How frugal innovation shape global sustainable supply chains during the pandemic crisis: Lessons from the COVID-19

Abstract

Purpose- The COVID-19 crisis has created enormous strain in global supply chains. The disruption has caused severe shortages of critical items, including Personal Protective Equipment (PPE) (e.g. face masks), ventilators, and diagnostics. The failure of industry to meet the sudden demand for these necessary items has caused a severe humanitarian crisis. These situations, resulting from the COVID-19, crisis have led to the informal growth of frugal innovation in sustainable global supply chains. In this paper we provide a detailed overview of drivers of frugal-oriented sustainable global supply chains, following lessons acquired from emerging countries' attempt to deal with the COVID-19 pandemic.

Design/Methodology/Approach- We utilized a focused group approach to identify the drivers and we further validated them using existing literature published in international peer-reviewed journals and reports. We adopted total interpretive structural modeling (TISM) to analyze the complex relationships among identified drivers.

Findings- We present a theoretical framework to explain how the drivers are interlinked. We have developed our framework through a synthesis of the TISM modeling and MICMAC analysis. We observed that government financial support, policies & regulations, under the mediating effect of leadership and the moderating effect of national culture and international rules & regulations, has a significant effect on the adoption of emerging technology, volunteering initiatives, and values & ethics. Further, emerging technology, volunteering initiative, and values & ethics have a significant effect on supply chain talent and frugal engineering. These results provide some useful theoretical insights that may help in further investigating the role of frugal innovations in other contexts.

Originality/ value- We find that outcomes of the methodical contributions and the resulting managerial insights can be categorized into four levels. Industry and researchers alike can use our study in order to develop the decision-support systems guiding frugal-oriented sustainable global supply chains amid the COVID-19 pandemic and in recovering them thereafter. Suggestions for future research directions are offered and discussed.

Keywords: Pandemic, COVID-19, Global Supply Chain, Supply Chain Disruptions, Frugal Innovation, National Culture

"The rapid spread of COVID-19 has led to a global shortfall in essential items, turning many countries into resource-constrained environments. In response, an unprecedented number of do-it-yourself hobbyists (i.e. makers) have started to use digital fabrication tools to produce critical items. These bottom-up communities are mobilizing as part of a global movement to produce innovative solutions to much-needed items, such as face masks, face shields and ventilators. As these individuals tackle widespread resource constraints, the conceptual lens of frugal innovation becomes highly relevant to study how these solutions developed. Frugal innovation is a type of resource-constrained innovation that refers to the practice of doing more with less, for more people", (Corsini et al. 2021, p.195)

1. Introduction

As we are aware, COVID-19, which caused severe acute respiratory syndrome, was first identified in China in December 2019 (Guan et al. 2020). However, within a short span of time, the virus spread to other countries in Asia, Europe, and North America and was declared a pandemic by the World Health Organization (WHO) on 11 March 2020 (Guan et al. 2020; Ivanov, 2020; Ivanov and Dolgui, 2020a; Shih, 2020; Parast and Subramanian, 2021). Due to the severe health crisis resulting from COVID-19, governments of affected countries are required to slow the spread of the virus by imposing containment and suppression measures (Guan et al. 2020; Queiroz et al. 2020; El Baaz and Ruel, 2020; Sodhi and Tang, 2021; Belhadi et al. 2021). These suppression measures include limiting social gatherings and strict controls on travel and commercial activities that involve face-to-face contact aimed at '*flattening the curve*' (Santos et al. 2020). Guan et al. (2020, p. 577) state that flattening the curve " *is decreasing the rate of new infections to avoid overwhelming healthcare systems to less strict measures designed to shield immunologically compromised individuals, treat victims and achieve herd immunity*". Harris et al. (2020, p. 814) argue that "*necessity has been the mother of invention in the response to the COVID-19 pandemic, triggering many an innovation, often without the luxury of time to test these makeshift solutions to pressing problems. But there is much to be learned from times of crisis for times of plenty*".

COVID-19 has presented unprecedented challenges to both developed and developing economies (Handfield et al. 2020; Remko, 2020). COVID-19 has forced countries to respond to the unforeseen challenges with speed, but some countries have failed to meet the traditional processes of testing and trialing new technologies, processes, and medicines (Harris et al. 2020; Kovacs and Falagara Sigala, 2021) due to a lack of adequate resources. However, on the other hand, some countries like China, India, Pakistan, Vietnam, and other developing economies have adopted some extraordinary moves such as creating makeshift hospitals or developing ventilators or by producing millions of bottles of sanitizers within distilleries infrastructure (Brem et al. 2020). This clearly demonstrates how frugal innovation has played a significant role during these unprecedented times (Harris et al. 2020). Frugal

innovation does not mean compromising on quality. Instead, it should be viewed as an alternative solution to respond to the crisis in a resource-constrained environment (Shibin et al. 2018; Harris et al. 2020). Hence, in such an unprecedented public health crisis, frugal innovation offers a great opportunity to expand access to care and to ensure that this care, although perhaps not perfect (yet), is good enough under the current circumstances (Harris et al. 2020; Brem et al. 2020). Whilst existing literature has often focused on affordability and low cost in frugal innovation, there are many other factors relating to the concept, in the context of the pandemic, which are not yet fully understood.

Karmaker et al. (2020) argue that COVID-19 has disrupted supply chains on a global scale. Of the Fortune 1000 companies, 94% of them have experienced coronavirus-driven supply chain disruptions (Ivanov and Dolgui, 2020b; Karmaker et al. 2020). Despite the multiple challenges posed, the crisis has raised awareness among the organizations, citizens, and policymakers towards sustainability (Ivanov, 2020; Sarkis, 2021) and there is a pressing need for frugal innovation in supply chains to respond to the sustainability agenda (Corsini et al. 2021). In response, the international community has realized the need for frugal innovation in order to build sustainable global supply chains (Cheng et al., 2015; Subramanian and Gunasekaran, 2015; Shibin et al. 2018). Hence, we argue that frugal innovation is the simplest and most appropriate solution for almost all major challenges we face due to COVID-19. Following the COVID-19 crisis, SMEs in emerging markets such as India are now focusing more on frugal innovation (Nandi et al. 2021). Nidumolu et al. (2009) argue that the organizational and technological innovations are the bedrock of sustainability that will ensure bottom-line and top-line revenue enhancement. Ongoing innovations are necessary to make supply chains lean (Lamming, 1996; Lelah et al. 2012; Fournier et al. 2021) and it will ultimately help to improve organizational performance (Dubey et al., 2012; Hui et al., 2015; Shibin et al. 2018). At the same time, organizations have to ensure that innovation in business and sustainability in operations are going hand in hand, in order to support society and to minimize any possible negative environmental impacts (Talonen and Hakkarainen, 2014; Desai, 2012; Schaltegger & Wagner, 2011; de Camargo Fiorini and Jabbour, 2017). Horn and Brem (2012) argue: frugality and sustainability are the two major fields of future innovation management.

Despite the interest of both academics and practitioners in frugal innovation and sustainability, there are few articles discussing frameworks and other aspects of sustainability-oriented frugal innovations

related to global supply chains during a pandemic or other major crises (Ivanov, 2020; Karmaker et al. 2020; Ketchen and Craighead, 2020, 2021). So, following Whetten's (1989) arguments, we posit two guiding research questions:

RQ1: What are the key drivers of sustainability-oriented frugal innovation in global supply chain management in the context of the pandemic crisis?

RQ2: How are the drivers associated with each other?

To address our research questions, we used the TISM (Sushil, 2012; Dubey and Ali, 2014) approach to examine the relationships between the factors that are important for sustainability-oriented frugal innovations in the global supply chain during the pandemic crisis. We have organized our chapter as follows. The next section discusses the concepts of frugal innovation and sustainability, and then we present the methods, the model, and then a discussion of how the results contribute to the theory, with extensive directions as to the implications for managers and policymakers. Lastly, we draw some final conclusions.

2. Underpinning Theories

2.1 Conceptual framework

In our study of sustainability-oriented innovations in supply chains following the COVID-19 crisis we have used a number of organizational theories for the synthesis leading to the development of the final theoretical model. Firstly is the resource-based view (RBV), by which an organization can be considered as a bundle of resources consisting of tangible and intangible assets and tacit knowledge (Penrose, 1959; Barney, 1986; Grant, 1997). Based on the RBV, any firm can gain a competitive advantage via strategic use of resources that are very distinctive or superior compared to the resources of its competitors, if the resource requirements are exactly in a match with the environmental opportunities and business requirements (Thompson and Strickland, 1990). An extension of RBV is a knowledge-based view (KBV) of the firm, which acknowledges the importance of knowledge as a strategic resource contributing to the achievement of competitive advantage (Grant, 1996). The effective management of knowledge leads to better performance in innovative activities, such as new product development (Ettlie and Pavlou, 2006) and leads to organizational transformation (Zahra and George, 2002).

According to DiMaggio and Powell (1983), organizations are becoming similar in their nature, mainly because of three types of institutional pressures: coercive, mimetic, and normative. Thus according to institutional theory, which is our second theoretical lens, the performance and outcomes of organizations are influenced by external factors (Meyer and Rowan, 1977; Mizruchi and Fein, 1999). Government rules and regulations, the socio-political situation, market trends, and competition are some of these external factors (Law and Gunasekaran, 2012; Annala et al. 2019). Particularly during the pandemic crisis, institutional theory has become one of the very popular and well-accepted theories with which to examine the supply chain (see, Craighead et al. 2020). Following Barratt et al. (2011) arguments, we have adopted RBV and institutional theory to examine some of the drivers of the frugal innovation in global sustainable supply chains. Moreover, we utilize the contingency view (Sousa and Voss, 2008) in order to understand the context in which the resources and the external pressures yield differential outcomes during a pandemic crisis.

Finally, whilst Total Interpretive Structured Equation Modelling (TISM) has gained significant attention in recent years, the literature on TISM as a research method to generate theory is scant (Goyal and Grover, 2012; Mangla et al., 2014; Prasad and Suri, 2011; Singh and Sushil, 2013; Srivastava and Sushil, 2014; Yadav and Sushil, 2014; Dubey et al., 2015). According to Nasim (2011) and Sushil (2012), TISM has its own advantage over Interpretive Structured Modelling, because the causal relationships or transitive links between the constructs of the model are particularly well-explained using a TISM model.

2.2 Sustainability

In the operations management field, Kleindorfer et al. (2005) argue that sustainable operations management (SOM) practices have a positive impact on the economic performance of organizations and helps minimize the adverse effects of economic development on society and the environment. SOM deals with issues such as technology selection in production, energy and material usage optimization, and waste minimization (Drake and Spinler, 2013). According to Gimenez et al., (2012) and Gotschol et al. (2014) internal environmental programs within the organization have a positive impact on the economic, environmental, and social performance of a business, because any investment in such programs helps gain economic benefits for the organization in the long run (Graham et al. 2015; McDougall et al. 2021). Organizations must consider the term 'green' as a tool for achieving competitive advantage to go global and to increase market share, given that today's highly educated

and highly aware customers prefer eco-friendly products (Deif, 2011; Houe and Grabot, 2009; Graham et al. 2015). Social sustainability practices help the organization to achieve a greater social reputation (Hong et al., 2012; Marshall et al. 2015; Kauppi and Hannibal, 2017), whilst from an economic perspective of sustainability, Woolworths Company saved 9.3 million US Dollars after focusing on ecological, social, and economic indices, based on the triple bottom line initiative (Santos et al. 2014).

