State and citizen responsiveness in fighting a pandemic crisis: A systems thinking perspective

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Abstract
Management scholars have recognized organizational responsiveness among the essential capabilities of social organizations. It becomes essential for a social change to occur during a crisis, where the uncertainty or environmental dynamism is high. However, a social change cannot be successful unless constituent subsystems of a social organization exhibit responsiveness. Using systems theory, we conceptualize ‘nation’ as a social system and examine its responsiveness towards environmental uncertainty, taking an example of the COVID-19 pandemic. How can state and citizen community responsiveness help fight a pandemic crisis? We test these direct and moderating effects on data representing 14 countries. We perform a hierarchical regression analysis on the restructured, balanced country-wise panel data. Our findings highlight the importance of state and community interaction effects in controlling pandemic growth. Accordingly, we claim that only a collaborative approach by citizen communities with the respective governments will enable handling an uncertain situation.

KEYWORDS
environmental uncertainty, pandemic crisis, responsiveness, social systems

1 | INTRODUCTION

The world has witnessed many crises throughout history. These include natural disasters like earthquakes, volcanos, pandemics, and sometimes human-made disasters like wars and terrorism. There is evidence of colossal loss of lives, enormous physical damage to property, and drastic environmental changes as an aftereffect of such crises (Holguín-Veras et al., 2013). While such natural and human-made events of crises are not desirable, preparedness and effective response to deal with these crises situations or events are critical for any nation (Kumar & Havey, 2013; Liu et al., 2012). How the state, local governments, non-state institutions, and society collaborate for effective disaster preparedness will determine how quickly the situation could turn to normalcy (Kapucu, 2012; Schwartz et al., 2020). In other words, the responsiveness of both state and non-state actors to a crisis is crucial in overcoming its impact.

Throughout history, infectious diseases are ranked among the top causes of human death worldwide (Pettini & Mazzocco, 2020; Ritchie & Roser, 2018). For instance, the plague, infamously called Black Death, is a bacterial infection that struck in the sixth century and killed as many as 50 million people, perhaps half the global population at the time (Haensch et al., 2010). Another contagious disease, smallpox, may have killed as many as 300 million people in the 20th century alone. Human immunodeficiency virus or HIV, a virus that prevents the human body from fighting infections, still exists and lacks a vaccine, has killed an estimated 32 million people and infected 75 million, with more added every
Since the World Health Organization (WHO) characterized COVID-19 as a pandemic on 11 March 2020, routine life across the world has come to a standstill. Several countries have gone into a state of lockdown, leaving significant economic disruptions worldwide. As of 06 June 2020, the number of confirmed deaths worldwide was 387,155, and the confirmed number of infections reported was 6,535,354 (covid19.who.int), with a 6% fatality rate. Table 1 shows a summary of infections and deaths across 14 countries, based on the WHO Coronavirus Disease (COVID-19) Dashboard, updated as of 20 October 2021.

As part of the responsiveness measures against the COVID-19 crisis, between February and April 2020, more than 80% of countries worldwide had imposed strict containment and mitigation measures to control the spread of the disease. However, these state-imposed stringency measures varied in terms of scale and efficacy across countries. In order to demonstrate a continuum of state responsiveness across countries, the University of Oxford presented a government response stringency index. This index tracks the policy-related measures laid out by various governments to respond to the pandemic. While the state plays a crucial role in designing effective pandemic preparedness and response plans, the non-state actors such as the local communities, citizens, and social organizations are responsible for ingeniously participating in the implementation of these plans. In other words, the citizen community responsiveness has to demonstrate some level of cooperation with the state-imposed rubrics. However, the infections and death rates across countries grew during the first wave between April to July 2020 and again showed a rising trend in October 2020 when writing this article. Hence, the impact of state responsiveness and citizen community responsiveness on controlling the infection is questionable.

TABLE 1 Impact of COVID-19 pandemic in sample countries (confirmed cases and deaths per million population)

| Country (alphabetic order) | Confirmed cases | Deaths per million population |
|---------------------------|-----------------|-----------------------------|
| Australia                 | 147,248         | 1,558                       |
| France                    | 6,875,557       | 114,957                     |
| Germany                   | 4,401,631       | 94,808                      |
| India                     | 34,108,996      | 452,651                     |
| Italy                     | 4,722,900       | 131,655                     |
| Japan                     | 1,715,364       | 18,146                      |
| Malaysia                  | 2,401,866       | 28,062                      |
| Singapore                 | 154,725         | 246                         |
| Spain                     | 5,016,363       | 87,582                      |
| Sweden                    | 1,163,547       | 15,020                      |
| United Kingdom            | 8,592,086       | 138,439                     |
| Turkey                    | 7,714,379       | 68,060                      |
| United Arab Emirates      | 738,812         | 2122                        |
| United States of America  | 44,786,327      | 728,776                     |

One may argue that the pandemic by its nature would have some momentum, which will result in both, response time as well as recovery time, even with the best of intentions and actions concerning the state and citizen communities. Nevertheless, it is axiomatic that the infection rate may increase multi-fold beyond its natural momentum if the associated state and citizens in respective countries do not care to respond to contain it. Here we emphasize that while ‘caring to respond’ is axiomatic, the ‘impact of responsiveness’ is questionable. Naturally, two issues become prominent: (a) does the system respond, if so, how and (b) how prompt is the response? These questions represent the capability to respond, because a system can respond if and only if it would be capable and not otherwise, and the speed of response to environmental dynamism. The effectiveness or success of a response is beyond these two questions as an agenda to investigate.

The purpose of this study is to examine the sensitivity of state and citizen communities through their enabling roles of direct and interaction effects toward containment of pandemic crises. We used the event of COVID-19 to examine the research question: ‘To what extent do state and community responsiveness help reduce the infection growth?’ An answer to this question will serve as a valuable resource for policymakers, government authorities, operations managers and administrators in the healthcare profession, and citizens of a country, for contingency planning and decision making under crises. It becomes fundamentally important to understand the systemic role of state and citizens in controlling a pandemic growth for effective risk management under uncertainty.

To address the set research question, we examined the direct and moderating effects of state and community responsiveness on the COVID-19 pandemic growth. We
use systems thinking as an underpinning theoretic lens to hypothesize our research model, presenting ‘nation’ as a social system. Towards validation, our data comes from reliable data sources that include the World Bank Group, WHO, Apple Inc., and the University of Oxford for analysis across 14 countries (see note 1). Further, we included geographic features, health infrastructure, and international tourist arrivals as country-specific contextual variables for improving the practical implication of the model. We performed hierarchical regression analysis on the restructured, balanced country-wise panel data to arrive at findings.

Broadly, our findings underline the benefit of mobilizing and engaging both the state and non-state actors in a collaborative effort to deal with a pandemic crisis. The empirical results indicate that increased citizen community responsiveness will amplify the effect of state responsiveness in controlling pandemic growth. Based on our data sample, we confirm that without citizen responsiveness as a moderating factor, state responsiveness alone will not be able to control the pandemic growth effectively. By citizen responsiveness, we refer to citizens’ reactive compliance with state directives regarding tackling the crisis, and the citizens’ proactive interventions for dealing with the pandemic crisis in tacit or explicit, or formal or informal collaboration with the state. Accordingly, we claim that only a collaborative approach by citizen communities with the respective governments will enhance fighting a pandemic crisis. This effect cannot be attributed to individual constituents of a social system. This provides implications to a pertinent issue of emergence of response effectiveness of a nation as a system to the pandemic crisis wherein several separate yet coordinated, or at least, self-organized and unintentionally synchronous, less significant interventions by the state and citizen communities could have been spatiotemporally integrated to yield the necessary responsiveness.

We confirm that, while comprehensive state-driven public health plans may be vital for an effective pandemic response, they alone are insufficient to achieve the goal of pandemic containment. Therefore, policymakers and healthcare operations professionals must focus on driving awareness and creating infrastructure towards promoting citizen-driven responses such as social distancing, constrained citizen mobility, in-house toileting, avoiding spitting in open areas, and so forth. This multidisciplinary study contributes to several bodies of knowledge that include social organizations, operations risk management and associated decision making, systems thinking, and crisis management.

The remainder of the paper is structured as follows. We present a theoretical background on systems thinking and subsequently present a conceptualization of system responsiveness. A discussion on state and community responsiveness is also presented to establish theoretical constructs. The hypotheses are then presented, followed by a detailed description of the methods used. We present our results and associated discussions, followed by concluding notes.

