit peaks that the industry had never seen before, so the storage contractors would have difficulty quickly bringing aircraft back to service if many airlines simultaneously requested it. Retirement reduced costs more but was an irreversible loss of a production asset. Sales were also irreversible, but they at least generated some cash. In addition, airlines could make strategic choices during this crisis. One choice was whether to accelerate the retirement of less fuel-efficient aircraft while operating modern models having high-bypass engines and composite hulls. Another choice was whether to disproportionately idle the narrow-body

aircraft while operating the wide-body aircraft in case the profitable long-distance routes quickly opened. These choices are studied in a supplementary analysis.

Methodology

Sample and Data Collection

Data on aircraft disposals were obtained from the database AeroTransport Data Bank, which maintains a global database of aircraft and their operators and owners. It tracks all passenger aircraft that can hold 30 or more passengers and has data from 1930 onward. Because each aircraft has a unique identification number assigned by the manufacturer, individual aircraft can be tracked as they change owners and operators. The database also tracks the lessor airline of each aircraft owned by a leasing company. Data from January 2017 to August 2021 were collected, with the end point marking the end of the immediate response to the crisis.

Accounting data on the airlines were obtained from Compustat (U.S. and global editions) and matched to the aircraft database by name. There are 83 airlines in the data, but each analysis drops airlines with all observations having the outcome equal to zero (the fixed effects factor them out); therefore, the number of airlines in each analysis varies by the outcome measured.

Data on the governmental responses to the pandemic were obtained from the Oxford COVID-19 Government Response Tracker (Hale et al. 2021), which tracks a comprehensive range of governmental restrictions and other responses to the pandemic. Data on COVID-19 infections were obtained from the World Health Organization.

Variables

Dependent Variables. The dependent variables are monthly counts of the following aircraft events in the database: stored, retired (scrapped), and sold to another operator. Storage and scrapping are unilateral actions, whereas sales require a buyer. The database gives the timing of these events to the day, but for the analysis, the actions are aggregated to the month (e.g., the number of aircraft stored by Lufthansa in June 2020). Count model analysis is superior to event-history analysis of the timing of these events because airlines often stored, retired, or sold multiples at one date, so event timing is less informative than the count of events during a month.

Hypothesis-Testing Variables. The most important variable indicating the extent of the crisis is the policy stringency of the airline headquarter nation, which is a factor calculated based on the strictness of state lockdown policies that restrict people's mobility (Hale et al. 2021).³ It is updated monthly and interacted with the airline experience variables to measure how responsive each airline is to the environmental changes. Thus, Hypotheses 1a and 1b are tested by the product of state stringency and

indicator variables of prior crisis experience, with 9/11 experience (Hypothesis 1a) set to one for U.S. airlines that were in operation September 11, 2001 and financial crisis experience (Hypothesis 1b) set to one for airlines headquartered in high-GDP-per-capita nations (as defined by the World Bank) that were in operation January 1, 2008. To compare the effect strength of the financial crisis and 9/11 exposure, some models include an indicator variable set to one for non-U.S. airlines in high-GDP nations that were in operation September 1, 2001. Because the models distinguish airlines with a single crisis event from the others, the analyses do not suffer from the bias that many studies of cumulative failure events have (Bennett and Snyder 2017).

Crisis response by other airlines (Hypothesis 2) is set to the sum of aircraft subject to the same action in the same region (using the World Bank regions) in the previous month (e.g., the number of aircraft stored in Europe in May 2020). Using lags of only a month for these actions is suitable because airlines announce these actions as soon as the decision is made, even if the action takes time to complete. A storage decision is announced when the storage contract is signed, and a sales decision is announced when the sales contract is signed, whereas a retirement decision requires no contract to be announced. Aircraft are strategic assets that affect equity valuation, so airlines cannot delay announcement of these decisions. Transferring the aircraft to the storage site, the scrapyard, or the buying airline can happen later, and it will be done as soon as possible because it is costly to keep idle aircraft in operating airports.

Crisis observation by the focal airline (Hypothesis 3) is set to the average stringency in nations in the same region in the previous month. Here, too, a one-month lag is suitable because airlines regularly monitor peers, especially during a crisis.

Control Variables. COVID-19 infection cases are entered as the number of new infections registered per month. They are less consequential than mobility restrictions but are included to isolate the effect of mobility restrictions.

The airline size, measured as the logarithm of its total assets, is entered as a control. Because the analysis has fixed effects for each airline and because total assets cannot be adjusted quickly, an effect of this variable is not expected. Nor is an effect expected of other size variables, such as the number of employees or number of aircraft owned, and preliminary analysis indeed showed no effect of any size variable. The log assets variable was kept because among the three variables, it came closest to showing an effect, and its inclusion may help avoid an omitted-variable bias.

The analysis controls for the financial security of the airline by entering variables to capture its financial slack through the usual measures of absorbed slack, unabsorbed slack, and potential slack (e.g., Bromiley 1991,

Greve 2003a). These are derived from the theory of slack search in the behavioral theory of the firm (Cyert and March 1963), so they may apply to a learning organization seeking to find a solution to a novel problem.

Airlines could initiate problemistic search when the organization encounters performance below the aspiration level (Cyert and March 1963). Problemistic search is tested through the difference between performance, measured as return on assets, and an aspiration level formed as the average of a social aspiration level (average ROA of a peer group) and a historical aspiration level (a weighted average of own past ROA) (Shinkle 2012). Such search seems unlikely during this crisis because the problem the airlines were facing was the COVID-19 pandemic, which is different from having low ROA. Control variables equal to ROA minus the aspiration levels, split between the above and below aspiration-level segments, are still included as a precaution. The aspiration level was calculated as the weighted average of an exponentially weighted sum of last-year aspiration level and ROA and the mean last-year performance of other airlines (Greve 2003a). The parameters for updating the aspiration level and weighting the other-airline ROA were found by estimating the fully specified regressions over the range of possible parameters and choosing those that produced the greatest likelihood. All accounting variables are lagged by a year.