Matos et al (2020, p. 1750) argue that the entire globe is facing unprecedented challenges in the form of "*climate change, deforestation, biodiversity loss, inequality, famine, labor exploitation, modern slavery, and more recently global pandemics"*. On the other hand, consumers and key stakeholders are expecting organizations to be more responsible towards their contribution to minimizing environmental degradation (Wilhelm et al. 2016; Matos et al. 2020). The pandemic crisis resulting from COVID-19 has further increase awareness of environmental and social sustainability amongst consumers (He and Harris, 2020; Sarkis, 2021; Severo et al. 2021). Poist (1989) argues that sustainability in the supply chain is a business obligation to seek socially beneficial results, as well as economic ones, in its actions. Since then, many scholars have advocated the importance of social sustainability in the supply chain (Littig and Griebler, 2005; Linton et al., 2007; Hutchins and Sutherland, 2008; Pullman et al., 2009; Klassen and Vereecke, 2012; Marshall et al. 2015; Zhang et al. 2017; Alinaghian et al. 2020; Venkatesh et al. 2020) as the materials and products pass through multiple levels from supplier to customer. Poist (1989) further stated that the *environmen*t, *employee training*, *health, and safety*, *philanthropy*, *workplace diversity*, and *community issues including homelessness and hunger as facets of supply chain social responsibility*. We feel that Poist's (1989) argument is highly relevant in the context of the pandemic crisis, which has resulted in many people losing their jobs, often without any resources to survive the crisis i.e. in emerging countries where the government support is far below the minimum requirements (c.f., Sengupta and Jha, 2020; Pan et al. 2020; *Sharma, Talan & Jain, 2020*). Hence, we argue that sustainability is regarded as a source of competitive advantage for any organization (Forman and Jrgensen, 2004; Preuss, 2007) and is necessary for the effective operations of an organization, realized through SOM techniques. Furthermore, as Sarkis (2021) states, the three dimensions of sustainability: social, environmental, and economic, are difficult to disentangle during the COVID-19 crisis.

2.3 Sustainability-oriented frugal innovation and the pandemic crisis

Frugal innovation can be defined as the unique way of thinking and acting in response to challenges by effectively spotting the opportunities even in the worst circumstances and by improvising the solutions resourcefully in the simplest possible way (Radjou et. al., 2012; Shibin et al. 2018). Affordability is the key factor driving businesses in emerging markets and in this context frugal innovation acts as a key success factor. The major challenge companies may face in this regard is to align their business processes and products to make the price of their products and services at a level where economically disadvantaged consumers will also feel it is affordable. Shibin et al. (2018, p. 910) conceive frugal innovation as a way to "*consider affordability as the major criterion and try to meet the necessities of the poor by considering society as a whole and innovation become a development imperative"*. Furthermore, frugal innovation offers the best solution in a resource-constrained environment (Soni and Krishnan, 2014; Ernst and Kamrad, 2000; Sharma and Iyer, 2012). It is often considered as the foundation of social entrepreneurship, with the poor as consumers, co-producers, and innovators (Pansera and Sarkar, 2016; Shibin, 2018), thereby enhancing many underrepresented people's lives. Bhatti and Ventresca (2013) argue that frugal innovations can also be considered as a way to grow with less and to cut costs, which in turn will boost environmental and economic performance of organizations. Hence, they support sustainability, as, firstly, they are more energy or material-efficient; secondly, they promote technologies that are more democratic; and thirdly, they are pro-poor and consider society as a whole (Leach et al., 2012; Demeritt et al., 2011; Fagerberg et al., 2010).

Within developing countries, firms that follow the paradigm of frugal innovation aim at achieving extreme cost advantage (Zeschky et al., 2011). Developing affordable products and services is critical for Small-Medium-Enterprises (SMEs) in this context, and to this extent the role of knowledge management is important. Knowledge management, according to Alegre et al. (2011), involves "*identifying and leveraging the collective knowledge in an organization to contribute to its performance*" (p. 2). Utilizing and managing knowledge effectively can enable SMEs to overcome problems relating to product, service development, and help to develop sustainable businesses (Durst and Edvardsson, 2012). Cohen & Levinthal (1990) have argued for the reliance on firms that innovate on their knowledge capabilities, whereas Zahra and George (2002) suggest that it is absorptive capacity – being a capability for processing knowledge – that enhances innovation. In earlier studies, von Krogh (1998) acknowledged the importance of mobilizing knowledge resources and turning them into value-adding activities, thereby linking knowledge management to innovation and subsequently innovation performance.

2.4 Drivers of sustainability-oriented frugal innovation

We used a focused group approach to identify ten drivers of frugal innovation in the global sustainable supply chain. We also provide supporting literature to establish content validity. The drivers are as follows: government financial support, government policies and regulations, Leadership, talent, international rules and regulations, values & ethics, volunteering, culture, frugal engineering, and emerging Technology (see Table 1). In the next section we introduce each in turn.

2.4.1 Government Financial Support

Financial support is vital during a pandemic crisis; without proper financial support it is almost impossible to execute any sustainable innovation initiative (Mudgal et al. 2010; Karmaker et al. 2020). Cooke (2001) emphasizes the importance of funding, especially from public bodies, for encouraging regional innovation and the knowledge economy. Government funding is crucial in encouraging SMEs to adopt sustainable initiatives in their supply chains (Holt et al., 2001; Lee and Jang, 2003; Lee, 2008). Thus, public funding is a key facilitator in promoting innovation, sustainability, and cleaner technology initiatives in supply chains, especially during pandemic crises. The COVID-19 crisis caused severe disruptions in the supply chains around the globe due to necessary responses, including social distancing, testing, and quarantining policies, and income support packages (Ivanov, 2021). Ashraf (2020) found that the government-mandated measures, like social distancing and quarantining policies, have a direct negative effect on stock market returns, due to their adverse effect on economic activity, while they have an indirect positive effect through the reduction in COVID-19-confirmed cases. The government support packages also help the economy to recover and return to growth. Hence, we argue that government financial support is a significant contributor to any such sustainability initiatives to minimize the negative consequences resulting from the COVID-19 crisis.

2.4.2 Government policies and regulations

There is literature suggesting that government policies and regulations are one of the major drivers of an organization's sustainability initiatives in response to the pandemic crisis (Karmaker et al. 2020; Shih, 2020). External policies and regulations can enable innovations by compelling organizations to adopt best in class technologies and process standards, with deadlines that will boost sustainability performance (Henriques and Sadorsky, 1999; Porter and Van de Linde, 1995). Shibin et al. (2018)

identify government policies as one of the facilitators in achieving sustainability via frugal innovation. Woo et al. (2020) analyze the case of Singapore in controlling fatalities rate resulting from the COVID-19 in comparison to other developed countries like the United States, United Kingdom, France, Italy and Spain. The success of Singapore is attributed to its robust policy capacity, which was developed over the period and resulted from the previous learning which they gained from the 2003 SARS. On the other hand, countries like India, despite high population density and lack of adequate capacity to deal with rising COVID-19 cases, have adopted some strict measures like social distancing, lockdown, with high penalties for those who flout the strict rules (Ghosh et al. 2020). At this point in time, many experts have severely criticized Indian government decisions. However, whilst there are some merits in the criticisms, the strict measures and strong regulatory framework has yielded positive outcomes in the long run, by minimizing the fatalities (Paital et al. 2020). Thus, we argue that government policies and regulations are important for frugal innovation in a sustainable global supply chain in response to the pandemic crisis.

2.4.3 National Culture

A nation's culture may be understood as the shared psychological meanings and collective practices that separate one nation from another (Hofstede, 1980; Gupta and Gupta, 2019; Gupta et al. 2021). It has been operationalized in various ways (see, Guan et al. 2020). Guan et al. (2020) argue that people from the same nation are socialized to use their culture-specific orientations to shape their mental resilience that enables them to cope with the various degree of the stress caused by the unprecedented crisis; and there are significant cross-cultural differences in individuals' appraisals of stressors, choices of coping strategies, and indicators of adaptive outcomes (Gupta et al. 2021). During the COVID-19 crisis, in the absence of reliable vaccines, social distancing is one of the most reliable ways to prevent the transmission of the virus (Yan, 2021). The social distancing behavior various between different in different countries (Maloney and Taskin, 2020). Gupta et al. (2021), in one of their recent studies, have examined the different behavior in maintaining social distancing, using national-culture Hofstede's framework. Frey et al. (2020) found that the citizens practice more social distancing in low '*Individualism*' culture. Moreover, Huynh (2020) found that people in a high '*Uncertainty Avoidance*' culture are most likely to practice social distancing. Furthermore, Im and Chen (2020) argue that people practice social distancing irrespective of the *individualism culture* or *uncertainty avoidance culture*. This is purely based on the situation and the need of the hour. Hence, we argue that the national

culture plays a pervasive role in shaping the ways people assess and cope with career-related stressors associated with the COVID-19 pandemic.

Table 1: Drivers of sustainability oriented frugal innovation in global supply chain management in context to pandemic crisis

Drivers of sustainability oriented frugal innovation in supply chain	Authors (Year)
Government Financial Support (E1)	Holt et al., (2001); Cooke (2001); Lee and Jang, (2003); Lee, (2008); Mudgal et al. (2010); Ashraf (2020)
Government policies & regulations (E2)	Karmaker et al. (2020); Shih (2020)
National Culture (E3)	Gupta and Gupta (2019); Guan et al. (2020); Gupta et al. (2021); Gokemen et al. (2021); Yan (2021)
Talent (E4)	Lambert et al. (1998); Gammelgaard and Larson (2001); Giunipero et al. (2006);Dubey et al. (2018); Hartmann and Lussier (2020)
International rules and regulations (E5)	Ji et al., (2014); Plambeck and Wang, (2009); Bokusheva et al., (2012); Ji et al. (2014); McKinnon (2007); Walker et al. (2008); Zhu and Sarkis (2006); Zhu et al. (2007)
Values & Ethics (E6)	Gunasekaran and Spalanzani (2012); Drake and Schlachter (2008); Roberts, (2003); Awaysheh and Klassen (2010); Lee and Kim (2009); Svensson (2007)
Volunteering (E7)	Miao et al. (2020); Finsterwalder and Kuppelwieser (2020); Walker (2016)
Leadership (E8)	Dubey et al (2015); Dubey et al. (2018); Salem et al. (2019); Shih (2020); Woo et al. (2020); Sarkar (2021)
Frugal Engineering (E9)	Zeschky et al. (2011); Shibin et al. (2018); Harris et al. (2020); Vesci et al. (2021)
Emerging Technology (E10)	Mbunge (2020); Shibin et al. (2018); Shaw et al. (2020); Ivanov (2020)

2.4.4 Talent

Hartmann and Lussier (2020) argue that the pandemic resulting from COVID-19 has caused interrelated social, technological, and structural challenges for many organizations. This multitude of challenges, stemming from extreme lockdowns, has forced organizations to postpone important meetings and events (e.g., tradeshows, conferences, and customer meetings). Travel restrictions and border shutdowns by different countries have further worsened the situation. The lockdown or border shutdowns have led to several issues in supply chains as inventory shortages, supply chain breakdowns, product delivery problems, general difficulty maintaining daily operations, new work arrangements (e.g., virtual selling, changes to information flows, contraction and expansion of roles),

and the threat of temporary or permanent dismissal (Hartmann and Lussier, 2020; Ivanov, 2020; Shih, 2020). Kovacs et al. (2012) argue that supply chain talent is highly critical to manage such unprecedented challenges. Hence, organizations should focus on developing talented supply chain professionals for the success of frugal oriented global sustainable supply chain in response to pandemic crisis. In a previous study, Giunipero et al. (2006) emphasize that ensuring smooth functioning, strong strategic collaboration, and strategic cost reductions are very difficult without having a pool of talented supply chain professionals possessing strong technical, communication, and financial skills. Many researchers (Lambert et al., 1998; Gammelgaard & Larson, 2001; Tatham et al. 2013; Zhang and Lv, 2015; Dubey et al. 2018; Daghar et al. 2020); strongly argue that supply chain talent development needs further conscious and planned effort from organizations. Thus we too have considered supply chain talent as one of the drivers of sustainability-oriented frugal innovations in the sustainable supply chain, for responding to the pandemic crisis.

