Resilience through operational flexibility for crisis response: an international investigation of firm responses during COVID-19

Naser Shekarian  
Information Systems Department, Business School, University of Colorado Denver, Denver, Colorado, USA  
Ronald Ramirez  
Dean’s Office, College of Business Administration, California State University San Marcos, San Marcos, California, USA, and  
Jiban Khuntia  
Information Systems Department, Business School, University of Colorado Denver, Denver, Colorado, USA

Abstract
Purpose – Crisis response has emerged as a salient concern for firms in the onset of COVID-19. While research suggests that resilience is critical during such disruptions, there remains a need to examine how firms build resilience during evolving situations. This study focuses on resiliency created through operational flexibility and examines how firms developed resiliency to COVID-19 through an adaptation of three technology-based levers of flexibility: change in a firm’s product and service offerings, the channel it uses for sales and the location of a firm’s workforce.
Design/methodology/approach – This study uses a unique cross-sectional dataset generated from a survey administered by a reputable financial institution, from March 20 to June 20, during the inception of COVID crisis. This study uses ordinary least squares to analyze data from 6,076 firms across 20 countries.
Findings – Results indicate that flexibility through a combination of a change in a firm’s product and service offerings, with movement to selling through a digital channel, had a positive impact on firm sales. However, flexibility through a combination of change in product and service offerings with workforce location changes had negative impacts. Robustness analysis indicates that negative impacts worsen in countries with higher digitization and in manufacturing and retail firms as compared to service firms, indicating the inflexibility of physical goods–based business models. Results highlight dimensions through which technology-based flexibility can take place and the benefits of flexibility on firm performance.
Originality/value – This study provides managerial insights into technology-based operational flexibility mechanisms that can be employed for building performance resilience during unexpected disruptions. Research findings inform firms facing supply chain challenges and inflation pressures of business today.
Keywords Operational flexibility, Resiliency through operational flexibility, Crisis response, Information technology, COVID-19

1. Introduction
Firms experience crises, from economic downturns and industrial disasters to natural catastrophes and global pandemics. Such events threaten firm viability and existence through their large negative impacts (Williams et al., 2017). For instance, BP’s 2010 oil spill in the Gulf of Mexico led to more than sixty billion dollars in corporate losses [1]. Similarly, the terrorist attack of September 2001 impacted the US airline industry severely, reducing domestic airline revenues by ten billion dollars annually [2]. More recently, the COVID-19 pandemic and its closed borders, safety orders, supply disruption and demand decrease led to a reduction in global economic growth of −4% to −8% in 2020 (Weiss et al., 2021). Indeed, COVID-19 has created wide-ranging
global effects on international trade, supply chain viability and price inflation. Recessionary pressure is the latest headwind [3]. While it is not known when the effects of the current pandemic will eventually dampen, what is known is that this will not be the last disruptive macroeconomic event that firms will experience in the future. It is essential that firms understand how to build resiliency for operating during such times.

Most crises are unexpected, can threaten a firm’s key organizational priorities and afford only a limited time for an effective response (Williams et al., 2017). Actions taken during a crisis can also be risky to a firm as they can have a negative impact on a firm’s stakeholders. To deal with such disruptive events, firms can implement a three-stage crisis management plan: (1) pre-crisis, (2) the crisis and (3) post-crisis (Chen et al., 2019; Coombs and Holliday, 2011). The pre-crisis stage involves planning and preparation activities to develop contingency scenarios and action plans. The crisis stage involves utilizing organizational resources to create and develop ongoing and flexible response capabilities. The post-crisis stage involves a long-term effort to help a firm get back to normalcy, recover from the disruption and resume its daily business operation. While firms can take steps to prepare during the pre-crisis stage, the crisis that occurs may not be within the parameters of what was planned. Also, when a firm attempts to transition back to normalcy, it must first get through the crisis with a level of stability that allows for an attempt toward normalcy.

As such, it is vital that a firm possesses a capability to effectively respond when going through a disruptive event. Such was the case for firms immediately at the end of the dot-com bubble, after the 1979 energy crisis and at the start of subprime crisis in December 2007. Firms need an ability to overcome the challenges of a crisis as it occurs and resiliency offers that opportunity (Ambulkar et al., 2015; Chen et al., 2019; Sawalha, 2015).

The concept of resilience refers to “... the ability of a firm to absorb and adapt in a changing environment to enable to deliver its objectives and to survive and prosper” (ISO 22300 ITIL 4, 2021). Resilience enables a firm “to anticipate, prepare for, respond to, and adapt to both incremental changes and sudden disruptions in the environment” (ISO 22300 ITIL 4, 2021). A resilient firm can sustain itself through a crisis and have the ability to strategically assess uncertain environments (Sawalha, 2015; Tukamuhabwa et al., 2015). Research indicates that in the presence of high uncertainty, resilient firms are able to perform better as compared to non-resilient firms (Dubey et al., 2021; Gu et al., 2021).

In the initial stages of the COVID-19 disruption, firms made significant changes for survival, with technological capabilities playing a critical role in a firm’s flexibility and resiliency (Gu et al., 2021; LaBerge et al., 2020). Technological capabilities can improve the firm’s flexibility that, in turn, improves the resiliency of the firm in times of crisis. Firms can rely on technological capabilities and improve supply chain visibility and transparency (Ivanov, 2021). As a result, a firm is able to effectively cope with disruptive events and acquire an ability to swiftly respond to a change in the environment. This, in turn, enables a firm to become more resilient and retain its business performance in disruptive times (Chen et al., 2019). Indeed, technological capabilities are essential for informing change as IT brings new affordances to store, share and disseminate information across a firm (Jarvenpaa and Staples, 2000; Leonardi, 2007). The multidimensional data provide insights into customers, partners and markets and are evaluated using analytics technology for data-driven decision-making (Mitra et al., 2019). This then affords an organizational flexibility through innovation in new products and services and new organizational forms (Zammuto et al., 2007). New value creation processes are also possible (Edu, 2022). Collectively, IT’s role in facilitating and supporting change motivates firms to employ technology as a mechanism for affording organizational flexibility and agility (DeGroote and Marx, 2013; Edu, 2022) and resilience during times of crisis (Gu et al., 2021). A technology-centric resiliency enables a firm to acquire data, builds an information processing capability and allows a firm to inform key processes, products and organizational forms (Ivanov, 2021).
From a strategic view, a firm’s resiliency can be built through the organizational mechanisms of preservation, retrenchment and innovation (Wenzel et al., 2020). A preservation response involves building capabilities to enable a firm to continue operations at a pre-established level while facing an ongoing crisis or emerging uncertainty. A retrenchment response involves cutbacks, economizing decisions and complexity reduction to manage a crisis while formulating plans for short-term and long-term recovery. An innovation response entails the creation and adoption of new solutions enabled or constrained by a firm’s resource capabilities. As a final alternative, a firm can always choose to discontinue, permanent or temporary, its business activities in response to a crisis when an exit is the most financially prudent action. The COVID pandemic is full of firms who have taken this step through bankruptcy [4].

Resiliency has a multidimensional and complex nature (Tukamuhabwa et al., 2015). Resiliency provides a capability for the firm to respond to a disruption and restore normal operations to resist a shock and recover quickly (Ambulkar et al., 2015). In other words, the resilience capability allows a firm to quickly respond to changes in the environment and actively adjust its response strategies to prevent major disruption to its operations through retaining business performance. Essuman et al. (2020) show that a resilient firm that has developed a mechanism for dealing with a disruption can achieve superior performance outcomes like higher revenue. Wong et al. (2020) show that a firm’s resiliency is associated with a higher financial performance like ROA and profitability. In this study, we use the term resilience in a rather specific and narrow way related to how technology-based levers of operational flexibility mitigate the impact of a crisis on a firm’s sales. Prior research has used financial related measurements like profitability and sales to show a firm’s resiliency in times of disruption (Acquaah et al., 2011; Cheong, 2021).