Descriptive Statistics. Table 2 shows the descriptive statistics and correlation coefficients of the variables. Some high correlations warrant attention. The overall stringency and the regional stringency correlate highly,

which is a result of the many observations with a stringency of zero (before COVID-19). The financial crisis indicator variables correlate highly with each other and with regional stringency because of the many U.S. and European airlines in the data, most of which were founded before 9/11 and the financial crisis. These correlations mean that some caution is needed when interpreting the estimates. The high correlation of total and regional stringency is less problematic because the fixed effects condition out parts of this correlation.⁴ A test done by estimating models with only one of these at the time confirmed that the effects were stable. The high correlation of the various experience variables is more problematic as they partly explain the same variance. To handle this, the models will enter one at a time and compare how well they predict the outcomes before a parsimonious model combining the detectable effects is estimated.

Table 3 summarizes the actions taken by the airlines from March 1, 2020, which is the time at which it became clear that a pandemic was starting, although its magnitude was unknown. Placing aircraft into storage was most common followed by returning to service, although with an appreciable difference between the two. Sales and retirements were also common. Buying used aircraft also happened, and the number of purchases was smaller than that of sales because airlines and other firms outside the data set bought from airlines in the data set. Deep discounts were given on some sales (e.g., some were sale and lease-back contracts to release cash), so it is understandable that buyers could be found. Purchases of new aircraft may

Table 2. Descriptive Statistics and Correlations

Variable	Mean	Standard deviation	1	2	3	4	5
1. Stringency	17.59	28.32	1				
2. Cases	16.51	56.48	0.49	1			
3. ln assets	10.49	2.79	0.06	-0.12	1		
4. Absorbed slack	0.81	0.44	-0.09	0.05	-0.20	1	
5. Unabsorbed slack	0.09	0.08	0.13	0.26	-0.04	0.06	1
6. Potential slack	7.45	100.76	0.08	0.02	-0.01	-0.01	0.02
7. ROA below AL	-0.02	0.04	-0.06	-0.08	0.09	0.13	-0.11
8. ROA above AL	0.01	0.02	-0.12	-0.06	-0.10	0.28	-0.11
9. 9/11 experience	2.74	13.03	0.35	0.49	-0.06	0.05	0.18
10. Financial crisis	10.72	23.17	0.71	0.55	-0.08	0.10	0.13
11. Financial crisis outside USA	7.98	20.27	0.58	0.31	-0.05	0.08	0.03
12. Stringency in region	17.06	26.69	0.96	0.50	0.06	-0.06	0.14
Variable	6	7	8	9	10	11	12
6. Potential slack	1						
7. ROA below AL	-0.00	1					
8. ROA above AL	-0.05	0.32	1				
9. 9/11 experience	-0.08	0.00	0.03	1			
10. Financial crisis	-0.05	-0.04	-0.04	0.48	1		
11. Financial crisis outside USA	-0.01	-0.05	-0.07	-0.08	0.83	1	
12. Stringency in region	0.08	-0.07	-0.11	0.38	0.72	0.60	1

Notes. In total, there are 3,140 observations. Pearson correlations with no adjustment are used for fixed effects. AL, aspiration level.

Table 3. Airline Actions from March 2020 Onward

Action	Count
Storage	11,190
Return to service	8,641
Sale	958
Buy new	499
Buy used	357
Retirement	330
End lease	100
New lease	88
Cancel buy	88

be more surprising but also occurred. Most new aircraft purchases were by low-cost and regional carriers, which purchased aircraft models that had acquisition queues because orders exceeded production capacity (Boeing 737 MAX and the Airbus 320 family). This meant that delivery and full payment would happen after the end of the pandemic if the airline correctly estimated the pandemic duration, but purchases still required some advance payment and hence, financial risk. Finally, Table 1 in the online appendix shows the number of airlines in each nation.

Model Specification

The dependent variable is the number of each action taken in a month, so it is a count variable. Accordingly, the Poisson model is used, and because the data are a panel with multiple months per airline, it is possible to control for unmeasured time-constant differences among the airlines through conditional fixed effects. To allow use of different specifications, including some with multiway fixed effects, a Poisson pseudomaximum likelihood specification is chosen (Correia et al. 2020). The regular conditional Poisson maximum likelihood specification can also be used and produces comparable coefficient estimates, but using a single model across specifications simplifies comparison. The pseudolikelihood estimator has conservative standard error estimates that are robust to heteroskedasticity. The models displayed in the tables have fixed effects for the airline, so any time-stationary variable that distinguishes an airline (i.e., whether it is a flag carrier, whether it is a low-cost carrier (LCC), whether it has a cargo-transport subsidiary, and the headquarters location) is factored out by the fixed effect and is not entered as a covariate. Because the hypothesis-testing variables refer to events in the airline's past (the experience indicators) or are external to the airline (state stringency and peer actions), endogeneity is not a concern.

Findings

The first analysis is of aircraft storage, which is the action that has the least long-term implication. Stored aircraft are normally turned over to a storage firm and

are relocated and prepared for storage. Storage locations that are popular because of their dry climates are in Mojave, California (American airlines); Teruel, Spain (European airlines); and Alice Springs, Australia (Asian airlines). For safety reasons, they need to be prepared for return to service as well. Storage reduces cash outlays from operating aircraft that have little or no passenger traffic, but it has some cost and a risk of being unable to return aircraft into service as quickly as would be optimal.