2.4.5 International rules and regulations

"The novel coronavirus that spread throughout the world in 2020 certainly seemed to fit the definition of problems without passports, yet as the outbreak turned into the full-fledged COVID-19 pandemic, countries defied each of Annan's prescriptions, producing three patterns" (Johnson, 2020, p. 148). Dodds et al. (2020) expressed their concerns over the role of international bodies failing to bring uniformity in their policies to address concerns resulted from COVID-19. The restrictions on travel based on nationality have further worsened the relief efforts (Guan et al. 2020). European Union rules concerning, for instance, electrical and electronic equipment waste and the norms requiring vehicle manufacturers to guarantee the recycling of vehicle raw material, up to a minimum of 85%, are examples of international rules and regulations that will drive innovation and sustainability in the supply chain (Ji et al., 2014; Plambeck and Wang, 2009). International environmental emission regulations not only encourage companies to reduce the emissions from their products but also compel them to invest in emission reduction technologies and innovation (Bokusheva et al., 2012; Ji et al., 2014; McKinnon, 2007). There is rich literature arguing that international rules and regulation is a strong external factor driving sustainability and innovations in the supply chain (see Walker et al., 2008; Zhu & Sarkis, 2006; Zhu et al., 2007). However, the role of international rules and regulations in the context to frugal innovations during a pandemic crisis is not well understood. Sarkar (2021) argue that frugal innovations, supported by the government, in collaboration with institutions and the non-governmental organizations, are cheap and highly effective in controlling the negative effects of the COVID-19 crisis on health and

the economy. Hence, we posit that international rules and regulations are an important driver during the pandemic crisis.

2.4.6 Values & Ethics

Gunasekaran and Spalanzani (2012) argue that business ethics is an important driver of sustainability initiatives. Ethical practices are important in the sourcing, purchasing, and successful collaboration of organizations in supply chain networks (Drake and Schlachter, 2008; Roberts, 2003; Svensson, 2007; Lee and Kim, 2009; Awaysheh and Klassen, 2010). The responsible supply chain is becoming more relevant in this era of social turbulence and pandemic crisis (see, Karmaker et al. 2020; Ivanov, 2020). Hoejmose et al. (2013) further emphasize the need to include organizational strategies that aim at developing socially responsible supply chain processes. Majumdar et al. (2020) argue that socially responsible practices are not only critical for the industry, they further help assure the livelihood of the informal workers who play a significant role in emerging countries. For instance, the readymade garment industry utilizes such workers and their skills to meet the growing need for the face mask. This clearly demonstrates that the value & ethics helps frugal innovation to shape a sustainable global supply chain in response to the unprecedented crises resulting from the pandemic. Thus, we strongly argue that values & ethics are one of the drivers of frugal innovation in a sustainable global supply chain.

2.4.7 Volunteering

Miao et al. (2020, p.1) defines volunteering as "*a key component of coproduction, as coproducing volunteers actively provide relevant public services to their own communities, typically without tangible compensation".* Finsterwalder and Kuppelwieser (2020) argue that working with volunteers and voluntary groups to provide community services has the potential to fill acute gaps and prevent public agencies from being overwhelmed during crisis events, such as COVID-19. The COVID-19 pandemic created a critical need for volunteers working with the government to protect public health and to augment overwhelmed public services (Miao et al. 2020). Walker (2016) clearly argued that the role of local support is a critical driver to fight against the crisis resulting from the pandemic. Hence, we argue that volunteering is a key driver of frugal innovation in the sustainable global supply chain for responding the pandemic crisis.

2.4.8 Leadership

Gooty et al. (2010) describe leadership as the process of directing and influencing the task-related activities of group members. Salem et al. (2019) further argue that leadership plays a crucial role during a humanitarian crisis. Dubey et al. (2018) found that leadership has an important role to play in any organizational initiative, through belief and participation. Organizational researchers have recognized the activities of the leaders or top executives in shaping organizational strategies (Hambrick and Mason, 1984). Dubey et al. (2015) noted in one of their studies that leader's values and cognitive biases, which guide organizational strategies, decisions, and behavior, are critical factors behind successful organizational change. Hence, the role of leaders is especially critical in terms of resource allocations and deployment decisions that are necessary for organizational change (Dubey et al. 2021). We argue that the leadership perspective offers illuminating insights into operations and supply chain management literature, where resource allocations and deployment decisions may create different outcomes in dynamic and uncertain environments (Salem et al. 2019). Organizational scholars have also widely recognized the role of the top managers or leaders in dealing with paradoxes, contradictions, conflicts, and building requisite conditions for embracing dynamic changes (Gnyawali et al. 2016). Hence, following the preceding arguments, we believe leadership has an important role to play in the pandemic crisis in driving frugal innovation in the sustainable global supply chain.

.

2.4.9 Frugal Engineering

"*Due to the resource constraints typical in emerging markets, consumers in these markets are very value conscious; many have only recently shifted from being non-consumers to being consumers*" (Zeschky et al. 2011, p. 39). Harris et al. (2020) argue that the pandemic crisis has influenced the purchasing power of consumers. Recent strict measures adopted by the government have further increased poverty levels due to the lack of adequate opportunities offered by unorganized sectors and resources to meet human basic needs (Shammi et al. 2020; Harris et al. 2020; Vesci et al. 2021). In such a situation, innovations via optimal use of available resources and proper environmental strategies may prepare citizens to deal with the pandemic crisis in a far better way. The environmental strategies have a direct impact on the supply chain and competitiveness of the organization (Wu and Pagell, 2011; Shibin et al. 2018). Hence, we argue that frugal engineering is one of the drivers of frugal innovation that may help the global supply chain to respond to the pandemic crisis.

2.4.10 Emerging Technology

Mbunge (2020, p. 1632) argue that "*with the rapid increase in COVID-19 cases and deaths in affected countries, the integration of emerging technologies into contact tracing activities is inevitable. Integration of COVID-19 contact tracing activities with technology is not new, countries like South Korea, Germany, Singapore, Australia, Colombia, Australia, Egypt, Ghana, Austria, Israeli among others have launched aggressive technology-based contact tracing applications. These countries use several devices to communicate together through Bluetooth technology, Global Positioning System (GPS), wireless technology, mobile phone applications, wearable technology, and sensors".* Some countries have successfully exploited these innovative technologies (e.g., artificial intelligence (AI), big data, 5G technologies were used in combination with other emerging technologies like drones, automated vehicles, robotics, etc.), to test, track and trace COVID-19 infected people. Shaw et al. (2020) further argue that emerging technologies have been used to identify affected people to check their mobility, to reduce the risk of contamination, as well as to develop proactively recovery strategies and actions. Hence this is our final driver of frugal innovation to enable global supply chains to respond to the pandemic crisis.

3. Research Method

Following Kwak et al. (2018) and Shibin et al. (2018) recommendations we used focused groups to identify ten drivers of the sustainability-oriented frugal innovation in the global supply chain (see Table 1). We undertook five focus groups constituted with 25 experts from government organizations, non-governmental organizations, and manufacturing firms with over 10 years of experience. Kwak et al. (2018) argue that the focus group is an effective way of capturing ideas from a group of experts and further helps to triangulate expert's perceptions related to their research domain. We have used total interpretive structural modeling (TISM) to then examine the complex relationships among the ten drivers. In TISM, a group expert judgment methodology is used to understand the relationships among the drivers. Opinions from academics and industry experts having core experience in the supply chain domain were incorporated using a structural self-interaction matrix (SSIM) (see Table 2). The opinions from experts were further refined with the help of an extensive literature review, ensuring that no drivers were being dropped or added up.

Fifteen exploitable responses were chosen from responses from around twenty-five experts in the supply chain domain with the help of social networking sites. The experts approached had more than

fifteen years of industry or academic experience in the supply chain domain. The response rate was 60%. Warfield (1974) and Malone (1975) were the first operation research experts, who introduced the interpretive structural modeling (ISM) technique. The major steps involved in TISM can be listed out in the sequence as: literature collection on the topic; review of collected literature to identify the variables; explaining the VAXO matrix allocation rules to the experts; formulation of structural self-interaction matrix (SSIM) with the help of experts in the domain; conversion of structural self-interaction matrix to a binary matrix and then to final reachability matrix by considering transitivity property (Sushil, 2012; Dubey and Ali, 2014; Shibin et al. 2017; Sushil, 2018a,b) (see Table 3). Deriving the total driving power and dependence based on the binary matrixes to find out the level of variables; and making the directed graph (DIGRAPH) based on the levels of variables identified. ISM model can be finalized by preparing a structural model from DIGRAPH, which will be self-explanatory on the relationship among the variables (Kwak et al. 2018). Reviewing the structural model may be required to validate the conceptual stability and make necessary changes in the model. There are two possible responses such as 'yes' or 'no' for any question regarding the relationship between two variables. And thus there will be nC_2 possible number of paired comparisons, which will tally into 45 for 10 variables in our case. The ISM model can be taken to the next level of TISM by incorporating the interpretive logic between the drivers based on the expert explanation. These interpretive logics are the contextual relationships among the variables, which are derived through brainstorming.

Table 2: Structural self-interaction matrix of drivers (SSIM)

	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1
E1	V	V	O	O	V	V	V	O	X	X
E2	V	V	V	O	O	X	O	X	X	
E3	O	V	V	V	V	X	O	X		
E4	O	V	A	X	X	O	X			
E5	V	X	X	A	O	X				
E6	A	V	A	X	X					
E7	A	O	A	X						
E8	X	A	X							
E9	V	X								
E10	X									

E1-Government Financial Support, E2-Government Policies & Regulations, E3- National Culture, E4-Talent, E5-International rules and regulations, E6- values and ethics, E7- Volunteering, E8-Leadership, E9-Frugal Engineering, E10- Emerging Technology

4. **Data Analysis**

There are paired comparisons of each set and the parameters considered are represented by *i* and *j*. Four letters such as V, A, X, O are used to represent the type of relationship between any of these paired comparisons in the survey. Table 1 shows the structural self-interaction matrix of drivers considered in this study. The matrix is to be filled with:

V if *i* leads to *j* but *j* doesn't lead to *i*

A if *i* doesn't lead to j and *j* leads to *i*

X if *i* and *j* lead to each other

O if *i* and *j* are not related each other

4.1 Transitivity Principle

The transitivity principle is used in ISM to check the consistency of the model developed (Farris and Sage 1975; Sushil 2015a, b). According to the principle, if a leads to b and b leads to c if a leads to b and b leads to c, then a leads to c. The transitivity property also helps to remove any possible gaps among the variables. The final reachability matrix for drivers shown in table 3 is prepared by adopting the above-mentioned criteria and transitivity principle.

Table 3: Final reachability matrix-drivers

	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1	Driving power
E1	1	1	0	1*	1	1	1	0	1	1	8
E2	1	1	1	1*	1*	1	1*	1	1	1	10
E3	0	1	1	1	1	1	1*	1	1	0	8
E4	0	1	0	1	1	0	1	0	0	0	4
E5	1	1	1	0	0	1	0	1	1	0	6
E6	0	1	0	1	1	0	1	0	0	0	4
E7	0	0	0	1	1	1	1	0	0	0	4
E8	1	1*	1	1	1	1	1	0	0	0	7
E9	1	1	1	0	0	1	0	0	0	0	4
E10	1	1*	1	1	1	1*	0	0	0	0	6
Dependence	6	9	6	8	8	8	7	3	4	2	

* represent transitivity property checked

E1-Government Financial Support, E2-Government Policies & Regulations, E3- National Culture, E4-Talent, E5-International rules and regulations, E6- values and ethics, E7- Volunteering, E8-Leadership, E9-Frugal Engineering, E10- Emerging Technology

4.2 Level Partitioning

The process of ranking different variables into different levels is called level partitioning. To derive the levels of variables, the first step is the calculation of reachability and antecedent sets from Table 2

(Warfield 1974; Sushil, 2012; Haleem et al. 2012; Purohit et al. 2016). In any iteration, if the reachability set intersection antecedent set is the reachability set itself, and then that variable will be placed in the top level of the hierarchy. The final output of level partitioning is shown in Tables 5, and the conceptual framework of drivers of sustainability oriented frugal innovation in global supply chains is shown in Figure 2. The MICMAC analysis shown in Figure 1 for drivers clearly bifurcate the drivers into four quadrants, depending on their driving power and dependency. The binary matrix shown in Table 4 is created by considering the final reachability matrix, but only by using binary digits of 0 and 1.