Research identifies several organizational factors that can improve a firm’s responsiveness and operational resilience including flexibility, agility, adaptability, financial strength, collaboration and visibility (Dubey et al., 2021; Kamalahmadi et al., 2022; Tukamuhabwa et al., 2015). This study concentrates on the dimensions of operational flexibility for building a resilience mechanism. More specifically, this study adds to the literature by examining three technology-based operational flexibility levers for building a preservation resilience capability in firms during times of crisis. Operational flexibility demonstrates a specific concept and concerns the ability of a firm to better respond and rapidly adapt its production resources and operations when faced with environmental change (Kamalahmadi et al., 2022).

Operational flexibility is critical, especially in today’s business environment that is characterized by increasing uncertainties. Because globalization of sourcing, manufacturing and distribution, development of information technology and diversity of customer requirements cause firms to face highly volatile and uncertain environments (Gu et al., 2021). In addition, the high competitive pressure urges firms to shorten product life cycles, increase product variety and utilize new technologies to provide better customized products and services (Anand and Ward, 2004; Jin and Oriaku, 2013). As a consequence, business operations and supply chains are becoming highly complex and dynamic (Mauerhoefer et al., 2017). In this manner, operational flexibility is turning into a core strategic competency (Yu et al., 2015). Many firms have increased the flexibility of operations to acquire certain capabilities which enable them to adapt quickly to changing environments (Kesavan et al., 2014). Flexibility helps firms overcome many of the challenges associated with uncertainties and improves their overall competitiveness (Camison and Lopez, 2010). Because the achievement of sustainable competitive advantage largely depends upon a firm’s ability to change its processes swiftly and reconfigure strategically, and flexibility can provide such ability (Kesavan et al., 2014; Merschmann and Thonemann, 2011).

Moreover, flexibility can enable positive performance impacts in light of uncertainty by, for example, allowing a firm to reduce its supply chain risk through increased agility (Gupta et al., 2019; Swafford et al., 2008). While these studies are informative, there is a lack of research
examining how firms can build resiliency through technology-based operational flexibility change levers in times of crisis. More specifically, this study argues that resiliency for a firm can be achieved through three mechanisms of flexibility: product and service offerings flexibility, workforce flexibility and sales channel flexibility. These operational flexibility levers can combine to enable a firm to retain its business performance during a crisis. Product and service flexibility refers to the ability of a firm to adjust its product and service offerings, such as changes in existing product and service design, development and production in response to new situations like a disruption (Graves and Tomlin, 2003). This includes the creation of new products and services along new innovation paths. For example, Ant Group introduced a free COVID-19–related insurance coverage to its products in response to the COVID-19 pandemic. The firm made this adjustment to address a new customer need while promoting awareness of the firm’s offerings and improving customer loyalty. As a result of the adjustment of products, the firm’s sales improved, despite the COVID-19 crisis (Reeves et al., 2020). In this study, product and service offerings flexibility refers to a firm’s adjustment or conversion, partially or entirely, of its products and services in response to the COVID-19 pandemic. Workforce flexibility is the ability of a firm to enable employees to complete their daily tasks and activities virtually through the internet and online platforms (Liu et al., 2009). This is important as many firms shifted to remote or hybrid working modes after the first inception of the COVID-19 crisis. For example, 50% of employees in the US and 39% of employees in the European Union experienced remote working arrangements in 2020 (Babapour Chafi et al., 2021). Sales channel flexibility, the third dimension of operational flexibility in this study, refers to the ability of a firm to start or deepen sales activities via an online channel, in response to a new environment change (Jin and Oriaku, 2013). In other words, sales channel flexibility indicates a firm’s digital sales capability. For example, Lin Qingxuan company had to shut down 40% of its bricks and mortar cosmetics stores during the first inception of COVID-19, including a complete shutdown in Wuhan, China. However, the company used its in-store beauty advisors as online influencers to enhance customer engagement, and this enabled the expansion of online sales through the use of digital applications and services. As a result, the company’s sales in Wuhan achieved 200% year over year growth in 2020 (Chen and Biswas, 2021). Together, these three operational flexibility change levers contribute to a firm’s preservation response and enable a firm to build resiliency.

As a crisis hits, firms need to rely on operational flexibility capabilities to undergo concurrent and necessary operational changes to adapt to the new environment and retain business performance, with the changes often interdependent upon each other. Accordingly, this study examines the following questions:

**RQ1.** During times of crisis, how does operational flexibility build resiliency that can positively impact firm performance?

**RQ2.** How do the mechanisms of operational flexibility combine together for this impact?

To examine these questions, this study develops a framework of the synergistic benefits of three technology-based change levers of operational flexibility to build a preservation mechanism of resiliency. First, while the development of brand new product and service offerings may be extremely difficult during a crisis, a firm can adjust its current products and services to align with evolving circumstances. For example, restaurants may change their dine-in products and packaging to fit a “to-go” service. Hospitals may deter from offering elective services and concentrate on critical care operations. The adjustments of product and service offerings in response to unexpected situations have been conceptualized in prior literature (Graves and Tomlin, 2003; Yayla-Külliü et al., 2020).

Second, firms try to preserve their sales activities by converting or expanding the sales channel through which their product and service offerings are sold and/or delivered to customers. For instance, restaurants may shut down dine-in and shift to online ordering and
delivery only, or hospitals may rapidly adopt virtual care delivery options. Such sales channel adjustments provide an operational flexibility to adapt to unforeseen conditions (Jin and Oriaku, 2013). Third, managing an organization’s workforce during a crisis presents a significant challenge. Resilient firms look to preserve employee capabilities and functional roles and have the ability to utilize different work modes to enable employees to complete critical tasks. Some employees may be empowered with technology to work remotely while others may be able to maintain their existing work location through technology enhancements. Prior research suggests the ability to adapt an organization’s workforce to maintain operations is an essential flexibility component for firms during uncertain times (Lengnick-Hal et al., 2011; Liu et al., 2009).

The combined effects of the three mechanisms of flexibility, operationalized as two interaction terms in this study, are crucial for deriving value for firms, especially during times of crisis. Two hypotheses are developed to test this proposition. Specifically to examine (1) the interaction between product and service flexibility and workforce flexibility and (2) the interaction between product and service flexibility and sales channel flexibility. Since the relationship between remote workforce and digital technologies has been examined in previous research (Bai et al., 2021; Martínez-Sánchez et al., 2007), this study does not propose an interaction between workforce flexibility with sales channel flexibility.

Furthermore, the study examines whether these two interactions and their hypothesized relationships differ across industry sectors and country settings. The COVID-19 pandemic provides a natural context for studying how the combined effects of operational flexibility mechanisms contribute to resilient crisis response. Firms in different countries and local contexts responded to the COVID-19 uncertainty in unique ways, grappling with challenges to sustain operations, customers and revenues (Soto-Acosta, 2020). Shifting to remote work modes, online sales channels and operational adjustments were identified as response solutions for firms’ survival during the pandemic (LaBerge et al., 2020). Likewise, consumers also shifted to the convenience of online shopping channels, and employees had to stay at home following isolation orders.

