Research Update – A framework to study supply chain strategies against global pandemic

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Abstract

During the global pandemic, supply chains often look for an evidence-based framework to evaluate their responses to disruptions compared to other more successful responses. This study proposes such a framework based on the Haddon matrix that is traditionally used to prevent roadside injuries in road accidents. This tool will help to study supply chains and their vertical and societal linkages during the preparation, response and recovery phases of natural disasters such as global pandemics. Implications for the further development of our current research are outlined.

Keywords: *Supply chain resilience, Haddon Matrix, disaster management*

A Framework to Study Supply Chain Strategies Against Global Pandemic

The COVID-19 pandemic has caused significant challenges for global supply chains. Numerous national lockdowns and border closures continue to slow down the flow of raw materials and finished goods, disrupting every actor in the supply chain. However, the pandemic has not necessarily created any new challenges for these supply chains, at many places, it has just escalated the already present vulnerabilities in the system. There are supply chains that collapsed, yet there are few organizations and supply chains that emerged better prepared. These few organizations had better visibility into the structure of their supply chains and survived the severe disruptions through a proactive approach.

This shows that some supply chains proactively responded to the disruptions and implemented certain interventions/strategies that helped them survive rather than thrive amid this global pandemic. Considering this, there is a need for a framework that can bring together all these interventions for each phase of disaster which different supply chains can use to enhance their overall supply chain resilience during the global pandemic. This study proposes such tool based on Haddon matrix framework and and presents the steps to use it to successfully respond to the disruptions originating from the global pandemic.

Modified Haddon Matrix

The Haddon Matrix is not a new framework, William Haddon introduced this matrix in 1968 to scientifically study an event to identify its temporal phases and contributing factors (Haddon Jr, 1968). It has been widely used in road-safety research to determine root causes and the potential impact of interventions. Recently, it has also been cited and utilized in disaster management, especially for epidemic outbreaks (Cole et al., 2020; Hecht et al., 2019). The World Health Organization (WHO) has also identified the Haddon Matrix as a dynamic system-based framework for assessing pandemic disasters, where each cell of the matrix provides an opportunity for intervention to reduce the impact of the disruptions (Peden et al., 2004; Timpka et al., 2009). The Haddon Matrix is a two-dimensional matrix where rows represent temporal phases of any event that are described as; pre-event/preparation phase, event/response phase and post-event/recovery phase. The columns represent incident related factors, in particular; human/organization, agent, physical environment and social-cultural environment factors (Peck et al., 2008).

Dividing a problem and the strategies into two dimensions can be helpful to understand, prepare for, and respond to a wide range of disruptions in a practical and user-friendly way (Murray et al., 2014). The Haddon matrix has been used in several epidemiological studies as an effective tool to prevent adverse effects of accidents and diseases (Cole et al., 2020; Peck et al., 2008; Wall, 2012). Anparasan and Lejeune (2017) have utilized this matrix to study a cholera outbreak and provided evidence-based intervention tools for future outbreaks.

The authors demonstrated the effectiveness of this matrix as a planning tool to better react to such outbreaks. These examples show the usefulness of the Haddon matrix and its varied applicability. The main benefit of this matrix is the ability to divide an event/disaster into smaller sections and systematically find intervention strategies. Whereas most previous studies applying the Haddon matrix focus on influenza and cholera outbreaks, this study focuses on Covid-19, a disease that is new and wreaking havoc on supply chains all over the world.

Haddon Matrix – Rows (Disaster Management Life Cycle)

Disaster management is an applied science that seeks the systematic observation and analysis of disasters to improve measures related to preparedness, emergency response and recovery (Carter, 2008). Adopting this approach, the Haddon matrix utilizes the disaster management life cycle's three phases: preparedness, response and recovery (Banipal, 2006; Day et al., 2012; Balgah & Kimengsi, 2022).

The preparedness/mitigation aspects of the disaster cycle are part of the pre-event phase of the Haddon matrix. In case of a pandemic, this phase focuses on preventing supply chains from adversely impacting the related disruptions. This phase can comprise of activities such as; early warning or monitoring systems, maintaining acceptable health and sanitation standards, cultivating awareness, pre-positioning stocks, coordinating with suppliers, and increasing visibility across supply chains (Ali et al., 2017; Allotey et al., 2010; Christopher & Rutherford, 2004; Tomasini & Wassenhove, 2009). Preparation is crucial as many organizations within a supply chain, where an inability to scan the environment and poor preparation for simple supply chains risks and can intensify the consequences (Scholten et al., 2014), especially in the context of a pandemic.