Table 4: Binary matrix of drivers

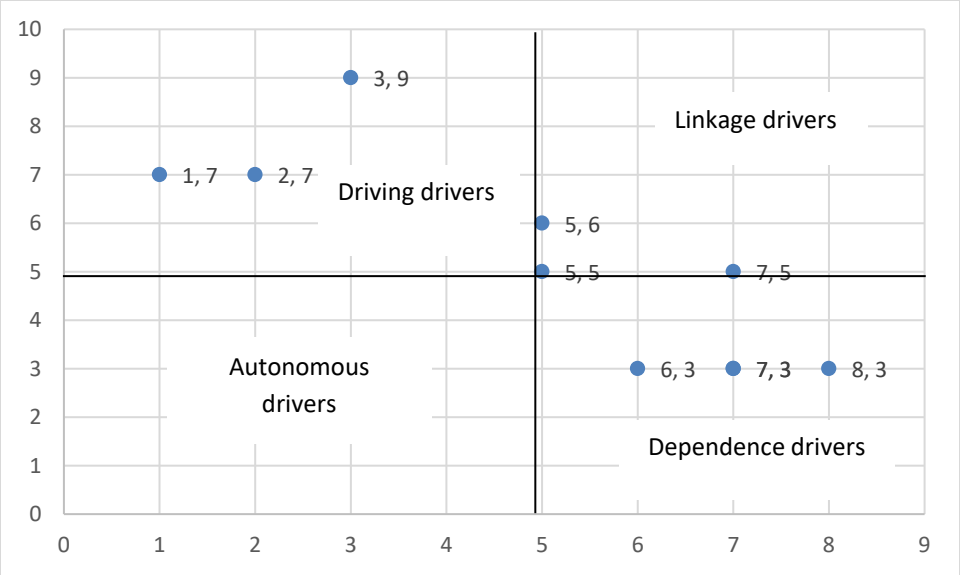
	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1	Driving power
E1	1	1	0	1	1	1	1	0	1	-	7
E2	1	1	1	1	1	1	1	1	-	1	9
E3	0	1	1	1	1	1	1	-	1	0	7
E4	0	1	0	1	1	0	-	0	0	0	3
E5	1	1	1	0	0	-	0	1	1	0	5
E6	0	1	0	1	-	0	1	0	0	0	3
E7	0	0	0	-	1	1	1	0	0	0	3
E8	1	1	-	1	1	1	1	0	0	0	6
E9	1	-	1	0	0	1	0	0	0	0	3
E10	-	1	1	1	1	1	0	0	0	0	5
Dependence	5	8	5	7	7	7	6	2	3	1	

E1-Government Financial Support, E2-Government Policies & Regulations, E3- National Culture, E4-Talent, E5-International rules and regulations, E6- values and ethics, E7- Volunteering, E8-Leadership, E9-Frugal Engineering, E10- Emerging Technology

Table 5: Level matrix of drivers

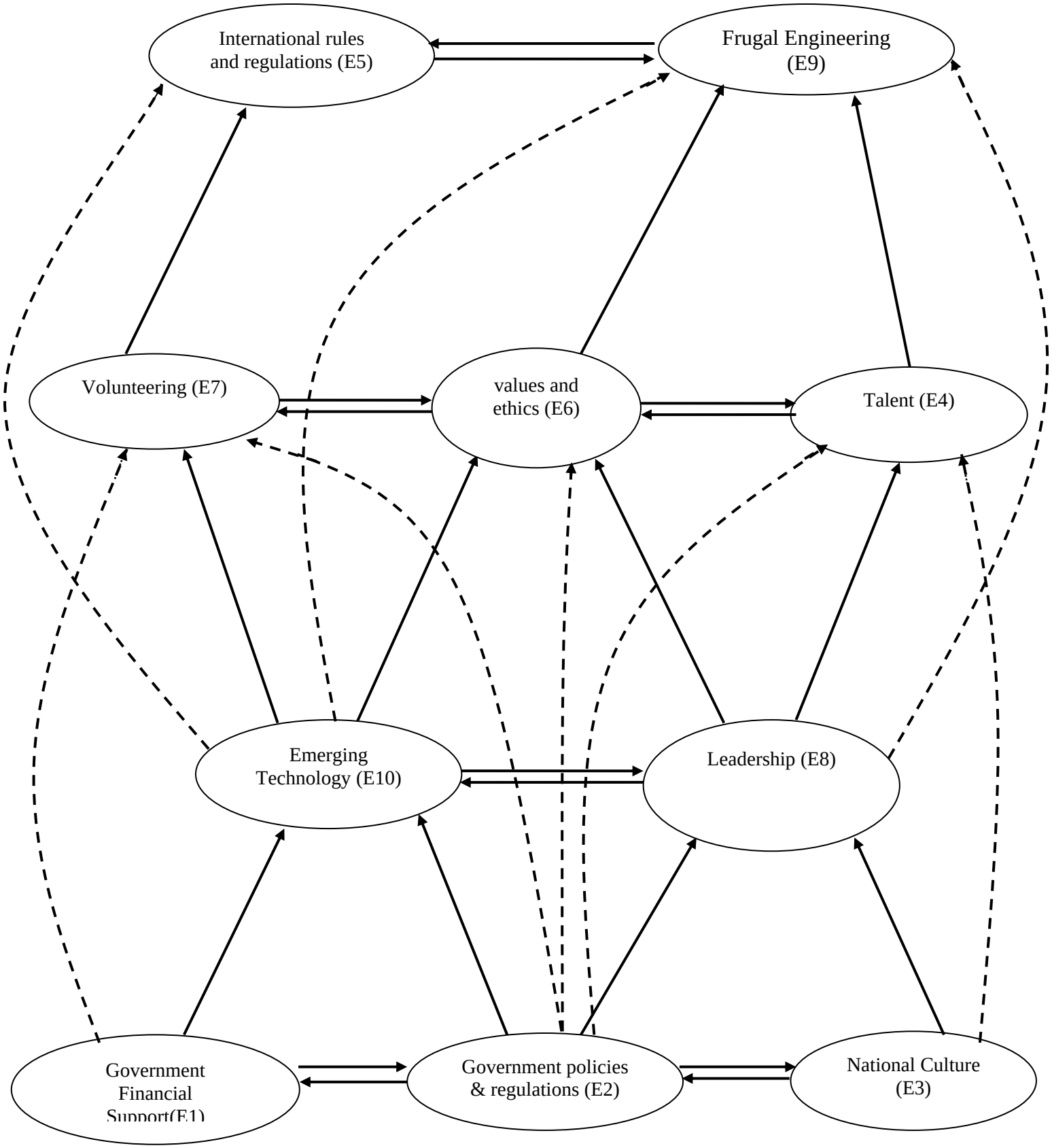
Variable	Level
E5,E9	Level 1
E4,E6,E7	Level 2
E8,E10	Level 3
E1,E2,E3	Level 4

Fig. 1 MICMAC analysis of drivers



E1 (1, 7)-Government Financial Support, E2 (3,9)-Government Policies & Regulations, E3(2,7)- National Culture, E4(6,3)-Talent, E5 (7,5)-International rules and regulations, E6 (7,3)- values and ethics, E7(7,3)- Volunteering, E8 (5,6)-Leadership, E9 (8,3)-Frugal Engineering, E10 (5,5)- Emerging Technology

Fig. 2: TISM model of drivers



5. Discussion

COVID-19 has caused severe economic distress in the last year. Developed economies have faced unprecedented economic crises due to strict government measures that affected many sectors that includes the hospitality industry, the manufacturing industry, the travel and tourism industry and many others. In this study, we have undertaken an extensive literature review to understand the concept of frugal innovations in the supply chain, the natural link between sustainability and frugal innovations and any possible research gaps. We have understood that there is very limited work, if any, exploring the scope for combining sustainability attributes and frugal innovation concepts in context to the pandemic crisis from institutional theory and resource-based view perspective (Harris et al. 2020; Karmaker et al. 2020). We argue that frugal innovations and sustainability concepts can coexist and can be mutually beneficial if they try to be more energy or material efficient, to promote technologies that are more simple and popular, and they are pro-poor and consider society as a whole. Our findings are in line with the arguments of some recent studies (see, Rosenberg, 2013; Immelt et al. 2009; Shibin et al. 2018). Via synthesis of the TISM model and the MICMAC analysis to provide a theoretical model (Dubey et al. 2015; Luo et al. 2018), we have developed a theoretical model that shows how frugal innovation, in global sustainable supply chains, can address the needs of pandemic crises in context to emerging countries (Harris et al. 2020; Karmaker et al. 2020). We propose research propositions based on Figure 3. We observe that the government financial support (E1) and the government policies and regulations (E2) affects the adoption of emerging technologies (E10), encourage the volunteering (E7) and help shape the value and ethics (E6), under the mediating influence of the leadership (E8). We found that the arguments are firmly rooted in the resource-based view (Penrose, 1959; Barney, 1986; Grant, 1996; Grant, 1997), institutional theory (DiMaggio & Powell, 1983; Craighead et al. 2020), and the upper echelon theory (Hambrick and Mason, 1984). Based on these arguments we draw our research propositions as:

P1: *The government financial support and government policies & regulations under the mediating effect of leadership, significantly influence the adoption of emerging technologies;*

P2: *The government financial support and government policies & regulations under the mediating effect of leadership, significantly influence volunteering;*

P3: *The government financial support and government policies & regulations under the mediating effect of leadership, significantly shape values and ethics;*

We further observe that leadership (E8) has differential effects on the adoption of emerging technologies (E10), volunteering (E7) and, values and ethics (E6). These differential effects can be explained using national culture (E3) and international rules & regulations (E5) as moderating constructs. Our study draws on contingency theory (Luthans and Stewart, 1977; Sousa and Voss, 2008) and we echo the views of some scholars who state that the effect of leadership is contingent on the context in which leaders take decisions – see, for example, Currie and Lockett (2007) and Little (2014). We propose our research propositions as:

P4: *The national culture has a significant moderating influence on the paths joining leadership and emerging technology/volunteering/value and ethics;*

P5: *The international rules & regulations have a significant moderating influence on the paths joining leadership and emerging technology/volunteering/value and ethics;*

We further observe that the adoption of emerging technologies (E10), volunteering (E7) and, values and ethics (E6) have a significant influence on supply chain talent (E4) and frugal engineering (E9). Supply chain talent (E4) has a significant effect on frugal engineering (E9). We draw our research propositions as:

P6: *The adoption of emerging technologies, volunteering and, values and ethics have a significant influence on supply chain talent / frugal engineering;*

