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Understanding the impact of the Covid-19 pandemic through the lens of innovation

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Abstract

In this article, we explore the Covid-19 crisis through the lens of innovation. We focus on the threat and opportunity drivers of innovation, and some of their product/service and process outcomes. We contribute to crisis innovation theory and practice by suggesting that there are two categories of innovation during multi-level crises, such as a pandemic: (1) reactive, threat-driven innovations that are created to contain and respond to organizational problems and disruptions that arise from the crisis; and (2) proactive, opportunity-driven innovations that are created to capitalize on environmental needs and opportunities. We highlight the role of human, physical interdependence in organizations' core technologies that create threats for some organizations and opportunities for others during the pandemic.

JEL CLASSIFICATION: O32; O34; H12

Keywords

Crisis management, Covid-19, opportunity- and threat-driven innovations, product and process innovation

Introduction

The Covid-19 virus pandemic is a multi-level crisis that has disrupted societies across the globe. It is a crisis for various entities, such as individuals, organizations, and societies at large because it threatens their survival and goals (Kovoor-Misra, 2020). As of 23 March 2021, over 123 million cases of Covid-19 and more than 2.7 million deaths have occurred worldwide (World Health Organization [WHO], 2021). Also, by December 2020, S&P Global Market Intelligence reports that there have been 610 bankruptcies in various industries (Wahba, 2020). However, the crisis has not been devastating for all organizations. For instance, 45 of the 50 publicly traded and most valuable corporations have made a profit. Even though some organizations have been able to do so because of layoffs, others have been profitable through innovations (MacMillan et al., 2020; White, 2020). The pandemic is a novel crisis, the likes of which has not occurred since the Spanish flu of 1918 providing us with a unique opportunity to consider various organizational phenomena.

In this article, we reflect on the pandemic through the lens of organizational innovation. When organizations innovate, they produce, modify, and/or adopt a new value-added product, service, process, management system, or market (Crossan & Apaydin, 2010; Gopalakrishnan & Damanpour, 1997). We specifically focus on threats and opportunities, as drivers of organizational innovation during the pandemic, and some of their product/service and process outcomes. We focus on both organizations that are experiencing an organizational crisis, and others who are not in crisis but are innovating to exploit opportunities in their environments. We begin with a review of some key aspects of the crisis innovation literature, and then discuss the threat drivers of innovation during the pandemic and some product/service and process innovations. Next, we review some of the opportunity drivers of innovation and some product/service and process innovations that organizations have been able to generate. We find that

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organizations are able to innovate and reduce threat, and/or capitalize on relevant opportunities in their environments. Therefore, we suggest that there are two categories of innovation during the pandemic: (1) reactive, threat-driven innovations that are created to contain and respond to an organizational crisis; and (2) proactive, opportunity-driven innovations that are created to capitalize on environmental needs and provide opportunities for growth. We also highlight the role of human, physical interdependence in organizations' core technologies that create threats for some organizations and opportunities for others during the pandemic. We conclude our article with a discussion of the implications of our insights for crisis innovation theory and practice.

Organizational crisis innovation

Organizational innovation is complex and is comprised of three main components: drivers and determinants of innovation; the process of ideation, development, and implementation of the innovation; and the outcomes of innovation (Crossan & Apaydin, 2010; Damanpour, 1991; Garud et al., 2013; Gopalakrishnan & Damanpour, 1997; Damanpour & Gopalakrishnan, 2001). Therefore, innovation is both a process and an outcome (Crossan & Apaydin, 2010). In this article, we focus on the crisis as a driver of innovation during the pandemic and some outcomes of organizational innovation. We do not address the processes by which the innovations are generated, adopted, and implemented.

Drivers of innovation are the triggers that initiate innovation in the organization and can be external or internal. External drivers can be new regulations, new markets, and a crisis; and internal drivers could be new knowledge and resources (Crossan & Apaydin, 2010; Zouaghi et al., 2018). Prior crisis innovation research has focused on crises that have been external drivers of innovation, such as the 9/11 terrorist attacks (Birkland, 2004; Goll & Rasheed, 2011), and the 2007–2008 recession (Knudsen, 2019; Zouaghi et al., 2018). Here, we focus on the Covid-19 crisis as an external driver of innovation.

