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Embracing scepticism as a non-physical form of redundancy: lessons learnt from the UK blood supply chain

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Abstract

This paper seeks to understand how supply chain actors demonstrate scepticism as a non-physical form of redundancy to maintain supply chain resilience. It provides lessons learnt from three case studies of dyadic blood supply chains involving three blood centres and twelve hospitals in England. This paper identifies three key elements of scepticism, namely *information duplication*, *warranting*, and *cross-evaluation*. These elements act as preventive mechanisms, avoiding the unwanted consequences of routine behaviour, and averting mindless actions resulting from reactive operations. We argue that scepticism can be adopted as a complement to supply chain redundancy practices, increasing the robustness and agility of supply chain operations, and therefore enhancing supply chain resilience. To the best of our knowledge, this is the first paper to address the notion of scepticism, emphasising the pivotal role of human behaviour in the supply chain resilience literature. Despite its specific context, the findings could potentially be applied in other industries.

Keywords: disruption, scepticism, information duplication, warranting, cross-evaluation, preventive mechanism, mindful action

Introduction

Supply chains (SCs) across the world are under perennial risk of disruption from both natural and human sources (e.g. tsunami, flood, fire, explosion, hurricane). These disruptions can lead to significant delays in delivery, lost sales, and termination of production, affecting the whole supply chain operation (Ivanov and Dolgui 2020). Most recently, the global COVID-19 pandemic has interrupted many businesses and their supply chains (Lin and Lanng 2020), forcing them to be resilient to cope with unexpected events.

Redundancy is considered an antecedent of SC resilience (Purvis et al. 2016; Shekarian and Parast 2020; Mackay, Munoz, and Pepper 2020). The extant supply chain literature defines redundancy as "keeping excess capacity and backup system[s] to reduce the likely impact of potential disruption" (Ali and Gölgeci 2019, 799; see also

Sheffi and Rice 2005; Ivanov and Sokolov 2013; Yang and Hsu 2018). SC redundancy is achieved through the use of multiple suppliers in different locations, slack resources in production and transport capacity, safety stock, strategic inventory, and emergency backup or storage facilities to anticipate and absorb disturbances from the supply chain environment (Craighead et al. 2007; Zsidisin and Wagner 2010; Bode et al. 2011; Ali, Mahfouz, and Arisha 2017), all of which involve physical or tangible infrastructures. It is argued that SC redundancy increases flexibility and the speed at which resources can be deployed (Johnson, Elliot, and Drake 2013; Jüttner and Maklan 2011), preventing delays in responding to and recovering from disruptions and therefore enhancing SC resilience (Tukamuhabwa et al. 2015).

The pivotal role of physical SC redundancy is evidenced by its prevalence in the SC resilience literature. Hohenstein et al. (2015), Tukamuhabwa et al. (2015), Ali, Mahfouz, and Arisha (2017), and Ali and Gölgeci (2019) all conducted systematic literature reviews into the phenomenon of SC resilience, and each identified 20-30 academic studies discussing redundancy, published since the early 2000s. Whilst all SC redundancy studies have currently focused on physical or tangible infrastructures which are often costly (see Purvis et al. 2016; Mackay, Munoz, and Pepper 2020), Sagan (2004) notes that overreliance on such forms of redundancy could in fact lead to failures due to complacent behaviour. Although establishing necessary additional physical infrastructure is an important preventive measure, it is dangerous to assume that this will automatically enhance SC resilience. Whilst non-physical elements of SC resilience such as situational awareness (e.g. sensing, interpreting, early warning, continuity planning, vulnerability mapping) (Ali, Mahfouz, and Arisha 2017) and collective mindfulness (Lusiantoro and Yates 2021) are important, we argue that additional

assurance mechanisms in the form of scepticism are required to ensure that the redundancy is effective.

Originated from the Greek word “skeptomai”, scepticism means to think, to consider, or to examine by questioning or showing doubt on something (Skarmeas and Leonidou 2013). Scepticism can be a personal trait or enacted in response to certain situations and sceptical people can change their minds amid enough evidence (Mohr, Eroğlu, and Ellen 1998). Whilst studies on scepticism in the context of SC resilience is scarce, some research suggest that scepticism could help organisations maintain their reliable performance as it prevents mindless behaviour that could lead to catastrophic consequences (Hopkins 2007; La Porte and Consolini 1998; Roberts 1990; Roberts and Rousseau 1989; Rochlin 1993; Weick, Sutcliffe, and Obstfeld 1999). Whilst scepticism has been considered as a state of mind and “cognitive response that can result from situational factors” (Skarmeas and Leonidou 2013, 1832), it relies on non-physical efforts to trigger appropriate actions. It is different from other non-physical elements of resilience such as situation awareness and visibility (Ali, Mahfouz, and Arisha 2017), in that scepticism involves critical thinking on the sensed events.

Earlier studies investigating resilience in the organisational context have advocated that, whilst physical redundancy is important, resilient performance can also be achieved and maintained through sceptical attitudes to the evaluation and control of events which lead to disruptions (Weick, Sutcliffe, and Obstfeld 1999; Weick and Sutcliffe 2007). Adopting scepticism avoids misinterpretation and misjudgement of routine and non-routine events, creating a system which challenges mindless assumptions (Weick and Sutcliffe 2007). At an organisational level, Weick, Sutcliffe, and Obstfeld (1999) suggest that scepticism is an important preventive approach to system resilience, and it should be considered as an additional form of redundancy,

which is effective in maintaining resilient organisational performance across a range of operational conditions. With scepticism, events are not only sensed, but they go through a cognitively redundant process of checking and rechecking to ensure appropriate actions in response to the events. We therefore call this a non-physical form of redundancy.

Despite its importance, our understanding of scepticism and its role in SC redundancy remains scant. This paper attempts to address this gap by answering the question: *how do supply chain actors maintain SC resilience through the demonstration of scepticism?* We draw upon the seminal works of Williams (1999), Weick, Sutcliffe, and Obstfeld (1999), and Owen-Smith (2001) who theorise on how scepticism should be employed to maintain reliable performance amongst a group of people in an organisation. This paper contributes by extending these ideas beyond the context of a single organisation to that of supply chain, using the blood supply chain (BSC) in England as an example. We reveal information duplication, warranting, and cross-evaluation as three elements of scepticism demonstrated by the BSC actors. We conclude that scepticism helps BSC actors maintain SC resilience and propose that scepticism is adopted as an additional non-physical form of redundancy, a novel approach to enhance SC resilience. We contribute by refining the initial theoretical framework of SC redundancy by treating scepticism as an additional dimension of SC redundancy and explain the mechanisms by which each scepticism element enhances SC resilience.

Practically, this research suggests that scepticism could be used to avoid complacent behaviour, overcompensation, and social shirking on the existing system. It highlights the danger of overreliance on physical redundancy including technologies and that scepticism could help mitigate the costly failure. As such, SC practitioners need

to understand their operations and when human interventions are required to fail-safe the process. In addition, SC practitioners need to know how to diagnose the health of systems and technologies and how to respond to their failures. This research also highlights that certain technologies could support the enactment of scepticism in SCs.

This paper is organised as follows. Following this introduction to the research, a brief literature review into supply chain redundancy and scepticism is presented. The research methodology is then described followed by the findings. Finally, the paper is concluded.

Literature Review

Supply Chain Resilience

SC resilience has been extensively studied in the extant literature (e.g. Hohenstein et al. 2015; Ali, Mahfouz, and Arisha 2017; Tukamuhabwa et al. 2015; Ali and Gölgeci 2019; Han, Chong, and Li 2020; Spieske and Birkel 2021). In general, SC resilience can be defined as the ability of a supply chain to cope with changes or disruptions through proactive and reactive SC risk management strategies (see Mackay, Munoz, and Pepper 2020; Shishodia 2020; Kaur and Singh 2020; Ali, Nagalingam, and Gurd 2017; Hohenstein et al. 2015; Wieland and Wallenburg 2013). A proactive SC resilience strategy covers "actions taken prior to the disruption occurrence and involves planning to either reduce the probability of occurrence […] or mitigate the severity of disruptions". Whereas, a reactive strategy involves adjusting actions after disruptions have (unexpectedly) occurred or in response to changes in the environment "to minimise the detrimental impact of disruptions" (Mackay, Munoz, and Pepper 2020, 1548). In essence, Wieland and Wallenburg (2013) argue that proactive and reactive SC resilience strategies can be defined across two fundamental dimensions, *robustness*, the

ability of a SC to avoid and resist changes or damaging disruptions without necessarily adapting its current configuration (Durach, Wieland, and Machuca 2015; Wieland and Wallenburg 2012, 2013) and *agility*, "the ability of a supply chain to rapidly respond to change by adapting its initial stable configuration" (Wieland and Wallenburg 2012, 890).