The study tests the hypotheses through an econometric analysis of data spanning multiple countries and economic groups. In this context, country-level institutional factors such as information quality, transparency and governance can contribute to the environment in which a firm operates and needs to flexibly adapt (Fainshmidt et al., 2018). The COVID-19 shock also represented a unique situation that created significant uncertainty and disruption across the globe. Because of closed borders and supply delays, the COVID-19 shock impacted not only firm operations locally but also internationally across borders. The empirical analysis utilized a unique cross-sectional database created by merging two datasets concerning 6,076 firms across 20 countries. The database provides information for firms in manufacturing, retail and service industry sectors. The results of an ordinary least square analysis support the hypotheses. Results suggest the interaction between workforce flexibility and product and service offerings flexibility worsens total sales during a crisis, highest in manufacturing firms, followed by retail and service firms. However, sales channel flexibility complements product and service flexibility to increase total sales, highest in service firms, followed by manufacturing and retail firms.

The sensitivity of the results is checked using instrumental variables and other robustness methods such as comparing the economic groups. For example, the study uses a two-stage least squares (2SLS) estimation (Wooldridge, 2016) to check the existence of exogeneity among the explanatory variables, validate the causal implications and address the reverse causality concern (Kesavan et al., 2014; Mithas et al., 2011). Research findings confirm how unique combined effects of the three technology-based operational flexibility mechanisms differ in the creation of value and how they can be utilized by firms to respond and survive during a crisis. In short, this study extends prior work on operational flexibility (Anand and Ward, 2004; Rojo et al., 2018; Stevenson and Spring, 2007; Yu et al., 2015).
to identify new strategic possibilities for crisis preparedness through resiliency (Dubey et al., 2021; Kamalahmadi et al., 2022; Tukamuhabwa et al., 2015).

2. Theoretical development
2.1 Resilience through operational flexibility
Operational flexibility is a well-established concept in operations research (Bernardes and Hanna, 2009; Das, 2001; Fredericks, 2005; Ketokivi, 2006; Yu et al., 2015). Several organizational theories have been used to develop the concept of operational flexibility and examine its role and impact on organizational and supply chain performance, including the theories of contingency (Anand and Ward, 2004; Yu et al., 2015) and resource-based (Fredericks, 2005; Hou, 2020). For example, Anand and Ward (2004) show that the effectiveness of operational flexibility in manufacturing firms is contingent upon the requirement of the environment. More specifically, operational flexibility can make a greater differential impact in an environment with higher turbulence. Because operational flexibility can enable a firm to swiftly build effective capabilities to cope with a turbulent environment. Hou (2020), through the lens of resource-based theory, shows that IT capabilities can enable a firm to become more flexible to develop unique supply chain and operational capabilities. These capabilities, in turn, lead to positive performance impacts such as revenue growth and operational excellence. Das (2001), through the concept of strategic alignment, develops a theoretical framework of operational flexibility in manufacturing firms. Operational flexibility can create an alignment between operational priorities and business strategies. Because operational flexibility enables a firm to adjust the development of products and services, and change business processes to effectively respond to a market change.

This study follows the existing research on operational flexibility to develop a theoretical framework of the synergistic benefits of operational flexibility dimensions to retain the performance of a firm in times of crisis. Literature highlights various operational flexibility practices that can impact firm resiliency including agile adaptability, fast response, and resource utilization (Pettit et al., 2019; Tukamuhabwa et al., 2015). Operational flexibility is a strategic imperative for firms that operate in uncertain and dynamic environments. Crises, globalization, technological changes, and changes in customer needs create an environment of high uncertainty for firms (Rojo et al., 2018). Flexibility can enable a firm to change its resources and production operations to appropriately react to new environmental challenges (Anand and Ward, 2004; Swafford et al., 2008; Yayla-Küllü et al., 2020; Yu et al., 2015). The ability to react and adapt, or resiliency, is achieved through an organization’s ability to transform (Lengnick-Hall et al., 2011). That is, to recognize opportunities and change directions in work modes, workflows, processes, and technologies in support of functional-level strategies and performance improvement in the face of uncertain and adverse conditions (Lengnick-Hall et al., 2011).

Especially, technology plays a key role in improving operational flexibility in the organization to become more resilient. The adoption of technologies like ERP systems (Swafford et al., 2008) and data analytics (Wu et al., 2020) has enabled informed insights for business process improvement and new product development. Technologies allow a firm to integrate, disseminate, and utilize external knowledge within critical processes (Wu et al., 2020). Consequently, technology enabled capabilities can improve flexibility in the development of new products and services by integrating different sources of information (Zammuto et al., 2007). Moreover, technological capabilities enable a firm to better identify its available options for making decisions related to utilizing key organizational resources in operational processes and the development of products and services (Swafford et al., 2008). In addition, a firm can enhance transparency and visibility in its operations and supply
chains through the adoption of digital technologies to swiftly respond to a change in the environment (Chen et al., 2019). This can then lead to more flexibility and then resiliency (Ivanov, 2021).

2.2 Mechanisms of operational flexibility: product and service offerings, sales channel, and workforce

Literature defines operational flexibility as a concept with four major mechanisms related to product and service development, human resources, technology, and the supply chain. Product and service development flexibility has been identified as a critical factor in supply chain management during market uncertainty (Graves and Tomlin, 2003; Yu et al., 2015). Flexibility in products and services can be achieved through management and change of production lead times, production capacity, and product variety in fulfillment of customer expectations (Mitra and Bhardwaj, 2010; Sun et al., 2009). How product and service offerings can be adjusted are dependent on the crisis environment as well as the ability of a firm to reconfigure its resources to meet new requirements.

Human resource flexibility is the ability of an organization to redeploy its labor force in innovative ways (Lengnick-Hall et al., 2011) and has manifested itself in recent times through the use of remote and work-from-home models during the COVID-19 pandemic. The ability of a firm’s employees to work virtually can impact cost efficiency and employee performance, and ultimately, market share (Ketkar and Sett, 2010). These positive outcomes are achieved through office space reduction, fewer required building assets, availability of a telecommuting infrastructure, adjusting work schedules to match the need of customers across time zones, and retaining employees throughout different cities (Choudhury et al., 2021).

The flexibility enabled through technology allows a firm to manage new uncertainties and maintain operations through technology’s information sharing and coordination capabilities (Jin and Oriaku, 2013; Swafford et al., 2008). In recent times, a pertinent example includes rapidly shifting to online sales channels when in-person channels are no longer available. Not only does this allow continued operations, but the functional shift (switching to online sales channels) also offers technology-based benefits like lower-cost operations, transaction efficiency, and a broader customer reach (Swafford et al., 2008).

Supply chain flexibility enables a firm to respond to supply and demand changes in an efficient manner. A firm with supply chain flexibility can manage the operational processes from procurement to customer fulfillment without extra time and cost (Graves and Tomlin, 2003). Moreover, supply chain flexibility enables a firm to respond to new environmental changes through operational process adjustment, resource reallocation, and new functional-level strategies. Prior research finds evidence of positive performance impacts from such changes, for example, in the areas of customer satisfaction (Camison and López, 2010) and risk mitigation in manufacturing and related supply chains (Gupta et al., 2019).