A crisis can motivate and be a driver of organizational innovation because of the attributes in the situation. A crisis situation is characterized by threat to survival and/or goals, uncertainty as to its causes, effects, and means of resolution, and there is urgency because losses can escalate, if it is not quickly contained (Kovoor-Misra, 2020; Pearson & Clair, 1998). Also, multiple stakeholders are impacted by the event and are involved in its resolution, and they foster urgency to address the situation. In addition, it is important to note that a crisis also has opportunities for organizations to innovate, learn, strengthen relationships with stakeholders, enhance the organizational brand, and grow (Kovoor-Misra, 2020). These attributes also apply to the Covid-19 pandemic. For example, Covid-19 poses an economic threat to the survival and goals of organizations, and is a human and social threat to the health and lives of various stakeholders. Multiple organizational stakeholders are involved in the crisis, as governmental agencies establish policies and regulations, employees face reduced or lost jobs; customers fear risks to their health in patronizing services, such as restaurants and gyms; and suppliers face disruptions to their operations. The crisis has created uncertainty for leaders as they grapple with understanding the infectious nature of the virus; its impact on individuals; and how best to address the economic, health, and social consequences of the crisis. In addition, despite these challenges, organizations during the pandemic also have opportunities to learn; innovate to solve problems and meet new needs; build technological and management capacity; strengthen relationships with their employees, customers, and other key stakeholders; enhance their brand; and grow their businesses. However, the degree to which the Covid-19 pandemic is a threat versus an opportunity for organizations varies by industry- and organization-specific attributes, and we discuss this further in the following sections of the article.

Innovation as *outcomes* can vary and take a number of forms (see Crossan & Apaydin, 2010, and Gopalakrishnan & Damanpour, 1997, for a review). In this article, we focus on two forms of innovation outcomes: product/service and process. Product/service innovations are new outputs of the organization for the market. In contrast, process innovations involve new approaches, methods, and technologies that are used in production. The referent in terms of newness can be internal, such as new for a particular organization or external and new for the industry (Crossan & Apaydin, 2010; Gopalakrishnan & Damanpour, 1997).

Prior innovation research, in the contexts of the 2007–2008 financial crisis and recession or the 9/11 terrorist attacks have studied (1) how pre-crisis innovation strategies are associated with smaller demand contractions during a crisis (Knudsen, 2019); (2) the types of innovation used during environmental uncertainties (Madrid-Guijarro et al., 2013); (3) the effect of dynamic capabilities within the firm on organizations' abilities to innovate and weather the crisis (Makkonen et al., 2014); (4) the innovations that emerged because of lessons learned from the crisis (Birkland, 2004); and finally, (5) how innovation output impacts the valuation of firms post-crisis (Nemlioglu & Mallick, 2020). Our article, contributes to crisis innovation research by studying threat and opportunity drivers of innovation during a pandemic and their outcomes.

Threat-driven innovations during the pandemic

A crisis by definition is a threat to the survival and goals of an organization (Kovoor-Misra, 2020). Threatening situations tend to be negative for the perceiver, and there is an expectation of loss rather than gain (Jackson & Dutton, 1988). As organizations are faced with a threat with the onset of a crisis, they tend to be reactive, and threat-rigidity

Table 1. Core technology interdependence and organizational examples.

People interdependence in manufacturing	People interdependence in delivery	
	Low	High
High	• Meatpacking • Pharmaceuticals • Appliance and automotive manufacturing	• Sports Leagues • Hospitals • Airlines
Low	• Video streaming • Network connectors	• Ride-sharing companies

effects may be experienced, where they rely on familiar routines rather than new behaviors to cope (Kovoor-Misra & Nathan, 2000; Staw et al., 1981). However, once organizations have got their bearings, they are able to improvise, innovate, and solve problems to reduce the threats and losses in the situation, and contain the crisis (Kovoor-Misra, 2020). For instance, members of Cantor Fitzgerald, one of the financial services firms that was located in the Twin Towers, had to develop new process innovations to address the needs of the families of their lost employees and new roles and responsibilities for employees so that they could continue to trade after the 9/11 terrorist attacks (Barbash, 2003). Such innovation serves as a means for survival, and a way to overcome the unprecedented challenges for the organization in crisis (Glodzinski & Marciniak, 2016; Klodane & Zvaigzne, 2017; Vergne & Depeyre, 2016).

