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Exploring the elements of supply chain resilience in Malaysia's Defence Industry – A Conceptual Framework

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Abstract: The defence supply chain (DSC) plays a crucial role in a nation by ensuring that military operations are adequately equipped and supported. This requires DSC to be resilient to ensure the success of military operations. However, challenges such as over-dependence on international suppliers for defence assets supplies, limited local technological capability, and economies of scale, as well as a lack of strategic procurement approach have the potential to weaken Malaysia's defence industry. By drawing on defence and supply chain literature, this study examines the supply chain resilience (SCRes) in the defence industry and develops a conceptual framework. The proposed theoretical framework advances research in SCRes and defence; and provides avenues for future research opportunities. In general, this study argues that supply chain (SC) network design, visibility, flexibility, collaboration, redundancy and agility significantly influence the resilience defence supply chain (RDSC).

Keywords: *resilience, defence, supply chain, conceptual*

1. Introduction

The defence industry entails "…activities that are related to the production and manufacturing of capital items consisting of land, air, sea, weapon systems and military solutions, components and spares, as well as those in relation to the MRO"; which are meant for the country's need of defence and security [1]. The defence supply chain (DSC) refers to the network of organisations, activities, resources, and processes involved in the procurement, production, and delivery of goods and services necessary to meet the needs of the armed forces. It encompasses all aspects of supply chain management (SCM), from sourcing raw materials and components to delivering finished products and services to end users. The DSC is critical to ensuring that military operations are adequately equipped and supported, and its resilience is essential to the success of military operations. The DSC often involves complex and sensitive components and systems which require rigorous oversight and management to ensure its security, quality, and efficiency.

The resilience defence supply chain (RDSC) is vital for various reasons. The defence industry plays a critical role in national security, and disruptions to the DSC can seriously affect a country's ability to protect itself. By improving the RDSC, a nation can ensure that it has the necessary resources and capabilities to respond to unexpected events, such as natural disasters, cyber-attacks, or supply chain disruptions [2]. Furthermore, higher resilience allows DSC to anticipate better, react and adapt to the changing environment, thereby improving and lowering SC performance (i.e., availability, lead-time, inventory position, customer complaints) volatility [3]. Additionally, the RDSC

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is significant from an economic perspective. The defence industry is a major contributor to many countries' economies, and disruptions to the DSC can have ripple effects throughout the broader economy. By enhancing the resilience of the DSC, a country can mitigate the potential economic impact of disruptions, ensuring it can continue to meet its defence needs.

Nevertheless, RDSC is imperative from a sustainability perspective. The defence industry is a significant consumer of natural resources, and disruptions to the SC can have negative environmental impacts. By enhancing the resilience of the DSC and promoting sustainable practices, countries can ensure that they can meet their defence needs in an environmentally responsible and sustainable long-term way.

The importance of Malaysia's defence industry can be translated through the development of the Defence White Paper (DWP) and National Defence Policy in which the overriding principle of these two is to be an indigenous industry by reducing the dependency on foreign defence assets [4,5]. In light of this, it is crucial to explore this principle as the nation continues to acquire its defence assets from foreign companies like Spain, Turkey, and South Korea [5,6]. Moreover, high dependency on foreign suppliers could expose defence firms to increased SC disruptions. It was reported that SC disruptions cost organisations an average of 45% of one year's profits [7]. Major SC disruptions (i.e., the Covid-19 pandemic, the US-China trade war, and Russia's invasion of Ukraine) can no longer be considered sporadic events [8] as they have the potential to weaken RDSC. Several challenges have also been identified to impede the RDSC.

First is the limited defence capability. Although Malaysia allocated more than RM40 billion (2006 – 2020) to modernise the Malaysian Armed Forces (MAF) and upgrade its old assets through offset and industrial collaboration programs, hardly any evidence was seen [1]. In fact, Malaysia was ranked 40th in global arms imports between 2016 – 2020, an increase of 114% in imports between 2011 – 2015 and 2016 – 2020. The over-reliance towards foreign suppliers is due to the limited capability in defence industrial and technological absorptive capabilities [1,6]. Similarly, [9] confirms that the industry faces a persistent shortage of STEM talent and limited R&D capabilities, which impede its progress. In contrast, other Asian countries such as Indonesia, Singapore, and South Korea have moved to the second-tier arms-producing country, being able to develop an indigenous defence industry [10]. Indonesia, for example, is capable of producing defence equipment such as rifles, missiles and ammunition, combat vehicles, and tanks for its own needs as well as for other countries such as Bangladesh, Cambodia, Mali, Nigeria, and the United States (US) [11].