In times of significant uncertainty and unforeseen disruption, such as the COVID-19 pandemic, preserving and maintaining performance essentially mandates operational change. This is difficult as firms face unique institutional, infrastructure, and technological challenges to shift appropriately in the new environment. For instance, adopting workforce flexibility toward remote- and virtual-working models requires both technological and management practice change. On the other hand, factory-based operating models for the manufacture of physical products require a physical presence and as such, workforce flexibility models are naturally limited. Collectively, given the extensive evidence, this study expands existing research on the impacts of operational flexibility (Anand and Ward, 2004; Camison and Lopez, 2010) by examining how three key mechanisms of operational flexibility (product and service offerings, workforce, and sales channel) and their
combinations contribute to a firm’s performance through building resiliency in times of crisis (Dubey et al., 2021; Ivanov, 2021).

2.3 Operational flexibility, technology, and performance

2.3.1 Complementarity between product and service offerings flexibility with workforce flexibility. The flexibility of product and service offerings refers to the ability of a firm to adjust or change the current product or service in response to new environmental changes (Yu et al., 2015). It shows the amount of responsiveness or adaptability for any future change in the design or development of a product or a service, including new products or new services and derivatives of existing ones. Product and service flexibility is a capability requiring concurrent changes in different operational functions, both internally in areas like manufacturing or externally like with processes involving supply chain partners. Successful change may also depend on completion and deployment times as well as the scope of change and the workforce involved, all of which can be challenging (Sirkin et al., 2005). To stay competitive, a firm needs to swiftly sense market changes and adapt existing or develop new products and services (White et al., 2005).

Technology plays a vital role in sensing market changes and providing flexibility in continuous product and service development (Swafford et al., 2008). Firms can rely on technological capabilities to customize their products and services and respond to market changes rapidly (Wu et al., 2020). Technology improves a firm’s sense-making of customer expectations (Zammuto et al., 2007), which can be harnessed by process and organizational level IT capabilities to improve the firm’s products and services (Mauernhofer et al., 2017; Wu et al., 2020). Organizational level IT capabilities help to build an information management and communication foundation that align with technology and business strategies. Process level IT capabilities through web-based platforms improve virtual collaboration. Digital capabilities also enable a firm to develop autonomous products and services, personalize product and service features, and provide real-time interactions with customers (Ardolino et al., 2018).

Workforce flexibility concerns the ability of employees to adapt to new operational processes as well as the location of where work is to be performed. During the COVID-19 pandemic, working remotely became a central component of workforce flexibility (LaBerge et al., 2020). Technology is critical to workforce flexibility as it enables employees to work in remote locations as well as to implement any necessary process adjustments as work shifts from the traditional setting. Higher technology intensity can enhance information dissemination and exchange within a firm, which, in turn, improves employees’ decision making and problem solving attitudes (Choo, 1996; Kawakami et al., 2015). Also, technology can facilitate workforce flexibility through improvements in information access, reduction in coordination and collaboration challenges between firm units, and improved decision making for critical processes like products and services (Ardolino et al., 2018; Bharadwaj et al., 2007; Kawakami et al., 2015).

In sum, during times of crisis, changes to product and service offerings and remote shifting of the workforce complement each other and contribute to higher levels of firm performance. Therefore, it is expected that product and service offerings flexibility will interact with workforce flexibility for a positive performance impact:

\[ H1. \text{ Product and service flexibility with workforce flexibility will combine to improve performance of a firm during a crisis.} \]

2.3.2 Complementarity between sales channel flexibility with product and service offerings flexibility. Sales channel flexibility involves a shift in the channels through which goods and services are offered and sold. For example, launching or expanding a company’s online sales
channel requires an information technology infrastructure that allows a scaled shift to an online ordering process and service departments that can operate virtually with customers. Such an infrastructure enables cross platform coordination through seamless information flow (Gosain et al., 2004; Jin and Oriaku, 2013; Swafford et al., 2008). In other words, when a firm decides to shift to an online channel, it needs to have a robust information infrastructure connecting and integrating all aspects of electronic service (Jin and Oriaku, 2013). This allows a firm to interact with its customers on-demand, improve responsiveness, and integrate after-sales services with transaction processes, creating the opportunity for higher firm performance (Jin and Oriaku, 2013; Lee and Whang, 2000).

The study also argues that opening or shifting to online sales channels during a crisis can complement shifts in product and service design and development. An existing, robust information technology infrastructure provides the opportunity to move to an online sales channel when necessary. Moreover, technology can enable a firm to effectively implement and coordinate new promotion and pricing actions to motivate a behavior shift to new sales channels (Luo et al., 2012; Zhu et al., 2020). The technology infrastructure will support the flow of information and physical goods outcomes and provide a capability to gather, store, access, share, and analyze data associated with the online electronic transactions for future improvements (Gosain et al., 2004; White et al., 2005). Thus, moving to an online sales channel during times of crisis complements changes to product and service offerings, positively impacting performance. Therefore, it is expected that product and service offerings flexibility will interact with sales channel flexibility for a positive performance impact:

\[ H2. \text{ The combination of simultaneous changes in product and service offerings with a shift to an online sales channel will serve to improve performance of a firm during a crisis.} \]

2.3.3 Complementarity between workforce flexibility and sales channel flexibility with product and service offerings flexibility across sectors. Unexpected events can result in significant disruption. In the case of COVID-19, the global supply chain has been impacted significantly due to border lockdowns, changing modes of work, and new environmental restrictions (Gu et al., 2021). For example, firms have experienced material delays due to a shortage of shipping containers and from backed-up ports, as well as a shortage of production and service [5, 6]. Adding to this challenge, in manufacturing firms, the focus of business models is on building physical products in specific, highly capitalized locations, using an onsite production line workforce (Chen et al., 2019). Similarly, traditional retail firms sell products primarily through physical stores and depend on in-store sales and customer service teams (Graves and Tomlin, 2003). As such, a rapid transition to remote work and maintaining current operational levels in manufacturing and retail firms can be more challenging compared to service firms; through their IT infrastructure and technological capability, service firms can transition their non-physical and non-location specific operations more easily (Ardolino et al., 2018). Thus, in times of uncertainty, service firms should be able to adopt operational changes more rapidly and maintain or return to earlier performance levels (DeGroote and Marx, 2013).

According to a Census survey administered during May and June of 2020 [7], the increase in the share of the remote workforce in service sector firms like information and “professional, scientific, and technical services” were highest compared to firms in all other sectors. Firms in manufacturing and retail trade sectors, on the other hand, had remote workforce shifts lower than the average of all firms. Regarding operational indicators such as delays in supply and delivery, retail and wholesale firms experienced the highest negative impacts, followed by
manufacturing firms. Service firms, on the other hand, experienced impacts lower than the 
average of all firms because of the continued offering of their products and services. 
Also, service firms, enabled with a front-end technology infrastructure, will be able to 
create higher information sharing and coordination capabilities in their upstream 
operations (Soto-Acosta, 2020). Consequently, such firms will be able to implement new 
changes in product and service offerings through online sales channel flexibility; the ability 
to rapidly switch to and scale online sales channels for business transactions. These 
benefits should be higher in service firms than in manufacturing and retail firms due to the 
non-tangible nature of their sales offerings and the non-dependency of physical locations 
for sales transactions. The recent Census survey indicates such possibilities [8]. Regarding 
total revenue, firms in service-oriented sectors were higher than those in manufacturing, 
retail trade, and wholesale trade sectors. Also, educational services had the highest online 
sales share increase. Therefore:

\[ H3a. \] During a crisis, the combination of simultaneous changes in a firm’s product and 
service offerings and a shift of its workforce to a remote work mode will have higher 
positive performance impacts in service firms than in manufacturing and retail firms.

\[ H3b. \] During a crisis, the combination of simultaneous changes in a firm’s product and 
service offerings and a shift to online sales channels will have higher positive 
performance impacts in service firms than in manufacturing and retail firms.