These two fundamental SC resilience strategies have been applied in many contexts. Kaur and Singh (2020) develop disaster resilient procurement models to select suppliers for both proactive and reactive humanitarian SC operations. They propose that in a proactive situation, orders should be allocated to disaster resilient suppliers, whereas in a reactive scenario, order reallocation is needed to minimise the cost penalties of any shortages (Kaur and Singh 2020). Similarly, in project-driven SCs, Shishodia et al. (2020) propose a supplier assessment approach and show that whilst project contexts could affect suppliers' resilience, early warning signals of supplier failure and proactive measures are required to enhance SC resilience overall (Shishodia, Verma, and Jain 2020).

Finally, in the context of small and medium-sized enterprises in perishable product supply chains, Ali, Nagalingam, and Gurd (2017) propose SC resilience as a second order-construct with both proactive and reactive elements. In this context, business certifications, globalisation, vertical integration, training and development, and quality management are included as proactive elements, whereas responsiveness to customers' needs and competitors' strategies as well as multi-sourcing and public-private collaboration are listed as reactive elements of SC resilience (Ali, Nagalingam, and Gurd 2017). The extant literature also highlights the importance of SC resilience and digital transformation in healthcare and agri-food operations and how industry 4.0

technologies could help the supply chains mitigate negative impacts of operational disruptions (Senna et al. 2021; Ali and Govindan 2021).

Supply Chain Redundancy

Hohenstein et al. (2015) and Ali and Gölgeci (2019) suggest that SC redundancy is one of the most important and frequently mentioned topics of SC resilience. The basic premise of SC redundancy is risk mitigation, reducing the catastrophic impacts of potential disruptions across the supply chain (Ali and Gölgeci 2019; Sheffi and Rice 2005; Ivanov and Sokolov 2013; Yang and Hsu 2018). SC redundancy plays a critical role as a shock absorber, particularly for short-term disruptions (Hohenstein et al. 2015; Craighead et al. 2007; Zsidisin and Wagner 2010; Bode et al. 2011). It also provides the ability to cope with and adapt reactively to unexpected disruptions (Hohenstein et al. 2015). We propose Figure 1 as an initial theoretical framework of SC redundancy adapted from the extant literature.

The figure suggests that both proactive and reactive SC redundancies are the antecedents of SC resilience (Mackay, Munoz, and Pepper 2020; see also Purvis et al. 2016; Shekarian and Parast 2020). Proactive redundancy (e.g. buffer/safety stock) is a common measure used to increase *resistance* to disruption and therefore SC robustness (Mackay, Munoz, and Pepper 2020; Durach, Wieland, and Machuca 2015). It is effectively an *insurance,* a loss aversion mechanism against failure in the SC (Mackay, Munoz, and Pepper 2020). On the other hand, reactive redundancy refers to *expediting* resources (e.g. ordering additional inventory from suppliers who can achieve shorter lead times), increasing the speed of response and therefore agility in reacting to disruptions (Mackay, Munoz, and Pepper 2020; Wieland and Wallenburg 2013).

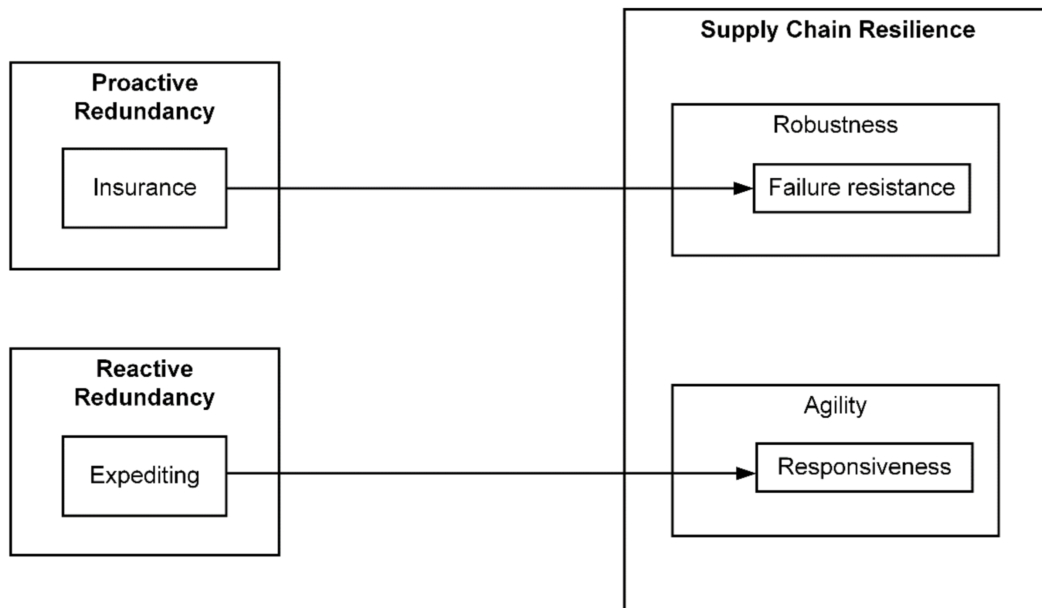

Figure 1. Initial theoretical framework of SC redundancy

Source: adapted from Mackay, Munoz, and Pepper (2020), Durach, Wieland, and Machuca (2015), and Wieland and Wallenburg (2012, 2013)

Despite its importance in enhancing SC resilience, SC redundancy is considered an expensive solution (Sheffi and Rice 2005; Purvis et al. 2016). This is mainly due to the physical nature of redundant systems required as back-ups against disruptions. As Sheffi and Rice (2005, 44) state:

> Redundancy is the familiar concept of keeping some resources in reserve to be used in case of a disruption. The most common forms of redundancy are safety stock, the deliberate use of multiple suppliers even when the secondary suppliers have higher costs, and deliberately low capacity utilization rates. The incremental cost of safety stock, additional suppliers or backup sites is effectively an insurance premium. (Sheffi and Rice 2005, 44)

Whilst physical redundancy is without doubt required to maintain SC resilience, this argument raises intriguing questions: is it enough to rely only on such physical form of redundancy? Is there a less physical and more cost-effective approach to system redundancy? If so, how can supply chain actors develop this form of redundancy? These

questions have gained very limited attention in the extant supply chain management literature. However, the concept of scepticism has the potential to answer these important questions.

Scepticism

Scepticism is an attitude centred on doubt as to the truth of something. People with a higher degree of scepticism are more risk averse decision makers (Omer, Sharp, and Wang 2018). However, scepticism is more than merely being risk averse, it also indicates that people are more prejudiced, negative, or pessimistic towards something; it is about alertness to and careful consideration of the validity of the received information (Brown and Krishna 2004). Williams (1999, 35) argues that "a skeptic is someone with a skeptical attitude: he [or she] questions things (particularly, received opinions); he [or she] practices suspension of judgement." This evidence-seeking attitude is usually embedded amongst rational thinkers (Williamson, 2000). The basic assumption of scepticism is that decision making is based on imperfect information and sceptical decision-making processes are conducted to 'satisfy' stakeholders through rules, routines, standard operating procedures (SOPs), and sense making of shared information (Nelson and Winter 1983; Weick 1995). As such, scepticism manifests as invisible control over the appropriateness of organisational processes.

In sociology, Owen-Smith's (2001) seminal paper illustrates the act of scepticism using the case of the scientific work of a research group in a neuroscience laboratory. In this setting, scepticism is deployed as an evaluation and control mechanism "in which critical or directive comments are made about the technical, substantive, or theoretical details of a scientific claim" (Owen-Smith 2001, 429). Interactions and dialog are developed to confirm scientific findings and actions ensure their validity and justification (Owen-Smith 2001). According to Owen-Smith (2001),

scepticism can be enacted through informal meetings to establish workplace control by setting rules that govern daily decision-making. It can also be enacted to challenge the appropriateness of the current assumptions, arguments, or approaches proposed by the group members (Owen-Smith 2001).