The strategic importance of the Indonesian defence industry can be seen through its defence budget allocation. In 2018, the Indonesian Ministry of Defence received the most significant budget allocation of $6.9 billion USD, higher than other ministries, such as the Ministry of Health and the Ministry of Research and Technology [11]. In 2023, however, Indonesia allocated more than $8,000,000,000 USD for its defence budget (ranked 25/145), higher than Malaysia ($2,593,874,880 USD, ranked 61/145) and even Thailand ($5,860,000,000 USD, ranked 37/145), and North Korea ($4,500,000,000, ranked 45/145) [12]. Although Malaysia shows an increase in the defence budget allocation, the amount is still relatively small compared to other countries like Indonesia and Singapore [6,13].

Another major issue facing the Malaysian defence industry is the need for a strategic procurement approach. Despite asset requirements planning documents, most procurement activities are still based on an ad-hoc basis, with limited involvement of local industry input [1]. Ad-hoc, underfinanced defence projects that emphasise economic returns and political intervention are some examples that show the immaturity of the procurement approach [1,13]. This is also the case for Boustead Naval Shipyard (BNS) and SME Ordnance (SMEO), who monopolise government contracts [14]. Previous studies have shown that traditional procurement limits long-term collaboration, information sharing, and the development of tacit knowledge between SC partners [15]. Strategic collaboration is vital to aligning the interests of defence SC firms, an essential component of building resilient SCs.

Despite the attention and growth in SCRes publications to date, there needs to be more understanding of building resilience in the context of defence SC. Most studies have focused on manufacturing firms and specific contexts, such as disaster relief, agri-foods and the healthcare industry. Responding to calls for further research by Scholten, Stevenson, and van Dock[16], the study explores the elements of building an RDSC.

2. Theoretical Background

In recent years, the topic of SCRes has gained increasing attention from both academics and practitioners due to its potential risks to business continuity. Resilience is considered one of the important elements that SC must incorporate to effectively and efficiently manage disruptive events [2]. The concept of resilience, however, has its root in various disciplines [17–19] such as psychology [21], engineering [20], and ecosystems. Undeniably, some of its elements have been adopted by the domain of operations and supply chain management (OSCM) to conceptualise the SCRes. Ali, Mahfouz, and Arisha [18] analysed the extant literature to study the concept of resilience and found that the concept can be defined at three different levels: a) organisational, b) network and c) system- perspective.

From the firm-level perspective, SCRes can be defined as the ability of an organisation to react to an unexpected disturbance and return to normal operations [2]. Christopher and Peck[22], on the other hand, defined SCRes from a system perspective as the ability of a system to restore to its original state or adapt to a new, more desirable state after

being disrupted. Both of these work formed the basis of the SCRes literature and motivated other studies in the field of OSCM. Although SCRes work has been conceptualised at three different levels, most definitions share the similar view that resilience is about the ability of an organisation, supply chain, and system to be alert, respond, and restore at the same or better operating state [23].

Many published studies have discussed formative elements to build resilience SC. Indeed, several terminologies have also been used to describe the attributes of SCRes, including strategies [24], elements [18], capabilities [25], and antecedents [26,27]. In their seminal work, [22] used the term principles to operationalise the concept of SCRes. Other researchers then use these principles to describe capabilities [25] and elements of SCRes. These differences demonstrate the diversity of resilience understanding in the OSCM field. Nonetheless, the term element is used to bring consistency with previous literature [18,22].