The research model is shown in Figure 1. In the first two hypotheses, the study examines 
two interactions on firm performance: (1) the interaction of product and service offerings 
flexibility with workforce flexibility, and (2) the interaction of product and service offerings 
flexibility with sales channel flexibility. In the third hypotheses set, these two interactions 
are examined across groups with unique characteristics; manufacturing, service, and retail 
industry sectors.

![Research model](image)

**Note(s):** * Dotted lines represent non-hypothesized direct effects
3. Methodology

3.1 The cross-country firm-level data and variables

The data for this study originates from a survey conducted by a reputable international financial institution with a worldwide presence, from March to June of 2020. The timeframe provides an opportunity to examine firms, their response, and subsequent performance impacts during an acute stage of the COVID-19 pandemic crisis. Cross-sectional data has been at the foundation of many informative studies in the strategy and value of IS studies, including Bharadwaj et al. (2007, p. 427), Gosain et al. (2004, p. 589), Gupta et al. (2019, p. 46), and Jarvenpaa and Staples (2000, p. 1003). The dataset was matched with a firm-level enterprise survey on business characteristics and performance metrics, collected by the same agency, in the year 2019. Through the use of gross domestic income and digital adoption index (DAI) using publicly available data from the Organization for Economic Co-Operation and Development (OECD), the study is also able to examine the research hypotheses across country groups at different stages of economic development.

The description of research variables, including dependent, independent, and control variables, are provided in Table 1. As detailed in Table 1, the dependent variable in this study is the sales change percentage in 2020 compared to 2019 for the same month. The independent variable product and service offerings flexibility showing if the firm has adjusted or changed its products and services in response to the COVID-19 crisis. Workforce flexibility shows the share of the firm’s workforce working remotely. Sales channel flexibility shows the percentage of the firm’s online sales out of total sales. The study adds several control variables [9] to include firm-specific and industry-specific factors guided by existing research in organizational performance (Bardhan et al., 2013; Kesavan et al., 2014; Mithas et al., 2011; Wu et al., 2020). The study includes the size of the firm (Mithas et al., 2011) by adding two control variables: the number of employees in thousands (number of employees) and firm enterprise size (multi-established firm). Since different types of firm ownership can impact firm performance (Chaganti and Damanpour, 1991), government-owned percentage, as another control variable, is included. Also, since a firm’s focal supply chain functions are related to operational performance (Zhu et al., 2020), the study includes them as control variables (supply change, demand change, and total hours worked change). The study uses manufacturing and retail dummies to control for firms’ sectors. This is done to control for industry specific factors that might influence the estimated contributions of our variables of interest (Kesavan et al., 2014; Mithas et al., 2011). Developed country and developing country dummies are also included to control for the economies (Schneider, 2005).

Table 2 provides the descriptive statistics and correlation amongst variables. The correlation between demand change and supply change as two control variables and developing country and developed country as two dummy variables are greater than 0.5. However, all correlations above absolute value of 0.03 are significant at the 0.01 level. Also, since the VIF test shows the value of 3.38 as the highest, multicollinearity should not be a concern (Wooldridge, 2016). These variables were also dropped from the baseline model and the estimation results were consistent.

3.2 Estimation equation

An appropriate ordinary least squares (OLS) estimation with robust and clustered standard errors was used for analysis, with the potential to minimize the sum of square differences between the predicted and observed values (Hoechle, 2007). OLS has a long tradition in critical business value of IS literature (Kohli and Devaraj, 2003; Tiwana, 2015; Wei et al., 2011). The study specifies the standard OLS equation:
\[ Y_i = X_i \beta + \epsilon_i \]  

Where \( Y \) represents a dependent variable, \( X \) represents a vector of an independent or control variable, such as product and service offerings flexibility, \( \beta \) is a vector of parameters to be estimated, and \( \epsilon \) is the error term associated with observation \( i \). To examine the hypotheses, the base specification includes an examination of the direct effects of independent variables on total sales change. Specifically, the study uses the following model to examine the direct effects of independent variables on total sales change:
<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
<th>1</th>
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<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
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<td>0.35</td>
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<td></td>
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<td>0.17</td>
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<tr>
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<tr>
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<td>0.01</td>
<td>0.01</td>
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<td>0.03</td>
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<tr>
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<td>0.01</td>
<td>0.00</td>
<td>0.03</td>
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<td>0.04</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SupChg</td>
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<td>1</td>
<td>0.52</td>
<td>-0.01</td>
<td>-0.00</td>
<td>0.01</td>
<td>0.05</td>
<td>0.05</td>
<td>0.02</td>
<td>0.05</td>
<td>0.49</td>
<td>0.69</td>
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<td></td>
</tr>
<tr>
<td>GovtOwnedPerc</td>
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<td>100</td>
<td>0.10</td>
<td>-0.04</td>
<td>-0.04</td>
<td>-0.03</td>
<td>0.04</td>
<td>0.02</td>
<td>-0.01</td>
<td>0.10</td>
<td>0.08</td>
<td>0.08</td>
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<tr>
<td>DevD</td>
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<td>1</td>
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<td>-0.10</td>
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<td>0.08</td>
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<td>-0.04</td>
<td>-0.03</td>
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</tr>
<tr>
<td>DevI</td>
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<td>-0.01</td>
<td>0.01</td>
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<td>-0.07</td>
<td>-0.13</td>
<td>0.08</td>
<td>-0.80</td>
</tr>
</tbody>
</table>

Table 2. Descriptive statistics and correlation matrix ($n=6,076$)
As the hypotheses require a test of interaction effects, equation (2) is adjusted to include the interactions. Specifically, the study uses the following model to examine two interaction effects: (1) product and service flexibility interaction with workforce flexibility, and (2) product and service flexibility interaction with sales channel flexibility:

\[
SlsChgPerc = \beta_{10} + \beta_{11}ProdSvcOffrFlex + \beta_{12}WkfcFlex + \beta_{13}SlsChnFlex + \beta_{1c}ControlsC + e_1
\]  

To compare these two interactions across sectors and test the third set of hypotheses (H3a and H3b), this study uses equation (3) and estimates the model for service, manufacturing, and retail sectors separately. Homoscedasticity is examined by employing Breusch-Pagan test and White’s test. The results show significant p-values; implying the null hypothesis is rejected. Therefore, to address the homoscedasticity concern, the study used robust standard errors (Wooldridge, 2016). Multicollinearity was calculated using the variance inflation factor, which showed a value of less than 3.38 across all five models. Independent variables were mean-centered prior to calculating the interaction terms (Wooldridge, 2016). A set of additional analyses were conducted for robustness checks and further insights.

4. Results
4.1 Estimation results to test the hypotheses
Table 3 shows the results of the key combinations amongst variables to test hypotheses. The interaction effect of workforce flexibility with product and service offerings flexibility is significant and negative on sales change (Table 3, column 4, \( \beta = -0.122, p < 0.01 \)). Wald-test results indicate that F-statistics for \((ProdSvcOffrFlex \times WkfcFlex)\) is significant \([F (1, 6,061) = 3.87 \ Prob > 0.049]\); reflecting on the value added by this combination to the baseline model (McDowell, 2005). However, the interaction sign is not consistent with hypothesis H1 and suggests the complementarity between workforce flexibility and product and service offerings flexibility is associated with a decrease in total sales. Multiple concurrent changes as a response to the crisis may be one reason for the negative outcome. Because there may be a natural flexibility limit to location-specific production processes such as in the manufacturing of a physical product. Similarly, an operational change involved with a change in product and service can only be adjusted when a firm’s operations have flexible options or can accommodate creep with shared priorities. Without this, inter-related elements of a firm’s operations will not sync, and disruption can occur (Mitra and Bhardwaj, 2010). Furthermore, quick changes to products and services need to be coordinated and communicated with the workforce, which may not be feasible without a comprehensive information sharing platform and coordination across a firm (Lee and Whang, 2000; Swafford et al., 2008). As a result, a firm’s responsiveness in relation to its competitors could be slower and lead to negative performance outcomes in uncertain times that demand rapid changes (Sun et al., 2009).