In the context of crisis management, Weick, Sutcliffe, and Obstfeld (1999) define scepticism as doubts that the precautions in place are sufficient. A sceptical attitude is embedded in the collective mindfulness principle of *reluctance to simplify* the interpretation of events which emerge alongside routine behaviour in organisations (Weick, Sutcliffe, and Obstfeld 1999; Weick and Sutcliffe 2007, 2015). Researchers argue that this principle is critical, particularly for high reliability organisations (HROs) such as nuclear power plants, aircraft carriers, and air traffic control systems, which operate in complex, demanding, tightly coupled, and risky environments where failure (including misinterpretation or misjudgement of potentially disruptive events) may lead to catastrophic and fatal consequences. By being reluctant to simplify their interpretation of unexpected events, i.e. sceptical, these organisations strive to minimise errors and sustain excellent performance across a range of operational conditions (Hopkins 2007; La Porte and Consolini 1998; Roberts 1990; Roberts and Rousseau 1989; Rochlin 1993).

Weick, Sutcliffe, and Obstfeld (1999) argue that scepticism can be treated as a form of redundancy which is employed to ensure HROs maintain high performance. According to Weick, Sutcliffe, and Obstfeld (1999, 43), "all humans are fallible, and that skeptics improve reliability […] When a report is met with skepticism and the skeptic makes an independent effort to confirm the report, there are now two observations where there was originally one. The second set of observations duplicates and backs up the first set and may itself be double-checked by still another skeptic. This

skepticism may counteract the potential complacency that redundant systems may foster." Scepticism prevents people from being preoccupied with their own beliefs, which could be misleading (Weick, Sutcliffe, and Obstfeld 1999). These control mechanisms need to be enacted as part of collective mindfulness to identify potential failures within the organisation and are fundamental to the organisation's readiness to cope with unexpected disruptions (Weick, Sutcliffe, and Obstfeld 1999), enhancing resilient performance in the age of uncertainty (Weick and Sutcliffe 2007).

Whilst scepticism seems to relate to information sharing, it is important to note that they are not the same concept. In line with Nelson and Winter (1983), Weick (1995), and Owen-Smith (2001), information sharing in general could be treated as an enabler of scepticism, not the scepticism itself. In the SC context, information sharing could be used to study the interactions and therefore sceptical behaviours between SC actors because it is a prerequisite of SC resilience. Flexible communication and immediate information sharing across the SC are required to *sense* disruptive events, before and after they occur (Purvis et al. 2016; Naim et al. 2006). In other words, information sharing could facilitate SC actors to question *the status quo* which might be fallible. Similarly, SC actors could critically evaluate the shared information to avoid misleading interpretation (see Vraga and Tully 2021). Prior studies of information sharing in the SC resilience literature have not considered this (see also Kembro and Näslund 2014; Kembro, Selviaridis, and Näslund 2014).

Despite its obvious importance, the concept of scepticism is not fully understood. To date, it has been researched as a form of redundancy only in the context of a single organisation (see Weick and Sutcliffe 2015, 2007; Weick, Sutcliffe, and Obstfeld 1999; Lekka 2011). However, as organisations now increasingly participate in inter-organisational networks, involving more complex interactions, we argue that

scepticism becomes an important and relevant concept within the context of SC resilience (see Lusiantoro and Yates 2021). This paper seeks to investigate this phenomenon in the context of the blood supply chain (BSC), determining how BSC actors demonstrate scepticism across a range of operational conditions and its resultant impacts on BSC resilience.

Methodology

This research uses a theory-elaborating multiple case study as the research design (Yin 2014; Ketokivi and Choi 2014). Theory elaboration is appropriate as we use pre-existing conceptual ideas of scepticism in an organisational context (see Williams 1999; Weick, Sutcliffe, and Obstfeld 1999; Owen-Smith 2001) to understand how scepticism is demonstrated in a supply chain context. This approach is in line with what Fisher and Aguinis (2017) call the *vertical contrasting* of theory elaboration, i.e. the use of a theory developed at one level of analysis to explain a phenomenon at another level of analysis.

Case study is chosen as this research is exploratory in nature (Childe 2011; see also Edmondson and McManus 2007). The notion of scepticism is currently underexplored in the extant supply chain management literature; an in-depth description of the phenomenon is required (see Yin 2014). Whilst enabling theory elaboration (Benbasat, Goldstein, and Mead 1987), multiple cases are likely to result in a more generalisable, parsimonious, and robust theory than a single case (Eisenhardt and Graebner 2007). Multiple cases also increase external validity and reduce the possibility of researcher bias (Voss, Tsikriktsis, and Frohlich 2002). Inherent in the nature of qualitative research, generalisability in this multiple case design refers to theoretical or analytical generalisability, emphasising transferability of the findings to other settings and situations (see Carminati 2018; Leung 2015) rather than statistical generalisation (see Yin 2014).

Three blood supply chain (BSC) cases in England, each consisting of one blood centre and four associated hospitals, were investigated in this research. The BSC requires stringent and tightly managed operating conditions. Blood products require temperature-controlled facilities along with storage and transport processes that comply with strict safety and quality regulations. Blood products are transported from donors to patients through a series of continuous and time critical logistical processes. Ultimately, failure to provide safe blood can lead to a patient's death. In emergency conditions such as major haemorrhage, terrorist attacks, or natural disasters, blood safety and availability must not be compromised. Highly resilient operations are required to maintain reliability in the BSC and to save lives across a range of operational conditions. The BSC is therefore an exemplar of resilient supply chain operations (see Morgan et al. 2015).

The BSC cases were selected using a convenience approach (see Aggarwal and Srivastava 2016; Pagell and Krause 1999). Case selection considered size, location, and the blood inventory management practices of the entities (Table 1). This variety ensured validity and rigour whilst reducing bias (see Stanger 2013). The number of blood centres and hospitals selected in each main case concurs with Flyvbjerg (2006), selecting three to four operationally varied cases. Whilst variation such as hospital size potentially has an impact on operational efficiency (see Eakin 1991; Hsing and Bond 1995; Polyzos 2002; Watcharasriroj and Tang 2004), it is not the intention of this research to focus on analysing the impact of this variation on sceptical attitudes or redundancy performance (see Scholten and Schilder 2015; Stanger 2013). Instead, this variation is important to capture a comprehensive view of BSC operations and therefore scepticism amongst BSC actors.

Data collection

Semi-structured interviews were used to collect qualitative data. Interviews were conducted face to face with key informants responsible for ensuring blood safety and availability in blood centres and their associated hospitals. To ensure the validity of the information collected, interviews started with general questions on the role of informants and the extent to which they were involved in managing blood safety and availability in the blood centre or hospital. Subsequently, the informants were asked to describe how they (representing the blood centres or hospitals) ensured blood safety and availability across a range of operational conditions, not only in normal conditions, but also when unexpected conditions occurred such as blood stockouts, blood safety problems, fridge failures, terrorist attacks, or floods in their facilities. They were then asked to describe their interactions in the form of inter-organisational information sharing between the blood centres and hospitals to manage blood safety and availability across the dyad.

We initially targeted 15 informants. This number was determined following our case study design that involved 15 entities, so each is represented by one informant. However, upon further discussion during the interview sessions, our initial informants recommended some additional informants to be interviewed because they have further relevant information that is valuable for the research. Following the recommendation, this snowballing process (Morgan 2008) resulted in total of 29 informants to be interviewed. The informants represent a range of hierarchical levels who are directly involved in managing blood safety and availability both within entities and at the national level, ensuring trustworthiness of the findings. Interviewing informants with multiple roles at multiple hierarchical levels reduces informant bias (Martin and

Eisenhardt 2010). With the informants' consent, the interviews were recorded, the length of recordings varied from 30 minutes to 2.5 hours.

Following the interviews, whenever possible, walkthroughs in the form of blood centre and laboratory tours were conducted to understand the real operations in place to ensure blood safety and availability and supporting documents, artefacts, and/or archives were also collected. This triangulation of data sources increases the accuracy of the data as well as the credibility and robustness of the research (Jick 1979; Martin and Eisenhardt 2010; Rothbauer 2008). Prior to data analysis, the collected data were transcribed verbatim. The transcripts were then sent back to the key informants for validation and to ensure accurate interpretation of any specific terminology mentioned during the interviews. These processes also ensure trustworthiness of the findings (see Nowell et al. 2017).