Table 4 shows the findings, testing the hypotheses individually before estimating a parsimonious model with the most important effects discovered from the individual tests. The variables measuring airline experiences do not have main effect estimates in the model because they are factored out by the firm fixed effects, but interactions can be estimated and interpreted as usual. Model (1) in Table 4 shows that the 9/11 experience made airlines place more aircraft into storage as the government-imposed mobility stringency increased ($p = 0.001$), as predicted by Hypothesis 1a. Model (2) in Table 4 shows that the financial crisis experience had no such effect on airlines in high-GDP nations, indicating a lack of support for Hypothesis 1b. Model (3) in Table 4 enters financial crisis experience for airlines in high-GDP nations outside the United States, and the estimated effect is negative ($p = 0.016$). This suggests incorrect learning by airlines that went through the financial crisis and were based outside the United States, which seems reasonable given that the financial crisis led to a more gradual drop-off in passenger traffic than 9/11. The pandemic crisis had demand losses that resembled 9/11 more than the financial crisis.

Model (4) in Table 4 shows strong imitation of other airlines in the region ($p < 0.001$), supporting Hypothesis 2 on mimetic learning. Model (5) in Table 4 shows no contextual learning (Hypothesis 3) as stringency in the region did not lead to more storage of aircraft. Model (4) in Table 4 has the best fit statistic, so learning from the actions of others through imitation predicted the aircraft storage best among the individual effects. The parsimonious Model (6) in Table 4 shows that the 9/11 experience loses significance but that imitation remains significant when entered jointly.

Table 5 shows models of aircraft retirement. This is an important action because scrapping an aircraft can be done unilaterally by the airline; unlike storage, its effect is permanent, so it reduces financial constraints at the cost of constraining strategic options. Scrapped aircraft have no more cash outlays, and they cannot be brought back into service. Model (1) in Table 5 shows that the 9/11 experience did not lead to more scrapping, so Hypothesis 1a is not supported for scrapping. Model (2) in Table 5 shows that financial crisis experience led to more scrapping ($p = 0.026$), supporting Hypothesis 1b. Model (3) in Table 5 shows a similar coefficient estimate

Table 4. Poisson Models of Aircraft Storage

	(1)	(2)	(3)	(4)	(5)	(6)
<i>Stringency</i>	0.017 (0.006)	0.019 (0.005)	0.030 (0.005)	0.013 (0.005)	0.016 (0.014)	0.014 (0.005)
<i>Cases</i>	-0.014 (0.004)	-0.011 (0.003)	-0.012 (0.003)	-0.007 (0.002)	-0.010 (0.002)	-0.009 (0.003)
<i>ln assets</i>	2.356 (1.471)	2.155 (1.343)	2.415 (1.597)	2.123 (1.435)	2.137 (1.340)	2.330 (1.604)
<i>Absorbed slack</i>	-2.409 (0.420)	-2.064 (0.337)	-2.163 (0.413)	-1.875 (0.348)	-2.014 (0.349)	-2.136 (0.439)
<i>Unabsorbed slack</i>	-6.912 (2.497)	-7.743 (2.550)	-7.722 (2.464)	-5.876 (2.048)	-7.681 (2.460)	-5.521 (2.076)
<i>Potential slack</i>	0.001 (0.001)	0.000 (0.001)	-0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)
<i>ROA below AL</i>	8.498 (4.952)	9.936 (5.295)	7.674 (5.227)	4.243 (3.890)	9.792 (5.224)	3.385 (3.907)
<i>ROA above AL</i>	-19.308 (7.911)	-18.683 (7.237)	-19.680 (8.422)	-17.142 (7.411)	-18.845 (7.235)	-18.244 (8.508)
Stringency interactions						
<i>9/11 experience</i>	0.024 (0.007) 0.001**					0.009 (0.007) 0.190
<i>Financial crisis</i>		0.006 (0.006) 0.298				
<i>Financial crisis outside USA</i>			-0.016 (0.007) 0.016*			-0.009 (0.006) 0.134
Region						
<i>Storage</i>				0.001 (0.000) 0.000***		0.001 (0.000) 0.000***
<i>Stringency</i>					0.008 (0.014) 0.552	
Constant	-21.441 (15.698)	-19.487 (14.345)	-22.229 (17.080)	-19.528 (15.334)	-19.344 (14.312)	-21.563 (17.111)
Log pseudolikelihood	-18,916.23	-19,409.30	-19,177.15	-17,844.65	-19,422.88	-17,606.88
Observations	3,140	3,140	3,140	3,140	3,140	3,140

Notes. Poisson pseudolikelihood estimation is given with fixed effects for firms. Robust standard errors clustered by firm are in parentheses, and significance levels are displayed below for the hypothesis-testing covariates.

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

for airlines outside the United States ($p = 0.011$), so having experienced the financial crisis and observed 9/11 did not weaken the response.

Model (4) in Table 5 shows that retirement in the region was not imitated, so Hypothesis 2 is not supported. Stringency in the region positively affects retirement ($p = 0.026$), so learning from the context occurred, as proposed by Hypothesis 3. In Model (3) in Table 5, distinction of airlines outside the United States gave the best model fit among the individual effects.

The parsimonious Model (5) in Table 5 retains the earlier findings, except that the financial crisis loses significance.