2 | THEORETICAL PREMISES

2.1 | Systems thinking

Based on Von Bertalanffy’s (1972) biologically inspired general systems theory, systems thinking is founded on the truth that wholes are not necessarily equal to the sum of their constituent parts and could be more than the sum (synergy) or less (inefficiency) (Van Assche et al., 2019). Contrary to the Cartesian paradigm, characterized by the belief that the behaviour of the whole can be understood entirely from the properties of its parts, systems thinking asserts that a system’s constituents can only be understood within the larger context of the whole. Put differently, systems thinking is a holistic approach to analysis that focuses on how a system’s constituent parts interrelate and how they perform over time within the context of larger systems. Systems thinking scholars often refer to system properties that include responsiveness, emergence, evolution, autopoiesis, and allopoiesis to describe this phenomenon (Hammond, 2019; Hariharan et al., 2021).

Expanding the Von Bertalanffy’s (1968), p. 55 definition of a system, Hariharan et al. (2021) elucidated systems thinking as (i) a system will always consist of at least two interacting parts (elements), (ii) a system is different and distinct from its environment, and (iii) the system as a whole or some of its parts interacts with the environment. A deeper look at this definition focuses on examining the social systems. Sociology researchers recognized the social system as a pattern of interactions and relationships between and among individuals and social groups (Dreachslin et al., 2012). This definition points to at least two interacting parts in a social system. The multitude of interactions among these elements determines the linkages, that is, the system’s structure, form, and composition. Thus, changing one part of the system can affect the whole system’s behaviour. Consequently, a system’s behaviour results from the effects of supporting (reinforcing) or opposing (balancing) patterns exhibited by the constituent parts of a system or its subsystems (Bullas & Bryant, 2007; Sunder et al., 2018).
Alongside these internal interactions, some systems learn and adapt from their environment. For example, the US President, Johnson in 1965 who believed in serving the country based on what the country needs, for the first time in the US federal government ordered that the 'planning-programming-budgeting' system in the country should adapt to the changing needs of the citizen community (Jackson, 2009). Thus, the US citizen community representing the environment in this example points to the system being different and distinct from its environment. It also denotes that the system (or its parts) interacts with the environment to achieve its goals. This characteristic responsive behaviour of a system to changes in the environment, as an open system determines its responsiveness. When all system elements collectively behave in a certain way that they would not do alone is referred to as emergence, another key characteristic of a system. Put differently, emergence refers to the existence or organization of collective behaviours over time. Examples include socialist movements, labour movements, feminist movements, urbanization, and laissez-faire capitalism as an economic system that triggered the industrial revolution (McGuire, 2017).

The conception that systems thinking is relevant for managers is widespread (Sunder & Ganesh, 2021). The management literature endorsed that organizations are complex systems, and therefore, applications of systems thinking to examine organizations are appropriate (Senge, 1992). Systems thinking has been used in several disciplines of management research that include environmental, social, political, economic, human resources, operations, strategy, healthcare, and educational systems, among many others. Haines (2016) highlighted the importance and application of systems thinking for deriving and controlling systemic properties, which is core to managers in business organizations. However, this concept becomes vital in social organizations where the systemic complexities are more pronounced; for example, conflicts and unequal power distribution among various communities in a country are severely complex (Loveridge & Saritas, 2009). Stroh (2015) pointed out the application of systems thinking in social organizations that include patterns of behaviour between and among individuals and social groups. Accordingly, Stroh (2015) highlighted how systems thinking could help anticipate and avoid the negative longer term consequences of well-intended solutions. This phenomenon becomes essential in situations where environmental dynamism or uncertainty is high, as, in such situations, components of a social system (communities/groups within a social organization) often tend to behave against each other (Khayut et al., 2014; McCool & Kline, 2020).

2.2 | Social system: Nation as a context

A social organization is a pattern of interactions and relationships between and among individuals and social groups (Dreachslin et al., 2012). These interactions constitute interactive features in basic social units such as family, enterprises, clubs, states, and so forth. Ahrne (1994), in the book Social Organisation, characterized social organizations through affiliation, recognition, and exclusion. While affiliation and recognition imply the bonding of constituent subsystems (individuals or groups) with the overall social system, exclusion represents a characteristic where only a few subsystems admit to participating with everything a social organization intends to perform. In contrast, other subsystems oppose or exclude to participate. Forms of affiliation in recognition include employment, citizenship, or membership, and forms of exclusion include activities like paying proper wages, taxes on time, and so forth.

The development of organization theory (see Powell, 1991, p. 189) recognized exclusion using the term ‘loose coupling’, a commonly observable characteristic in social organizations. An organization's affiliates give up the right to control a few of their actions that involve exclusion. For example, in the case of a family or a state, the affiliating authority or the head personnel is vested with some level of authority to control all the members or groups involved but does not have full control (Coleman, 1994). The constituent people (individuals or groups) have higher possibilities to choose their way of life irrespective of the level of control that exists in the system (Ahrne, 1994). This argument resonates well with Goffman’s (1968, p. 280) Asylums, ‘Our sense of being a person can come from being drawn into a wider social unit; our sense of selfhood can arise through the little ways in which we resist the pull’.

In this study, we examine the context of the nation as a social, organizational system using a systemic property, namely, ‘responsiveness’. We use responsiveness, a construct often used in operations management (OM) literature that represents the quality of a system to respond correctly, quickly, and cohesively under uncertainty (Bernardes & Hanna, 2009). We focus on analysing how the outcomes of a social system change under uncertainty as the behaviour of its constituent subsystems change.

2.3 | Nation's subsystems: State and citizen community responsiveness

Collectivist social organization refers to developing countries that bypass formal institutions and instead rely on
informal institutions to uphold social obligations (Greif, 1994). They rely on a horizontal social structure, stressing relationships within communities rather than a social hierarchy between them. While these organizations include nations determined by governments as affiliated authorities of the state, literature points to citizens at both individual and group levels as its systemic components or subsystems. Thus, alignment or agreement between the state and the citizens becomes fundamentally crucial for the efficient functioning of nations as social organizations. The economy and society benefit when integration and alignment of state and citizens exist. However, the criterion of exclusion affirms some possibility of misalignment of citizens with decisions of the state. Yet, the intensity of state-citizen alignment varies from country to country based on various factors (like a form of government, history, practices, empowerment, voting power of citizens, technology, policy interventions, etc.). For example, Singhal and Singhal (2019) highlight differences between India and China from a technology and manufacturing perspective. In another study, Detges (2017) points to a lack of trust as a reason for state–citizen disagreements under critical conditions like natural disasters such as a severe drought.

The state–citizen disagreements in democratic nations where citizens have voting power impose severe concerns in crises or natural disasters, where responsiveness becomes critical. They become particularly problematic when citizens do not comply with the state to demonstrate responsiveness to a critical situation (Procacci, 1998). Della Porta and Parks (2018) highlight the situation during the European financial crisis. Paudel and Regmi (2018) point to the importance of responsiveness that includes interest to change and swiftness of responses to a given situation warranting those responses of both government and citizens during a natural crisis. They examine the context of the Gorkha earthquake 2015, where the government and citizen community played a significant role in fighting the crisis. In another study, Sinha et al. (2019) highlights how successful adaptation demonstrated by both state and citizen communities in response to a disaster helped a nation in its recovery process. They provide an example of a disaster management structure using the internet of things that envisaged the formation of the National Disaster Management Authority in India, prescriptions of which were firmly accepted and followed by the citizen communities in the country. Thus, in the context of nations as social organizations, responsiveness at times of crisis does not create a strong impact for recovery when the subsystems do not exhibit adaptability. In other words, in times of crisis, it is not an independent response at a system level (state responsiveness), but significant cooperation and alignment for adaptation by the citizen communities (community responsiveness) help in the recovery process. Yet, this hypothesis needs further validation and sets an agenda for this study.

3 | BRIEF LITERATURE BACKGROUND ON RESPONSIVENESS

Management scholars have recognized organizational responsiveness among the essential capabilities and intimately tied it to an organization’s existence in a dynamic and uncertain environment (Gunasekaran et al., 2007; Reichhart & Holweg, 2007; Storey, 2005). Strategy researchers used the term ‘red queen effect’ to highlight the importance of responsiveness not only as a means of competitive advantage but for a system’s survival as a response to environmental dynamism (Barnett & Pontikes, 2005). The term ‘responsiveness’ has been used in several management areas, including time-based competition, business process reengineering, flexible manufacturing, agile manufacturing, and service supply chains (Buser et al., 2018; Kritchanchai & MacCarthy, 1999). Much of the literature has focused on improving aspects of responsiveness in manufacturing and service systems. However, the construct has received some scholarly attention in social system contexts.

A literature review posits several definitions of responsiveness, most of which are conceptualized in the context of business organizations (Bernardes & Hanna, 2009). A few studies in operations management (OM) also defined responsiveness (Bernardes & Hanna, 2009; Holweg, 2005; Storey, 2005; van Donk & van der Vaart, 2007). While the former OM scholars have linked responsiveness to the internal operating conditions related to the design of manufacturing systems (Gindy et al., 1999) and supply chains (Holweg, 2005), more recently, responsiveness is exclusively linked to uncertainty connected to external entities (Wang et al., 2014). Further, the strategic management literature suggests multidimensional constructs for measuring responsiveness, defining it as a strategic decision-making capability to match environmental threats and opportunities (David et al., 2007; Holweg, 2005). Table 2 presents sample literature definitions of responsiveness. While a few of these definitions are generic but hold good in a social context as well.