Table 1. Profile and data description of the selected cases

Cases	Entities	Total hospitals served by the blood centre (BC)	Annual red blood cells issued from blood centres (units)	Additional attributes	Interviewed informants	Walk-throughs	Supporting documents, artefacts, or archives
Strategic views	Central NHSBT	Over 250	-	-	Head of Hospital Customer Service	-	-
					National Lead Patient Blood Management Practitioner Team	-	-
					National Product Manager	-	√
					Assistant Director Governance and Resilience	-	√
BSC-1	BC-1	49	273,286	-	Hospital Services Team Manager	√	√
	SG Hospital	-	>9,700 (very high)	University Teaching Hospital	Lead Transfusion Practitioner, Transfusion Practitioner	√	√
	FP Hospital	-	>6,250 <=9,700 (high)	General Hospital	Lead Transfusion Practitioner, Transfusion practitioner, Biomedical Scientist	√	√
	W Hospital	-	>4,000 <=6,250 (moderate)	General or District General Hospital	Chief Biomedical Scientist the Transfusion Manager	√	√
	WH Hospital	-	>1,000 <=4,000 (low)	District General Hospital	Blood Transfusion Coordinator and Quality Lead, Associate Practitioner, Biomedical Scientist	√	√
BSC-2	BC-2	13	72,186	Partly VMI	Hospital Services Manager	√	√
	JR Hospital	-	>9,700 (very high)	University Teaching Hospital; Fully VMI	Laboratory Manager, Transfusion Practitioner, Project Development Manager	√	√
	WP Hospital	-	>4,000 <=6,250 (moderate)	General or District General Hospital	Transfusion Practitioner, Senior Biomedical Scientist	√	√
	NG Hospital	-	>4,000 <=6,250 (moderate)	General or District General Hospital	Operational Manager Transfusion and Haematology	√	√
	SM Hospital	-	>4,000 <=6,250 (moderate)	General or District General Hospital	Lead Biomedical Scientist	√	√
BSC-3	BC-3	15	66,507	Partly VMI	Hospital Services Manager	-	√
	RB Hospital	-	>4,000 <=6,250 (moderate)	General or District General Hospital; Fully VMI	Transfusion Head Biomedical Scientist and Clinical, Transfusion Services Manager	√	√
	SHG Hospital	-	>9,700 (very high)	University Teaching Hospital	Blood Transfusion Section Manager	√	√
	QA Hospital	-	>6,250 <=9,700 (high)	General Hospital	Blood Transfusion Operations Manager, BMS Section Leader	√	√
	BNH Hospital	-	>1,000 <=4,000 (low)	District General Hospital	Transfusion Operations Manager, Senior Biomedical Scientist	√	√
	-	-	The low – very high scales are based on the Blood Stocks Management Scheme (BSMS) hospital size classification. The BC issues are based on 2016-2017 data.	The hospital type classification is based on data provided by BSMS. VMI: vendor managed inventory	-	-	-

Data analysis

To reveal sceptical attitudes within the BSC, this research investigates the 'interactions' (Owen-Smith 2001) between blood centres and their associated hospitals, which are manifested in the information sharing processes (see Simon 1959; March and Simon 1958; Nelson and Winter 1983; Weick 1995) used to manage blood safety and availability across the dyad, identified through interviews and other supporting data. Coding and analysis of the qualitative data were conducted using template analysis, a method of thematic analysis of textual data that allows flexibility in coding structure.

Tentative *a priori* themes (i.e. *questioning* and *cross checking*) were first defined based on the seminal works of Williams (1999), Owen-Smith (2001), and Weick, Sutcliffe, and Obstfeld (1999), followed by an iterative process of applying, modifying, and re-applying the initial template (King 2012). First-order coding identified any excerpts from the transcripts indicating *doubts* (Williams 1999; Weick, Sutcliffe, and Obstfeld 1999; Owen-Smith 2001) in managing blood safety and availability across the dyad. To ensure trustworthiness and to minimise bias, *in vivo* technique was applied at this stage by using words or phrases taken from the original excerpts (King 2008). Second-order coding classified the initial codes into categories based on the pre-defined *a priori* themes. Excerpts that did not meet these categories were coded under new themes. For example, there were many excerpts indicating that blood centres not only question inappropriate blood orders but ask for evidence or defer their judgement to people with more expertise. As such, instead of coding the excerpts simply as "*questioning*", we treated them as an emerging theme of "*warranting*".

Inspired by a process-based approach to theory elaboration (see Pratt, Rockmann, and Kaufmann 2006; Petriglieri, Ashford, and Wrzesniewski 2019), we then

identified the mechanisms by which the emerging acts of scepticism help maintain SC resilience through the two key SC strategy dimensions, robustness (i.e. failure avoidance and resistance) and agility (e.g. responsiveness) – see Mackay, Munoz, and Pepper (2020), Durach, Wieland, and Machuca (2015), and Wieland and Wallenburg (2012, 2013). To ensure rigour, the first researcher performed the coding process, which was then doubled checked by and agreed with the second researcher. Table 2 provides the overview of the coded data structure.

The data were then structured and analysed using within-case and cross-case analysis to seek for replication of sceptical attitudes across the three cases. We ensured that our findings identified common patterns in at least two out of the three BSC cases investigated to be considered valid. As such, the cases were treated as a series of experiments. Each case served to confirm or disprove the interpretations drawn from the previous cases, ensuring the robustness and rigour of the research. This process for conducting case study data analysis was adapted from Bourgeois and Eisenhardt (1988) and Martin and Eisenhardt (2010), who provide clear practical guidance on the notion of replication logic in multiple-case research. Coding and data analysis were supported by NVivo 11 Plus software.

Findings

Blood centres in England are centrally managed by National Health Service Blood and Transplant (NHSBT), a single national organisation that manages the complete blood supply chain from donors to hospitals. Consequently, interactions not only occur between blood centres and their associated hospitals, but also between Central NHSBT and all hospitals. For example, blood centres often provide advice on blood stock management, quality, and/or incident-related issues to their associated hospitals. In addition, Central NHSBT frequently shares information on general blood safety and

availability issues with all hospitals across the country. Similarly, hospitals not only share order and complaint information with their associated blood centres, but also share information such as blood stock levels, usage, wastage, and safety incidents with Central NHSBT via national reporting systems.

The data collected in our study shows that BSC actors share a large amount of information covering many aspects of the BSC (e.g. inventory management, supply, delivery, changes in operations, blood safety incidents). To do this, they use a wide variety of different information sharing media ranging from conventional (e.g. telephone, email, face-to-face meeting) to more advanced information sharing systems (e.g. online blood ordering system (OBOS), web-based stock levels, usage, wastage, and safety incident reporting systems). This indicates a rich and flexible range of interactions between BSC actors.

Our investigation focusses on these interactions and the processes on which they are based. By analysing these interactions across our cases, we identify three key elements of scepticism that help BSC actors maintain redundancy and therefore resilient operations, namely *information duplication, warranting,* and *cross-evaluation*. The mechanisms by which these elements help to achieve SC resilience are summarised in Table 2. We link the scepticism elements to SC resilience elements and dimensions based on the extant literature, following Mackay, Munoz, and Pepper (2020), Durach, Wieland, and Machuca (2015), and Wieland and Wallenburg (2012, 2013). For example, information duplication (e.g. sending the same information through different information sharing media), warranting (e.g. questioning the validity of orders), and cross-evaluation (e.g. stock holding review) were conducted by blood centres and hospitals prior to potentially disruptive events that could have significant negative impacts on the BSC operations. This phenomenon represents proactive resilience

strategies (Mackay, Munoz, and Pepper 2020). When enacted, the scepticism elements could empower hospitals to be involved in the BSC planning, to build resilience strategies, be aware of and question unusual events, pause actions, thus minimising the potential impact of future BSC disruptions. We classify these mechanisms as failure avoidance (Durach, Wieland, and Machuca 2015; Wieland and Wallenburg 2012, 2013) that could help the BSC maintain robustness, a critical dimension of SC resilience (Durach, Wieland, and Machuca 2015; Wieland and Wallenburg 2012, 2013).