The response phase starts when the disaster event occurs or is ongoing and the supply chain starts facing supply chain disruptions (Cozzolino et al., 2012). Actions and outcomes of this phase largely depend on the preparation phase. Naturally, well-prepared supply chains would be in a better position to respond. In the case of pandemic disruptions, how quickly one organization can communicate to other organizations,

Table 1
Rows in Haddon Matrix

Phases	Pre-event	Response	Post-event
Haddon Matrix	The pre-event phase in the Haddon matrix involves the mitigation and preparedness aspects of a disaster cycle.	The response phase takes place when the agent interacts with the host.	The post-event phase is when the damage has been done
In the case of the epidemic (Anparasan & Lejeune 2017)	In case of a disease outbreak, this phase focuses on preventing the agent or virus from reaching the susceptible host or human body. This phase includes activities such as monitoring for possible indications of a disease outbreak, maintaining satisfactory health and sanitation standards, improving awareness and conducting accrued surveillance among populations at risk.	When a virus enters the body of a human. There is ample opportunity for intervention in order to prevent severe infection or death of the host. Early identification of a host should ideally translate into early treatment mechanisms so that the health of the host does not deteriorate further.	The affected community needs to transition from response to recovery. The post-event phase involves decisions taken to minimize further harm to human life, such as evacuation and improvement of infrastructure, and to return the situation back to normal as soon as possible.
Hecht et al 2019	In case of SC resilience, pre-event phase includes formal emergency planning and staff training	Response activities include staff attendance, operational redundancies (infrastructure, inventory, and location), supplier diversity.	Post-event activities include learning and adaptiveness, and insurance.
Our suggested research approach	In case of Covid 19, we can consider pre-event as the time before the spread of this virus.	Response phase started once countries started lock down and Covid 19 was declared as global pandemic	Post evet is the phase once governments has controlled the situation and markets started opening up, although this is a long term phase that will spread across many years to come.
Timeline	Before Dec/Jan 2020	Varies based on individual countries but generally from January or February 2020	No timeframe needed here. Activities and interventions with long-term impact can be categorised and linked with this phase.

how quickly supply chains can assess the damage and how quickly they can restore their operations are crucial steps in the phase.

The Haddon matrix post-event phase is similar to the recovery phase of the disaster life cycle, where the damage has been done, and the affected organizations in the supply chain need to transition from response to recovery. At this stage, it is critical to exploit the impact of the recovery strategies to help the supply chains adapt and move on from the response phase. In the case of Covid-19, we can adapt the following timeframe and rationale (summarized in Table 1).

- Pre-event – Inventions/strategies introduced before the spread of the virus (before Dec/Jan 2019). We can consider this disruption/event when individual countries started to lockdown their borders and introduced social distancing measures.
- Response – this phase varies based on individual countries. For example, China was the origin of this pandemic; therefore, the response phase started in December 2019, whereas, in most countries, the spread of virus became apparent in January or February 2020 when governments started to shut down their borders and WHO declared Covid-19 as Pandemic.
- Post-event (recovery) – Similar to response, this phase varies as some countries were swift in placing the social distancing measures, hence were quick to restore some level of commerce and social activities. Instead of defining a particular timeframe, activities and interventions with long-term impact can be categorised and linked with this phase.

Haddon Matrix – Columns (Event Factors / Categories)

The columns of the matrix represent four main factors or components that have been determined as relevant to any disaster, these being; the host, the agent, the physical environment and the socio-cultural environment. In most of the previous Haddon matrix studies, the *host* represents human beings and the *agent* represents the virus/vehicles (Peck et al., 2008). Additionally, some authors have studied organizations as the host and risks as the agents (Hecht et al., 2019; Runyan, 1998). In this study, the Authors propose to use the supply chain and all the factors related to its inter-organizational interactions as the *host*. Similarly, supply chain disruptions and risks related to Covid19 can be considered as the *agent* in the second column of the proposed matrix. Next, the Authors propose to categorize logistical issues such as inventory, storage, and transportation as part of the *physical environment* while interventions related to the interaction with other government agencies, research

Table 2
Columns in Haddon Matrix

Definition	Host	Agent	Physical	Socio-cultural environment
Haddon matrix (Anparasan & Lejeune 2017) (Runyan 1998)	The host is the person that is susceptible to injury (children in home, students at school)	The agent is the primary cause of the occurrence of an event, cigarette, matches, firearm and bullets)	The physical environment comprises physical infrastructure and mechanisms that must be in place to effectively address a disaster (home, school)	The socio-cultural environment encompasses social and cultural practices as well as laws and regulations that affect each phase of the disaster
In the case of epidemic (Anparasan & Lejeune 2017)		The agent is the disease-causing virus	In case of an epidemic, the physical environment includes requirements for healthcare facilities, availability of healthcare professional and availability of drugs	In case of an epidemic, the Socio-cultural includes requirements such as funding needs, effective transition mechanisms, and related policies.
Hecht et al 2019	In case of SC resilience, this includes organisations and its related stakeholders.	In case of SC resilience, this includes efforts to manage a risk	In case of SC resilience, the physical environment includes requirements/strategies to plan and respond to a disruption.	In case of SC resilience, Socio-cultural environment is related to developing and maintaining relationships within and across different organisations.
Our research approach	In case of a SC, host include SC network partners (including upstream and downstream SC partners)	In case of a SC, an agent includes the SC risks that can disrupt the flow of goods, and the efforts to manage the SC risks e.g. risks originated from the Covid-19 situation.	In case of a SC, the physical environment includes logistical activities/strategies to plan and respond to a SC risk.	In case of a SC, socio-cultural environment is related to developing and maintaining relationships with the wider community such as government, emergency institutes, local bodies, competitors…

institutes, emergency organizations and competitors as part of the *social environment* (see Table 2).