Christopher and Peck[22] identified four elements: SC engineering, SC collaboration, agility and SC risk management, that underpin SCRes. In fact, these elements are considered primary capabilities for developing SCRes in disaster management [25]. Jüttner and Maklan[23] highlighted that improving SC flexibility, visibility, velocity and collaboration capabilities enhance SCRes and thereby reduces the SC vulnerability. Tukamuhabwa, Stevenson, Busby, and Zorzini[24], on the other hand, cited flexibility, redundancy, SC collaboration and SC agility as the most frequently cited elements. A systematic literature review of SCRes identified 27 elements, with SC network design/configuration (38) and flexibility (37) as the most widely addressed elements, followed by redundancy (30), visibility (29), collaboration / collaborative planning (23), and agility (21) [18]. Hence, this study discusses these elements and examines their criticality in the context of RDSC. Other elements with a score of fewer than 15 publications will not be considered in this research. Such elements are anticipation/ awareness/ sensing, IT capability, robustness, SC risk management culture, and SC continuity.

3. Conceptual Framework

Recognising significant SC risks and vulnerabilities, many firms are considering major transformations in their SC network design to enhance the efficiency and effectiveness of their SC operations as well as to create new forms of competitive advantage. This decision needs to be made in the long term, considering the impracticability of firms to change their network design and facility location in the short term [28]. Kim, Chen, and Linderman[29] defined a supply network as a collection of nodes (facilities) connected by arcs (transportation). SC network has been conceptualised as a complex adaptive system since it comprises entities exhibiting adaptivity, myriad interactions and a composed of a complex system [30]. A survey conducted by Gartner shows that less than 25% of respondents have a high and effective SC resilient network [31]. Understanding the nodes, arcs, and their configuration in the end-to-end supply network can help to assess disruption and resilience [29]. It is also a fundamental prerequisite to improving SC resilience. Mapping tools can be applied to identify "pinch-points" (i.e. limited capacity and alternative options may not be available) and "critical paths" (i.e., long lead times, linkages with poor visibility, high levels of identifiable risks, and a single source of supply) [22]. Thus, this study posits:

P1 *SC network design improves RDSC*

Although Christopher and Peck[22] considered flexibility as the secondary element of SCRes, flexibility is the second most mentioned element of SCRes [32]. Flexibility is considered the greatest potential in creating resilience. It refers to the internal capability of an organisation to respond to SC disruptions by investing in infrastructure and resources before they are required. This may include a flexible workforce, production systems, and sourcing strategies [2]. On the other hand, Pettit, Fiksel, and Croxton[33] viewed flexibility in terms of sourcing and order fulfilment as critical in increasing resilience. Flexibility in sourcing is defined as the "ability to change inputs or the mode of receiving inputs" (p.12), whereas flexibility in order fulfilment refers to the "ability to quickly change outputs or the mode of delivering outputs" (p.12). Previous studies have shown that flexibility in capacity and sourcing has been evidenced to reduce the negative effect on firms' cost and revenue targets throughout a financial crisis [23]. This is concurred by Kamalahmadi, Shekarian, and Mellat Parast[34] that flexibility in suppliers' practice reduces expected lost sales, total cost, and increases the expected service level. Hence, this study posits:

P2 *SC flexibility improves RDSC*

Redundancy is another element considered to have tremendous potential in creating resilience. In contrast to flexibility, redundancy is concerned with maintaining a capacity to respond to disruptions in the SC network through capital and capacity investments prior to the point needed. An essential distinction between flexibility and redundancy is capacity that may or may not be used; it is a spare capacity that would be used to replace the lost capacity caused by disruptions [2]. Kim, Chen, and Linderman[29] in their study stated that creating redundancy in nodes and arcs does not enhance the overall resilience of the network. This indicates that from a network perspective, redundancy may not sometimes lead to higher resilience in a well-established network. In contrast, Kamalahmadi, Shekarian, and Mellat Parast[34] found that redundancy provides improvements in cost reduction and service level; however, redundancy in backup suppliers (i.e., a secondary supplier that is used only when a primary supplier is at risk) outperforms flexibility in terms of flexible-suppliers (i.e. the capability to increase volume flexibility in the time of disruptions). Furthermore, redundancy has been found to be crucial in attaining SCRes

in highly resilient organisations (HROs) such as air traffic control, US navy aircraft carrier, and nuclear plant [35]. As such, this study posits:

P3 *SC redundancy improves RDSC*

Collaboration is another most frequently mentioned element of SCRes. Collaboration is related to working effectively with other entities for mutual benefit through collaborative forecasting, communications, postponement of orders, risk sharing, and product life cycle management [33]. Collaboration can either be horizontal or vertical and operational or strategic. Horizontal and vertical collaboration is critical to building SCRes in each phase of disaster management (i.e., mitigation, preparedness, immediate response, and recovery) [23]. In addition, Christopher and Peck[22] denotes collaboration as the ability to respond to SC disruptions with partners through collaborative planning. Collaborative planning is essential to gain better visibility of demand and be alert to any supply disruptions. Constant information sharing and learning from both horizontal and vertical SC members are vital in preparing them for disaster. Doing this has enabled firms to avoid and reduce adverse risks related to revenue, cost and lead times [23]. As such, this study posits:

P4 *SC collaboration improves RDSC*

SC visibility is one of the most frequently mentioned elements in improving SCRes [36] and it is referred to as the capability of "being perceived by the eye or mind" [23]. It is perceived as the ability to see the end-to-end SC inventories, demand and supply conditions, and production and purchasing schedules [22]. This allows organisations to have knowledge of the status of operating assets and the environment [33]. Further, SC visibility supports effective responses and helps organisations to avoid the non-availability of supplies and mitigate the negative effect of cost targets [23]. However, SC visibility can only be achieved through close collaboration within and between firms [22] and SC mapping. SC mapping is influential in understanding the upstream and downstream SCs [22,36], and their key SC bottlenecks and constraints [36]. Therefore, this study posits:

P5 *SC visibility improves RDSC*

SC agility is a vital counterpoint to resilience. It is concerned with the ability of a firm's SC to adeptly counter market changes and fulfil customer demands swiftly and flexibly [37]. This is because long response times to SC disruption can potentially put organisations at risk. However, the ability to respond swiftly depends on two key ingredients: visibility and velocity [22]. In contrast, Patel and Sambasivan[37] indicated that flexibility is an enabler of SC agility. This aligns with a study by Scholten, Scott, and Fynes [25] that visibility, velocity, and flexibility are antecedents of agility, which are essential for building SCRes. Their study has suggested that SC agility should be emphasised in the preparedness and response phases of SCRes. Thus, this study posits:

P6 *SC agility improves RDSC*

The conceptual framework is depicted in Figure 1.

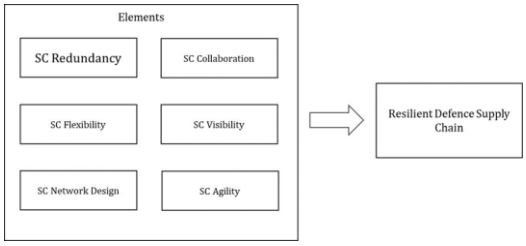

Figure 1. Proposed conceptual framework

4. Discussion and Conclusions

Recognising the need to build an RDSC, this paper develops a conceptual framework that considers SCRes elements in the defence context. This study argues that six SCRes elements are needed to build the RDSC by stating a set of propositions. This conceptual framework offers several theoretical implications and opens avenues for future research.

4.1. Theoretical implications

This study makes several theoretical contributions to research examining SCRes, particularly to the emerging literature at the interface of SCRes and defence. Extant literature has typically focused on building SCRes in manufacturing firms [38,39] and specific contexts, such as disaster relief [30], agri-foods [40], and the healthcare [26] industry. These contributions are vital in advancing SCRes literature. Nonetheless, there is a need to uncover what are the elements required in building resilience in the DSC context. In addition, this study also makes contributions to the SCRes research domain by examining it in an emerging country. Unlike prior research that favoured developed countries [39,41,42], this study shifts the focus to emerging countries, particularly, Malaysia.

The study also makes an important contribution by advancing the literature on defence, specifically exploring the elements that are needed in building an RDSC. A large number of studies have been published concerning the Malaysian defence industry. However, these studies attempt to uncover various defence issues related to defence value [43], an overview, challenges, and direction of the industry [1,9,44], the logistics issues of Malaysian Armed Forces (MAF) [13], and defence funding allocation [6].

This study concludes by offering directions for future research. The study encourages future research to explore listed propositions empirically. There is a need to examine whether all six elements are required to build an RDSC. Triangulation of quantitative and qualitative data is encouraged to overcome the bias issues that may arise from a single approach. Future researchers may examine the elements of SCRes in other emerging countries to make comparisons.

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