Information duplication, warranting (e.g. asking for written evidence on the discarded recalled units), and cross-evaluation (e.g. checking and understanding hospitals' conditions) were also embraced by blood centres and hospitals in response to disruptions, representing reactive resilience strategies (Mackay, Munoz, and Pepper 2020). The enacted scepticism elements could help them respond quickly to blood safety and availability issues and avoid BSC failure from worsening. We classify these mechanisms as assured responsiveness and failure avoidance, which are the manifestations of BSC agility and robustness respectively (Mackay, Munoz, and Pepper 2020; Durach, Wieland, and Machuca 2015; Wieland and Wallenburg 2012, 2013). These two are important dimensions of SC resilience (Durach, Wieland, and Machuca 2015; Wieland and Wallenburg 2012, 2013).

Table 2. Scepticism and supply chain resilience

SC resilience strategies	Scepticism-related excerpts (first-order coding)	Scepticism elements (second-order coding)	Mechanisms	SC resilience elements	SC resilience dimensions
Proactive	‘Receiving hospitals were consulted, and an engagement plan created […] Various channels of communication were developed including: planning questionnaires provided to all hospitals involved, telephone and face-to-face meetings with laboratory leads and a dedicated web-based question and answer portal.’	Information duplication	‘These techniques empowered individual hospitals to participate fully in the planning process and build comprehensive operational and resilience strategies.’	Failure avoidance	Robustness
			‘[…] to communicate and agree on how NHSBT and hospitals would operate together during the [Olympic] games to deliver timely and sufficient supplies […] the key actions agreed to minimise the potential impact of operational and logistical challenges during the games.’		
Reactive	‘[…] “We think there is a problem with this unit number”, that will be a telephone conversation initially and the same back to us if they know there is a problem they will phone first and say “unit number, whatever”, you need to do a recall and they will send us the fax written copy as well. So we’ve got not just the verbal. […] So we get both the verbal and the written coming through afterwards.’	Information duplication	‘[…] cause you know you can’t quite often hear when somebody says something to you over the phone, there can be an error in what somebody hears to what somebody said. So a “g”, they think it’s a “t” or what happened.’	Failure avoidance	Robustness
			‘There is a written, but it is via email or fax and also by telephone conversation if we want advice or we want to alert them quickly.’	Assured responsiveness	Agility
Reactive	‘And then in the emergency situations, we still use OBOS, but we also follow that up with the phone call to NHSBT, to our issue department directly, hospital services I believe they are called now.’	Information duplication	‘We ring them directly because you know we are aware, certainly overnight, there might only be one person, one member of staff. They are maybe in a fridge somewhere stocking up. They may not notice the order coming through on OBOS.’	Failure avoidance	Robustness
			‘So we always follow up for emergencies with the phone call.’	Assured responsiveness	Agility
Reactive	‘[…] if it’s really really urgent, we might have to order some by picking up the phone and ordering on OBOS.’	Information duplication	‘Because it [ITS] won’t be that quick if it’s really really an emergency. So if it’s a massive, a major incident for example, then part of our action is to	Failure avoidance;	Robustness; agility

SC resilience strategies	Scepticism-related excerpts (first-order coding)	Scepticism elements (second-order coding)	Mechanisms	SC resilience elements	SC resilience dimensions
			ring the NBS [blood centre], say we are in a major incident. And they'll automatically give us some boxes of blood that they would send to us. So, ya, that wouldn't be dealt with via ITS [VMI]. I mean ITS is working all the time. But because it's only a snapshot every half hour, an hour, that's not quick enough if you've got a major incident going on, you need to get your stock much quicker, so we'd need to ring and use OBOS, we call them.'	assured responsiveness	
Proactive	'So we wouldn't say to the hospital that you need this instead of this. But we might advise. If we notice that something is out of the ordinary that they have ordered, we might question and say "did you want to speak with the clinician?"'	Warranting	'[…] and we might question it and if they order really out of ordinary [related to blood safety issue].'	Failure avoidance	Robustness
	'We wouldn't necessarily order more blood stock until we know the emergency.'	Warranting	'So we would actually pause stuff in as we get to get feedback, we would then update the National Blood Service as to what particular stock we may need.'	Failure avoidance	Robustness
Reactive	'[…] we'd have written evidence that they discarded that [recalled] unit.'	Warranting	'[…] this one it asks us for the fate of that incident. So, they have to put the outcome. So, again from a safety point of view and we have to trust them if they've sent us back and said "discarded".'	Assured responsiveness	Agility
Reactive	'[…] that BSMS helps a lot in giving us accountability. […] It's those things that make you share the information, keep you in check.'	Cross-evaluation	'So, you don't want to be wasting it. [...] So when you have those transparency figures and you can see how much you are wasting and when we have summary reports like [the NHSBT administrator sends] us.'	Failure avoidance	Robustness
Reactive	'But, if you suddenly have an incident in a trust, somebody dies, it really wakes everybody up. And it's those stories and those lessons that	Cross-evaluation	'So, when something goes wrong, everyone suddenly goes, "oh my god that could have been me", you know. When everything, the thing about transfusion it is actually really safe, as much as I	Failure avoidance	Robustness

SC resilience strategies	Scepticism-related excerpts (first-order coding)	Scepticism elements (second-order coding)	Mechanisms	SC resilience elements	SC resilience dimensions
	you've learned, that are the best way of sharing that back [to hospitals], really.'		go on about it, it is very safe compared to a lot of other things that happen to patients. So, people will become quite complacent because you can give transfusions for 20 years and never see a reaction and never have a problem and you become like "ya another transfusion, whatever" so you become really complacent about the checks that you should do. And you think "ah the blood's safe, there is no point in doing this observation, it's fine".'		
Proactive	'So obviously they monitor things nationally. […] And they also request our help and they offer, you know, suggestions for alternatives and ways that we could help review our, they ask us to review our stock holding, are we able to reduce at all.'	Cross-evaluation	'We would get email and fax notification when stocks were getting low. […] And when they are getting low on a particular, it's usually a particular group of a particular product, then we'll get notified.'	Failure avoidance	Robustness
Reactive	'So we had that conversation on a one to one level with about 30 hospitals that morning to explain, try to understand, explain to them what's happening and to understand what issues they would have.'	Cross-evaluation	'They rang them all up and they sort of said, "look you know we've got this big problem, we just sent you a communication, a standard communication that we're struggling, but we've got this problem. You know, how are you in terms of stocks, what's going on this morning, have you got any you know foreseen, do you think you're gonna need platelets quickly, have you got, you know anything?"'	Failure avoidance; assured responsiveness	Robustness; agility

Information duplication

Our findings suggest that to maintain SC resilience, redundant information is shared between blood centres and their associated hospitals, showing BSC actors' reluctance to rely only on one means of interaction. We label this notion *information duplication*. Whilst the idea of using multiple resources (i.e. multiple information sharing media) reflects physical redundancy (see Hohenstein et al. 2015; Ali and Gölgeci 2019), the fact that identical information is shared more than once demonstrates the doubt that defines scepticism (see Weick, Sutcliffe, and Obstfeld 1999; Williams 1999; Owen-Smith 2001). We argue that information duplication is a result of scepticism because we find evidence from our data showing keywords, such as "consult", "can't quite", "can be an error", "be assured", "might only be", "maybe", "may not notice", etc. which indicate doubts and the need to have backups just in case.