Literature also points to the role and impact of responsiveness in times of crisis and disasters, where the magnitude of uncertainty is very high. Chick et al. (2008) presented the importance of supply chain coordination in response to the H1N1 pandemic. By highlighting the
importance of responsiveness employing government-industry partnerships, the authors demonstrated the development of a vaccine to fight influenza. Klassen and Menor (2007) reported process-related issues that play a role in a pandemic outbreak that reduces variability and improves agreements and alignment in decision-making across various subsystems involved. Besides the bargaining power of the parties involved, centralized decision-making and effective communication that clarifies the purpose and transparency within and between the subsystems improve the responsiveness of a system in times of a natural crisis like an epidemic (Jones et al., 2010; Kraiselburd & Yadav, 2013). Takeda and Helms (2006) highlighted the importance of quick and effective decision-making at times of disaster in decentralized systems like social organizations when compared with centralized systems. While decision making by the governments plays a significant role over the affected areas, the operational adaptation by the citizen communities, quasi-government organizations, private firms, military, and regional authorities by cooperation and support in executing the state decisions becomes important (Cozzolino, 2012; Rodríguez-Espíndola et al., 2018).

### Table 2: Definitions of responsiveness

| Source                        | Definition of responsiveness                                                                 | What is clear, and what is missing?                                                                 |
|-------------------------------|---------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| Weick (1979)                  | ...an ability to modify operating strategies of a social organization to match sudden environmental changes | While this definition focuses on the ‘ability to modify’, the effectiveness or success of a response to environmental dynamism is assumed. An able system can fail to ensure its survival and stability due to various reasons. |
| Zhang and Sharifi (2000)      | ...the ability of [social] enterprises to cope with unexpected changes, to survive unprecedented threats from the environment | Here, the word ‘cope’ indicates the requirement of effectiveness in responses. But the missing element is the sufficient ‘speed’ to cope. |
| Holweg (2005)                 | ...strategic decision-making capability to match environmental threats and opportunities     | Here, the word ‘match’ could be considered equivalent to the word ‘cope’ used by Zhang and Sharifi (2000). Again, ‘speed’, i.e., swiftness to decide and act on environmental changes, is missing. |
| Narasimhan et al. (2006)      | ...an ability to efficiently change the operating states in response to uncertain demands placed upon it | The term ‘efficient change’ subsumes swiftness. However, efficient change does not always mean an effective change. |
| Reichhart and Holweg (2007)   | ...exclusive response linked to uncertainty connected to external entities                   | This definition captures the flexibility of a system to respond. The term ‘exclusive response’ could be considered to embrace ability and adaptability, but again, swiftness to respond is missing. |
| Bernardes and Hanna (2009)    | ...business-level performance capability of purposeful and timely change in behaviour of an operating system in response to an external stimulus | This definition captures agility, purpose-orientation, flexibility, and promptness of responsiveness. |
| Hariharan et al. (2021)       | ...determined as changes in state of rigidity, permeability, fuzziness, and perceptibility of a system | While responsiveness cannot be ‘determined’, it can be represented in terms of the changes in the state of rigidity, permeability, fuzziness, and perceptibility of system boundaries. |

### 4 Conceptualization of System Responsiveness Using Theoretical Premise of Systems Thinking

Holweg (2005) traces the roots of responsiveness back to systems thinking in management. Reichhart and Holweg (2007) observed that most authors seem to link responsiveness with ‘flexibility’—willingness to change or reconfigure a system in response to environmental uncertainty. Narasimhan et al. (2006) addressed responsiveness as an ability to reconfigure available options to accommodate unforeseen environmental circumstances fundamentally and subsumes or is supported by flexibility. Holweg (2005) pointed out that system flexibility can be rephrased as responsiveness, as flexibility often
represents means of responding to changes. Thus, it is logical to point to responsiveness as a function of flexibility. Here responsiveness should not be viewed myopically as willingness to change or interest to change alone, rather responsiveness is flexibility that is demonstrated, that is, a means of responding to change. Conceptually, flexibility represents a system’s demonstrated capability to change its structure and/or behaviour temporarily either on its own or in the wake of external stimuli, to fulfil a specific purpose. However, in doing so, the system retains its fundamental structural and behavioural characteristics.

However, in the context of social organizations, only a low level (or sometimes even nil) inheritance by the subsystems or components of a system is observed (von Bertalanffy, 1968). While the alignment of subsystem properties is ideally expected to be on par with the system in a business context, it will not always be the case in social organizations. For instance, not all citizens of a country follow state regulations. The general public (in democratic countries), including consumers, taxpayers, and voters, are rationally passive and often are intrinsically opposed to public policies that would harm their interests (Moon & Pino, 2018). Thus, as a corollary to the principle of holism (Aristotle’s holism), the properties of a system cannot be derived from the properties of its subsystems and vice versa.

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\text{Responsiveness} = f(\text{Flexibility at system level} \mid \text{not necessarily exhibited by all its constituent parts})
\]

Further, flexibility alone cannot determine the responsiveness of a system, as the rate of change in uncertainty needs a timely response, and hence how fast/quickly a system exhibits flexibility becomes important (Krichanchai & MacCarthy, 1999). Especially in a social crisis or a natural disaster, it becomes fundamentally important for a system to respond to environmental change quickly (Rink et al., 2013). Zaheer and Zaheer (1997) relate their notion of responsiveness to decision-making speed under uncertainty. Thus, responsiveness is a necessary and sufficient indicator of a system’s swiftness that indicates its behaviour in situations under sudden environmental changes (Upton, 1995). Thus, it is important to distinguish responsiveness as a property of a system and swiftness as a characteristic of responsiveness.

A few scholars defined this notion of swiftness as ‘agility’, a component of system responsiveness (Sambamurthy et al., 2003; Zaheer & Zaheer, 1997). However, swiftness, by only itself, is independent of context and hence does not represent agility in its complete sense. Instead, agility should be viewed as a combination of swiftness and ease of performing a physical or mental task. Here ease denotes an implicit purpose or aim, and context to swiftness. Thus, we can infer that: Agility = f(Swiftness, Ease). Even if one of them is zero, then Agility is also zero.

As per D’Aveni’s (1994) characterization of agility, responsiveness is an outcome of an agile system that carries the capability to change itself to environmental changes rapidly. This denotes the notion of explicit purpose. Put differently, lack of agility may imply slow responsiveness and lack of purpose (including context), will make responsiveness irrelevant and meaningless. Thus, responsiveness becomes an emergent property of a system, at least due to the combination of its agility and its purpose. Extending the above discussion, it is sensible to point out that responsiveness is a function of agility and purpose, given that a system is flexible.

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\text{Responsiveness} = f(\text{Agility}, \text{Purpose} \mid \text{given flexibility exists in a system})
\]

However, a flexible and agile system with purpose need not be necessarily responsive, as the system components (or subsystems) must cautiously adapt to the system’s flexibility in response to environmental uncertainty (Matson & McFarlane, 1999). For example, in a social system like a democratic nation, citizens choose to support/oppose government intervention. This phenomenon referred to as adaptation denotes the degree of choice that citizens could entertain concerning the government’s change. It is important to note that adaptation noted above is different from adaptability, a system property. While adaptation demonstrated by a system could be viewed as a phenomenon in a single or only in some instances, adaptability is a (consistent) property of a system. To clarify, adaptability of a system depends on (a) intelligence in the system (to anticipate and sense the environment, including feedbacks, and to dynamically devise responses by structural reconfiguration and/or behavioural modification) and (b) responsiveness. In other words, Adaptability = f(Intelligence, Responsiveness) and is an emergent characteristic of a system.

While this may emerge at times, this logic of a few elements of a system not adapting to the change calls for the reasoning of the adaptation of a subsystem. The subsystem(s) may choose to adapt to systemic reconfiguration or not (Talebi et al., 2019). Adaptation refers to the defensive or reactive acceptance of new and swift decisions (i.e., agility and purpose) by its constituent subsystems as a response to accommodate unknown uncertainty (i.e., full systemic flexibility). Here, adaptation
is meant within a flexible and agile system with purpose, at the subsystem level. From the above example, while flexibility is ‘interest to change’ at a system level, adaptation refers to ‘choice to adapt’ at a subsystem or element level of a system. Here, it is important that both flexibility and adaptation should reflect the demonstrated ‘capability’ to change. Further, adaptation is different from system agility as the former refers to ‘intent’ and the latter to ‘swiftness’ of a capable system, and an agile system’s constituents need not always be adaptive. Thus, we conceptualize responsiveness as a function of adaptation within a flexible, agile and purposeful system.