However, not all organizations experience the same level of threat during a societal crisis. For instance, during the 9/11 crisis, the primary threat was to those organizations located in the Twin Towers and other organizations in its vicinity. The ripple effects were then also felt by the city of New York and the country as leaders sought to ascertain the causes, effects, and means of resolutions for the crisis. Similarly, we suggest that not all organizations experience the same level of threat during the Covid-19 pandemic. This is because the nature of the threat from a virus that is airborne; transmitted by individuals through physical, social interactions; and can be deadly (Centers for Disease Control and Prevention [CDC], 2020) creates vulnerabilities for some organizations over others. Organizations with a *core technology that requires human and physical interdependence* either in manufacturing the product or service or in their delivery are most under threat from the impact of the virus. In addition, the measures taken to mitigate the virus, such as lockdowns by various governments across the world, have also caused disruptions in the core technology and supply chains for global manufacturing organizations, such as those in the automobile industry (Vitale, 2020). In this section, however, we focus on the threat containment innovations of some organizations that have high human physical interdependence in their core technologies as they are directly affected by the Covid-19 virus. For these organizations, there is a motivation to innovate either through creation and/or adoption to reduce human, physical interdependence in their core technology, and the cost to health and life from the Covid-19 virus.

The core technology of organizations is the processes and methods used to produce products and services by transforming raw materials (inputs) into finished products or services (outputs) (Jones, 2013). Due to the Covid-19 virus being highly contagious, airborne, transmitted by individuals who are asymptomatic, and debilitating and fatal for diverse populations (CDC, 2020), organizations that have a core technology that requires individuals to be physically interdependent both in the manufacturing, or in the delivery of their products or services are most impacted by the crisis. Table 1 categorizes some industries by these types of interdependence and provides some examples.

As indicated in Table 1, organizations, such as hospitals, sports leagues, and airlines, are most impacted by the pandemic because of their high interdependence among the employees in operations and between employees and customers in their delivery of services. These organizations tend to use physically interdependent work teams and also have close proximity with their customers and between customers as they utilize their services. For instance, patients in hospitals need physical care, airline patrons are packed in the plane while flying and need service, and spectators who watch a game in-person are in close proximity with each other and with the event staff. Other organizations in the business of meatpacking; pharmaceutical, appliance, and automobile manufacturing; and ride-sharing are also impacted because they have a high interdependence in one of the core technology dimensions. For instance, employees at meatpacking plants, and pharmaceutical, appliance, and automobile manufacturing organizations are at close proximity with each other as they work in assembly lines. Also, drivers in ride-sharing companies are in close proximity with the passengers in their cars. Therefore, the greater the threat from physical interdependence in the core technology of the organization, the greater is the urgency for innovation to reduce economic losses and threats to human life during the pandemic.

The extent that organizations can be innovative and resilient during a crisis is influenced by their financial resources, system capabilities, stakeholder relational

Table 2. Some industries and types of threat- and opportunity-driven innovations.

	Threat driven	Opportunity driven
Product/service innovations	*Hospitals*—Treating Covid-19 and increasing remote services *NBA*—Using technology, to create a virtual fan experience in the arena *Airlines*—Flight to Nowhere, and freight delivery	*Pharmaceutical companies*—Developing treatments and vaccines *Appliance and Automotive*—Repurposing capacity to develop ventilators and hand sanitizers Video Conferencing companies—Developing productivity enhancing tools for customers like video-clipping, file and screen sharing
Process innovations	*Hospitals*—New protocols and technologies for sanitizing and use of PPE for Covid-19, the creation of Covid-19 wards, and crowdsourcing and analytics to manage the supply chain *Airlines*—New protocols for sanitizing and onboarding, and more crew on flights *Meatpacking plants*—New protocols for distancing, sanitizing, and use of PPE *Ride-sharing*—Adapting platform to use existing drivers for food delivery, freight transport, and temporary work	*Network Connectors*—Developing process innovations to increase capacity