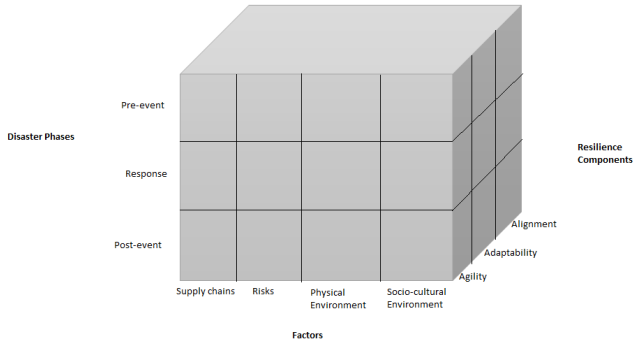
Rationale for a Third Dimension of the Haddon Matrix

The Haddon matrix has been applied in a two-dimension format in nearly all previous studies. However, Runyan (1998) introduced cost, effectiveness, feasibility and preferences as third dimension factors to further analyze the interventions identified in the Haddon matrix, but the focus was only on injury prevention and decision-making around it.

Categorizing the interventions in the disaster management life cycle is one thing, but whether these interventions brining any supply chain resilience is also essential consideration especially during global pandemic. Therefore, in this study, we suggest introducing the supply chain resilience components as the third-dimension elements for this modified Haddon matrix. Resilience can be defined as the ability of a system to bounce back from disturbance (Burnard & Bhamra, 2011). Moreover, Klibi and Martel (2013) define resilience as the ability of a supply chain network to resist and effectively respond to disruptions and to recover quickly from failures. Other scholars have defined it as the capability of supply chains to anticipate/prepare, respond and recover from disruptions in an efficient and effective way (Fiksel, 2003; Ponomarov, 2012). Many resilience concepts are borrowed from other disciplines and it is a wide-ranging research concept. While a full review of this subject is beyond the scope of this research, we define supply chain resilience with reference to Umar et al. (2017) as: The ability to prepare, respond and quickly recover from disasters by employing agility, adaptability and alignment strategies.

Indeed, many other components of resilience are identified in the literature, but these can all be summarized into thehigher-order constructs of agility, adaptability and alignment (Cabral & Grilo, 2012; Dubey & Gunasekaran, 2016; Lee, 2004; Walker et al., 2004). Here, *agility* is a quick response with all available resources, *adaptability* refers to the systems' ability to adapt to the new situation during and after the disruptions, and *alignment* is the alignment of business processes (integration) and commercial interests with other supply chain partners. Thus, the proposed modified Haddon matrix demonstrating the additional third dimension is presented in Figure 1. We suggest that this modified Haddon matrix will help identify the decision-making challenges and opportunities specific to each phase of the pandemic outbreak.

Figure 1
Proposed three-dimensional Haddon matrix



Steps In Using The Matrix

There can be multiple ways to use this matrix, however, we suggest the following steps in order to use this three-dimensional Haddon matrix; different supply chains can modify according to their needs.

1) Rigorous research needs to be done in order to determine the problem in need of intervention, this can be too general such as "SC disruptions originating as a result of the pandemic" or quite specific as "demand fluctuations or delivery delays".
2) Define columns of the matrix as the targets of change, this definition needs to be clear and concise. We have provided one way of defining these in this paper, but there could be other ways as well e.g. relationship between different supply chain actors can also be part of the socio-cultural environment.
3) Define rows of matrix, disaster phases timeline needs to be very well defined here.
4) Determine weights to be applied to each value listed in third dimension: agility, adaptability and alignment. It depends on the organization which value they prefer the most, but all of these three need to be present in one way or the other in order to have resilient supply chain.
5) Interventions can be brainstormed or can be based on the field research, if these are brainstormed then further collect data to assess each intervention.
6) Assess each intervention against the three components of supply chain resilience, factor rating method can be used here to assess.
7) Make decisions about the best options
8) Document the process for future to reanalyse.

Conclusion

The purpose of this study was to propose and assess an analytical framework to help reduce the adverse impacts of future supply chain disruptions. The three-

dimensional Haddon matrix includes the disaster phases; preparedness, response, and recovery; contributing factors such as actors, risks assessed in both the physical environment and the socio-cultural environment; adding the third dimension built around the resilience components of agility, adaptability, and alignment. One of the significant advantages of the suggested tool is that it balances the critical trade-off decisions between practicalities and comprehensiveness while allowing flexibility via customization and stakeholder engagement in the evaluation phase. The next steps are elaborating the customized versions of the suggested Haddon matrix for policymaking at the governmental level and for continuity management at institutional and company levels.

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