P7: *The supply chain talent has a significant influence on frugal engineering;*

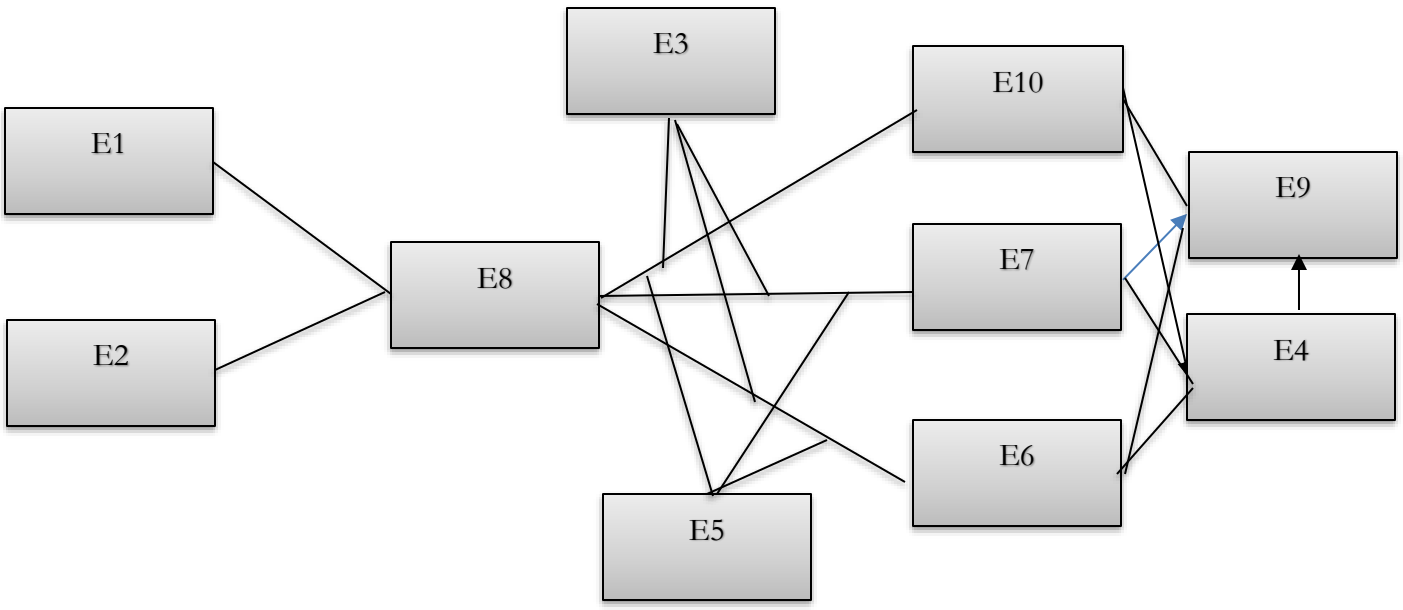


Figure 3: Theoretical Model

E1-Government Financial Support, E2-Government Policies & Regulations, E3- National Culture, E4-Talent, E5-International rules and regulations, E6- values and ethics, E7- Volunteering, E8-Leadership, E9-Frugal Engineering, E10- Emerging Technology

5. 1 Theoretical Contributions

The operations and supply chain management (O&SCM) field has experienced an intensity of in-depth studies on the integration of value propositions into business models with sustainable innovation (Foxon and Pearson, 2008; Boons and Ludeke-Freund, 2013). However, due to the fact that limited studies provide theoretical justifications (Madhok, 2002), we have generated a theoretical model that attempts to provide some degree of clarity in terms of the complex associations that exist among the drivers of frugal innovations to enable global supply chains to respond to the pandemic crisis. We derive seven research propositions that suggest how these ten drivers are interlinked to each other; building on RBV, institutional and contingency theory.

We propose that leadership, under the moderating influence of the national culture, has significant effects on the adoption of emerging technologies, volunteering and, values and ethics. These observations further support the arguments of previous scholars (Gupta and Gupta, 2019; Maloney and Taskin, 2020; Gupta et al. 2021). This further shapes our understanding of *how* and *why* different countries have different interpretations of the policy and practices of social distancing and wearing of face masks to avoid the spread of the virus. Moreover, national culture provides a theoretical lens to examine the influence of leadership in shaping strategies related to the adoption of technology (Kaba and Osei-Bryson, 2013). Our study extends the previous literature which has analyzed the direct effects of national culture on the adoption of technology (Kaba and Osei-Bryson, 2013; Hallikainen and Laukkanen, 2018). We propose that leadership, under the moderating effect of national culture, has a significant effect on the adoption of emerging technologies during the COVID-19 crisis. Moreover, we further propose *how* and *why* different countries have different interpretations of volunteering and value & ethics during the pandemic resulting from the COVID-19 crisis. We further explain how international trade & regulations shapes leader's decision-making abilities during the COVID-19 crisis, which in turn has a significant influence on the adoption of technology, supporting volunteering, and shaping value & ethics. Hence, we believe our theoretical contribution is significant in two ways: Firstly, we explain the role of frugal innovation in shaping a sustainable global supply chain especially

during a pandemic crisis. Secondly, we shed light on the current pandemic crisis and the efforts taken by emerging economies to respond to the challenges it is creating, using organizational theories (i.e., RBV, institutional and contingency theory). Our attempt is a way to address the current research calls of some leading scholars (see, Craighead et al. 2020; Shih, 2020).

5.2 Implications to Practice

We examined the drivers and interlinkages of sustainability-oriented frugal innovations in global supply chains, in the context of the pandemic crisis, using interpretive logic. The findings of our study offer guidance to supply chain professionals and policymakers on the critical areas to focus upon that prepare organizations to deal with the resource constrained environments that are created during pandemic crises. Government financial support (E1), government policies & regulations (E2), and national culture (E3) are found to be the most powerful driving factors of sustainability oriented frugal innovations in global supply chains during a pandemic crisis. International rules and regulations (E5) and frugal engineering (E9) are also powerful drivers. Our results further guide policymakers to understand how these drivers are interlinked. For example, in the absence of E1, E2 and E3, it is quite difficult to achieve E5 and E9. Moreover, emerging technology (E10) and leadership (E8) play a mediating role. E10 and E8 further helps enhance volunteering (E7) efforts and further shape values & ethics (E6) and talent (E4), which are considered as crucial drivers separating the traditional sustainable global supply chain from frugal-oriented sustainable global supply chains, when responding to the pandemic crisis. We have further synthesized the TISM model and the MICMAC output to develop a research model (see Figure 3). Figure 3 shows how the national culture (E3) and international trades and regulations (E5) act as moderating constructs to the paths joining leadership (E8) and the emerging technology (E10), volunteering (E7) & value and ethics (E6). These findings strongly suggest that managers engaged in exploiting frugal innovation capability must appreciate the role of soft dimensions. For instance, the role of national culture and the role of leaders are critical in achieving desired success in a resource constrained environment.

5.3 Limitations and future research directions

We caution our readers that the findings of our study should be understood in a particular context and evaluated in the light of their own limitations. Like all studies, our study has some limitations, which we believe may help shape future research. We have based our study based on a limited sample

size that may not be enough to establish the causality of our identified inter-linkages. However, we believe our model may be validated using large data collected using a structured questionnaire. Moreover, we believe that a comparison must be drawn to understand how the theoretical model differs in developed economies. Moreover, the study provides a basis for further in-depth analysis of leadership, national culture, emerging technology, and frugal innovation using resource dependence theory, resource orchestration theory, and awareness-motivation-capability framework. For instance, leadership is often considered a crucial factor as leaders are quite capable of understanding the culture of the innovators engaged in searching for cost-effective solutions to the existing pandemic crisis. Hence, what leadership style is more suitable in this context is yet to be understood. Moreover, the existing literature on national culture has provided mixed results. In some studies, authors have observed that "*individualism*" has a significant effect on the behavior of the citizens during the COVID-19 crisis and some advocate the role of "*uncertainty avoidance*". However, the existing literature still doesn't provide a clear picture as to the dimensions of national culture that will help achieve better results in the case of frugal innovation.

6. Conclusion

The COVID-19 crisis has created enormous strain in global supply chains due to severe lockdowns and other government measures to prevent the spread of the COVID-19, in order to save the lives of vulnerable citizens. The economic crisis has invited the attention of the world community engaged in designing low-cost global supply chains to help resource constrained economy to fight against the unprecedented challenges posed by the pandemic crisis resulting from COVID-19 (Corsini et al. 2021). Especially in countries situated in the Indian sub-continent and Africa, the majority of the population who survive below the poverty line have no access to necessary items that are important to fight against COVID-19. Hence, our study took inspiration from some of these countries' initiatives to produce innovative solutions to much-needed items, such as face masks, face shields, and ventilators, which provides an interesting path to other developed economies that are facing resource constraints due to struggling economies. Despite promising results shown by some of these communities, to date there is hardly any literature that examines the relationship between frugal innovation and sustainable global supply chains. In an attempt to address pressing research calls we adopted the conceptual lens of frugal innovation to understand the drivers of sustainable global supply chains to address the challenges posed by the COVID-19 crisis. We have used a focused group approach to identify the drivers of the frugal innovation and further validated these drivers using

literature drawn from multiple sources. To further establish the relationship amongst these drivers, we have used TISM. Then we have carried out MICMAC analysis to further understand the nature of these drivers. We have further synthesized the TISM model and MICMAC output to generate a research model and derive seven research propositions. To our knowledge, this is one of the first attempts in the context to the pandemic crisis that the role of frugal innovation in shaping sustainability in the global supply chains has been studied. We hope that our study will inspire many scholars engaged in the scientific examination of frugal innovation capability, particularly in adverse situations, to undertake further research building upon our findings.

Acknowledgement

The authors thank Professor Beverly A Wagner and Dr. Gary Graham, the participating government and the non-governmental organizations for their inputs during the development and preparation of the study. We also express our sincere thanks to the reviewers for their critical inputs during the review stage. In addition the authors appreciate the support which we have received from our project, operations and workplace management research group (POW), Liverpool Business School and the Montpellier Business School, for their research support that helped us to undertake the study.

References

AO Dos Santos, M., Svensson, G., & Padin, C. (2014). Implementation, monitoring and evaluation of sustainable business practices: framework and empirical illustration. *Corporate Governance*, *14*(4), 515-530.

Alegre, J., Sengupta, K., & Lapiedra, R. (2011). Knowledge management and the innovation performance in a high-tech SMEs industry. *International Small Business Journal*, 31(4), 454-470.

Alinaghian, L., Qiu, J., & Razmdoost, K. (2020). The role of network structural properties in supply chain sustainability: a systematic literature review and agenda for future research. *Supply Chain Management: An International Journal*, 26(2), 192-211.

Annala, L., Polsa, P. E., & Kovács, G. (2019). Changing institutional logics and implications for supply chains: Ethiopian rural water supply. *Supply Chain Management: An International Journal*, 24(3), 355-376.

Ashraf, B. N. (2020). Economic impact of government interventions during the COVID-19 pandemic: International evidence from financial markets. *Journal of Behavioral and Experimental Finance*, *27*, 100371.

Awaysheh, A., & Klassen, R. D. (2010). The impact of supply chain structure on the use of supplier socially responsible practices. *International Journal of Operations & Production Management*, *30*(12), 1246-1268.

Barney, J. (1986) Strategic Factor Markets: expectations, luck, and business strategy. *Management Science*, 32, 1231–41.

Barratt, M., Choi, T.Y., & Li, M. (2011). Qualitative case studies in operations management: Trends, research outcomes, and future research implications. *Journal of Operations Management*, 29(4), 329–342.

Belhadi, A., Kamble, S., Jabbour, C. J. C., Gunasekaran, A., Ndubisi, N. O., & Venkatesh, M. (2021). Manufacturing and service supply chain resilience to the COVID-19 outbreak: Lessons learned from the automobile and airline industries. *Technological Forecasting and Social Change*, *163*, 120447.

Bhatti, Y. A., & Ventresca, M. (2013). How can 'Frugal Innovation' be conceptualized?. *Available at SSRN 2203552*.

Birtchnell, T. (2011). Jugaad as systemic risk and disruptive innovation in India. *Contemporary South Asia*, *19*(4), 357-372.

Bokusheva, R., Finger, R., Fischler, M., Berlin, R., Marín, Y., Pérez, F., & Paiz, F. (2012). Factors determining the adoption and impact of a postharvest storage technology. *Food Security*, *4*(2), 279-293.

Boons, F., & Lüdeke-Freund, F. (2013). Business models for sustainable innovation: state-of-the-art and steps towards a research agenda. *Journal of Cleaner Production*, *45*, 9-19.

Brem, A., Viardot, E., & Nylund, P. A. (2020). Implications of the Coronavirus (COVID-19) outbreak for innovation: Which technologies will improve our lives?. *Technological Forecasting and Social Change*, 120451.

Carter, C. R., & Easton, P. L. (2011). Sustainable supply chain management: evolution and future directions. *International Journal of Physical Distribution & Logistics Management*, *41*(1), 46-62.

Cheng, Y., Farooq, S., & Johansen, J. (2015). International manufacturing network: past, present, and future. *International Journal of Operations & Production Management*, *35*(3), 392-429.

Cohen, W.M., & Levinthal, D.A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly*, *35* (1), 128-152.

Cooke, P. (2001). Regional innovation systems, clusters, and the knowledge economy. *Industrial and corporate change*, *10*(4), 945-974.

Corsini, L., Dammicco, V., & Moultrie, J. (2021). Frugal innovation in a crisis: the digital fabrication maker response to COVID-19. *R&D Management*, *51*(2), 195-210.