PPE: personal protective equipment.

capacity, and the adaptability of their products or services (Kovoor-Misra, 2020). Organizations that have financial slack can buffer themselves from the crisis, withstand losses, and invest in the innovation process. In addition, prior system capability in terms of leadership, online technologies, human resources, innovative cultures, and infrastructure, such as experienced crisis teams, also enable the organization to respond with speed to the crisis. In addition, prior positive stakeholder relationships with a network of key internal and external stakeholders also enable the organization to access knowledge and informational resources, and goodwill, and they provide an ease of coordination and collaboration in the innovation process (Kovoor-Misra, 2020). Finally, the extent to which an organization's products or services can be modified and adapted within the constraints on social interactions because of the virus can also determine the scope and types of innovation. Table 2 highlights industries, such as hospitals, sports leagues, airlines, meatpacking plants, and ride-sharing companies, that were impacted because of physical interdependence in their core technologies, and provides some examples of their product and process innovations, as they sought to contain the Covid-19 crisis. We discuss these examples below. In the next section, we discuss pharmaceutical, appliance, and automotive organizations to highlight how some of them were also able to undertake opportunity-driven innovations to exploit urgent and relevant needs in their environments.

Hospitals: These organizations have been at the front-line striving to contain the damage from the novel Covid-19 virus. Therefore, they were forced to innovate and provide a new health care service of treating Covid-19 patients. In addition, to respond to the urgency, protect their staff, and have capacity to respond to the number of Covid-19 patients, some hospitals partnered with various technology companies to adopt innovations. These partnerships provided them with technological tools to innovate and provide remote services, such as virtual visits, digitally enabled triage that provided a symptom checker, and other remote monitoring technologies to manage those with mild Covid-19 symptoms (Collens, 2020). To execute on their product innovations, some hospitals also created process innovations. They created special Covid-19 wards to separate these patients from others, and created new protocols for sanitizing and the use of personal protective equipment (PPE). Some hospitals also used process innovations to crowdsource PPE from construction workers, nail salons, and others; analytics to manage their supply chain and the need for ventilators, medications, and future PPE needs; cameras to take the temperature of anyone coming into the hospital; and digital platforms for employees to manage their mental health (Collens, 2020). Therefore, through innovations, the hospitals were able to partially reduce their interdependence with their infected patients. However, they also incurred costs both to their finances, and to the health and lives of their employees who were exposed to the virus.

Sports Leagues: Organizations, such as the NBA also experience high physical interdependence in their core technologies. However, because of financial resources through television and advertising revenue and the capacity to modify some of their processes they have created process innovations, such as a "Bubble" to isolate their players from the virus. They have partnered with the Walt Disney World Resort in Orlando to house and feed their players in various hotels and play their games on the premises. They have created strict social distancing and quarantining rules, test the players and staff regularly, and use technology, such as the Oura Ring and the Disney Magic bands to collect health information and track location

(Eadicicco, 2020; Haislop, 2020). These process innovations are targeted at buffering the core technology from the threats of the virus. In addition, since fans are not able to watch the games in-person, the NBA is also using technology to make modifications to their product. To enhance the attractiveness of remote entertainment, they are utilizing a tap-to-cheer app so that fans can virtually cheer on their teams and they have partnered with Microsoft Teams to have the pictures of fans shown on large screens in the arena (Asmelash, 2020).

Airlines: In contrast, airlines are limited by the size of their planes and the cost of flying and have few opportunities to create significant product innovations to transport their passengers. However, Eva Airways, a Taiwanese Airline, has created a product innovation, such as a "Flight to Nowhere." They offered a trip from Taipei to Taipei, and a Hello Kitty plane took some 300 passengers for a 3-hr flight over a number of local attractions (Thet, 2020). Other airlines, such as Emirates have created a new freight service called Emirates SkyCargo where they converted their passenger planes to carry freight. In addition, they have created process innovations, such as the use of rapid Covid-19 tests, new procedures for onboarding to create distance between passengers, and they use a larger crew to provide additional sanitizing of cutlery and restrooms (De Mey, 2020).