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\text{Responsiveness} = f (\text{Adaptation within a flexible and agile system with purpose})
\]

Figure 1 summarizes the above discussion towards providing a theoretical background to responsiveness. For semantic clarity, we define responsiveness as a characteristic of a system responding to environmental dynamism denoted as a degree of flexibility, agility with purpose, and adaptation. The effectiveness of system responsiveness is demonstrated when a system ensures its survival, stability, and strength in the wake of environmental dynamism. In this sense, reorganization, or reconfiguration by the system (autopoiesis) becomes necessary.

It is important to note that all relevant subsystems inter-relationships influence ‘adaptability’. This ought to be beyond each of those components' capabilities to adapt swiftly to uncertainty in the environment. In fact, systems thinkers are aware and understand that a system’s behaviour is at once both, a function of its components and their integration to form the whole (Sunder & Ganesh, 2021). Put differently, the adaptability of a subsystem does not make complete meaning in the context of system responsiveness unless it is viewed within the larger system’s effectiveness to adapt. Here, effectiveness denotes demonstrated and consistent success by displaying both, intelligence, and responsiveness, which includes flexibility, and agility with purpose in adapting to environmental dynamism. Thus, Effective Adaptability = f (Effective [intelligence \times responsiveness]) to ensure survival, stability, and strength of the system in the wake of environmental dynamism. Thus, a system’s adaptability can be understood as an emergent phenomenon founded on its intelligence and responsiveness denoted by flexibility at system level, agility and purpose, and adaptation at subsystem level.

5 | HYPOTHESES AND HYPOTHEZED MODEL

This section proposes the hypotheses towards creating a hypothesized model for further validation. The above conceptualization of responsiveness and literature discussions confirm that flexibility, agility and adaptation are characteristics of system responsiveness at the macro level, and an entity or system-element responsiveness at the micro or unit level, and subsystem responsiveness at the meso level. Put differently, responsiveness emerges from the above three characteristics. COVID-19 could demonstrate evidence to this for autopoiesis to occur. Almost all countries have prioritized safety and pushed their citizens to a new state of living under lockdown. While this is significantly a new level of existence that nations have demonstrated, the respective governments played a significant role as nations’ affiliates in imposing several stringent measures to control the pandemic infections (Hale, Petherick, et al., 2020). State Responsiveness (SR) is the level of responsiveness of a state that includes mechanisms, decisions, processes, and policies to the environmental threats posed to the community (Dahl & Polyarchy, 1971). In times of pandemic crisis like COVID-19, which has created a disruption to a healthy life with high levels of uncertainty, nations as social systems have exhibited a high level of flexibility, agility and adaptation (Loayza & Pennings, 2020; Sharma et al., 2020). This state responsiveness across nations reflects the assumption that stringent measures imposed on its citizens should control or even reduce the pandemic infection growth rate. However, this assumption has no evidence from past studies and deserves validation. Thus, we posit the below hypotheses for testing.

**FIGURE 1** Conceptual representation of system responsiveness [Colour figure can be viewed at wileyonlinelibrary.com]
**H1a.** State responsiveness helps reduce the growth of pandemic infections.

The state response to external events like a pandemic has primarily involved government decisions and then subsequent actions on citizen communities, apparently with minimal community input (Marston et al., 2020). However, experiences from past pandemics show that community engagement and response to state-initiated mechanisms and policies or ‘community responsiveness’ is critical to limiting the growth of pandemics (Gillespie et al., 2020). While H1a portrays the role of governments, it does not capture the citizen communities’ adaptability towards fighting the pandemic crisis. For the citizen community as a subsystem, its adaptability is essential to represent the responsiveness of a nation as a system comprising two major subsystems, namely, government and citizen communities. Based on the above discussion on adaptation, it is evident that (at least in democratic countries) citizen communities have a choice to co-operate with the state by following the stringent measures imposed on them. Several studies pointed that in many situations, citizens have chosen to abide by the stringent measures, exhibiting trust in state regulations (Detges, 2017). However, a few situations also indicate that the citizens have not abided by the state-imposed measures in fighting the COVID-19 pandemic. For example, in many countries, according to Apple Incorporation’s mobility report (Bergman & Fishman, 2020), citizens have made attempts to walk and travel during the lockdown, a mere reflection of compromise on citizens’ responsiveness. Thus, it will be valuable to assess the citizen community’s responsiveness towards reducing pandemic infections. We define citizen community supportive responsiveness (CR) as ‘the collective response of the community to COVID-19 pandemic in from of compliance with state restrictions for citizen travel and mobility’. Consequently, we posit:

**H1b.** Citizen community supportive responsiveness helps reduce the growth of pandemic infections.

The recent WHO guidelines (Hale, Petherick, et al., 2020) recommend a moderating role of communities in preventing a resurgence in infected cases as the countries are gradually rolling back the lockdowns. While H1a and H1b postulate independent cause–effect relationships between state and community responsiveness on pandemic growth, it is essential to evaluate their interaction from a systemic perspective and their synergetic effect on pandemic growth. Thus, we hypothesize:

**H2.** The subsystem interaction of state and citizen community responsiveness (moderated by citizen community responsiveness) helps reduce the growth of pandemic infections.

Figure 2 summarizes the hypothesized model, and subsequently, the below section describes the measures used to collect data towards testing the hypotheses.

### 6 | METHODS

We used panel-data regression with random-effects models to analyse the hypotheses derived in the previous section. The advantages of using panel data or...
longitudinal data over cross-sectional data are more accurate inference of model parameters due to availability of more degree of freedom and sample variability; higher capacity of capturing the complexity of human behaviours; and simplifying computation and statistical inference (Arellano & Honoré, 2001; Baltagi, 2005; Hsiao et al., 2016). Further, the considerations that affect the selection of random effects model, that is, the effects of unobserved heterogeneity, are assumed as random variables over the fixed effects model, that is, the effects are assumed as fixed parameters for the panel data regression. An overview of the research design used in this study is presented in Figure 3.

In stage 1, we documented the theoretical background for this study and developed the conceptual model for ‘system responsiveness’. We adopted a multidisciplinary review of the existing literature to define the key constructs-state and community responsiveness in stage 2. This is followed by the formulation of the hypothesized model in stage 3. The proposed measurement scales and coding for the identified constructs are presented in stage 4. A description of the reliability of data sources, data collection, and data preparation for the dependent, independent, and control variables used in the framework is presented in stage 5. Finally, stage 6 examines hypotheses on the main effects and moderating effects.

6.1 | Description of variables and associated measurements and metrics

Based on the above discussions, we conceptualize SR and CR as two independent variables towards examining their systemic impact on fighting the pandemic infections growth rate, the dependent variable. These variables are described below alongside the control variables and their associated measures.

6.1.1 | State responsiveness (SR)

To test H1a, we adopted a cross-national and cross-temporal measure of SR throughout pandemic expansion called Stringency Index (Hale, Petherick, et al., 2020). This composite index scores the governments across countries on the robustness, consistency, and timeliness of their response to fight the growth of the pandemic. It comprises a series of indicators (18 as per version 6.0 of working paper dated 29 April 2020 of Hale et al.) divided into three dimensions: containment and closure; economic response; and health system. While the dimension on ‘containment and closure’ captures the government systems and policies on lockdowns and closures to curb the infectious disease outbreak, the economic response dimension quantifies the effective

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**FIGURE 3** Research design for the study
[Colour figure can be viewed at wileyonlinelibrary.com]
management of economic consequences of closures by the government, and the health system dimension scores the preparedness of a country’s health infrastructure to fight the infection.

Considering the purpose of our study, we used the dimension on ‘containment and closure’ comprising eight indicators ($I_1$-$I_8$) to measure the variable on SR in our model. These indicators are scaled on an ordinal scale (0 to 3; 0 shows no government initiative and 3: the highest intensity of government initiatives) of intensity/severity of response. Additionally, a dummy variable (0–1; 0 indicates a targeted response applicable to a specific sector or jurisdiction and 1 indicates a general response applicable across the economy or throughout the jurisdiction) is used to capture the geographic scope of government response. For arriving at the individual indicator score, the ordinal score of the indicator is added with the binary score (general vs. targeted). The maximum value then rescales the resulting score of an individual indicator for that indicator across countries to derive the final score, which ranged between 0 and 100. A score of 0 indicates the missing data for the individual indicator. In the case of missing data for more than three indicators, the index calculation is disregarded. Thus, the Stringency index (for evaluating SR) on any given day is calculated by averaging the final score of each of the eight contributing indicators using Equation (1). Then, the relative SR values (SR Index) are arrived at for the COVID-19 period (considered for this study) by comparing the SR stringency score with that of the normal period (before the pandemic started). For this purpose, the baseline for stringency score is considered as 100 which corresponds to zero stringency by government during normal period.

$$SR\text{\,Index} = \frac{1}{8} \sum_{j=1}^{8} I_j,$$  \hspace{1cm} (1)

where $I$ is indicator of ‘containment and closure’ initiatives and $j$ is number of indicators.