Craighead, C. W., Ketchen Jr, D. J., & Darby, J. L. (2020). Pandemics and Supply Chain Management Research: Toward a Theoretical Toolbox. *Decision Sciences*, 51(4), 838-866. DOI: 10.1111/deci.12468.

Currie, G., & Lockett, A. (2007). A critique of transformational leadership: Moral, professional and contingent dimensions of leadership within public services organizations. *Human relations*, *60*(2), 341-370.

Daghar, A., Alinaghian, L., & Turner, N. (2020). The role of collaborative interorganizational relationships in supply chain risks: a systematic review using a social capital perspective. *Supply Chain Management: An International Journal*. DOI: 10.1108/SCM-04-2020-0177.

Davenport, T. H., & Beers, M. C. (1995). Managing information about processes. *Journal of Management Information Systems*, *12*(1), 57-80.

de Camargo Fiorini, P., & Jabbour, C. J. C. (2017). Information systems and sustainable supply chain management towards a more sustainable society: Where we are and where we are going. *International Journal of Information Management*, *37*(4), 241-249.

Deif, A. M. (2011). A system model for green manufacturing. *Journal of Cleaner Production*, *19*(14), 1553-1559.

Demeritt, D., Dobson, A., Li, T. M., Leach, M., Scoones, I., & Stirling, A. (2011). Pathways to sustainability: perspectives and provocations. *Environment and Planning A*, *43*(5), 1226-1237.

Desai, R. (2012). Teaching technologists sustainable innovation. *International Journal of Innovation Science*, *4*(1), 25-34.

Diabat, A., & Govindan, K. (2011). An analysis of the drivers affecting the implementation of green supply chain management. *Resources, Conservation and Recycling*, *55*(6), 659-667.

DiMaggio, P.J., & Powell, W.W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review, 48*(2), 147–160.

Dodds, K., Broto, V. C., Detterbeck, K., Jones, M., Mamadouh, V., Ramutsindela, M., ... & Woon, C. Y. (2020). The COVID-19 pandemic: territorial, political and governance dimensions of the crisis, *Territory, Politics, Governance*, 8(3), 289-298.

Drake, M. J., & Schlachter, J. T. (2008). A virtue-ethics analysis of supply chain collaboration. *Journal of Business Ethics, 82*(4), 851-864.

Dubey, R., Singh, T., & Tiwari, S. (2012). Supply chain innovation is a key to superior firm performance an insight from indian cement manufacturing. *International Journal of Innovation Science*, *4*(4), 217-230

Dubey, R., Bag, S., & Ali, S. S. (2014). Green supply chain practices and its impact on organisational performance: An insight from Indian rubber industry. *International Journal of Logistics Systems and Management*, 19(1), 20–42.

Dubey, R., & Ali, S. S. (2014). Identification of flexible manufacturing system dimensions and their interrelationship using total interpretive structural modelling and fuzzy MICMAC analysis. *Global Journal of Flexible Systems Management*, 15(2), 131–143.

Dubey, R., Gunasekaran, A., Sushil, & Singh, T. (2015). Building theory of sustainable manufacturing using total interpretive structural modelling. *International Journal of Systems Science: Operations & Logistics*, *2*(4), 231-247.

Dubey, R., Gunasekaran, A., & Ali, S. S. (2015). Exploring the relationship between leadership, operational practices, institutional pressures and environmental performance: A framework for green supply chain. *International Journal of Production Economics*, *160*(February), 120–132.

Dubey, R., Singh, T., & Gupta, O. K. (2015). Impact of agility, adaptability and alignment on humanitarian logistics performance: mediating effect of leadership. *Global Business Review*, *16*(5), 812-831.

Dubey, R., Gunasekaran, A., Papadopoulos, T., Childe, S. J., Shibin, K. T., & Wamba, S. F. (2017). Sustainable supply chain management: framework and further research directions. *Journal of cleaner production*, *142*, 1119-1130.

Dubey, R., & Altay, N. (2018). Drivers of coordination in humanitarian relief supply chains. In *The Palgrave handbook of humanitarian logistics and supply chain management* (pp. 297-325). Palgrave Macmillan, London.

Dubey, R., Gunasekaran, A., Childe, S. J., & Papadopoulos, T. (2018). Skills needed in supply chain-human agency and social capital analysis in third party logistics. *Management Decision*, 56(1), 143-159.

Dubey, R., Bryde, D. J., Foropon, C., Tiwari, M., Dwivedi, Y., & Schiffling, S. (2021). An investigation of information alignment and collaboration as complements to supply chain agility in humanitarian supply chain. *International Journal of Production Research*, 59(5), 1586-1605.

Durst, Susanne, & Edvardsson, R.I. (2012) Knowledge management in SMEs: a literature review, *Journal of Knowledge Management*, 16(5) pp.879 - 903

Dyllick, T., & Hockerts, K. (2002). Beyond the business case for corporate sustainability. *Business Strategy and the Environment*, *11*(2), 130-141.

El Baz, J., & Ruel, S. (2020). Can supply chain risk management practices mitigate the disruption impacts on supply chains' resilience and robustness? Evidence from an empirical survey in a COVID-19 outbreak era. *International Journal of Production Economics*, 107972.

Ernst, R., & Kamrad, B. (2000). Evaluation of supply chain structures through modularization and postponement. *European journal of operational research*, *124*(3), 495-510

Ettlie, J.E., & Pavlou, P.A. (2006). Technology-based new product development partnerships. *Decision Sciences* 37(2): 117–147.

Fagerberg, J., Srholec, M., & Verspagen, B. (2010). Innovation and economic development. *Handbook of the Economics of Innovation*, 2, 833-872.

Farris, D. R., & Sage, A. P. (1975). On the use of interpretive structural modeling for worth assessment. Computers & El*ectrical Engineering*, 2(2), 149–174.

Finsterwalder, J., & Kuppelwieser, V. G. (2020). Equilibrating resources and challenges during crises: a framework for service ecosystem well-being. *Journal of Service Management*, 31(6),1107-1129.

Forman, M., & Jrgensen, M. S. (2004). Organising environmental supply chain management. *Greener Management International*, 2004(45), 43-62.

Fournier, P. L., Chênevert, D., & Jobin, M. H. (2021). The antecedents of physicians' behavioral support for lean in healthcare: The mediating role of commitment to organizational change. *International Journal of Production Economics*, *232*, 107961.

Foxon, T., & Pearson, P. (2008). Overcoming barriers to innovation and diffusion of cleaner technologies: some features of a sustainable innovation policy regime. *Journal of cleaner production*, *16*(1), S148-S161.

Frey, C. B., Chen, C., & Presidente, G. (2020). Democracy, culture, and contagion: Political regimes and countries responsiveness to Covid-19. *Covid Economics*, 18, pp.1-20.

Frota Neto, J.Q., Bloemhof-Ruwaard, J.M., van Nunen, J., Van Heck, E., (2008). Designing and evaluating sustainable logistics networks. *International Journal of Production Economics* 111 (2), 195–208.

Gammelgaard, B., & Larson, P. D. (2001). Logistics skills and competencies for supply chain management. Journal of Business logistics, 22(2), 27-50.

Georgiadis, P., & Besiou, M. (2008). Sustainability in electrical and electronic equipment closed-loop supply chains: a system dynamics approach. *Journal of Cleaner Production*, 16(15), 1665-1678.

Ghosh, K., Sengupta, N., Manna, D., & De, S. K. (2020). Inter-state transmission potential and vulnerability of COVID-19 in India. *Progress in Disaster Science*, *7*, 100114.

Gimenez, C., Sierra, V., & Rodon, J. (2012). Sustainable operations: Their impact on the triple bottom line. *International Journal of Production Economics*, 140(1), 149-159.

Giunipero, L., Handfield, R. B., & Eltantawy, R. (2006). Supply management's evolution: Key skill sets for the supply manager of the future. *International Journal of Operations & Production Management*, 26(7), 822–844.

Gnyawali, D. R., Madhavan, R., He, J., & Bengtsson, M. (2016). The competition–cooperation paradox in inter-firm relationships: A conceptual framework. *Industrial Marketing Management*, *53*, 7-18.

Gokmen, Y., Baskici, C., & Ercil, Y. (2021). The Impact of National Culture on the Increase of COVID-19: A Cross-Country Analysis of European Countries. *International Journal of Intercultural Relations*, 81, 1-8.

Gotschol, A., De Giovanni, P., & Vinzi, V. E. (2014). Is environmental management an economically sustainable business*? Journal of Environmental Management*, 144, 73-82.

Goyal, S., & Grover, S. (2012). A comprehensive bibliography on effectiveness measurement of manufacturing systems. *International Journal of Industrial Engineering Computations, 3*(4), 587–606.

Graham, G., Freeman, J., & Chen, T. (2015). Green supplier selection using an AHP-Entropy-TOPSIS framework. *Supply Chain Management: An International Journal*, 20(3), 327-340.

Grant, RM. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal*, 17, 109–122.

Grant, R. M. (1997). The knowledge-based view of the firm: implications for management practice. *Long range planning*, *30*(3), 450-454.

Guan, D., Wang, D., Hallegatte, S., Davis, S. J., Huo, J., Li, S., ... & Cheng, D. (2020). Global supply-chain effects of COVID-19 control measures. *Nature Human Behaviour*, 4, 577-587.

Guan, Y., Deng, H., & Zhou, X. (2020). Understanding the impact of the COVID-19 pandemic on career development: Insights from cultural psychology, *Journal of Vocational Behaviour*,119 (June), 103438.

Gunasekaran, A., & Spalanzani, A. (2012). Sustainability of manufacturing and services: Investigations for research and applications. *International Journal of Production Economics, 140*(1), 35–47.

Gupta, M., & Gupta, S. (2019). Influence of National Cultures on Operations Management and Supply Chain Management Practices—A Research Agenda. *Production and Operations Management*, *28*(11), 2681-2698.

Gupta, M., Shoja, A., & Mikalef, P. (2021). Toward the understanding of national culture in the success of non-pharmaceutical technological interventions in mitigating COVID-19 pandemic. *Annals of Operations Research*, 1-18. DOI: 10.1007/s10479-021-03962-z.

Haleem, A., Sushil, Qadri, M. A., & Kumar, S. (2012). Analysis of critical success factors of world-class manufacturing practices: an application of interpretative structural modelling and interpretative ranking process. *Production Planning & Control*, *23*(10-11), 722-734.

Hall, J. (2006). Environmental supply chain innovation. In Greening the supply chain (233-249). Springer London.

Hallikainen, H., & Laukkanen, T. (2018). National culture and consumer trust in e-commerce. *International Journal of Information Management*, *38*(1), 97-106.

Hambrick, D. C., & Mason, P. A. (1984). Upper echelons: The organization as a reflection of its top managers. *Academy of Management Review*, *9*(2), 193-206.

Handfield, R. B., Graham, G., & Burns, L. (2020). Corona virus, tariffs, trade wars and supply chain evolutionary design. *International Journal of Operations & Production Management*, 40(10), 1649-1660.

Hartmann, N., & Lussier, B. (2020). Managing the sales force through the unexpected exogenous COVID-19 crisis. *Industrial Marketing Management*, 88, 101-111.

Harris, M., Bhatti, Y., Buckley, J., & Sharma, D. (2020). Fast and frugal innovations in response to the COVID-19 pandemic. *Nature Medicine*, 26,814-817.

He, H., & Harris, L. (2020). The impact of Covid-19 pandemic on corporate social responsibility and marketing philosophy. *Journal of Business Research*, *116*, 176-182.

Henriques, I., Sadorsky, P., (1999). The relationship between environmental commitment and managerial perceptions of stakeholder importance. *Academy of Management Journal* 42 (1), 87–99.

Hoejmose, S., Brammer, S., & Millington, A. (2013). An empirical examination of the relationship between business strategy and socially responsible supply chain management. *International Journal of Operations & Production Management*, 33(5), 589-621.