Table 6 shows the analysis of aircraft sales. This is an important action because sales also permanently dispose of aircraft, and unlike retirements, they bring in payment. Sales are not unilateral actions, however, and the COVID-19 pandemic was a difficult environment for selling aircraft; therefore, this analysis is mainly to ensure that no effects are overlooked. As one might

Table 5. Poisson Models of Aircraft Retirement

	(1)	(2)	(3)	(4)	(5)	(6)
<i>Stringency</i>	0.013 (0.003)	−0.002 (0.004)	0.003 (0.007)	0.010 (0.004)	−0.013 (0.010)	−0.022 (0.010)
<i>Cases</i>	−0.001 (0.002)	−0.003 (0.001)	−0.001 (0.001)	−0.002 (0.001)	−0.002 (0.001)	−0.001 (0.002)
<i>ln assets</i>	−0.101 (0.372)	0.049 (0.374)	−0.109 (0.372)	−0.012 (0.377)	0.025 (0.372)	−0.0641 (0.382)
<i>Absorbed slack</i>	0.204 (0.348)	−0.048 (0.340)	0.157 (0.303)	0.062 (0.331)	0.038 (0.335)	0.0944 (0.345)
<i>Unabsorbed slack</i>	−6.011 (2.322)	−5.305 (2.347)	−6.151 (2.171)	−5.486 (2.426)	−5.057 (2.345)	−5.652 (2.125)
<i>Potential slack</i>	0.001 (0.000)	0.001 (0.000)	0.001 (0.000)	0.001 (0.000)	0.001 (0.000)	0.001 (0.000)
<i>ROA below AL</i>	3.249 (5.760)	2.776 (5.965)	4.544 (5.819)	2.584 (5.993)	3.645 (6.236)	5.434 (5.899)
<i>ROA above AL</i>	−2.657 (6.329)	0.347 (5.809)	−3.187 (5.815)	−0.578 (5.722)	−0.545 (5.651)	−2.458 (6.209)
Stringency interactions						
<i>9/11 experience</i>	−0.009 (0.009) 0.347					
<i>Financial crisis</i>		0.014 (0.006) 0.026*				0.004 (0.011) 0.741
<i>Financial crisis outside USA</i>			0.016 (0.006) 0.015*			0.015 (0.008) 0.096
Region						
<i>Retirement</i>				−0.012 (0.011) 0.293		
<i>Stringency</i>					0.024 (0.011) 0.026*	0.023 (0.010) 0.021*
Constant	1.169 (4.037)	−0.426 (4.054)	1.310 (4.035)	0.264 (4.103)	−0.221 (4.032)	0.791 (4.141)
Log pseudolikelihood	−1,353.62	−1,351.00	−1,342.31	−1,356.40	−1,353.11	−1,336.57
Observations	2,176	2,176	2,176	2,176	2,176	2,176

Notes. Poisson pseudolikelihood estimation is given with fixed effects for firms. Robust standard errors clustered by firm are in parentheses, and significance levels are displayed below for the hypothesis-testing covariates.

* $p < 0.05$.

expect, there are hardly any findings; Hypotheses 1a, 1b, and 3 do not find support for sales. There is an effect of regional sales ($p = 0.049$), so airlines appear to have sought to imitate sales by peers in the region (Hypothesis 2), with some success. Model (4) in Table 5 fits the data best and is also the parsimonious model given the absence of effects in the other models.

The firm control variables have consistent effects or no effects across the actions examined. When organizational slack had a measurable effect, it was in the

direction of fewer storage, retirement, and sale events. Thus, airlines with savings acted less urgently than those without. Higher returns on assets relative to the aspiration level decreased sales as one might expect if low performance in the previous year strengthened the response to the crisis.

Alternative Explanations

Potential alternative explanations for these findings can emanate from industry-specific considerations or

Table 6. Poisson Models of Aircraft Sale

	(1)	(2)	(3)	(4)	(5)
<i>Stringency</i>	−0.001 (0.002)	0.000 (0.002)	0.001 (0.002)	−0.001 (0.002)	−0.002 (0.009)
<i>Cases</i>	0.000 (0.001)	0.001 (0.001)	0.001 (0.001)	0.000 (0.001)	0.001 (0.001)
<i>ln assets</i>	0.171 (0.141)	0.174 (0.139)	0.178 (0.138)	0.136 (0.143)	0.165 (0.128)
<i>Absorbed slack</i>	−0.377 (0.316)	−0.287 (0.301)	−0.323 (0.311)	−0.278 (0.300)	−0.303 (0.308)
<i>Unabsorbed slack</i>	−2.993 (1.559)	−3.131 (1.514)	−3.156 (1.496)	−3.248 (1.514)	−3.047 (1.509)
<i>Potential slack</i>	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
<i>ROA below AL</i>	−4.436 (1.762)	−4.817 (1.733)	−4.840 (1.760)	−4.344 (1.743)	−4.642 (1.784)
<i>ROA above AL</i>	−7.557 (3.561)	−8.371 (3.802)	−8.336 (3.777)	−6.740 (3.674)	−8.035 (3.621)
Stringency interactions					
<i>9/11 experience</i>	0.005 (0.005) 0.272				
<i>Financial crisis</i>		−0.002 (0.004) 0.627			
<i>Financial crisis outside USA</i>			−0.004 (0.004) 0.318		
Region					
<i>Sales</i>				0.011 (0.006) 0.049*	
<i>Stringency</i>					0.001 (0.009) 0.901
Constant	−0.881 (1.404)	−0.959 (1.393)	−0.972 (1.382)	−0.723 (1.404)	−0.868 (1.307)
Log pseudolikelihood	−3,721.06	−3,723.20	−3,720.49	−3,705.11	−3,723.77
Observations	3,014	3,014	3,014	3,014	3,014

Notes. Poisson pseudolikelihood estimation is given with fixed effects for firms. Robust standard errors clustered by firm are in parentheses, and significance levels are displayed below for the hypothesis-testing covariates.

* $p < 0.05$.

alternative theoretical perspectives. Pressure from external actors, such as sources of financing, might be a potential explanation of these findings, but there are reasons to doubt this explanation. The trigger of airline decision making was internal—their awareness of declining cash and potential bankruptcy—but pressuring banks to extend loans (or risk bankruptcy and debt cancellation), leasing firms to defer payments, and governments to provide support were also part of their action repertoire. The rapid pace of events meant that

the airlines, not external actors, were the main decision makers.