### 6.1.2 Citizen community responsiveness (CR)

For measuring CR, we used secondary data published by Apple Inc. as part of their COVID-19 mobility trends report. Apple mobility trends report, which is published daily, features changes in requests for directions by transportation type by citizens of all available countries/regions, subregions, and cities as per Apple corporations’ records. As per their website (https://www.apple.com/covid19/mobility), the data have been gathered based on Apple Maps on their customers’ iPhone. These data are presented to reflect citizen travel and mobility at the country level. While citizen mobility captures the change in volume of citizens walking, driving, or taking public transport in their communities, the travel indicates the traffic to transit, retail, and recreation locations. Thus, this secondary data obtained from Apple Inc. reports represents a reasonable CR estimate.

We used two of the three indicators prescribed by the Apple mobility trends report to calculate the CR score. They are ‘amount of walking’ and ‘amount of driving’ by citizens of individual countries considered for this study. A CR stringency index is calculated as a median of walking and driving scores to represent how stringently the citizens of each country follow the state restrictions on travel (walking and driving). Like the State Stringency Index, the baseline for calculating the CR index is fixed as 100. In other words, a CR stringency score on a normal day is considered as 100, and the relative CR values are arrived for the COVID-19 period (considered for this study) by subtracting the median CR scores of a day from that of the normal period (before the pandemic started), as shown in the Equation (2).

$$CR\text{\,Index} = 100 - \text{Median (Walking, driving,) \hspace{1cm} (2)}$$

### 6.1.3 Pandemic growth (PG)

For estimating the effects in the model, we defined the dependent variable as pandemic growth (PG) as ‘the rate of infection or speed of COVID-19 spreading’. The measure used for this variable is based on the 7-day moving average of daily new laboratory-confirmed cases (officially released by WHO) in the selected countries. This measure is considered apt considering the frequent use of disease growth rate and acceleration estimates for monitoring the impact of public health measures on the spread of the disease in health research (Utsunomiya et al., 2020). Unlike the pandemic growth indices offered by traditional predictive models (based on predetermined application conditions such as seasonality of disease, population mobility, and others) used in epidemiological research (Wu et al., 2003; Zeng et al., 2004), the 7-day moving average based metric was considered to be more intuitive and reliable for assessing the variables for state and community responsiveness in our research model.

For testing, we measured this variable, as shown in Equation (3).
6.1.4 Control variables

The historical accounts of external events like past pandemics and infectious disease outbreaks demonstrate that the region-specific control variables create conditions for the transmission of the pandemic (Wang et al., 2020). These control variables are geographic features (such as temperature, wind speed, and population density) and health infrastructure conditions (for instance, number of doctors, nurses, and hospital capacity) and tourism-related considerations (Bootsma & Ferguson, 2007; Browne et al., 2016; Peterson & Williams, 2009). Thus, for testing the effect of the predictor and moderating variables on the outcome, we controlled for geographic and health infrastructure and tourism-related variables. In our theoretical model, we controlled for possible impacts of geographic features of the 14 sampled countries. We have included population density (PD) as the control variable as there is recent evidence of a higher rate of transmission of disease-causing viruses in densely populated countries (Ahmadi et al., 2020; Wang et al., 2020). PD is measured as per Equation (4) based on Worldbank (2020a) data.

\[
PD = \frac{\text{Midyear population}}{\text{land area in square kilometres}}
\]

Additionally, we also controlled for the effects of health infrastructure on PG by adding a variable on the number of hospital beds (HB) in the country as health care conditions contribute towards mortalities due to infections (Quinn & Kumar, 2014). We measured this variable using the HB (per 1000 people) data reported by WHO (WHO, 2020a) and accompanied by country data using the Equation (5).

\[
HB = \Sigma \text{(Public + Private) hospitals + Rehabilitation centers}
\]

Several studies have demonstrated the role of tourism-related factors related to inbound and outbound tourism in amplifying the propagation of infectious diseases by influenza and corona viruses in the past (Browne et al., 2016). In this regard, Labonté et al. (2011) highlighted the role of developing global transport networks as a vector in the spread of pathogens leading to increasing pandemic threats in the 21st century. Thus, to control the effects of tourism-related aspects of the selected countries, we introduced two control variables for inbound (arrivals) and outbound (departures) in the model. The first variable on inbound tourism (InT) is measured using the International Inbound Tourist data maintained by the World Bank Group (Worldbank, 2020b). InT refers to the number of tourist arrivals into a country, with the tourists staying there for less than 12 months. The purpose of the visit is other than an activity remunerated from within the country visited.

\[
\text{InT} = \text{Average number of international tourist arrivals per year (in Thousands)}
\]

Another control variable on outbound tourism (OuT) is measured using the International Outbound Tourism 2019 data (Worldbank, 2020c). OuT refers to the number of departures that people make outside their country of residence for tourism. In this study, OuT is measured using Equation (7).

\[
\text{OuT} = \text{Average number of outgoing travelers per year (in Thousands)}
\]

The population's age structure also explains the rate of morbidity and mortality due to pandemics (Cortis, 2020; Lemaitre & Carrat, 2010). In a recent study, Cortis (2020) compared the age distribution of confirmed cases across three cohorts, that is, youths with less than 15 years of age, the working population between 15 to 64 years, and elderly above 65 years of age in Korea and China. The results showed that the confirmed cases in the youth cohort were far lower than the other two cohorts despite an equivalent number of tests held for all three age groups in both countries. The author suggested reporting age-specific mortality rates and age-specific morbidity rates over crude rates to measure the pandemic growth in
a country. Many prior clinical research studies on the infectivity of influenza and coronaviruses have used old-age dependency ratio (the ratio of the number of people aged 65 and above to the number of people 15–64 years old) as an explanatory variable (Ujiiea et al., 2020). Therefore, to control the effect of the age-structure of the population for the selected countries, we introduced three control variables in our model.

The first control variable on age dependency ratio or ‘% working-age population’ (% WP) is defined as the ratio of the number of people younger than 15 years or older than 64 years to those with age between 15 and 64 years or the working-age population. In this study, WP is measured using the World Bank 2019 data compiled based on the Equation (8).

\[
\% WP = \text{Proportion of dependents per 100 working age population}
\]  

The other variables for controlling the effect of age-structure of the population in the model are % young population (% YP) and % adult population (% AP) measured using World Bank 2019 data based on Equations (9) and (10), respectively.

\[
\% YP = \text{Proportion of population between 0 and 14 years to total population}
\]  

\[
\% AP = \text{Proportion of population between 15 and 64 years to total population}
\]  

National health authorities of different countries adopt their own infection testing policies about the type of diagnostics tests (classified as reverse transcriptase-polymerase chain reaction or RT-PCR tests, antigen tests, and antibody tests), frequency of testing, and nature of population to be tested in these countries (Rao et al., 2020). Rao et al. (2020) compared the COVID-19 testing strategy adopted by national health authorities of the United Kingdom (UK) and India, the two countries significantly affected by this pandemic. The authors revealed that whereas the testing strategy of Indian health authorities was focused on high-risk groups, UK authorities had cast their net wide to test both symptomatic and asymptomatic patients admitted to hospitals, hospital staff, essential workers, and their families. The authors emphasized that the testing policies for controlling the pandemic ought to be country-specific based on local circumstances. Hence, for controlling the effect of diverse infection testing strategies adopted by the health authorities in the selected countries, we introduced a control variable on the frequency of virus testing (TEST). We used the average number of COVID-19 tests performed per 1000 people maintained by the Our World in Data (2020) database (Equation 11). A description of the measurement scales and coding for the constructs used in the study is given in Table 3.

\[
\text{TEST} = \text{Total number of tests per thousand people} \quad (11)
\]

### 6.2 Data collection

We examine the daily data for COVID-19 pandemic infections across 14 countries towards validating this conceptualization. Fourteen countries considered are (in alphabetic order) Australia, France, Germany, India, Italy, Japan, Malaysia, Singapore, Spain, Sweden, Turkey, UK, United Arab Emirates, and United States.

We used cross-country and cross-temporal secondary data on the identified variables to test the conceptual model from various reliable sources: the University of Oxford, Apple Inc., WHO, and the World Bank Group. This empirical study covers the period from 14 February to 15 April 2020, with 843 observations of daily data representing 14 most-affected countries. This period is apt considering the evolving state response as per the PG’s expansion in infected cases and mortalities.