Hofstede, G. (1980). Motivation, leadership, and organization: do American theories apply abroad?. *Organizational Dynamics*, *9*(1), 42-63.

Hofstede, G., & Bond, M. H. (1984). Hofstede's culture dimensions: An independent validation using Rokeach's value survey. *Journal of cross-cultural psychology*, *15*(4), 417-433.

Holmström, J. (1998). Business process innovation in the supply chain–a case study of implementing vendor managed inventory. *European journal of purchasing & Supply Management*, 4(2), 127-131.

Holt, D., Anthony, S., & Viney, H. (2000). Supporting Environmental Improvements in Small and Medium-Sized Enterprises in the UK. *Greener Management International*, (30).

Horn, C., & Brem, A. (2013). Strategic directions on innovation management-a conceptual framework. *Management Research Review*, *36*(10), 939-954.

Houe, R., & Grabot, B. (2009). Assessing the compliance of a product with an eco-label: From standards to constraints. *International Journal of Production Economics*, *121*(1), 21-38.

Hui, Z., He-Cheng, W., & Min-Fei, Z. (2015). Partnership management, supply chain collaboration, and firm innovation performance: an empirical examination. *International Journal of Innovation Science*, *7*(2), 127-138.

Huynh, T. L. D. (2020). Does culture matter social distancing under the COVID-19 pandemic?. *Safety Science*, *130*, 104872.

Im, H., & Chen, C. (2020). Cultural dimensions as correlates of favoritism and the mediating role of trust. *Cross Cultural & Strategic Management*, 27(3), 417-445.

Immelt, J. R., Govindarajan, V. and Trimble, C. (2009), "How GE Is Disrupting Itself", *Harvard Business Review*, 87(10), 56-65.

Isaksson, R., Johansson, P., & Fischer, K. (2010). Detecting supply chain innovation potential for sustainable development. *Journal of Business Ethics*, *97*(3), 425-442.

Ivanov, D. (2020). Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case. *Transportation Research Part E: Logistics and Transportation Review*, *136*, 101922.

Ivanov, D., & Dolgui, A. (2020a). Viability of intertwined supply networks: extending the supply chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak. *International Journal of Production Research*, *58*(10), 2904-2915.

Ivanov, D., & Dolgui, A. (2020b). OR-methods for coping with the ripple effect in supply chains during COVID-19 pandemic: Managerial insights and research implications. *International Journal of Production Economics*, 107921.

Ivanov, D. (2021). Supply Chain Viability and the COVID-19 pandemic: a conceptual and formal generalisation of four major adaptation strategies. *International Journal of Production Research*, 1-18. DOI: 10.1080/00207543.2021.1890852

Jacobsson, S., & Bergek, A. (2011). Innovation system analyses and sustainability transitions: Contributions and suggestions for research. *Environmental Innovation and Societal Transitions*, *1*(1), 41-57.

Ji, G., Gunasekaran, A., & Yang, G. (2014). Constructing sustainable supply chain under double environmental medium regulations. *International Journal of Production Economics*, 147, 211-219.

Johnson, T. (2020). Ordinary Patterns in an Extraordinary Crisis: How International Relations Makes Sense of the COVID-19 Pandemic. *International Organization*, 74(S1), E148-E168. DOI: 10.1017/S0020818320000430.

Kaba, B., & Osei-Bryson, K. M. (2013). Examining influence of national culture on individuals' attitude and use of information and communication technology: Assessment of moderating effect of culture through cross countries study. *International Journal of Information Management*, *33*(3), 441-452.

Karmaker, C. L., Ahmed, T., Ahmed, S., Ali, S. M., Moktadir, M. A., & Kabir, G. (2020). Improving supply chain sustainability in the context of COVID-19 pandemic in an emerging economy: Exploring drivers using an integrated model. *Sustainable Production and Consumption*, *26*, 411-427.

Kauppi, K., & Hannibal, C. L. (2017). Institutional Pressures and Sustainability Challenges in Supply Chains. *Supply Chain Management: An International Journal*, *22*(5), 458-472.

Kovács, G., Tatham, P., & Larson, P. D. (2012). What skills are needed to be a humanitarian logistician?. *Journal of Business Logistics*, *33*(3), 245-258.

Kovács, G., & Falagara Sigala, I. (2021). Lessons learned from humanitarian logistics to manage supply chain disruptions. *Journal of Supply Chain Management*, *57*(1), 41-49.

K. Ojha, A. (2014). MNCs in India: focus on frugal innovation. *Journal of Indian Business Research*, *6*(1), 4-28.

Ketchen Jr, D. J., & Craighead, C. W. (2020). Research at the intersection of entrepreneurship, supply chain management, and strategic management: Opportunities highlighted by COVID-19. *Journal of Management*, *46*(8), 1330-1341.

Ketchen Jr, D. J., & Craighead, C. W. (2021). Toward a theory of supply chain entrepreneurial embeddedness in disrupted and normal states. *Journal of Supply Chain Management*, 57(1), 50-57.

Ketokivi, M. A., & Schroeder, R. G. (2004). Strategic, structural contingency and institutional explanations in the adoption of innovative manufacturing practices. *Journal of Operations Management*, 22(1), 63-89.

Khatwani, G., Singh, S. P., Trivedi, A., & Chauhan, A. (2015). Fuzzy- TISM: A fuzzy extension of TISM for group decision making. *Global Journal of Flexible Systems Management*, 16(1), 97–112.

Kim, S.W. (2009). An investigation on the direct and indirect effect of supply chain integration on firm performance. *International Journal of Production Economics* 119 (2), 328–346.

Kleindorfer, P. R., Singhal, K., & Wassenhove, L. N. (2005). Sustainable operations management. *Production and Operations management*, *14*(4), 482-492.

Kwak, D. W., Sanchez Rodrigues, V., Mason, R., Pettit, S., & Beresford, A. (2018). Risk interaction identification in international supply chain logistics: developing a holistic model. *International Journal of Operations and Production Management*, *38*(2), 372-389.

Lambert, D. M., Cooper, M. C., & Pagh, J. D. (1998). Supply chain management: implementation issues and research opportunities. *The international journal of logistics management*, *9*(2), 1-20.

Lamming, R. (1996). Squaring lean supply with supply chain management. *International Journal of Operations & Production Management*, *16*(2), 183-196.

Law, K. M., & Gunasekaran, A. (2012). Sustainability development in high-tech manufacturing firms in Hong Kong: Motivators and readiness. *International Journal of Production Economics*, 137(1), 116-125.

Leach, M., Rockström, J., Raskin, P., Scoones, I. C., Stirling, A. C., Smith, A., & Folke, C. (2012). Transforming innovation for sustainability. *Ecology and Society*, 17(2), 11.

Lee, B., & Jang, K. (2003). Supply chain environmental management: A policy option towards sustainable industry in Korea. *Korean J. Environ. Management*, *1*(1), 71-91.

Lee, S. M., Lee, D., & Schniederjans, M. J. (2011). Supply chain innovation and organizational performance in the healthcare industry. *International Journal of Operations & Production Management*, *31*(11), 1193-1214.

Lee, S. Y. (2008). Drivers for the participation of small and medium-sized suppliers in green supply chain initiatives. *Supply Chain Management: An International Journal*, *13*(3), 185-198.

Lelah, A., Mathieux, F., Brissaud, D., & Vincent, L. (2012). Collaborative network with SMEs providing a backbone for urban PSS: a model and initial sustainability analysis. *Production Planning & Control*, *23*(4), 299-314.

Liang, H., Saraf, N., Hu, Q.,& Xue, Y. (2007). Assimilation of enterprise systems: the effect of institutional pressures and the mediating role of top management. *MIS Quarterly*, 31 (1), 59–87.

Little, A. C. (2014). Facial appearance and leader choice in different contexts: Evidence for task contingent selection based on implicit and learned face-behaviour/face-ability associations. *The Leadership Quarterly*, *25*(5), 865-874.

Liu, H., Ke, W., Wei, K. K., Gu, J., & Chen, H. (2010). The role of institutional pressures and organizational culture in the firm's intention to adopt internet-enabled supply chain management systems. *Journal of Operations Management*, 28(5), 372-384.

Luthans, F., & Stewart, T. I. (1977). A general contingency theory of management. *Academy of Management Review*, *2*(2), 181-195.

Luo, Z., Dubey, R., Papadopoulos, T., Hazen, B., & Roubaud, D. (2018). Explaining environmental sustainability in supply chains using graph theory. *Computational Economics*, *52*(4), 1257-1275.

Madhok, A. (2002). Reassessing the fundamentals and beyond: Ronald Coase, the transaction cost and resource-based theories of the firm and the institutional structure of production. *Strategic Management Journal*, *23*(6), 535-550.

Majumdar, A., Shaw, M., & Sinha, S. K. (2020). COVID-19 debunks the myth of socially sustainable supply chain: A case of the clothing industry in South Asian countries. *Sustainable Production and Consumption*, *24*, 150-155.

Malone, D. W. (1975). An introduction to the application of interpretive structural modeling. *Proceedings of the IEEE*, 63(3), 397–404.

Maloney, W., & Taskin, T. (2020). *Determinants of social distancing and economic activity during COVID-19: A global view*. The World Bank. DOI: 10.1596/1813-9450-9242. (Date of access: 14th March, 2021)

Mangla, S.K., Kumar, P., & Barua, M.K. (2014). Flexible decision approach for analysing performance of sustainable supply chains under risks/uncertainty. *Global Journal of Flexible Systems Management*, 15(2), 113–130.

Marshall, D., McCarthy, L., Heavey, C., & McGrath, P. (2015). Environmental and social supply chain management sustainability practices: construct development and measurement. *Production Planning & Control*, *26*(8), 673-690.

Matos, S.V., Schleper, M.C., Gold, S. & Hall, J.K. (2020). The hidden side of sustainable operations and supply chain management: unanticipated outcomes, trade-offs and tensions. *International Journal of Operations & Production Management*, 40(12), 1749-1770.

Mbunge, E. (2020). Integrating emerging technologies into COVID-19 contact tracing: Opportunities, challenges and pitfalls. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *14*(6), 1631-1636.

McDougall, N., Wagner, B., & MacBryde, J. (2021). Leveraging competitiveness from sustainable operations: frameworks to understand the dynamic capabilities needed to realise NRBV supply chain strategies. *Supply Chain Management: An International Journal*. DOI: 10.1108/SCM-11-2018-0393.

McKinnon, J.D., 2007. Bush weighs range of emission caps. TheWall Street Journal, 23.

Melville, N. P. (2010). Information systems innovation for environmental sustainability. *MIS Quarterly*, *34*(1), 1-21.

Meyer, J. W., & Rowan, B. (1977). Institutionalized organizations: Formal structure as myth and ceremony. *American Journal of Sociology*, 340-363.

Miao, Q., Schwarz, S., & Schwarz, G. (2020). Responding to COVID-19: Community volunteerism and coproduction in China. *World Development*, *137*, 105128.

Mizruchi, M. S., & Fein, L. C. (1999). The social construction of organizational knowledge: A study of the uses of coercive, mimetic, and normative isomorphism. *Administrative Science Quarterly*, *44*(4), 653-683.

Mudgal, R. K., Shankar, R., Talib, P., & Raj, T. (2010). Modelling the barriers of green supply chain practices: An Indian perspective. *International Journal of Logistics Systems and Management*, 7(1), 81–107.

Mukerjee, K. (2012). Frugal innovation: the key to penetrating emerging markets. *Ivey Business Journal*, *76*(4), 1.

Nandi, S., Sarkis, J., Hervani, A. A., & Helms, M. M. (2021). Redesigning Supply Chains using Blockchain-Enabled Circular Economy and COVID-19 Experiences. *Sustainable Production & Consumption*, 27(July),10-22.

Nasim, S. (2011). Total interpretive structural modeling of continuity and change forces in e-government. *Journal of Enterprise Transformation, 1*(2), 147–168.

New, S., Green, K., Morton, B., 2000. Buying the environment: the multiple meanings of green supply. In: Fineman, S. (Ed.), The Business of Greening. Routledge, London, 33–53.