For example, to ensure hospital awareness and to improve blood safety, NHSBT shares blood management updates related to the Hepatitis C Virus status of blood components with hospitals (whether the blood components are contaminated by the virus), both verbally through the regional transfusion committee meetings and electronically via email. Additionally, in preparation for the London 2012 Olympic Games, NHSBT shared information using a variety of information sharing media. This duplication ensured blood availability, strengthening SC robustness and thus maintaining resilience throughout the major event. As the following quote explains:

> Receiving hospitals were consulted, and an engagement plan created, to communicate and agree on how NHSBT and hospitals would operate together during the [Olympic] games to deliver timely and sufficient supplies. Various channels of communication were developed including: planning questionnaires provided to all hospitals involved, telephone and face-to-face meetings with

> laboratory leads and a dedicated web-based question and answer portal. (Glasgow et al. 2014, 5)

Information duplication is also identified when a combination of telephone and fax is used to share information on a product recall. Whilst ensuring that BSC actors are immediately aware of the product recall, the use of combined verbal (telephone) and written (fax) media ensures that no mistakes are made in sharing information which could lead to blood safety incidents. Whilst avoiding failure, this duplication also ensures that responses are both quick and appropriate, enacting SC robustness and agility and thus maintaining the resilience of the product recall process. As the Blood Transfusion Section Manager at the SHG Hospital describes:

> There is a written [communication] but it is via email or fax and also by telephone conversation if we want advice or we want to alert them quickly. […] So we've got not just the verbal, because you know you can't quite often hear somebody says something to you over the phone, there can be an error in what somebody hears to what somebody said. So a 'g', they think it's a 't' or what happened. *Blood Transfusion Section Manager SHG Hospital BSC-3*

The Head of Hospital Customer Service at NHSBT emphasises a similar point:

> It might be they would be phoned and sent a written instruction you know by an email so they'd have double communication because you've got to be assured of a response. *Head of Hospital Customer Service NHSBT*

During emergency conditions, hospitals use the telephone in addition to the online ordering systems (OBOS) to share urgent order information. The use of redundant information sharing media is crucial to both confirm the order and to ensure that blood centre staff act immediately. This is particularly pertinent as emergency conditions often occur during the night, when the number of staff processing orders in

blood centres is reduced and staff are more likely to be occupied with other tasks. As an Operational Manager for Transfusion and Haematology at the NG Hospital describes:

> We ring them directly because you know we are aware certainly overnight, there might only be one person, one member of staff. They are maybe in a fridge somewhere stocking up. They may not notice the order coming through on OBOS. So we always follow up for emergencies with a phone call. *Operational Manager Transfusion and Haematology NG Hospital BSC-2*

Hospitals also use redundant information sharing media to speed up ordering and delivery processes. Sophisticated systems such as vendor managed inventory (VMI) are often not quick or flexible enough to respond appropriately to emergency blood orders. Transfusion Head Biomedical Scientist and Clinical Transfusion Services Manager at RB Hospital emphasises:

> We might have to if it's really really urgent, we might have to order some by picking up the phone and ordering on OBOS, so. Because it [the VMI information system] won't be that quick if it's really really emergency. So if it's a massive, a major incident for example. *Transfusion Head Biomedical Scientist and Clinical Transfusion Services Manager RB Hospital BSC-3*

These findings show that information duplication is used to avoid failure of critical blood supply whilst ensuring quick and appropriate responses to critical situations. Such mechanisms support both the robustness and agility dimensions of SC resilience.

Warranting

This research also finds that BSC actors develop scepticism through *warranting* behaviour. Warranting involves not only *questioning* (Williams 1999; Owen-Smith 2001; Weick, Sutcliffe, and Obstfeld 1999) but also seeking justification to challenge the appropriateness of the actions proposed by BSC actors. Warranting reflects the fact

that BSC actors do not automatically trust each other, thus avoiding assumption-based decision making. For example, to ensure that suitable, safe blood products are provided for patients, the Blood Centre Hospital Services Manager at BC-2 will question orders from their associated hospitals if the manager thinks that they are inappropriate or out of the ordinary. This avoids potentially harmful transfusions, maintaining SC robustness as a proactive strategy in achieving BSC resilience. As the manager suggests:

> If we notice that something is out of the ordinary that they have ordered, we might question and say 'did you want to speak with the clinician?'. *Hospital Services Manager BC-2 BSC-2*

Warranting is also demonstrated by blood centres when they do not fulfil unspecified requests for fresh blood from the hospitals. This is to ensure that fresh blood is only requested for justifiable clinical purposes. Unnecessary requests for fresh blood potentially lead to overstocking of short-dated blood in blood centres, which in turn is likely to be wasted. Such failures need to be avoided to maintain SC robustness and therefore SC resilience.

During emergency conditions, hospitals immediately share information with their associated blood centre, to let them know that a major incident has been declared. However, reflecting the act of warranting, hospitals will not share order information until they know the nature of the emergency. This ensures that they provide accurate information and only order what is necessary, avoiding unnecessary overstocks and thus maintaining SC robustness and agility at the same time. As the Transfusion Practitioner at the SG Hospital suggests:

> We wouldn't necessarily order more blood stock until we know the emergency. So we would actually pause stuff in as we get to get feedback, we would then update the National Blood Service as to what particular stock we may need. *Transfusion Practitioner SG Hospital BSC-1*

Further demonstrating warranting, blood centres share information to ask hospitals to confirm whether a recalled product has been transfused and to understand whether the transfused patient has experienced adverse effects, before taking further action. When an unsafe blood product is recalled, blood centres do not assume that hospitals will respond appropriately and require written evidence of the hospitals' actions to be shared with them. Whilst reflecting failure avoidance and thus SC robustness (i.e. avoiding the use of unsafe recalled blood), this sceptical behaviour also represents the agility of the BSC actors to maintain their resilience. As the Blood Centre Hospital Services Team Manager at BC-1 describes:

> So, again from a safety point of view and we have to trust them if they've sent us back and said 'discarded', then we have to assume they've thrown it away.
> *Hospital Services Team Manager BC-1 BSC-1*

Failure to warrant routine behaviour can lead to unwanted consequences, such as overstocks, which create inefficiency in the BSC. For example, due to an issue in internal operations, a hospital in BSC-1 placed an unnecessary duplicate order with the blood centre to cover their stocks during the Christmas holiday. This unnecessary order went undetected by the blood centre which subsequently delivered a very large amount of blood, creating an overstock in the hospital's blood bank and subsequent wastage. As a Transfusion Practitioner at SG Hospital describes:

> So blood was ordered for the following mid-day delivery. But there was an internal breakdown so then we had another person place an identical order for red cells and we ended up with an overstock of red cells. And you could argue that the National Blood Service [NHSBT blood centre] could have queried the fact that there was too large an order for the same delivery, but they didn't. They just delivered it in good faith and we ended up with blood so we didn't need to order in blood for 7 or 8 days after that due to that [over]stocking.' *Transfusion Practitioner SG Hospital BSC-1*

Cross-evaluation

BSC actors also maintain their scepticism by conducting what we label as *cross-evaluation* to improve blood safety and availability and to avoid mindless operations. They not only cross check (Weick, Sutcliffe, and Obstfeld 1999) whether activities are running well, but they attempt to evaluate and learn from other BSC actors to avoid failure in the future, thus maintaining SC robustness which leads to SC resilience. Our data suggest that, although the output of cross-evaluation is the future failure avoidance, it happens after a certain event has occurred, so that we categorise it within the reactive redundancy strategy. The act of cross-evaluation is demonstrated when NHSBT hospital services are evaluated. This action is conducted at the transfusion practitioner regional meeting on a quarterly basis. Important information on key performance indicators is shared to evaluate potential improvements to blood safety and availability across the BSC.

Another way to ensure cross-evaluation is through two-way information sharing of blood wastage data between the hospitals and Central NHSBT via the Blood Stocks Management Scheme (BSMS). This practice provides accountability, motivating hospitals to prevent unnecessary wastage in their facilities. As the following excerpt suggests:

> Somebody sees [the records] there, their [reporting] time you know. So, you don't want to be wasting it. You want to utilise it as best as you can. So, that BSMS helps a lot in giving us accountability. So when you have those transparency figures and you can see how much you are wasting and when we have summary reports like [the NHSBT administrator sends] us. It's those things that make you share the information, keep you in check I think. *Blood Transfusion Operations Manager QA Hospital BSC-3*

The act of cross-evaluation is also manifested when NHSBT shares lessons learnt about blood safety incidents in order to reduce complacency about the safety of blood transfusion, leading to potential improvements in blood safety in the hospitals. As a member of the National Lead Patient Blood Management Practitioner Team at NHSBT emphasises:

> So, people will become quite complacent because you can give transfusions for 20 years and never see a reaction and never have a problem and you become like 'ya another transfusion, whatever' so you become really complacent about the checks that you should do. And you think 'ah the blood's safe, there is no point in doing this observation, it's fine'. But, if you suddenly have an incident in a Trust, somebody dies, it really wakes everybody up. And it's those stories and those lessons that you've learned, that are the best way of sharing that back [to hospitals], really. *National Lead Patient Blood Management Practitioner Team NHSBT*

Finally, cross-evaluation is demonstrated when information is shared by blood centres to advise hospitals of possible alternatives, in cases where the ordered product is out of stock. Whilst sharing blood shortage information, blood centres also ask the hospitals to review their own stock levels to see whether they can reduce their order to help ameliorate the regional or national situation. Whilst showing robustness through failure avoidance, this cross-evaluation mechanism also demonstrates the responsiveness of the blood centres to tackle emerging blood supply issues, displaying BSC agility and therefore resilience. As an Operational Manager Transfusion and Haematology at the NG Hospital suggests:

> We would get email and fax notification when stocks were getting low. So obviously they monitor things nationally. And when they are getting low of a particular, it's usually a particular group of a particular product, then we'll get notified. And they also request our help and they offer you know suggestions for alternative and ways that we could help review our, they ask us to review our stock

> holding, are we able to reduce at all. *Operational Manager Transfusion and Haematology NG Hospital BSC-2*

Similarly, during unexpected and disruptive events, such as a flood at the major manufacturing centre at Filton, NHBST shared information with the immediately affected hospitals, explaining the event, and checking their stock conditions to understand their needs. Thus, demonstrating agility under emergency conditions, a critical element of SC resilience. As described by a member of the National Lead Patient Blood Management Practitioner Team at NHSBT:

> They [emergency team] rang them [affected hospitals] all up and they sort of said, 'look you know we've got this big problem, we just sent you a communication, a standard communication that we're struggling, but we've got this problem. You know, how are you in terms of stocks, what's going on this morning, have you got any you know foreseen, do you think you're gonna need platelets quickly, have you got, you know anything?'. So we had that conversation on a one to one level with about 30 hospitals that morning to explain, try to understand, explain to them what's happening and to understand what issues they would have. *National Lead Patient Blood Management Practitioner Team NHSBT*

In summary, this research reveals three key elements of scepticism demonstrated through the interactions between blood centres and their associated hospitals in the dyadic BSC. These elements reflect how the BSC actors demonstrate non-physical forms of redundancy that are crucial in maintaining blood safety and availability across a range of operational conditions. We argue that scepticism can lead to SC robustness and agility, two critical elements of SC resilience. It is not only a preventive approach to avoid errors or disruptions in normal conditions, but it is also used to guide mindful and appropriate responses in the event of incidents and emergencies. The following section discusses the findings.

Discussion

This research contributes to the literature on SC resilience by providing "enlightenment" (DiMaggio 1995) and a "revelatory insight" (Corley and Gioia 2011) into the role of scepticism as a novel element of SC redundancy that enhances SC resilience. We refine the initial theoretical framework (Figure 1) by proposing a relationship between scepticism and failure avoidance as an important element of SC robustness and therefore resilience (see Figure 2). The refined framework also specifies that scepticism could lead to assured and appropriate responses, increasing SC agility and therefore resilience.

At the level of the single organisation, Weick, Sutcliffe, and Obstfeld (1999) argue that scepticism is a key tenet of collective mindfulness, a dynamic social process that reflects the shared behaviours of the members of the organisation to continuously communicate, interact, and capture details about emerging disruptions (Vogus and Sutcliffe 2012). This process minimises errors and enables the members of the organisation to demonstrate similar behaviours, thus achieving resilient performance (Weick and Sutcliffe 2007; Vogus and Sutcliffe 2012). Using the UK BSC, our study reveals that scepticism at the supply chain level goes beyond the acts of *questioning* and *cross checking* which are observed at the level of a single organisation (see Williams 1999; Owen-Smith 2001; Weick, Sutcliffe, and Obstfeld 1999).

In the BSC, questioning is supported by evidence and cross checking is deepened, incorporating information duplication and evaluation to ensure continuous improvement and appropriate situational assessment. One plausible explanation for this is that, unlike a single organisation, supply chain management involves inter-organisational actions, implying that "the system becomes more complex and harder to comprehend" (Weick, Sutcliffe, and Obstfeld 1999, 57; Surana et al. 2005). In such

environments, supply chain actors are highly interdependent, with errors affecting the whole supply chain operation (Surana et al. 2005). This applies to the BSC, where actions need to be mindfully executed, avoiding misinterpretation and errors that could lead to fatal consequences. In this context, scepticism provides a way to achieve coherent collective behaviour (see Surana et al. 2005). It creates knowledge redundancy, ensuring that all supply chain actors possess sufficient knowledge to function together (Silvakumar and Roy 2004). In the context of the UK BSC, scepticism helps the BSC actors to work together to achieve the collective goal of maintaining blood safety and availability across a range of operational conditions. This leads to our first proposition:

P1. Scepticism, as an element of redundancy, is demonstrated differently at the supply chain compared to the organisational level.

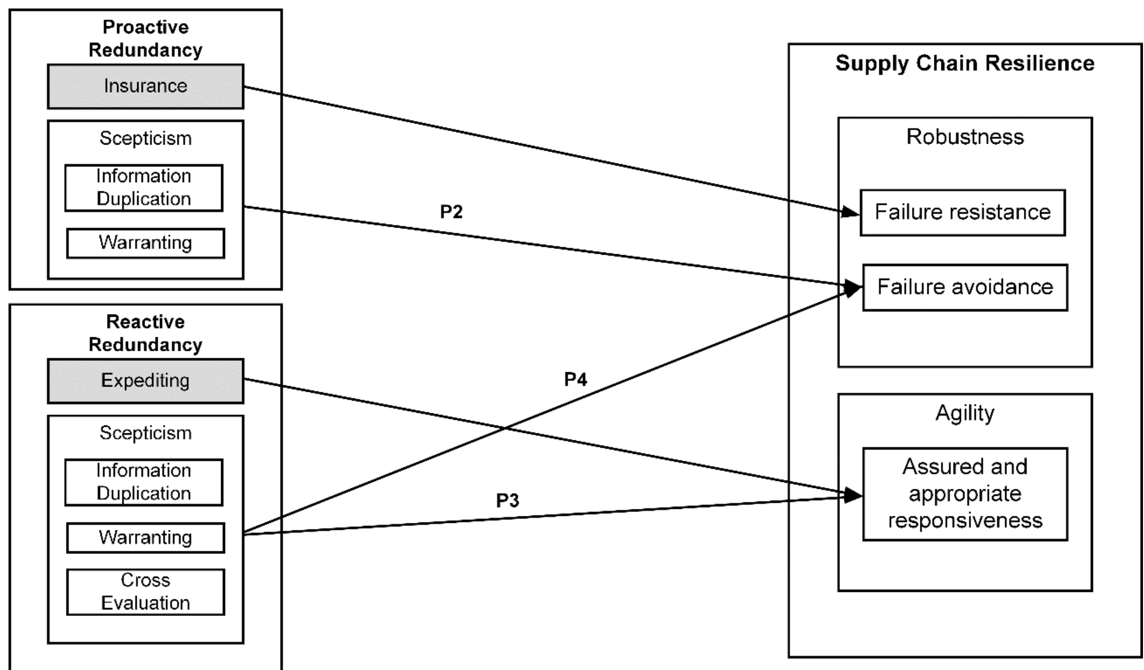

Figure 2. A refined theoretical framework of SC redundancy with scepticism

The extant literature has emphasised the importance of proactive physical redundancy (e.g. buffer/safety stock) as an insurance, enabling a SC to be resistant to

disruption and therefore maintaining SC robustness as a key dimension of SC resilience (Figure 1). We define failure resistance in accordance with Durach, Wieland, and Machuca (2015), referring to the ability of a supply chain to withstand disruptions. In other words, when disruptions happen, despite being affected, the supply chain operations remain undamaged. In the UK BSC, such proactive physical redundancy was manifested when NHSBT built up stock in preparation for the London 2012 Olympic Games. It is also demonstrated in their policy of having a minimum of three days national stock cover, ensuring supply when unexpected events occur (Lusiantoro 2014).

Durach, Wieland, and Machuca (2015) and Wieland and Wallenburg (2012, 2013), however, suggest that robustness is not only about failure resistance, but also failure avoidance and that no physical forms of redundancy are currently advocated to support this mechanism. In line with Durach, Wieland, and Machuca (2015), we define failure avoidance as the ability of a supply chain to take measures to prevent disruptions and not to be affected by them. In the BSC context, our research contributes by proposing scepticism (i.e. information duplication and warranting) as a novel approach to failure avoidance (Figure 2). We argue that it can be added as a non-physical form of redundancy to complement the physical redundancy mechanisms. This leads to our second proposition:

P2. SC actors' sceptical behaviour has a positive impact on their ability to avoid failure, strengthening SC robustness and therefore maintaining SC resilience.