For SR, we used the data collected by researchers at Blavatnik School of Government, the University of Oxford through the Oxford COVID-19 Government Response Tracker (OxCGRT) (Hale, Angrist, et al., 2020) available on the public internet domain as open data. The tracker started collecting the data on a series of indicators (started with 11 and expanded to 18 as on 29 April 2020) of government response to pandemic (SR index) from 04 January 2020. This data covering 100+ countries was regularly revised as per the progress in governments’ responses to curtail the PG in their respective countries. Publicly available information, including government press releases, briefings, and news articles, has been used as a source of this data. The database is available in a time-series form to enable academic research.

For CR, we used data on the change in community travel and mobility collected by Apple Inc. Apple’s mobility trends report started posting the citizens’ mobility across more than 100 countries starting in January 2020. The data has been gathered based on Apple Maps mobile application on their customers’ iPhone. This citizen mobility has been captured based on three indicators: walking, driving, and public transport.
We used WHO’s epidemiological data on laboratory-confirmed COVID-19 cases across member states and national authorities for assessing PG. This global data on the epidemiology and response to the pandemic event is released through the COVID-19 information dashboard and daily situation reports generated by WHO and its technology partner (WHO, 2020b). This dashboard provides access to reliable data submitted directly by the national health countries across the 194 member states of WHO. The situation report provides a daily summary of surveillance, preparedness, and response to the pandemic across countries. We used the time series data on COVID-19 infection growth rates for the 14 sampled countries to measure the variable on PG in our model.

The data for the seven out of eight control variables in our model were collected from the data catalogue maintained by the World Bank Group. The first control variable on population density (PD) is estimated based on the time-series data reported by the Food and Agriculture Organization and World Bank (World Bank, 2020a). It is measured as the midyear population divided by land area measured in square kilometres. The population estimates consider all residents regardless of legal status or citizenship (except for refugees not permanently settled in the

**TABLE 3** A summary of measures used

| Variables                     | Measurement (Source)                                                                 | Indicators                                                                 | Scales/Coding                              |
|-------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------|--------------------------------------------|
| State responsiveness          | SR Index (Blavatnik School of Government, University of Oxford)                      | Closing of schools, Closing of workplace, Cancellation of public events, Restriction on gatherings, Closing of public transportation, Staying at home, Requirements, Restrictions on internal movement, Control on international travels | Ordinal scale (0–3) and binary for geographic scope (0–1) |
| Citizen Community responsiveness | CR Index (Apple Mobility Trends report)                                               | Amount of walking by citizen, Amount of driving by citizen                 | Ratio                                      |
| Pandemic Growth               | PG (World Health Organization)                                                       | Daily moving average of infected rates                                     | Ratio                                      |
| Control variables             |                                                                                      |                                                                          |                                             |
| Geographic features           | PD (Food and Agriculture Organization and World Bank)                                | midyear population per square kilometres                                   | Ratio                                      |
| Health infrastructure         | HB (World Health Organization)                                                        | Inpatient beds                                                            | Ratio                                      |
| Tourism                       | InT (World Tourism Organization, Compendium of Tourism Statistics, Yearbook of Tourism Statistics) | Number of tourist arrivals by air or tourists staying at hotels            | Ratio                                      |
|                               | OuT (World Tourism Organization, Compendium of Tourism Statistics, Yearbook of Tourism Statistics) | Number of tourist departures                                              |                                             |
| Age-structure of population   | % WP (World Bank estimates)                                                          | Proportion of dependents per 100 working-age population                    | Ratio                                      |
|                               | % YP (World Bank estimates)                                                          | Proportion of population between 0–14 years to total population            |                                             |
|                               | % AP (World Bank estimates)                                                          | Proportion of population between 15–64 years to total population           |                                             |
| Infection testing policies of country | TEST (Our World in Data)                                                              | Total number of tests per thousand people                                 | Ratio                                      |
country of asylum) in a country. The land area data represent a country’s total area (excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones). For the second control variable on health infrastructure, we used the hospital beds data from the World Health Organization last updated on 09 April 2020 (WHO, 2020a). This time-series data are a summation of inpatient beds available in public and private hospitals and rehabilitation centres It also includes hospital beds in chronic and acute care centres in some cases. Further, the two control variables on international tourism are based on the estimates of inbound and outbound tourists based on the World Tourism Organization, Compendium of Tourism Statistics, Yearbook of Tourism Statistics, and other sources (World Bank, 2020b).

The data for the three control variables on the age-structure population of selected countries are based on time-series data on age distribution maintained by World Bank (World Bank, 2020c). The last control variable on infection testing policies is measured by the total number of COVID-19 tests performed across different countries maintained by the Our World in Data (2020) database. For analysis, the data for all control variables were assumed to be constant for the period of this study, that is, 14 February to 15 April 2020.

6.3 Data analysis

For the empirical analysis, we restrict data to create balanced country-wise panels with continuous information from 14 February to 15 April 2020 (we have not used data from 04 January due to limited variance in the predictor variables during this period). Initially, we examined the endogeneity between SR and PG using the Hausman test of endogeneity (Baltagi, 2005). This test is also useful for choosing between the fixed-effects model or the random-effects model for regression analyses in panel data analysis. The test results ($\chi^2 = 8233$, $df = 2$, $p$ value = 0.08967) using our panel data show that the random-effects model is favoured with no significant correlation between the predictor variable and the error term (null hypothesis: preferred model is random effects) (Baltagi, 2005). Further, the random-effects model is considered apt, considering our panel data’s multiple levels of observations (country-level, time). Unlike the fixed effects model, the random-effects model allows the modelling of shared errors across these multiple levels of observations and accounts for unobserved heterogeneity at different levels (Alcacer et al., 2013). Predictors. Many recent empirical studies using multilevel analysis of time-variant variables have also employed random-effects regression models (Dyer & Whetten, 2006; Krasnikov et al., 2009; Modi & Mishra, 2011).

Our research model suggests that the effect of a predictor variable, SR, on a dependent variable, PG, relies on the level of a third variable, the CR. This perspective defined as ‘fit as a moderator’ in the strategy research (Venkatraman, 1989) is that the fit between the predictor variable and the moderator variable determines the criterion variable. In more general terms, a moderator (viewed categorically or characteristically) will affect the magnitude and direction of the relationship between a predictor and outcome variable (Cohen & Keren, 2008). For analysing the strength of moderating effects in a relationship, an interaction (or multiplicative) term involving the product of moderator and predictor is entered in the regression analyses. The moderation effect is validated if the coefficient for the interaction term is statistically significant (Baron & Kenny, 1986).

We centred the data for both the independent variables (by subtracting the means) before calculating the interaction term (i.e., $SR*CR$) to address the multicollinearity issue caused by using the interaction term in the regression equation (West et al., 1996). We further verify whether our estimates are driven by multicollinearity by examining all variables’ variance inflation factor (VIF). All the VIFs were below five (Hair et al., 2014); thus, multicollinearity between variables was discarded.

We used three different regression models with PG as the dependent variable to test the main effects ($H1a$ and $H1b$) and moderating effects ($H2$). Model 1 included the control variables (PD, HB, InT, OutT, %WP, %YP, %AP, TEST) only. In Model 2, the direct effects of the predictor variables (SR and CR) are introduced. In Model 3, we tested the hypothesized moderating relationships by introducing $SR*CR$.

7 Results and Discussion

We used bivariate correlation statistics to evaluate the strength and significance of the association between PG, SR, CR, and contextual variables. Further, random effect regression analyses were carried out following a hierarchical process to test the main effect and moderating effect proposed in our hypothesized model (Krasnikov et al., 2009; Modi & Mishra, 2011). Table 4 shows the correlation matrix.

The results (see Table 4) showed that individually SR and CR have a statistically significant association with PG. Further, the negative effect of SR on the PG confirms that the state responsiveness in terms of timely enactment and amendment of policies to sustain readiness and
allocation of additional resources for capacity development plays a key role in curbing the disease outbreaks with pandemics potential. Additionally, the significant negative impact of CR on PG implies the vital role of all sectors of society, such as individuals, families, and communities (represented as citizen communities in this study), in alleviating the effects of a pandemic (Gillespie et al., 2016, 2020). Additionally, when comparing state responsiveness with community responsiveness, the slightly more negative effect of SR (−0.341) than CR (−0.333) perhaps reveals the natural leadership of government for the responsiveness efforts in fighting against a pandemic. Regarding the control variables, three out of eight, that is, PD (0.076), InT (0.103), and %WP (0.067), and showed a weak and statistically significant association with PG. These results indicated that densely populated countries with higher share of working-age population and higher rate of international tourist arrivals faced a higher rate of transmission of disease-causing viruses such as Covid-19 (Wang et al., 2020). The results of three empirical models in testing the hypothesized model are summarized in Table 5.