The interaction effect of sales channel flexibility with product and service offerings flexibility is significant and positive on sales change (Table 3, column 4, \( \beta = 0.131, p < 0.01 \)). Wald-test results indicate that F-statistics for \((ProdSvcOffrFlex \times SlsChnFlex)\) interaction is statistically significant \([F (1, 6,061) = 6.43 \ Prob > 0.011]\); reflecting on the value added by this combination to the baseline model (McDowell, 2005). These results support
<table>
<thead>
<tr>
<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
</tr>
</thead>
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<tr>
<td>Dependent variable: Sales change percentage</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>ProdSvcOffrFlex</td>
<td>3.470*** (0.741)</td>
<td>3.517*** (0.741)</td>
<td>3.323*** (0.743)</td>
<td>3.336*** (0.742)</td>
<td>2.837** (1.432)</td>
<td>3.942*** (1.013)</td>
<td>2.398 (1.629)</td>
</tr>
<tr>
<td>WkfcFlex</td>
<td>0.038* (0.020)</td>
<td>0.073*** (0.027)</td>
<td>0.036* (0.020)</td>
<td>0.092*** (0.027)</td>
<td>0.082* (0.045)</td>
<td>0.124*** (0.043)</td>
<td>0.047 (0.068)</td>
</tr>
<tr>
<td>SlsChnFlex</td>
<td>0.098*** (0.019)</td>
<td>0.100*** (0.019)</td>
<td>0.054** (0.026)</td>
<td>0.038* (0.026)</td>
<td>0.046* (0.045)</td>
<td>-0.015 (0.040)</td>
<td>0.114** (0.057)</td>
</tr>
<tr>
<td>ProdSvcOffrFlex × WkfcFlex</td>
<td>-0.074*** (0.038)</td>
<td>-0.122*** (0.040)</td>
<td>-0.135** (0.066)</td>
<td>-0.188*** (0.061)</td>
<td>-0.053 (0.063)</td>
<td>-0.142* (0.063)</td>
<td></td>
</tr>
<tr>
<td>ProdSvcOffrFlex × SlsChnFlex</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control variables</td>
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<td></td>
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<td></td>
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<tr>
<td>MultiEstFirm</td>
<td>-2.491** (1.018)</td>
<td>-2.594** (1.019)</td>
<td>-2.508** (1.018)</td>
<td>-2.541** (1.019)</td>
<td>-3.978** (2.004)</td>
<td>-2.103 (1.498)</td>
<td>-3.032 (1.907)</td>
</tr>
<tr>
<td>Mfg</td>
<td>7.484*** (0.807)</td>
<td>7.487*** (0.807)</td>
<td>7.453** (0.807)</td>
<td>7.335*** (0.806)</td>
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<tr>
<td>Retail</td>
<td>3.617*** (1.004)</td>
<td>3.582*** (1.004)</td>
<td>3.598*** (1.004)</td>
<td>3.550*** (1.003)</td>
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<tr>
<td>NoOfEmpK</td>
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<td>4.563*** (0.011)</td>
<td>4.637*** (0.010)</td>
<td>4.757*** (0.100)</td>
<td>21.955*** (5.178)</td>
<td>3.478*** (1.001)</td>
<td>10.439** (5.294)</td>
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<tr>
<td>TotHrsWrkChg</td>
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<td>13.116*** (0.745)</td>
<td>13.138*** (0.745)</td>
<td>13.193*** (0.744)</td>
<td>15.952*** (1.459)</td>
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<tr>
<td>DemChg</td>
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<td>20.913*** (0.798)</td>
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<td>20.930*** (0.797)</td>
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<td>SupChg</td>
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<td>7.370*** (0.795)</td>
<td>7.372*** (0.795)</td>
<td>9.134*** (1.569)</td>
<td>6.031*** (1.064)</td>
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</tr>
<tr>
<td>GovtOwnedPerc</td>
<td>0.151*** (0.030)</td>
<td>0.152*** (0.030)</td>
<td>0.150*** (0.030)</td>
<td>0.151*** (0.030)</td>
<td>0.036 (0.003)</td>
<td>0.161*** (0.028)</td>
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<tr>
<td>DevD</td>
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<td>6.303*** (1.448)</td>
<td>6.192*** (1.448)</td>
<td>6.325*** (1.448)</td>
<td>5.582*** (1.613)</td>
<td>5.077*** (1.613)</td>
<td>8.255*** (2.915)</td>
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<td>-0.210 (1.321)</td>
<td>-0.365 (1.321)</td>
<td>-0.211 (2.125)</td>
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<td>0.428</td>
<td>0.428</td>
<td>0.428</td>
<td>0.382</td>
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<td>0.518</td>
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<tr>
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<td>0.427</td>
<td>0.427</td>
<td>0.428</td>
<td>0.378</td>
<td>0.408</td>
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<tr>
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<td>348.52</td>
<td>324.05</td>
<td>324.37</td>
<td>303.77</td>
<td>90.55</td>
<td>157.43</td>
<td>98.67</td>
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</table>

**Note(s):** RSE: Robust standard errors; Significance levels: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$
hypothesis H2 and suggest that sales channel flexibility complements product and service offerings flexibility for an increase in total sales. As a sensitivity test, combined Wald-test for both interaction terms show significant F-statistics $[F (2, 6,060) = 7.82 \ Prob > 0.004]$, reflecting the combined robust value added by both combinations.

Columns 5 to 7 in Table 3 present the key results of how the hypothesized combination effects vary across industry sectors to test hypotheses 3a and 3b. To examine whether different coefficients (ProdSvcFlex $\times$ WkfcFlex and ProdSvcFlex $\times$ SlsChnFlex) per industry sector are comparable, the study created two three-way interaction terms for each baseline model interaction by multiplying with manufacturing and retail as two dummy variables in a single regression model. The study then performed Wald-test by using the “test” command in Stata. The result of Wald-test gives $[F (2, 6,070) = 7.17 \ Prob > 0.000]$ and $[F (2, 6,070) = 8.52 \ Prob > 0.0000]$ values, respectively. By comparing the coefficients, the complementarity of product and service offerings flexibility and workforce flexibility has a lower negative impact on total sales for service firms than manufacturing and for retail firms is not significant. While the sign of coefficients is in the opposite direction, the differences in impact are as expected. Therefore, H3a is broadly supported for service and manufacturing firms, but does not hold for retail firms. Also, the complementarity between product and service offerings flexibility and sales channel flexibility has a greater impact on total sales for service firms than for manufacturing and retail firms. Therefore, H3b is supported.