For an alternative theory to explain these effects, it would need to generate similar predictions. For Hypothesis 2, institutional theory and theory of innovation diffusion are alternative explanations because both predict imitation of peer organizations (DiMaggio and Powell 1983, Rogers 1983). The main reason to allocate this finding to learning theory is that the behaviors modeled here are not institutions or innovations, but they

are behaviors that can be learned by observing others (Levitt and March 1988). Hypotheses 1a and 1b appear harder to match to an alternative theory. They posit influence from the organizational experience to its crisis adaptation, which is a clear learning theoretical prediction, with the novelty stemming from the extremely long duration between the experience and its application to the COVID-19 crisis. The theory explains the duration by narratives being invoked in crisis situations, but an alternative explanation is that the actions taken during these earlier crises were more memorable than what earlier research has studied. Hypothesis 3, which states that observing a nearby crisis generates adaptation, is derived from the bricolage argument, and it appears difficult to draw from an alternative theory.

Supplementary Analysis

A supplementary analysis examined the ending of aircraft leases. Although there are few such events (see Table 2), it is prudent to check whether they can be predicted from the same models as sales or retirements. This analysis showed less ending of leases in nations with financial crisis experience and no other effects. This is not surprising. Lease contracts are highly binding on the lessor airline, preventing them from ending leases for strategic or cash-flow reasons. Conversations with industry insiders indicated that deferred payments were occasionally negotiated when a lessor airline had cash-flow problems.

One may wonder whether these findings are general across all types of airlines or whether airlines have structural differences that influence their learning. The data do not have enough observations for complete examination of this issue, but two tests were done and are displayed in the online appendix. First, airlines classified by International Air Transport Association as low-cost carriers may respond differently to the crisis. To investigate this, all hypothesis-testing variables were interacted with an indicator for whether the airline was an LCC, doubling the number of coefficients estimated and allowing chi-squared tests of coefficient estimate differences. For storage, the tests revealed minor magnitude differences in the coefficient estimates but also, that LCCs showed evidence of learning from the context ($b = 0.006$, $p = 0.015$). This difference is substantively important because it means that Hypothesis 3, which did not hold in a pooled analysis, holds for LCCs. For retirement, the estimates showed that LCCs, unlike regular carriers, did not respond to financial crisis experience, retirement by peer firms, or regional stringency, so Hypotheses 1b, 2, and 3 were supported for regular carriers but not LCCs. For sales, there was no difference.

Second, airlines that are current or past flag carriers for their nation may learn differently. This division is not meaningful for the 9/11 exposure because there are no U.S. flag carriers, but for the other hypotheses, testing

could be done. The following differences were found. Flag carriers exposed to the financial crisis outside the United States were less responsive for storage and retirement decisions, and flag carriers were also less responsive to the regional rate of sales. The differences were substantively important because the estimates showed that flag carriers did not have statistically significant reactions, so the hypotheses that held when all carriers were analyzed pooled were, in fact, a mixture of strong effects on nonflag carriers and nonsignificant (but same sign) effects on flag carriers. Thus, the analysis of low-cost carriers and flag carriers uncovered some differences in how they responded, but the main results held across carrier types.

One may also speculate that the effects were stronger before effective vaccines had been developed and distributed. To examine this possibility, models were estimated that compared the coefficient estimates before and after February 2021. In February 2021, the number of vaccines with positive phase 3 trial data increased because Johnson & Johnson and Novavax were added to the stock of vaccines with proven effectiveness (Pfizer and Moderna were already in distribution). Also, in the United States, the number of vaccinated individuals exceeded that of infected individuals for the first time. Model estimates shown in the online appendix confirmed that the coefficient estimates were significantly larger before February 2021 than after February 2021 in the analysis of storage decisions. For retirements, the coefficient estimates of 9/11 and financial crisis experience were also larger before February 2021 than after February 2021. There was no difference for sales.

The next analysis examines whether airlines sought to make their actions adaptive during the crisis or whether their responses were undifferentiated across aircraft models. This analysis is exploratory, so the significance levels should not be taken as hypothesis tests but rather, as indications of whether the effect sizes have some degree of statistical support. Because these analyses divide each airline action into different types of aircraft, the responses are likely to be correlated. To account for the correlation, the estimates are done as bivariate Poisson models using copula functions (Famoye 2010, Xu and Hardin 2016).

Table 7 distinguishes between the standard aircraft models and the new generation of aircraft using fuel-efficient engines and winglets, often combined with lightweight hulls made of composites. Boeing 787 and Airbus 350 are famous examples, but the Airbus neo (new engine option) models and 737 MAX are also fuel efficient (note that 737 MAX aircraft grounded by regulatory authorities were not coded as stored by the airline). For ease of presentation, Table 7 shows only the saturated models, but the complete analysis also includes models with individual variables as a test for consistency. The individual models confirmed the findings displayed here.