Meatpacking plants: These organizations have high interdependence of individuals in their manufacturing, more so than in their delivery, and have had to innovate to buffer themselves from the costs of this interdependence. They have made process innovations, such as using physical barriers between individuals, partnering with health networks to provide testing, and care for their employees, and companies like Tyson during the PPE shortage even created their own face shields out of plastic (Brower, 2020; Cato, 2020). Since these organizations are considered essential services and were able to only incrementally innovate to buffer themselves from some of the health risks associated with their core technology, a number of employees in these organizations have paid the price with their lives or with their health.

Ride-sharing companies: These organizations have high interdependence in the delivery of their services. With reduced demand for their services either because of the lockdown or because passengers' fears of catching the virus, they have had to innovate. For instance, companies like Uber felt pressure to not lose their drivers during the pandemic. They have adapted their platform and have created a new product app called Work Hub so that their over 240,000 drivers can find other jobs either by participating in Uber Eats (food delivery), Uber Freight (freight delivery), or Uber Works (blue-collar temporary jobs). They have also partnered with other large companies, such as FedEx, PespsiCo, and UPS to assist with their logistics (Krish, 2020).

In summary, these examples illustrate that as organizations strive to respond to the urgency in the Covid-19 pandemic, they innovate to either reduce the threat from the physical interdependence in their core technologies or buffer themselves from the risks associated with this interdependence. In this process, they create product and process innovations, and might partner with other organizations as they adopt innovations.

Opportunity-driven innovations during the pandemic

When a firm's environment is jolted because of an event like the pandemic, some organizations are presented with unique opportunities to realign themselves to the new conditions created by the crisis (Wan & Yiu, 2009). The firms that take advantage of these opportunities will find themselves better positioned, not just to manage the external crisis, but also to be more prepared for the post-crisis period. Opportunities, therefore are positive drivers, and when firms experience these drivers, there is a high potential for gain, and a feeling of having the autonomy to take advantage of the situation or crisis (Jackson & Dutton, 1988).

We suggest that the opportunity-driven innovations are likely to occur in industries where (1) the core technology is relatively loosely coupled in terms of people interdependencies both in manufacturing and in delivery; and (2) the organization may have had high interdependencies but was able to mitigate some of the risks from these interdependencies, and exploit urgent and relevant needs in their environments. In the former case, organizations could resort to the use of remote teams and could work with little or no direct human interaction in their core technology, either in the manufacturing and/or distribution of their products or services. Examples of such industries include companies in the business of video streaming, video conferencing, networking, and so on. In these industries, the pandemic created conditions that exponentially increased the demand for their products and found new markets for the use of their products (Koeze & Popper, 2020). In contrast, certain other organizations such as in appliance, automobile, and pharmaceutical manufacturing, even when the core technology was not completely protected, the crisis provided opportunities to adapt their core technology to respond to urgent environmental needs. Organizations in these industries had to adapt quickly since vaccines and other ancillary medical equipment needed to be developed in a timely manner (Ip, 2020; Lee & Trimi, 2021). These organizations had to quickly adopt innovations, such as the use of PPE, testing, and other measures to reduce the risks associated with physical interdependence in their core technology so that they could create product innovations.

The Covid-19 pandemic has created a number of opportunities for organizations because of the impact of the

virus. For instance, educational institutions and other institutions like health care and retailing have needed to "untact" (have no physical contact) in delivering their offerings (Lee & Lee, 2020), creating a demand for remote technologies. In addition, there is an increased need for products that help with remote social engagement and entertainment because of social distancing and lockdowns (Bello et al., 2020; Koeze & Popper, 2020). Furthermore, there is the urgent need to cure, manage, and control the Covid-19 virus, which has generated the search for vaccines, diagnostics, and therapeutics (Lee & Trimi, 2021). Finally, there are new opportunities for organizations to enter industries that had previously been restricted, such as medical devices because of the loosening of regulations (Ip, 2020).