4.2 Sensitivity and robustness checks
The direct effects of three change levers of operational flexibility are associated with higher sales during a crisis (Table 3, column 1), consistent with the existing research establishing the positive impact of operational flexibility on firm performance (Ketkar and Sett, 2010; Swafford et al., 2008). The control variables are generally in the expected directions. For instance, demand change and supply change have a significant and positive effect on total sales. Similarly, firm size and total working hours positively impact total sales. Figures 2 and 3 present combinations of key operational flexibility levers. Figure 2 shows that when there is higher workforce flexibility, the effect of product and service flexibility on total sales change will weaken. Research results may indicate that while a firm could shift its workforce to new locations quickly during COVID-19, the firm may not have yet been able to sufficiently transition its operational...
processes to the new environment. Figure 3 highlights that when sales channel flexibility increases, the effect of product and service flexibility on total sales change will strengthen as total sales increases. This indicates that swiftly changing sales channels is critical for delivering new forms or types of products and services more appropriate for the new crisis-oriented market.

4.3 Results of additional analyses
This study conducts an additional set of analyses. First, it compared the complementarity results across country groups based on the digital adoption index (DAI). DAI is a country-level measurement that is calculated by World Bank Group and shows digital adoption per country. Columns 1 and 2 in Table 4 provide the estimation results. This study performed the Wald test to confirm coefficients between models 1 and 2 are comparable. By considering the first combination in Table 4 (ProdSvcOffrFlex \( \times \) WkfcFlex), the coefficient for column two is less negative than the coefficient in column one. Therefore, the complementarity between product and service offerings flexibility and workforce flexibility has a higher negative impact on total sales for firms in countries with a higher level of digitization. Also, by considering the second complementarity (ProdSvcOffrFlex \( \times \) SlsChnFlex), the coefficient for column two is greater than the coefficient in column one. Moreover, the complementarity for column 1 is not significant. Therefore, the complementarity between product and service offerings flexibility and sales channel flexibility has a positive and greater impact on total sales for firms in countries with a lower level of digitization.

Second, the study examined the baseline models for capacity utilization as another dependent variable for manufacturing firms (Table 4, columns 3 and 4). Capacity utilization is a firm’s output produced as a percentage of the maximum possible output that can be produced. Except for workforce flexibility that has a negative impact on capacity utilization, the estimation results are consistent with the baseline models in Table 3. Because capacity utilization for manufacturing firms is a function of production line employees and processes. When manufacturing firms shift to remote work, production line employees will decrease, and it takes time to align and adjust to new changes; thereby, the capacity utilization will be impacted negatively.

Third, the study examines the existence of endogeneity among the model explanatory variables, which can be a threat to the causal implications. It is possible that firms with higher investments in R&D and IT resources have a more effective infrastructure,
<table>
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<th>Analysis type</th>
<th>(1) Country group comparison</th>
<th>(2) Country group comparison</th>
<th>(3) Another dependent variable</th>
<th>(4) Another dependent variable</th>
<th>(5) Instrumental variable</th>
<th>(6) Instrumental variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Above DAI average</td>
<td>Below DAI average</td>
<td>Direct effects</td>
<td>Interactions</td>
<td>Direct effects</td>
<td>Interactions</td>
</tr>
<tr>
<td>Variable</td>
<td>Sales change percentage</td>
<td>Capacity utilization</td>
<td>Sales change percentage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ProdSvcOffrFlex</td>
<td>0.902 (0.865)</td>
<td>5.236*** (1.362)</td>
<td>4.687*** (0.983)</td>
<td>4.574*** (0.983)</td>
<td>1.871* (1.121)</td>
<td>2.464** (1.086)</td>
</tr>
<tr>
<td>WkfcFlex</td>
<td>0.107*** (0.038)</td>
<td>0.072* (0.040)</td>
<td>-0.077*** (0.032)</td>
<td>-0.008 (0.047)</td>
<td>1.631*** (0.361)</td>
<td>2.266*** (0.402)</td>
</tr>
<tr>
<td>SlsChnFlex</td>
<td>0.060 (0.036)</td>
<td>0.012 (0.039)</td>
<td>0.085*** (0.031)</td>
<td>0.028 (0.046)</td>
<td>0.466*** (0.118)</td>
<td>0.616*** (0.121)</td>
</tr>
<tr>
<td>ProdSvcOffrFlex × WkfcFlex</td>
<td>-0.130*** (0.057)</td>
<td>-0.107*** (0.058)</td>
<td>-0.147*** (0.063)</td>
<td>-2.285*** (0.401)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ProdSvcOffrFlex × SlsChnFlex</td>
<td>0.054 (0.050)</td>
<td>0.183*** (0.061)</td>
<td>0.124** (0.059)</td>
<td>0.707*** (0.128)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control variables</td>
<td>All included</td>
<td>All included except industry sectors\textsuperscript{a}</td>
<td>All included</td>
<td>All included</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>3,793</td>
<td>2,283</td>
<td>2,851</td>
<td>2,851</td>
<td>5,913</td>
<td>5,913</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.449</td>
<td>0.348</td>
<td>0.284</td>
<td>0.286</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F/Wald ( \chi^2 )</td>
<td>237.18***</td>
<td>93.22***</td>
<td>110.51***</td>
<td>94.21***</td>
<td>2204.92***</td>
<td>2214.81***</td>
</tr>
</tbody>
</table>

Note(s): Standard errors in parentheses; ***\( p < 0.01 \), **\( p < 0.05 \), *\( p < 0.1 \)
\textsuperscript{a}The sample for models 3 and 4 only contains manufacturing firms.
and this can impact both independent and dependent variables in the conceptual model of this study (operational flexibility and financial performance). In addition, it is also possible that a firm's ability to make changes in its operations, like the adjustment of processes, depends on its business performance. To empirically validate the argument on the existence of exogeneity, this study employs the instrumental variable method. Specifically, two-stage least squares (2SLS) estimation is used. Following the literature (Kesavan et al., 2014; Salge et al., 2015; Zhu et al., 2020), two instrument variables were included. The first instrument variable is a firm's sales in 2019. Higher financial performance and reserves from the previous year enable a firm to be more flexible during times of crisis. For instance, a firm can make more investment in IT infrastructure to shift to remote work effectively. Also, a firm with higher financial reserves confronts fewer operational risks and is able to swiftly adjust its product and service development in response to environmental changes.

The second instrument variable is if a firm has its own online channel platform. According to DeGroote and Marx (2013), technological change levers in the supply chain increase supply chain responsiveness, which in turn enables a firm to react rapidly when a disruption occurs. A higher level of technology adoption enables a firm to be more agile, thereby retaining its performance level in times of crisis. When a firm has its own online sales platform, IT development flexibility increases, which in turn accelerates shifting to or expanding sales channels in response to a crisis.

Columns 5 and 6 in Table 4 show 2sls results. The direct effects of workforce flexibility, product and service offerings flexibility and sales channel flexibility on total sales change are positive and significant (Column 5). Additionally, the interaction effect of workforce flexibility with product and service offerings flexibility on total sales change is significant and negative (column 6, $\beta = -0.285, p < 0.01$), and the interaction effect of product and service offerings flexibility with sales channel flexibility on total sales change is significant and positive (column 6, $\beta = 0.707, p < 0.01$). Therefore, estimation results are consistent with baseline models in Table 3, and endogeneity should not be a concern.