Nidumolu, R., Prahalad, C. K., & Rangaswami, M. R. (2009). Why sustainability is now the key driver of innovation. *Harvard business review*, *87*(9), 56-64.

Paital, B., Das, K., & Parida, S. K. (2020). Inter nation social lockdown versus medical care against COVID-19, a mild environmental insight with special reference to India. *Science of the Total Environment*, 728, 138914.

Pan, S. L., Cui, M., & Qian, J. (2020). Information resource orchestration during the COVID-19 pandemic: A study of community lockdowns in China. *International Journal of Information Management*, *54*, 102143.

Pansera, M., & Sarkar, S. (2016). Crafting Sustainable Development Solutions: Frugal Innovations of Grassroots Entrepreneurs. *Sustainability*, *8*(1), 51.

Parast, M. M., & Subramanian, N. (2021). An examination of the effect of supply chain disruption risk drivers on organizational performance: evidence from Chinese supply chains. *Supply Chain Management: An International Journal*. DOI: 10.1108/SCM-07-2020-0313.

Penrose, E. (1959) *The theory of the Growth of the Firm*. Oxford: Oxford University Press.

Plambeck, E., Wang, Q. (2009). Effects of e-waste regulation on new product introduction. *Management Science* 55(3),333–347.

Poist, R. F. (1989). Evolution of conceptual approaches to the design of logistics systems: a sequel. *Transportation Journal*, 28(3), 35-39.

Porter, M.E., Van de Linde, C., 1995. *Green and competitive*. *Harvard Business Review* September–October, 120–134.

Prasad, U.C., & Suri, R.K. (2011). Modeling of continuity and change forces in private higher technical education using total interpretive structural modeling (TISM). *Global Journal of Flexible Systems Management*, 12(3–4), 31–40.

Preuss, L. (2007). Buying into our future: sustainability initiatives in local government procurement. *Business Strategy and the Environment*, 16(5), 354-365.

Purohit, J. K., Mittal, M. L., Mittal, S., & Sharma, M. K. (2016). Interpretive structural modeling-based framework for mass customisation enablers: an Indian footwear case. *Production Planning & Control*, 27(9), 774-786.

Queiroz, M. M., Ivanov, D., Dolgui, A., & Wamba, S. F. (2020). Impacts of epidemic outbreaks on supply chains: mapping a research agenda amid the COVID-19 pandemic through a structured literature review. *Annals of Operations Research*, 1-38.

Radjou, N., Prabhu, J., & Ahuja, S. (2012). *Jugaad innovation: Think frugal, be flexible, generate breakthrough growth*. John Wiley & Sons.

Rao, B. C. (2013). How disruptive is frugal?. *Technology in Society*, *35*(1), 65-73.

Remko, V. H. (2020). Research opportunities for a more resilient post-COVID-19 supply chain–closing the gap between research findings and industry practice. *International Journal of Operations & Production Management*, 40(4), 341-355.

Roberts, S. (2003). Supply chain specific? Understanding the patchy success of ethical sourcing initiatives. *Journal of Business Ethics, 44*(2-3), 159-170.

Rosenberg, T. (2013), A Hospital Network With a Vision, The New York Times, *http://opinionator.blogs.nytimes.com/2013/01/16/in-india-leading-a-hospital-franchise-withvision/?_r=0.* Last accessed on 24 October 2015.

Salem, M., Van Quaquebeke, N., Besiou, M., & Meyer, L. (2019). Intergroup Leadership: How Leaders Can Enhance Performance of Humanitarian Operations. *Production and Operations Management*, *28*(11), 2877-2897.

Santos, J. (2020). Using Input-Output Analysis to Model the Impact of Pandemic Mitigation and Suppression Measures on the Workforce. *Sustainable Production and Consumption*, 23,249-255.

Sarkis, J., (2003). A strategic decision framework for green supply chain management. *Journal of Cleaner Production* 11 (4), 397–409.

Sarkis, J. (2021). Supply chain sustainability: learning from the COVID-19 pandemic. *International Journal of Operations & Production Management*, 41(1), 63-73.

Schaltegger, S., & Wagner, M. (2011). Sustainable entrepreneurship and sustainability innovation: categories and interactions. *Business Strategy and the Environment*, 20(4), 222-237.

Sehgal, V., Dehoff, K., & Panneer, G. (2010). THE INNOVATORS-The Importance of Frugal Engineering-Providing new goods and services to" bottom of the pyramid" customers requires a radical rethinking of product development. *Strategy and Business*, (59), 20.

Sengupta, S., & Jha, M. K. (2020). Social policy, COVID-19 and impoverished migrants: challenges and prospects in locked down India. *The International Journal of Community and Social Development*, *2*(2), 152-172.

Severo, E. A., De Guimarães, J. C. F., & Dellarmelin, M. L. (2021). Impact of the COVID-19 pandemic on environmental awareness, sustainable consumption and social responsibility: Evidence from generations in Brazil and Portugal. *Journal of Cleaner Production*, 286, 124947.

Shammi, M., Bodrud-Doza, M., Islam, A. R. M. T., & Rahman, M. M. (2020). Strategic assessment of COVID-19 pandemic in Bangladesh: comparative lockdown scenario analysis, public perception, and management for sustainability. *Environment, Development and Sustainability*, 1-44. DOI: 10.1007/s10668-020-00867-y.

Sharma, A., & Iyer, G. R. (2012). Resource-constrained product development: Implications for green marketing and green supply chains. *Industrial Marketing Management*, *41*(4), 599-608.

Sharma, A., Adhikary, A., & Borah, S. B. (2020). Covid-19' s impact on supply chain decisions: Strategic insights from NASDAQ 100 firms using Twitter data. *Journal of Business Research*, *117*, 443-449.

Sharma, G. D., Talan, G., & Jain, M. (2020). Policy response to the economic challenge from COVID-19 in India: A qualitative enquiry. *Journal of Public Affairs*, *20*(4), e2206.

Shaw, R., Kim, Y. K., & Hua, J. (2020). Governance, technology and citizen behavior in pandemic: Lessons from COVID-19 in East Asia. *Progress in Disaster Science*, 100090.

Shibin, K. T., Gunasekaran, A., & Dubey, R. (2017). Explaining sustainable supply chain performance using a total interpretive structural modeling approach. *Sustainable Production and Consumption*, *12*, 104-118.

Shibin, K. T., Dubey, R., Gunasekaran, A., Luo, Z., Papadopoulos, T., & Roubaud, D. (2018). Frugal innovation for supply chain sustainability in SMEs: multi-method research design. *Production Planning & Control*, *29*(11), 908-927.

Shih, W. C. (2020). Is It Time to Rethink Globalized Supply Chains? The COVID-19 Pandemic Should Be a Wake-up Call for Managers and Prompt Them to Consider Actions That Will Improve Their Resilience to Future Shocks. *MIT Sloan Management Review* 61(4), 16–18.

Singh, A.K. & Sushil (2013). Modeling enablers of TQM to improve airline performance. *International Journal of Productivity and Performance Management, 62*(3), 250–275.

Smith, A., Voß, J. P., & Grin, J. (2010). Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research Policy,* 39(4), 435-448.

Sodhi, M. S., & Tang, C. S. (2021). Supply Chain Management for Extreme Conditions: Research Opportunities. *Journal of Supply Chain Management*, 57(1), 7-16.

Soni, P., & T. Krishnan, R. (2014). Frugal innovation: aligning theory, practice, and public policy. *Journal of Indian Business Research*, *6*(1), 29-47.

Sousa, R., & Voss, C. A. (2008). Contingency research in operations management practices. *Journal of Operations Management*, *26*(6), 697-713.

Srivastava, A.K, & Sushil (2014). Modelling drivers of adapt for effective strategy execution. *The Learning Organization, 21*(6), 369–391.

Subramanian, N., & Gunasekaran, A. (2015). Cleaner supply-chain management practices for twenty-first-century organizational competitiveness: Practice-performance framework and research propositions. *International Journal of Production Economics*, *164*, 216-233.

Sushil (2012). Interpreting the interpretive structural model. *Global Journal of Flexible Systems Management, 13*(2), 87-106.

Sushil (2015a). Strategic flexibility: The evolving paradigm of strategic management. *Global Journal of Flexible Systems Management*, 16(2), 113–114.

Sushil (2015b). Managing wastivity for sustainability. *Global Journal of Flexible Systems Management*, 16(1), 1–2.

Sushil. (2018a). How to check correctness of total interpretive structural models?. *Annals of Operations Research*, *270*(1-2), 473-487.

Sushil, S. (2018b). Interpretive multi-criteria valuation of flexibility initiatives on direct value chain. *Benchmarking: An International Journal*, 25(9), 3720-3742.

Talonen, T., & Hakkarainen, K. (2014). Elements of sustainable business models. *International Journal of Innovation Science*, *6*(1), 43-54.

Tatham, P., Altay, N., Allen, A. M., Kovács, G., Masini, A., Vaillancourt, A., & Van Wassenhove, L. (2013). Exploring the link between the humanitarian logistician and training needs. *Journal of Humanitarian Logistics and supply chain Management*, 3(2), 129-148.

Thompson, A. A. and A. J. Strickland. (1990). Strategic Management: Concepts and Cases, Irwin, Homewood, IL.

Vesci, M., Feola, R., Parente, R., & Radjou, N. (2021). How to save the world during a pandemic event. A case study of frugal innovation. *R&D Management*. DOI: 10.1111/radm.12459.

Venkatesh, V. G., Zhang, A., Deakins, E., & Mani, V. (2020). Drivers of sub-supplier social sustainability compliance: an emerging economy perspective. *Supply Chain Management: An International Journal*. DOI: 10.1108/SCM-07-2019-0251.

Walker, J. (2016). Civil society's role in a public health crisis. *Issues in Science and Technology*, *32*(4), 43-48.

Walker, H., Di Sisto, L., & McBain, D. (2008). Drivers and barriers to environmental supply chain management practices: Lessons from the public and private sectors. *Journal of Purchasing and Supply Management*, *14*(1), 69-85.

Warfield, J. N. (1974). Toward interpretation of complex structural models. *IEEE Transactions on Systems, Man and Cybernetics*, 5, 405–417.

Wilhelm, M. M., Blome, C., Bhakoo, V., & Paulraj, A. (2016). Sustainability in multi-tier supply chains: Understanding the double agency role of the first-tier supplier. *Journal of Operations Management*, *41*, 42-60.

Whetten, D. A. (1989). What constitutes a theoretical contribution?. *Academy of Management Review*, *14*(4), 490-495.

Woo, J. J. (2020). Policy capacity and Singapore's response to the COVID-19 pandemic. *Policy and Society*, *39*(3), 345-362.

Wu, Z., & Pagell, M. (2011). Balancing priorities: Decision-making in sustainable supply chain management. *Journal of Operations Management, 29*(6), 577-590.

Yadav, N., & Sushil (2014). Total interpretive structural modeling (TISM) of strategic performance management for Indian telecom service providers. *International Journal of Productivity and Performance Management, 63*(4), 421–445.

Yan, W. (2021). Government Policies, National Culture and Social Distancing during the First Wave of the COVID-19 Pandemic: International Evidence. *Safety Science*, 135, 105138.

Zahra, SA., & George, G. (2002). Absorptive capacity: A review, reconceptualization, and extension. *Academy of Management Review 27*, 185–203.

Zeschky, M., Widenmayer, B., & Gassmann, O. (2011). Frugal Innovation in Emerging Markets. *Research-Technology Management*, *54*(4), 38-45.

Zhang, H. Y., & Lv, S. (2015). Intellectual Capital and Technological Innovation: The Mediating Role of Supply Chain Learning. *International Journal of Innovation Science*, *7*(3), 199-210.

Zhu, Q., & Sarkis, J. (2006). An inter-sectoral comparison of green supply chain management in China: drivers and practices. *Journal of cleaner production*, *14*(5), 472-486.

Zhu, Q., Sarkis, J., & Lai, K. H. (2007). Green supply chain management: pressures, practices and performance within the Chinese automobile industry. *Journal of Cleaner Production*, *15*(11), 1041-1052.