The capacity for firms, however, to take advantage of these opportunities depends on favorable internal conditions, such as having high levels of slack resources in the form of excess manufacturing capacity, human resources, and cash resources. When a firm's performance has been higher than the expected level, firms have sufficient resources and abilities to start a slack motivated search (O'Brien & David, 2014). The available cash resources can be used for innovation through internal development, alliances, or acquisitions. The availability of excess manufacturing capabilities could be redeployed for new product opportunities, or can also help in modifying existing products and services. Based on the urgency of the required innovation and the costs and risks in the situation, organizations make decisions that influence the types of innovation that they undertake, and whether to go at the innovation alone or collaboratively (Copeland, 2020; Grandori & Soda, 1995; Wang et al., 2020). Therefore, the types of opportunity-driven innovations that occur during the Covid-19 pandemic depend on the intersection of environmental opportunities and the internal capabilities of organizations. Table 2 highlights some industries that had opportunities to create product and process innovations during the pandemic. Below, we use illustrative examples of some pharmaceutical, video streaming and networking, appliance, and automotive organizations to discuss the opportunities that they were presented with and the product and process innovations that they created.

Pharmaceutical companies

Pharmaceutical companies have been challenged to rapidly deploy their resources in the areas of therapeutics, vaccines, and diagnostics during the pandemic. The urgency of the need for "products," and the complexity and risks associated with the innovation process has resulted in many collaborative arrangements and partnerships among scientists, private foundations, pharmaceutical firms, and University research centers (Copeland, 2020). Examples of these collaborative efforts for Covid-19 vaccine development and treatments include AbbieVie partnering with the Food and Drug Administration (FDA), the National Institutes of Health (NIH) and the CDC to determine the efficacy of HIV drugs in treating COVID-19; and Amgen and Adaptive technologies working together to develop Covid-19 treatments (Abpi Report, 2020). In addition, Pfizer partnered with the German startup BioNTech for vaccine development and its vaccine efforts grew from something mundane: a new flu vaccine combined with an existing technology—mRNA—that was previously used for vaccine development for other diseases such as Ebola, SARS, and MERS (Herper, 2020). This kind of product innovation through the adaption and combination of previously evolved therapies has been labeled "cooptation" or exaptation (Garud et al., 2018). Such rapid product innovation is driven by the opportunity presented by the environment and the urgency to develop solutions for the crisis at hand.

Video conferencing and networking companies

For some companies in the B2C area (video conferencing) and in the B2B area (network communication), the pandemic has provided opportunities to grow their existing business and the innovations have been in the area of increasing their capacity to deliver their products and services. The opportunities for the videoconferencing companies came about because of three factors—ease of use of services, rise of remote work, and the growing popularity of telemedicine (Newman, 2020; Stowers, 2020). Some of the product innovations that these companies adopted proactively have facilitated their growth. The *product* innovations include customer productivity enhancing tools like video-clipping, file and screen sharing and live video editing, and the use of artificial intelligence/machine learning to transcribe audio and provide insights on attendee engagement (Stowers, 2020).

In the area of B2B, we use the example of network providers to illustrate opportunity-driven innovations. Companies in this industry saw an exponential increase in the demand for their services. Many of these companies have responded by innovating in the *product* and *process* areas to increase their operative capacity for delivery. For example, Verizon, AT&T, and T-Mobile have all made network improvements in 2020 to build network capacity, deliver faster download speeds for users, and engineer smarter networks that can more effectively manage resources (Newman, 2020).

Appliance and automotive manufacturing organizations

The pandemic also provided opportunities for some companies to quickly repurpose their manufacturing capacities and respond proactively by creating product innovations (Ip, 2020). For instance, appliance manufacturers such as

Dyson in the United Kingdom, and automotive manufacturers like General Motors have used their excess manufacturing capacity and skilled labor force to create ventilators that were in serious short supply (Bar Am et al., 2020). Also, True Value, the paint company, proactively made a changeover from paints to hand sanitizers based on demand and the information they gathered from their 4,500 hardware stores (Ip, 2020). The crisis stimulated the innovativeness of many of these manufacturing companies, and they became agile innovators by repurposing their slack and creating necessary *product* innovations (Lee & Trimi, 2021; O'Brien & David, 2014).