5. Discussion and contributions

5.1 Research findings

This study examines how operational flexibility creates a resilience in a firm that allows it to retain its performance during times of crisis and hypothesizes how three types of flexibility mechanisms work together to provide a level of resilience that has a positive firm impact. Firms can use technology to switch to a remote workforce and transition to an online sales channel to continue to offer their products and services in spite of the environmental challenges it faces. The study tests the research hypotheses through an econometrics analysis of data collected during the initial shock of COVID-19 in 2020. Surprisingly, it was found that a flexible response enabled through the interaction of a change in a firm’s workforce location with its product and service offerings reduced sales during the COVID-19 crisis. However, flexible response enabled through the interaction of a firm's digital sales channels with its product and service offerings enhanced sales during the COVID-19 crisis. Additional analyses suggests that the impact of these two interactions varies across firms in different industry sectors and country groups. The combination of changes in a firm’s workforce location and its product and service offerings impacted total sales more negatively for manufacturing firms and those firms in countries with a higher level of digitization. However, the flexible combination of changes in sales channels and product and service offerings contributed to higher sales in the service sector and in lower digitized countries.
5.2 Theoretical implications
This study extends research examining the role of operational flexibility, as the enabler of resiliency, on organizational performance (Rojo et al., 2018; Stevenson and Spring, 2007; Yu et al., 2015). Specifically, resiliency enabled through technology-based flexibility during times of environmental uncertainty and disruptive change. Existing research identifies resiliency as a critical lever of change in such environmental scenarios (Dubey et al., 2021; Kamalahmadi et al., 2022; Tukamuhabwa et al., 2015), but has yet to investigate this type of technology-based adjustment. Through operational flexibility, a firm can adapt to a new form of fit in three ways (Yu et al., 2015): a match of its operational flexibility mechanisms with environmental factors to absorb constant change; operational flexibility to effectively utilize intra- and inter-organizational resources to preserve supply chain performance; and a synergistic mix of operational flexibility mechanisms with organizational resources. This study demonstrates how combinations of technology-based operational flexibility mechanisms can enable a firm to productively respond in uncertain times and create a resiliency that generates performance benefits. This study specifically develops a theoretical model of resiliency through technology enabled operational flexibility levers (Gosain et al., 2004; Jin and Oriaku, 2013) that focus on human resource (Lengnick-Hall et al., 2011), and product and service change (Mitra and Bhardwaj, 2010; Sun et al., 2009).

During times of crisis, firms can rely on technology to enable a flexibility that can meet the challenges presented by environmental change that allow them to maintain positive sales activity. More generally, this study contributes to knowledge of how organizational change takes place through technological capabilities (Zammuto et al., 2007), that such capabilities can help a firm adapt to areas like product and service development (Ardolino et al., 2018; Mauerhoefer et al., 2017), and that such adaptations can positively and ultimately contribute to firm performance (Kawakami et al., 2015; Swafford et al., 2008).

This study contributes to resilience research by identifying mechanisms of technology-based operational flexibility that can provide an effective resilient response during unexpected disruptions. This preservation response involves using technology to build capabilities that enable firm operations to live through an unexpected crisis and the continued pursuit of strategic goals. The study also provides evidence of the importance of sectoral heterogeneity in leveraging operational flexibility modalities for resilience-based crisis response. Service sector firms appear to be in a better position to adapt to environmental change perhaps, in part, to the intangible nature of their offerings. There are no entrenched manufacturing capital assets impeding dynamic adaption to the environment. Furthermore, country-level factors influence operational flexibility, as items like governance quality, transparency, and digital readiness can impact an organization’s ability to change (Fainshmidt et al., 2018). However, our results imply that firms who are dependent on international sales and delivery, when faced with closed borders like those that existed during the early days of COVID-19, cannot counter negative sales forces despite the flexibility enabled through technology. At least, the dimensions of flexibility examined in this study.

5.3 Practical implications
The viability of firms during and after a time of crisis is not guaranteed. To ensure survivability and long run financial health, firms need to constantly develop unique organizational capabilities for crisis resiliency. Technology-based operational flexibility can offer this opportunity. Information technology can help with a firm’s information sharing, processing, and coordination capabilities, enabling informed decision making and reducing environmental uncertainty (Bharadwaj et al., 2007; Choo, 1996). Moreover,
the use of technology and management practices for building operational flexibility is critical during times of crisis. The research results indicate firms can build effective resiliency mechanisms through the combination of three technology-based operational flexibility change levers related to product and service offerings, workforce location, and a firm’s sales channels. This may speak to the importance of alignment of the various change levers of flexibility in an organization, as well as its production and support structure (Mitra and Bhardwaj, 2010; Sun et al., 2009). The latter is especially important given the challenges firms face today with employee calls or demands for hybrid or remote work (Arunprasad et al., 2022; Delany, 2022). This research contributes to the nascent body of work examining new work organizations, the role of technology, and the performance impacts of the evolving post-COVID forms of work (Bai et al., 2021). Not only have the results identified the combination of technology-based flexibility levers that can have positive impacts on firm performance, but the study has also identified combinations that can have adverse effects. In addition, the contribution of flexibility alternatives varies across contexts, and as such, the results indicate firms must choose a strategic response that fits their industry characteristics. Collectively, the study informs elements of a preemptive design to better prepare firms for future unexpected events. Disrupted supply chains and stockouts, price inflation, and a possible recession highlight the continued importance of firm flexibility.

5.4 Limitations
There are several limitations with this study. Firstly, research identifies other dimensions of technology-based operational flexibility that could be fruitful, including logistics flexibility and sourcing flexibility. Future research should examine the relative value of these flexibility options to guide future management decisions. Secondly, organizational complements such as company culture, strategy, and top management commitment (Mitra et al., 2019) can influence the effectiveness of organizational capabilities and how changes are taking place. Future research could include these change factors. Finally, this study examines technology-based flexibility mechanisms that were effective during the challenges of COVID-19. Future studies should examine if the combination of flexibility mechanisms in this study are equally effective in other disruptive contexts and identify what types of technology-based mechanisms are most effective given the context under consideration.

6. Conclusion
This study provides an empirical examination that identifies the importance of technology-based operational flexibility for positive firm performance during a major crisis (COVID-19) and how a resiliency capability can be developed from the combination of multiple flexibility change levers. For example, higher digital-enabled sales channel flexibility can strengthen the sales impact of flexible product and service offerings. However, there are situations where a combination of flexibility levers can have negative impacts based on the industry and country contexts of the firm. Analysis of such situations, negative or positive, indicates that firms must implement flexibility change levers that best fit their individual characteristics. For example, negative impacts can be higher in manufacturing firms whose physical goods are not conducive to digital-based transformations, format or sales infrastructure. On the other hand, sales channel flexibility combined with product and service offerings flexibility can be effective in service firms whose non-tangible offerings align with digitization. Firms in our sample, in countries with a higher digitization, experience negative impacts from the technology-based flexibility combinations we examine. We feel this is reflective of the impact of the shutdown of the international supply
chain that occurred during the first phases of the COVID-19 pandemic. No flexible solution would counter the closing of markets to a company’s physical goods, wherever its employees conducted work or how the goods were sold. Collectively, the results are informative for research on the role and impacts of technology-based operational flexibility during times of disruption and identify potential response mechanisms for firms who face such challenges.

Notes
5. https://www.wsj.com/articles/where-did-all-the-shipping-containers-go-11628104583
8. Revenue of firms in service sectors such as information, “professional, scientific, and technical services”, and “management of companies and enterprises” were less impacted compared to other sectors. https://www.census.gov/data/experimental-data-products/small-business-pulse-survey.html
9. Multi-Established Firm, Manufacturing Sector, Retail Sector, Govt. Owned Percent, Number of Employees, Total Hours Worked Change, Demand Change, Supply Change, Developed Country, and Developing Country.

References


Corresponding author
Ronald Ramirez can be contacted at: rramirez@csusm.edu