Table 7. Poisson Models of Aircraft Actions by Fuel Efficiency

	Storage standard	Storage fuel efficient	Sale standard	Sale fuel efficient
<i>Stringency</i>	0.007 (0.003)	0.011 (0.004)	−0.001 (0.003)	−0.003 (0.006)
<i>Cases</i>	−0.004 (0.002)	−0.003 (0.001)	0.002 (0.001)	0.002 (0.002)
<i>ln assets</i>	0.026 (0.034)	0.075 (0.038)	−0.016 (0.044)	−0.116 (0.085)
<i>Absorbed slack</i>	−0.854 (0.224)	−0.696 (0.285)	−0.421 (0.246)	−1.977 (0.545)
<i>Unabsorbed slack</i>	1.119 (1.795)	0.283 (1.515)	−0.455 (2.167)	0.464 (4.112)
<i>Potential slack</i>	0.001 (0.001)	0.001 (0.000)	0.001 (0.001)	0.001 (0.001)
<i>ROA below AL</i>	14.649 (5.149)	20.577 (3.919)	3.964 (3.440)	14.812 (15.043)
<i>ROA above AL</i>	−2.320 (6.704)	−35.887 (7.478)	−4.320 (5.525)	−82.840 (29.826)
Stringency interactions				
<i>9/11 experience</i>	0.022 (0.005)	0.023 (0.005)		
	0.000***	0.000***		
χ^2 test of difference		n.s.		
<i>Financial crisis outside USA</i>	0.007 (0.004)	0.009 (0.005)		
	0.051	0.063		
χ^2 test of difference		n.s.		
Region				
<i>Sales</i>	0.002 (0.000)	0.001 (0.000)	0.028 (0.008)	0.029 (0.011)
	0.000***	0.000***	0.000***	0.007**
χ^2 test of difference		0.000***		n.s.
Constant	0.772 (0.574)	−0.457 (0.529)	−0.185 (0.597)	0.069 (1.315)
Log pseudolikelihood		−21,980.65		−5,578.92
Observations	3,424	3,424	3,424	3,424

Notes. Bivariate Poisson Famoye parametrization is given with fixed effects for firms. Robust standard errors clustered by firm are in parentheses, and significance levels are displayed below for the hypothesis-testing covariates. The χ^2 test of difference of coefficients is two sided, and the table displays the probability that the coefficients are equal. n.s., not significant.

** $p < 0.01$ (two-sided tests); *** $p < 0.001$ (two-sided tests).

The analysis of storage decisions showed one difference between the standard models and the fuel-efficient ones. Regional storage decisions were imitated with much stronger effect for standard models than for fuel-efficient models. Retirement of fuel-efficient aircraft does not make sense and was not done by any airline, so this is not modeled. Sales showed no difference between standard and fuel-efficient models. Additional support can be gleaned from an event too rare to be analyzed (see Table 2). Although the aircraft manufacturers had large order books for their most fuel-efficient aircraft, few cancellations of orders were made.

Table 8 shows the analysis comparing narrow- and wide-body aircraft models. None of the variables indicating the airline’s own experience showed any significant difference between the two classes of aircraft models. Analysis of storage decisions shows that the narrow-body aircraft are much more strongly affected by the actions of other airlines in the region, and analysis of sale decisions shows the same result. The apparent imitation of storage decisions for narrow-body aircraft makes sense as this is an action with short-term consequences, but it is surprising that the airlines also imitated sales decisions for narrow-body aircraft. The

Table 8. Poisson Models of Aircraft Actions by Size

	Storage narrow-body aircraft	Storage wide-body aircraft	Retirement narrow-body aircraft	Retirement wide-body aircraft	Sale narrow-body aircraft	Sale wide-body aircraft
<i>Stringency</i>	0.009 (0.004)	0.007 (0.004)	−0.023 (0.010)	−0.049 (0.021)	−0.003 (0.004)	−0.005 (0.008)
<i>Cases</i>	−0.004 (0.002)	−0.007 (0.005)	0.000 (0.001)	0.000 (0.002)	−0.000 (0.001)	0.003 (0.001)
<i>ln assets</i>	0.005 (0.032)	0.090 (0.043)	0.037 (0.055)	0.126 (0.058)	−0.078 (0.047)	0.074 (0.040)
<i>Absorbed slack</i>	−0.615 (0.248)	−1.008 (0.366)	−1.406 (0.485)	−1.506 (0.941)	−0.418 (0.292)	−0.934 (0.334)
<i>Unabsorbed slack</i>	0.519 (1.869)	0.725 (2.071)	2.461 (4.054)	3.966 (3.428)	−0.223 (1.951)	0.696 (3.157)
<i>Potential slack</i>	0.001 (0.001)	−0.000 (0.001)	0.001 (0.002)	0.000 (0.001)	0.001 (0.000)	−0.002 (0.001)
<i>ROA below AL</i>	18.798 (6.580)	13.984 (4.109)	24.029 (9.215)	12.329 (7.577)	3.246 (3.879)	9.003 (5.556)
<i>ROA above AL</i>	−8.539 (7.806)	−17.757 (12.974)	11.967 (7.283)	14.508 (10.454)	−1.667 (6.306)	−19.253 (13.765)
Stringency interactions						
<i>9/11 experience</i>	0.024 (0.005)	0.024 (0.010)	0.039 (0.011)	0.046 (0.018)		
χ^2 test of difference	0.000***	0.017*	0.001**	0.013*		
<i>Financial crisis outside USA</i>	0.005 (0.004)	0.014 (0.006)	0.027 (0.008)	0.054 (0.015)		
χ^2 test of difference	0.234	0.015*	0.002**	0.000***		
Region						
<i>Same action</i>	0.002 (0.000)	0.001 (0.000)			0.035 (0.008)	0.008 (0.007)
χ^2 test of difference	0.000***	0.000***			0.000***	0.228
<i>Stringency</i>			0.013 (0.012)	0.006 (0.013)		
χ^2 test of difference			0.249	0.651		
						n.s.
Constant	0.843 (0.496)	−0.277 (0.663)	−1.921 (0.785)	−3.264 (1.252)	0.056 (0.713)	−1.813 (0.682)
Log pseudolikelihood		−23,112.21		−2,322.66		−6,015.64
Observations	3,454	3,454	3,454	3,454	3,454	3,454

Notes. Bivariate Poisson Famoye parametrization is given with fixed effects for firms. Robust standard errors clustered by firm are in parentheses, and significance levels are displayed below for the hypothesis-testing covariates. The χ^2 test of difference of coefficients is two sided, and the table displays the probability that the coefficients are equal. n.s., not significant.