The first regression model, that is, Model 1, included all eight control variables related to geographical features, health infrastructure, inbound/outbound tourism, age-structure of population, and infection testing policy for the selected countries. The results on positive and significant effect (β = .092, p < 0.01) of InT recognizes that inbound tourism is a contributor to disease spread (Gössling et al., 2020; Khan et al., 2009). This finding is significant because the first set of COVID-19 cases in most countries were imported infections through international flights (Chinazzi et al., 2020). Further, the keystone role of airport mobility in the spread of contagious illnesses like severe acute respiratory syndrome (SARS) is emphasized in past research on pandemic-related estimations (Browne et al., 2016). However, annual outgoing travellers (OuT) was an insignificant variable. This may be because several countries imposed outbound travel restrictions during the period that the data represents. For instance, several countries had cancelled the issued visa impacting OuT (Chowdhury & Misra, 2020). A weak though the positively significant influence of %YP (β = .191, p < 0.05) on PG can be explained by the fact that younger individuals tend to have a higher proportion of asymptomatic people or people with mild symptoms (Bonanad et al., 2015). Further, the young population has high socializing need. As per Patrick (2011), people below 15 years move around for social learning as a natural phenomenon at much higher rates than other age groups, where conscious movement occurs.

Our results indicate a negative but insignificant impact of %WP (β = −.481, p > 0.05) and %AP (β = −.961,
on growth of pandemic. This effect could be attributed to the self-learning mechanisms that adults practice to safeguard themselves during crises, unlike youth below 15 years. Additionally, the working population was restricted from moving about leisurely in public places, including their travel to offices (Brynjolfsson et al., 2020). The result on the insignificant impact of PD is in line with the inconclusiveness around the role of PD on the propagation and magnitude of epidemics and pandemics in the prior health geographic research (Chowell et al., 2011; Mills et al., 2004). Exploring the effect of PD on epidemic using historical data for the influenza pandemic of 1918, Li et al. (2018) found a weak relationship between PD and the death rates of epidemics under the conditions of sufficiently large density ranges and keeping the background noise under control. In a cross-sectional study on the impact of an Influenza pandemic in individual states and 49 cities of United States, Garrett and Rhine (2010) found that while the low population density in rural areas was found to be positively associated with mortality, no connection between population density or residential crowding and mortality or transmissibility was found on a larger county scale. Further, the beta coefficient for the contextual variable of hospital beds, which accounted for the health infrastructure of the country, is found to be negative ($\beta = -.08$) and significantly ($p < 0.05$) related to pandemic growth. This result confirms previous epidemiological research findings on the role of the sufficiency of healthcare infrastructure in the most vulnerable focal cities to face the pandemic over time. The positive and significant impact of TEST ($\beta = 0.427$, $p < 0.05$) on pandemic growth indicates the role of testing policies in controlling the pandemic (Rao et al., 2020).

In Model 2, the direct effects of the predictor variables, that is, SR and moderator variable CR, are introduced. Like Model 1, the contextual variables, that is, hospital beds and tourist arrivals, are consistent in their relationship with pandemic growth, and there is a significant change in the variance explained (change in $R^2 = 0.171$, change in $F$ statistics = 111.008, $p < 0.01$). As expected, individually SR and CR are negatively associated with pandemic growth ($\beta = -.203$, $p < 0.01$ and $\beta = -.276$, $p < 0.01$, respectively), thereby supporting $H1a$ and $H1b$. These findings are consistent to prior investigations from Spanish flu (1918) through SARS (2002) and H1N1 swine flu (2009–2010) on the vitality of state-driven epidemic preparedness and response network in identifying an outbreak and mobilizing resources (Schwartz, 2012; Yen et al., 2014). Our finding on the independent role of CR in the spread dynamics of COVID-19 is in line with the prior studies that

### Table 5 Regression results—pandemic growth

| Variable                                      | Standardized coefficients | Outcome  |
|-----------------------------------------------|---------------------------|----------|
| **Control Variables:**                        |                           |          |
| Population density PD                         | 0.189                     | 0.023    | 0.036    |
| Hospital beds available HB                    | −0.08*                    | −0.126** | 0.113*   |
| Annual tourist arrivals InT                   | 0.092**                   | 0.260*** | 0.214*** |
| Annual outgoing travellers OutT               | 0.001                     | 0.003    | 0.006    |
| % Working-age population %WP                  | −0.481                    | 0.535    | 0.294    |
| % Young population %YP                        | 0.191*                    | 0.088    | −0.085   |
| % Adult population %AP                        | −0.961                    | 0.458    | 0.212    |
| Average COVID-19 tests performed TEST         | 0.427*                    | 0.017    | 0.043    |
| **Independent Variables:**                    |                           |          |
| State responsiveness SR                       | −0.203**                  | −0.173** | H1a supported |
| Community responsiveness CR (Moderator)       | −0.276**                  | −0.257** | H1b supported |
| Interaction term: SR*CR                       | 0.087*                    | H2 supported |
| $R^2$                                         | 0.021                     | 0.192    | 0.198    |
| $R^2$ Change                                  | -                         | 0.171    | 0.005    |
| $F$ statistics                                | 3.871                     | 25.953   | 24.29    |
| $F$ statistics Change                         | -                         | 111.008**| 6.328*   |

*p < 0.05. **p < 0.01.
emphasized the role of citizens in adopting self-protective and responsiveness actions such as social distancing, restricted mobility and wearing face masks (Ekberg et al., 2009; Taylor et al., 2009). Thus, we emphasize that citizen community responsiveness, particularly at the beginning of the outbreak, could decrease infection probability and diminish the pandemic spread.

In Model 3, we test the hypothesized moderating relationships. We found that all prior relationships between the main effects and pandemic growth, as identified in Model 2, remain consistent in the direction and significance of effects for this full model. We hypothesized a decisive moderating role of CR on the relationship between SR and pandemic growth. In Model 3, the interaction term (SR*CR) was found to be significant and positive ($\beta = 0.087$, $p < 0.05$) and contributed to a significant change in the variance explained (change in $R^2 = 0.005$, change in $F$ statistics $= 6.328$, $p < 0.05$). While the statistical significance ($p < 0.01$) of $\beta$ for the interaction term showed that the effect of SR on pandemic growth depends on the level of CR, the positive sign indicates that an increase in CR will amplify the effect of SR in controlling the pandemic growth. Based on this empirical evidence, we found support for H2.

Interestingly, the findings on the significant moderating effects of interactive item SR*CR on curbing the growth rate of the pandemic have support from the collaborative governance literature (Ansell & Gash, 2008), which states that state-society collaboration is the key to effective pandemic preparedness. According to this literature, no single participating actor, i.e., the state or the community, has sufficient knowledge or capacity to manage complex problems in a complex socio-political environment (Agranoff, 2006; He & Harris, 2020; Kapucu, 2005; Thomas & Gilson, 2004). Thus, only a collaborative approach enhances the capacity of participating actors to resolve problems that cannot be solved, or solved easily, by a single actor (Simo & Bies, 2007).

### 7.1 Cross-country analysis

We performed the cross-country analysis by running the Model 3 separately for each country. The results of country-wise parameter estimates are presented in Table 6.

Tables 5 and 6 show an overall strong interaction effect of CR on the relationship between SR and PG for the US ($\beta_{SR*CR} = 0.96***$), Sweden ($\beta_{SR*CR} = 1.88***$), Italy ($\beta_{SR*CR} = 1.22**$), Singapore ($\beta_{SR*CR} = 0.48*$), Turkey ($\beta_{SR*CR} = 0.68***$), Australia ($\beta_{SR*CR} = 0.54*$), and India ($\beta_{SR*CR} = 0.38*$). Their interaction effect is substantially stronger than the overall interaction effect for the Model 3 ($\beta_{SR*CR} = 0.087$). Among these countries, the direct effects of both SR and CR on PG are insignificant for India and Turkey. One likely reason for this difference could be cultural overlap that exists between India and Turkey that is different from other countries (Özerdem & Kapucu, 2006). Additionally, Germany ($\beta_{CR} = -1.05***$, $\beta_{SR} = -0.61**$), and UAE ($\beta_{CR} = -1.33**$, $\beta_{SR} = -0.79*$)