In summary, the crisis has offered various opportunities for some organizations to create both product and process innovations. We find that when faced with demand and urgent need during the pandemic, firms that are able make the necessary resource investments and undertake proactive product and process innovations to capitalize on the opportunities in their environments.

Discussion and implications for research and practice

Since the Covid-19 pandemic is a multi-level crisis that affected societies, organizations, and individuals, it enabled us to consider the drivers and outcomes of organizational innovation in this context. Prior crisis innovation research has focused on other multi-level crises, such as the 9/11 terrorist attacks (e.g., Birkland, 2004; Goll & Rasheed, 2011) and the 2007–2008 financial crisis (e.g., Knudsen, 2019; Zouaghi et al., 2018). The Covid-19 pandemic differs from these other forms of crises in the nature of the cause of the crisis, its differential impact on organizations, and its management. Therefore, it provides us with a unique opportunity to consider both the threat and opportunity drivers for innovation during a pandemic, and the kinds of product and process innovations that were undertaken as organizations responded to the crisis.

In this article, we highlighted some of the factors that made some organizations more vulnerable to the Covid-19 crisis than others. We discussed how human, physical interdependence in the organization's core technology, either in the manufacturing of a product/service, and/or in its delivery created threats for some organizations and the need to innovate. In addition, the crisis created new needs and demand that provided opportunities for other organizations to innovate. In this context, we also discussed some product, service, and process innovations that firms undertook to contain the crisis and/or to exploit opportunities in the situation.

Based on our review, we suggest that there are two broad categories of innovation that occurred during the pandemic: those that were created to contain the threat of the crisis and those that were in response to environmental opportunities. Threat-driven innovations are largely reactive and motivated by the acceleration of problems. It is a means to survive in the existing business and retain existing customers. Consequently, it is consistent with other problem-driven searches for innovation (Chen & Miller, 2007; Chrisman & Patel, 2012; Wang et al., 2020). In contrast, opportunity-driven innovations are proactive and are created to capitalize on needs for new products during a crisis. This form of innovation could result in firms growing their existing markets and gaining new customers (O'Brien & David, 2014; Wang et al., 2020).

Our article contributes to crisis innovation research in three ways: (1) The Covid-19 pandemic highlights the role of an organization's core technology in creating vulnerabilities. Prior research on core technologies during a crisis has focused on the tightly coupled technologies during technological disasters (e.g., Perrow, 1984). This article highlights how tightly coupled technologies because of human interdependence in the manufacturing or delivery of a product or service make some organizations more vulnerable to a crisis, such as a pandemic.

(2) In addition, this article shows that even if a crisis creates threat-rigidity effects (Staw et al., 1981), at some point, organizations can innovate to contain the crisis. These innovations tend to be reactive, urgent, and a means to contain damage to the organization and its stakeholders. Finally, (3) we highlight that during a multi-level crisis, all organizations do not experience the same level of threat and opportunity. Therefore, some organizations are able to be proactive and exploit opportunities presented by the crisis. Much of the prior research on innovations during crisis have primarily focused on either threat or opportunity drivers of innovations. We have highlighted the role of both threat and opportunity drivers of innovation and their outcomes during the crisis.

We suggest two avenues for future research. First, future research can empirically test some of our insights to see if they hold in a larger sample of industries and organizations. Second, since our insights are offered while still in the containment phase of the pandemic in the United States, future research can study the longevity of these crisis innovations and the changes they bring about in organizations. Some innovations may be crisis specific, unique to the pandemic, and temporary fixes to reduce threat, such as the use of PPE. In contrast, other innovations, such as the use of remote teams, may get integrated into the organizations "new normal" post-crisis. Examining the longevity of these innovations can provide insights into the short- and long-term uses of crisis innovations.

To conclude, the Covid-19 pandemic provides us with the opportunity to understand the drivers and outcomes of innovations during the crisis. We find that innovations have provided organizations with a means to survive the pandemic, and to exploit opportunities during these challenging and difficult times.

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