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

evidence of adaptive changes in response to this crisis is not strong, but there are indications that airlines were less influenced by peers when making decisions on fuel-efficient and wide-body aircraft, which are arguably more important assets for competing in this industry.

Discussion and Conclusion

The study has examined whether theory on learning from experience can contribute to our knowledge on how firms act when facing an unprecedented crisis. This is a situation that appears not to permit learning from the firm's own history because the firm and its decision

makers have not experienced shocks of the same kind. It appears not to allow for learning from others because peer firms and their decision makers have not experienced shocks of the same kind either, so their actions should be less informative. Yet, putting aside considerations on how the firms *should* learn and focusing on how its decision makers may *prefer* to learn, it is possible to derive hypotheses on how they learn from own experience and peer experience. The findings indicated that these firms learned both from their own experience and from the experience of others, and they did so in systematic and predictable ways. Conventional learning theory (Levitt and March 1988, Argote et al. 2021) needs theoretical extensions to address organizations facing an unprecedented crisis, but once these are specified, it produces predictions.

Searching the organizational memory for crises that have some similarity, especially in the most economically significant dimension of the crisis, is a learning process that decision makers may apply when facing an unprecedented crisis. This process is theoretically novel, and the analysis showed support for some of the actions that these organizations took. Learning from a context with a high pace of change, possibly through taking advantage of response heterogeneity, is another theoretically novel process, and it also found support for some actions. The well-established learning through imitation was also supported for some actions. The findings are complex because some predictions are supported for some actions, but no hypotheses hold across outcomes.

Finding support for these predictions in the analysis *does not* mean that no decision makers analyzed the situation and independently made boundedly rational decisions along the lines of Simon (1955). Some or even many of the airlines may have found their own solutions to these problems in ways that the models cannot capture, except through the error term of the estimates. The support for these predictions *does* mean that sufficiently many airlines used these learning processes to make them predictive of airline actions, even if some airlines were acting differently.

An interesting possibility is that firms may be applying different learning processes depending on the action considered. Imitation predicted storage of aircraft very well, better than any other process, and this is the fastest and most easily reversible action an airline can take. It reduces cash outflows and has limited strategic consequences. The irreversible action of retiring aircraft, which has strategic consequences, showed no mimetic learning but instead, learning from own experience and from the context. Sales are also irreversible, but they brought in much-needed cash, and for this action, the analysis again shows that imitation predicts the actions best. These findings suggest that decision makers favored mimetic learning but were hesitant to apply it to the most consequential action. They indicate that

decision makers are aware of the weaknesses of mimetic learning when they are in a decision-making context in which all actors have insufficient information and hence, are unwilling to apply it to the most consequential decisions. Failure to find mimetic effects is so rare in research (e.g., Naumovska et al. 2021a) that it is important to examine the conditions under which organizations are less willing to trust the decisions of their peers. An unprecedented crisis is one such condition, although the failure to show mimetic effects was only for the most consequential and strategic action.

The support for learning through applying lessons from other demand-reducing crises, but only those that directly affected the same airline, is novel and in need of additional investigation. Theoretically, it has novelty because this prediction was derived from organizational memory and narrative retention (Walsh and Ungson 1991, Suddaby et al. 2010). Such a theoretical combination has great appeal because a focus on decision makers is fundamental to learning theory (Cyert and March 1963). It is also a notable finding given the context. First, U.S. airlines having greater proximity to this event seems counterintuitive. Although U.S. airlines were uniquely beset by bankruptcies and near bankruptcies after the 9/11 attack, the entire industry observed the events, and many other airlines suffered losses. Second, U.S. airlines having greater proximity to this event seems counterintuitive. The attack was nearly 20 years prior to COVID-19, with different executives in charge of U.S. airlines than the current leadership. Despite the change of leadership, the U.S. airlines were better able to draw from the 9/11 experience than other airlines, so some other memory retention than individual executives drawing from their own history was at work. The same reasoning holds for the financial crisis, although less strongly because it was 12 years prior to COVID-19. These findings constitute strong documentation of organizational memory lasting longer than the individuals with direct experience with events, and they deserve significant research follow-up.

The support for learning from context for the consequential action of retirement but not for storage is also of great interest. It makes perfect sense that decision makers would seek to learn from the actions of peer organizations but that they would not resort to simple imitation when choosing the strategically significant action of asset retirement. Apart from the conceptual appeal of this finding, this analysis cannot demonstrate how they went from observation of airlines in the region under great financial stress, presumably with a variety of airline responses, to decisions to retire more aircraft.

Future research should investigate the mechanisms underlying findings, such as these, with a particular emphasis on distinguishing this theory from alternative explanations. Because many firms went through similar crisis adaptations as these airlines during the COVID-19

pandemic, archival records can be used to reproduce these findings in different industries and hopefully, also go deeper into the firm decision making. To examine the mechanisms underlying the support for Hypotheses 1a and 1b, qualitative research on how these decisions were made (e.g., Rerup 2009) may unravel the internal considerations and the possible use of narratives from earlier events to provide ideas and mobilize support for asset disposals. Similar evidence on internal decision-making processes can be applied to understand how firms that observed severe crises nearby were able to turn a diverse set of solutions by peers into the decisive adaptations observed among airlines. Because the findings in this study matched predictions so well, reproduction of the findings in different contexts has become important. There are still viable alternative explanations, so more data on the decision-making process are also needed.

What do these findings mean for firm decision making? They show that learning from own experience and the experience of others occurs even when it seems daunting. The quality of the lessons can be questioned because it is based on narratives drawn from situations that are unlike the crisis that these firms were facing and even the contextual learning involved bricolage and improvisation. The 9/11 attack and the financial crisis are only similar to the COVID-19 pandemic for a decision maker considering demand loss and ignoring all other features of these crises. A terrorist attack, financial assets unraveling, and a deadly virus are radically different crises. Still, the main finding is that firms with the potential to learn can act in response to a global pandemic instead of being inert.