| **TABLE 6** Country-wide PG growth |
|-----------------------------------|
| **Country** | **SR** | **t value** | **CR** | **t value** | **SR × CR** | **t value** | **R^2** |
|------------|--------|------------|--------|------------|------------|------------|--------|
| Australia  | $-0.27^{**}$ | $-0.64$ | $-0.792^{***}$ | $-4.05$ | $0.54*$ | $1.64$ | $0.52$ |
| France     | $0.12^*$ | $0.39$ | $-0.923^{**}$ | $-3.05$ | $0.14^*$ | $1.28$ | $0.53$ |
| Germany    | $-0.61^{**}$ | $-2.39$ | $-1.05^{***}$ | $-3.93$ | $0.25^*$ | $1.71$ | $0.52$ |
| India      | $-0.18^*$ | $-0.24$ | $0.42^*$ | $0.54$ | $0.38*$ | $2.47$ | $0.41$ |
| Italy      | $-1.33^{**}$ | $-3.47$ | $-0.74^*$ | $-2.66$ | $1.22^{**}$ | $2.62$ | $0.72$ |
| Japan      | $0.02^*$ | $0.05$ | $-0.33^*$ | $-1.75$ | $0.22^*$ | $0.58$ | $0.39$ |
| Malaysia   | $-0.45^*$ | $-1.43$ | $0.13^*$ | $0.40$ | $-0.89^{**}$ | $-0.63$ | $0.32$ |
| Singapore  | $-0.85^{***}$ | $-5.22$ | $-0.86^{***}$ | $-5.92$ | $0.48^*$ | $2.56$ | $0.53$ |
| Spain      | $0.005^{**}$ | $0.01$ | $0.42^*$ | $2.19$ | $-0.19^{**}$ | $-1.54$ | $0.49$ |
| Sweden     | $-0.89^*$ | $-2.46$ | $-0.82^*$ | $1.41$ | $1.88^{**}$ | $3.24$ | $0.45$ |
| Turkey     | $-0.34^{**}$ | $-0.96$ | $-0.03^{**}$ | $-0.07$ | $0.68^{***}$ | $5.01$ | $0.31$ |
| United Kingdom | $-0.64^{**}$ | $-1.23$ | $0.24^*$ | $0.34$ | $0.52^{**}$ | $1.08$ | $0.37$ |
| UAE        | $-0.79^*$ | $-2.33$ | $-1.33^{**}$ | $-3.56$ | $-0.02^{**}$ | $-0.16$ | $0.36$ |
| United States | $0.03^*$ | $0.14$ | $-1.33^{***}$ | $-7.34$ | $0.96^{***}$ | $5.89$ | $0.63$ |

*p < .05, **p < .01. ***p < .001.
exhibited significant negative direct effect of both SR and CR on PG, even as the interaction effect of CR on SR-PG relationship is insignificant. This finding emphasizes the need to explore other constituents of nation as a system in these countries. Perhaps, the differences in economic and education systems could explain the differences in causation. Among other countries with significant interaction effect, Australia ($\beta_{CR} = -0.79^{***}$), Sweden ($\beta_{SR} = -0.89^*$), and the US ($\beta_{CR} = -1.33^{***}$) exhibited either strong negative direct effect of either SR or CR on the PG. Further, among the countries with insignificant interaction effect, France ($\beta_{CR} = -0.92^{**}$), and Spain ($\beta_{CR} = -0.82^*$) exhibited significantly negative effect of only CR on PG. Finally, Japan, Malaysia, and UK did not show any significant impact of SR, CR or moderation on PG. Likely reasons could be related to the capability of the system, reflected by the health infrastructure (like hospital beds, clinical resources, etc.) and system preparedness. In sum, while the statistical analysis provides some directions, we circle back to the basis of Systems Thinking, to present additional constituents of the system like national culture, group (subsystem) climate, community path dependency, economic and education systems etc., for future research consideration.

8 | CONCLUSIONS

This study presents three important contributions. First, it enables a systems view of examining a nation as a social system towards fighting a pandemic crisis. Alongside presenting the gaps in the definitions of system responsiveness, this study attempted to conceptualize responsiveness from System Thinking theoretic lens, in responding to a crisis. This conceptualization is generic to all crises and not specific to the COVID-19 case discussed in this study for empirical validation. We admit that our conceptualization of responsiveness as a function of flexibility, agility with purpose and adaptation, does not comprehensively consider the system adaptability and autopoiesis properties in scope of this paper. However, we believe that the discourse presented in this paper should trigger future research in this direction to integrate effectiveness and adaptability with the concept of responsiveness.

Second, this study examined the direct effects of SR and CR on pandemic growth. By taking the COVID-19 situation as the context, we presented how SR and CR play a vital role in eradicating pandemic outcomes. Based on the regression results, we reinforce the individual roles of state and citizen communities as constituent subsystems of a nation (as a social system) during a pandemic crisis. Our findings complement earlier studies by Gillespie et al. (2016), Chowell et al. (2011), Mills et al. (2004), Li et al. (2018), and Garrett and Rhine (2010). Third, this study examined the moderating effect of citizen community responsiveness through the interaction variable. We conclude that an increase in CR will amplify the effect of SR in controlling pandemic growth.

Consequently, we can infer that when working alone, the state will be partially effective in controlling pandemic growth. Thus, a collaborative approach between state and citizen communities is recommended. These results highlight that within a flexible and agile system, the adaptability of subsystems plays a pivotal role. Our findings complement previous studies, namely, Ekberg et al. (2009), Taylor et al. (2009), Schwartz (2012), Yen et al. (2014), Ansell and Gash (2008), Thomas and Gilson (2004), Agranoff (2006), and Kapucu (2005).

8.1 | Implications

8.1.1 | Theoretical and managerial implications

Introducing ‘nation’ as a social organization and examining social change within the set context are the core contributions to social organization literature. Also, the study findings related to a cause–effect relationship between the responsiveness construct and pandemic growth contribute to social organization body of knowledge by validating how non-state bodies (like citizen communities) play a significant role in making a state affiliates’ decision under uncertainty. The collaboration between the state and non-state bodies may be formal or informal; it may also involve several levels of government, private sector businesses, social organizations, and communities.

Second, this study marginally contributes to the operations management literature through its implications of responsiveness under inevitable crises. This paper has not dealt with core OM areas like system design, capacity or aggregate planning, resources forecasting, mobilization, allocation, scheduling, and optimization. However, this study opens doors for systems–operations research interface in the context of crisis management. This study argues that when responsiveness is the key, willingness to respond and to respond quickly alone are insufficient. Thus, this study positions adaptation as a vital ingredient of responsiveness within the operations management literature. From a systems thinking perspective, this study contributes to examining the system–subsystem relationships at an aggregate level. Further, driving the subsystem energies towards a prevailing direction becomes essential to improve system performance, cohesively. From a crisis management point of view, this study complements the rich literature on crisis management by
providing directions to policymakers and governments on decision-making under crisis.

8.1.2 | Social implications

This study implies that comprehensive state-driven public health plans may be vital for an effective pandemic response, but they alone are insufficient to achieve the goal of controlling pandemic growth. The widespread implementation of unpopular yet straightforward state protocols of pandemic control such as social distancing, constrained citizen mobility, hand washing, in-house toileting, and avoiding spitting in open areas requires far more than merely investing in traditional public health systems. Therefore, policymakers, healthcare leaders, and associated operations professionals must focus on driving awareness and creating infrastructure to promote citizen-driven responses. At the same time, cooperation with local communities and trust-building between state and citizens are essential for driving their interactions. Governments should invest in building awareness in citizen communities towards improving their state of living conditions. Additionally, understanding the local susceptibility to boost capacities and effectively allocating resources for pandemic control should be part of state regulations under crisis.

8.2 | Limitations and future directions

This study has certain limitations. One major limitation of this study is that our conceptualization of nation as a system falls short of other subsystems outside the state-citizen communities and their interactions. Future directions could be to identify other subsystems and characterize their possible holistic interactions through an influence or causal loop diagram. Another limitation is the duration of the panel dataset used for the analyses. In this study, we used the country-wise panel data for the initial phase of the pandemic (14 February to 15 April 2020). However, the pandemic took several turns after that and went through multiple phases triggering a multitude of interventions by the state, leading to several citizen reactions. However, this study is a first attempt to analyse the effects of state and citizen response to a pandemic crisis. Further, our data collection and analysis are limited to 14 countries. Adopting larger sample sizes could allow the rise of additional insights, contributing to the body of knowledge on the subject. Additionally, the analyses and results of the study are based on data aggregated at national level, however, analyses based on disaggregated data (state or province) may provide different results. Explicitly acknowledged by the author(s), this paper will be understood better than otherwise. Third, the specific context might be relevant since the COVID-19 outbreak has impacted several countries worldwide differently. Each country has used different practices to curb the pandemic effect, and our study involved only a few of them to represent SR and CR related variables. In this sense, to better represent the impact of SR and CR on COVID-19 infections and deaths, future studies could encompass a wider range of variables specific to every country. While our data sources are secondary, future research should collect primary data from respondents (through surveys) from other countries with similar socioeconomic conditions. Relevant metrics could be emergency mobilization of various resources, namely, temporary or makeshift clinics with beds and the required medical facilities, students in the final year of their education programs serving as ‘house surgeons’ of clinical practices, emergency fund schemes, and so forth. This would increase the external validity and reproducibility of the findings. Also, country-specific case studies would enable more field evidence to support/oppose our findings.

DATA AVAILABILITY STATEMENT
The data that support the findings of this study are available from the corresponding author upon reasonable request.

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