The extant literature also posits that reactive physical redundancy in the form of expediting resources is required to respond to disruptions, enacting SC agility and therefore SC resilience (Figure 1). In the UK BSC, resources are expedited when emergency orders from hospitals are immediately fulfilled, demonstrating the agility of

the BSC to respond to disruptive events. However, our understanding of agility in general has been limited to the speed of response, assuming that responses are executed and neglecting the fact that they could be inappropriate (see Mackay, Munoz, and Pepper 2020; Wieland and Wallenburg, 2013). Our findings reveal that scepticism in the forms of information duplication, warranting, and cross-evaluation, enhances our understanding of agility as they not only help avoid failure, but facilitate assured and appropriate responsiveness (Figure 2). This leads to our third proposition:

P3. SC actors' sceptical behaviour has a positive impact on their ability to respond quickly, confidently, and appropriately to disruptions, strengthening SC agility and therefore maintaining SC resilience.

Interestingly, we find that whilst being responsive to disruptions, BSC actors also attempt to avoid further failure in their systems through information duplication and cross-evaluation. The way NHSBT handled the impact of the national blood shortage as well as Filton manufacturing centre flooding on the BSC operations exemplify this interesting phenomenon. In other words, by being sceptical, the BSC actors strive to "contain" the impact of the disruptions from worsening (see Weick, Sutcliffe, and Obstfeld 1999; Weick and Sutcliffe 2007, 2015), maintaining robustness and therefore resilience to enable them to continue their BSC operations. This leads to our fourth and final proposition:

P4. SC actors' sceptical behaviour prevents failure from worsening, maintaining SC robustness and therefore SC resilience.

Managerial implications

Organisations within SCs facing uncertainty are often unclear as to the appropriate reaction to emerging problems. Therefore, adding physical resources as a redundancy

mechanism is a common response (Sagan 2004). Our findings show that scepticism offers an alternative to physical redundancy mechanisms in such circumstances. Deploying physical redundancy systems is often expensive and as such SC actors may be hesitant to waste their resources on systems which may not be necessary or may fail anyway. Scepticism offers an alternative to help avoid and mitigate these costly failures.

This research suggests that SC practitioners should pay a close attention to human behaviour by fostering sceptical attitudes to avoid failure in SC operations. For example, SC practitioners should be trained not to rely too much on buffer stock. Overreliance on buffer stock could lead to even higher buffer stock ending up being wasted. This phenomenon reflects what Sagan (2004) calls as "overcompensation". Organisations within the SC should therefore impose a policy to avoid this overcompensation. Maximum buffer stock could be determined, whilst frontliners could be trained to better understand product knowledge, so that cross evaluation could be implemented before ordering products for replenishment. Organisations within the SC could also establish an inventory control procedure where double checking by more than one person is required to ensure that certain orders are warranted.

Moreover, organisations within the SC should also avoid overreliance on SC technologies as physical forms of redundancy. This argument is in line with McKinsey's (2019) evaluation that neglecting the role of human nature in SC management and focussing too much attention on technology-generated solutions with limited human intervention could lead to failure of SC operations. Whilst technology is supposed to help human finish their tasks effectively and efficiently, they could create a "social shirking" phenomenon (Sagan 2004), in which SC actors could become complacent with the presence and sophistication of technologies, neglecting their important duty as system checkers. To avoid social shirking, organisations could impose

a policy that encourages human interventions for certain decisions that are difficult to automate by technologies. SC practitioners should be trained on how to diagnose the health of systems and technologies within organisations and how to respond to their failures.

To illustrate, hospitals which rely exclusively on the online blood ordering system (OBOS) at night could see failures in the delivery of emergency orders. Overreliance on OBOS creates social shirking, where hospitals believe that blood centre staff working overnight have seen and responded to orders sent through OBOS, so they do not need to double check. These actions lead to reduced robustness and therefore SC resilience. Hospital transfusion practitioners or blood stock managers who adopt scepticism in their ordering practices, not relying exclusively on technology-based systems, are more likely to successfully receive emergency orders and run robust and resilient operations overall. In addition to ordering via OBOS, the emergency orders are confirmed via telephone to ensure that they are prioritised and quickly sent to hospitals. These mechanisms also ensure that transfusion practitioners and staff working with the blood stock and ordering stay vigilant to avoid any failures in the system.

Whilst relying too much on technologies could lead to SC failure, it does not mean that technologies are bad for scepticism. Technologies based on a mistake-proofing technique such as Poka-Yoke (Chase and Stewart 1994) could support scepticism and be applied by SC actors to avoid inadvertent errors and therefore failure in SC operations. For example, a pop-up message could appear before orders are being processed by an online system to remind staffs to double check and to provide evidence to justify unusual orders. After the orders have been placed, a notification message could pop-up and be sent via email. The message could also remind staffs to use

telephone if they do not hear from the supplier within a certain time window, particularly in the case of emergency.

Finally, scepticism should be part of culture within the resilience and reliability seeking SCs. Information sharing becomes a critical enabler of scepticism, whereas SC actors' involvement and commitment are keys to develop the culture. Whilst there are abundant studies on information sharing within the extant SCM literature, in practice the willingness to share information could vary between organisations involved in SCs. Consensus between SC actors is therefore required to develop informed culture and therefore ensure SC wide application of scepticism.

Conclusions

To the best of our knowledge, this is the first paper to address the notion of scepticism within the SC resilience literature. This research reveals three key elements of scepticism demonstrated through the interactions between blood centres and their associated hospitals in the dyadic BSC, namely information duplication, warranting, and cross-evaluation. These elements reflect how BSC actors demonstrate the use of non-physical forms of redundancy that are crucial to maintain blood safety and availability across a range of operational conditions. We find that scepticism is not only demonstrated as a preventive mechanism to avoid errors or disruptions, but it could also be used to guide appropriate responses in the event of incidents and emergencies across the BSC. As such, we argue that scepticism is a novel approach to maintain SC resilience.

We contribute to the SC resilience literature by providing insight and enlightenment on scepticism as an additional element of SC redundancy that enhances SC resilience, extending its applicability from the organisational to the supply chain level. We contribute further by refining the initial theoretical framework of SC

redundancy, based entirely on physical forms of redundancy, to incorporate the notion of scepticism as a non-physical form of redundancy. In doing this, we develop a set of propositions which propose that employing scepticism enhances a supply chain's ability to avoid failures and assures appropriate responses to disruptions. This enhances both SC robustness and agility, two key dimensions of SC resilience. This has not been attempted by previous SC resilience researchers. Finally, we contribute practically by reminding SC practitioners of the danger of oversimplification of business processes (i.e. making assumptions without checking) and overreliance on the existing system, including technologies. We emphasise on appropriate human behaviours and actions as essential aspects of SC operations.

Our research has several limitations that could be treated as opportunities to further this research area. First, the nature of the case study method is such that statistical generalisation is not possible. However, with care, the results of this research could be applied in the healthcare context or other contexts with similar characteristics, such as those which handle perishable and scarce resources. Second, our research focusses on the unique phenomenon of the BSC in England. Inherent in this context is the requirement to operate under stringent regulatory and operational conditions in delivering blood as a critical product for human life. Whilst we do not specifically examine the impacts of these stringent regulations and product criticality on the acts of scepticism within the BSC, we leave this area as a potential avenue for future research.

Third, we limit our analysis to the dyadic supply chain level. Whilst the essential elements of scepticism have been revealed in this research, future research could extend our work by studying how scepticism is developed across the supply chain network and whether different elements of scepticism could emerge from the larger unit of analysis. Future research could use surveys to confirm our findings and provide statistical

generalisation of this phenomenon to a wider range of contexts. Agent-based modelling could also be used to understand how SC actors' scepticism affects SC performance within certain simulated conditions. In addition, experiments could be conducted to establish causal relationships between scepticism and SC performance.

Finally, future research could examine a potential conflict between lean or efficient approaches to SC management (e.g. eliminating wastes, reducing inspections, just in time or zero inventory) and our proposal to incorporate scepticism as an additional non-physical element of system redundancy. Whilst ensuring system reliability and therefore resilience, enacting scepticism in an operation may incur additional costs (e.g. additional training, creating more adaptive procedures, etc.). We therefore call for future research to assess the trade-off between reliability and efficiency-based approaches to SC management, the role of physical and non-physical redundancy in it, and the inherent cost implications of the different approaches. It is also interesting to explore the impacts of digital technologies on scepticism and therefore SC performance in the future.

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