The strategic implications of these findings are clear once the importance of airplane disposals is recognized. Airplanes are the central production asset for airlines, and their specifications are designed to match their market strategy, whether it involves differentiation across route ranges and cabin classes or instead, is based on low cost. The choices of whether to dispose of aircraft and how in an effort to avoid bankruptcy are a significant dilemma because they involve choices between safer short-term actions and long-term competitive advantage. Storing an aircraft idles the crew, leading to routine loss and higher costs (e.g., Argote 1999, Benkard 2000), and it also temporarily retreats it from markets. Failing to store an airplane that serves a market with insufficient demand produces cash outlays, and even storage of an airplane means greater cash outlays than scrapping or selling. Strategy is about assets, people, markets, and finances, and the aircraft decisions studied here touch all these dimensions.

Despite all these reasons to keep fleets operating during pandemic, the unexpectedly long period of significant mobility restrictions during the COVID-19 pandemic favored the more decisive airlines in storing, retiring, and selling aircraft. Arguably, they benefited

from the learning processes specified in the theory. This is an interesting observation, but it is also one that requires some reservation. Learning processes do not necessarily produce advantages, and one can easily imagine COVID-19 being briefer and less consequential, which would instead give advantages to airlines that disposed of fewer aircraft. The findings here document advantages from learning processes to the extent that firms are generally inert and reluctant to act in response to unexpected events and unprecedented crises. Learning theorists often assume that there is such a bias toward inaction, but examination of more crises is needed to establish this. The suggestion that these learning processes and the underlying experience fueling them are beneficial for the firm still stands, however, and it is worthwhile examining further.

Indeed, it is very promising that firm learning during an unprecedented crisis could be found. It means that the decision making is more predictable than one would anticipate and that further study will be fruitful. Many research questions come to mind. How consistent are these forms of learning across different types of crises and for actions that are either short term or irreversible? The analysis suggested that reversible and irreversible actions were different, but it was an analysis of a single crisis, so the question of whether firms respond differently to different types of crises is unanswered. Also, the analysis shows actions with respect to a strategic asset but not how less strategic assets are handled. How much are these findings influenced by the pivotal role of airplanes in the asset strategy of the airlines? Would firms that, unlike airlines, also have an abundance of peripheral assets act differently? Would human asset strategies be different? These questions should be answered. What features of a crisis determine the value of responses? There are already findings suggesting that incomplete knowledge about a situation reduces the value of responses (e.g., Maslach et al. 2018, Decreton et al. 2023, Kim et al. 2023).

Following this research, additional lines of investigation seem promising. First, researchers should recognize that crises that are unprecedented or just unusual can be observed relatively frequently, especially when considering a single industry or geographical region. For example, the 2024 crisis of missiles targeting ship traffic through the Suez Canal has serious economic consequences for the shipping industry. It resembles the earlier crisis of the container ship *Ever Given* blocking the Suez Canal in 2021, but it is different because shipping firms can still use the Suez Canal at some risk to their ships, crews, and cargo. Many such cases can be found when searching carefully. Examination of the hypotheses derived here can be done in such contexts and will serve to examine how general these findings are. Detailed investigations of the underlying processes also deserve investigation. An important assumption in the

theory is that consequential events, such as a crisis, will be retained as narratives over long periods of time and can be evoked when a similar crisis occurs. The retention of narratives over long periods of time is already established for culturally significant events (Ravasi et al. 2019) and other consequential events (Adoriso 2014), and research has also documented that narratives can also be consequential when they are very selective in their representation of facts (Anteby and Molnár 2012). Further investigation of what narratives enter organizational memory and how they are used during crises would be an important step forward. The intraorganizational decision-making processes also deserve more attention. Work documenting that a rare and consequential event produced highly contested interpretation colored by actor motivation suggests that a more detailed view of decision makers and their sensemaking is needed (Rerup and Zbaracki 2021).

The analysis has provided a useful set of answers but also, a wide range of follow-up questions, no doubt because firms rarely face an unprecedented crisis, and accordingly, few have investigated firm decision making during an unprecedented crisis. This needs to end. We need to know more about how firms respond to rare, unprecedented, and even unique crises and at what cost this action—or inaction—is done. Perhaps the rare research on crises was a reasonable response of scholars given that serious crises have been infrequent and that organizational responses to crises were seen as unpredictable. Both statements are no longer true. Many firms face unprecedented crises on a range of dimensions, including those triggered by this pandemic and the ongoing effects of pollution, climate change, and climate instability as well as geopolitical conflict and contestation. Similarly, the indications of predictable responses shown in this study are a promising start. More research is urgently needed.

Acknowledgments

The author is grateful for helpful comments from Matthew Bothner, Markus Reitzig, and Marc-David Seidel as well as seminar participants at the European School of Management and Technology, George Washington University, INSEAD, the University of Vienna, and Vienna University of Economics and Business. Felipe Csaszar and two reviewers gave excellent guidance in developing the paper. Michelle Ie gave valuable research support.

Endnotes

¹ Because the airlines faced a liquidity crisis and hence, potential bankruptcy, cash outflows were what mattered. The term costs is used here because it is simpler, and all the costs in this discussion produced cash outflows.

² See <https://www.youtube.com/watch?v=M5azNpTwVk8>.

³ The stringency index is maintained by the University of Oxford, and it is described in detail at <https://www.bsg.ox.ac.uk/research/research-projects/covid-19-government-response-tracker>.

⁴ For linear regression, a correlation matrix can be made by deviating each covariate from the firm mean. This is equivalent to conditioning out fixed effects in linear models but not in the Poisson models estimated here.

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