The anchoring heuristic and overconfidence bias among frontline employees in supply chain organisations

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Abstract

The purpose of this study is to assess the extent to which the anchoring heuristic and overconfidence bias can lead to inaccurate judgments in operational settings among frontline employees of complex multi-stakeholder supply chain organisations. Data is obtained from an experiment-based questionnaire of frontline employees in a United Kingdom based freight forward and materials handling company. Analysis is undertaken using descriptive and inferential statistics. Results suggest that frontline employees within this complex multi-stakeholder supply chain organisation consistently overestimate probabilities when framed in a conjunctive manner. They also consistently underestimate probabilities when framed in a disjunctive manner and exhibit considerable overconfidence in their judgements. Mixed evidence was found regarding susceptibility to anchoring and overconfidence in terms of level of expertise and geographical location. Overall, the study elucidates the specific dimensions of anchoring and overconfidence that may lead to judgmental biases in complex multi-stakeholder supply chain decisions. The findings highlight the critical role of communication in establishing reflective monitoring of, and improvements to, heuristics usage by frontline employees involved in daily supply chain decisions. It also suggests that practitioners should be encouraged to reflect on *whether*, *when* and *how* anchoring and overconfidence should be employed as key judgmental aids in statistical estimations.

1. Introduction

1.1 Frontline employees

Supply chains have become more global in nature over the last few years, leading to their increased vulnerability to disruption (Scheibe and Blackhurst 2018; Pettit et al. 2019). Under such circumstances, the literature posits that the success of complex multi-stakeholder supply chains is increasingly dependent upon how firms sense and respond to customer needs, especially when those needs are either unanticipated or unplanned (Jeng 2018). One of the means by which complex multi-stakeholder organisations seek to be responsive to customer needs is through employee participation in decision-making (Kitapci and Sezen 2007). Thus, the performance of supply chains is largely dependent on the decisions made by multiple individuals engaged in its administration and management (Narayanan and Moritz 2015). Decisions across supply chains will generally include those which are customer facing (downstream- from end user to consumption), and those not deemed to be customer facing (upstream- from procurement of materials to manufacturing and assemblage).

Despite most literature suggesting that key decisions in organisations are typically made and guided by senior managers, there is increasing evidence which suggests that key organisational decisions that drive responsiveness are in fact made by those who have a direct interface with customers; the so called 'frontline employees' (see Ellinger et al. 2010; Jeng 2018). However, traditionally, frontline

employees have often been denied the basic independence to make key decisions (Peccei and Rosenthal 2001). Empowering employees can mean that such staff are not required to request and wait for managerial approval prior to making the most basic of decisions (Ojiako et al. 2013; Marinova et al. 2017; Venkatachalam et al. 2020). Moreover, employees are able to make real-time decisions and, in the process, respond more quickly to customer needs (Al-Mudimigh et al. 2004).

Frontline employees are those "*service workers who personally interact with customers in retail and service encounters*" (Sirianni et al. 2009; p. 966). The literature suggests that the role of frontline employees is important because the effectiveness of service delivery and recovery (which occurs when services fails) is *absolutely* dependent on an instantaneous response (Beatty et al. 2016). In fact, the role of frontline employees is so crucial to service that neither an organisation nor its customers is ever likely to realise any service benefits without the frontline employee mediation. Thus, the view that senior managers actually do maintain a peripheral role in strategic decision-making suggests some conflation between the terms 'key' and 'strategic' decision-making.

The notion that frontline employees play a crucial role in organisational decision-making, service engagement and strategic implementation appears widely shared (see Coelho and Augusto 2010; Cadwallader et al. 2010; Ojiako et al. 2013; Zimmermann et al. 2018). For example, Coelho and Augusto (2010) posit that frontline employees play a critical decision-making role in that they are the ones most likely to discover, communicate, respond to and deliver latent customer needs. Cadwallader et al.'s (2010) exploration of the role of frontline employee participation in service encounters suggested that the role of frontline employees in building and maintaining new and existing relationships with stakeholders is critical to any organisations customer engagement strategy. In articulating three roles performed by frontline employees in service contexts, Singh and Marinova (2013) posit that frontline employees are the essential element that determines whether innovation in service is a success or failure. These three roles can be theoretical broadly set out as follows. The first role involves the minimization of variations and errors in service. This implies that frontline employees play a crucial role in resolving problems and implementing service process standards set by organisations. These standards may include for example average response times for complaint resolution. The second role involves maximizing customer satisfaction by acting in a manner that builds customer trust – for example, providing prompt or timely responses to customer enquiries. The third (final) role involves a trade-off between the first and second role guided by the need for *concurrency*. Hence, an organisation's ability to sense and respond to the needs of various actors across its supply chain will only succeed to the extent that its frontline employees are positively engaged and provided with greater opportunities and resources to engage in effective decision-making processes (Lewis and Entwistle 1990). The literature has also explored the importance of frontline employees from a boundary spanning perspective, noting that

frontline employee value emanates from their critical role in idea gathering and dissemination (Woisetschläger et al. 2016) and creativity (Coelho and Augusto 2010). It is important to note that while there is available literature emphasising the crucial role of frontline employees in organisational decision-making, their decisions can be impugned. For example, Pedersen et al. (2018) examined how discretionary judgements of frontline employees can be marked by various forms of bias.

1.2 Frontline employees in supply chains

Frontline employees also play a vital role in supply chains because they are both core to service differentiation and to the enhancement of resilience in supply chains (Jeng 2018). Stolze et al. (2018) has suggested that, in supply chains, the decision making of frontline employees serves as the "…*foundation for understanding cross-functional integration and firm-level outcomes*" (p. 3). Frontline employees are likely to be key to implementing the drastic improvements required to develop supply chains that are both responsive and customer-driven (Eloranta et al. 1995). This view is widely shared within a growing literature that alludes to the critical role of frontline employees in logistics and supply chain management decision making (see for example, Marshall et al. 2018; Stolze et al. 2018). These literatures highlight that decision-making challenges for frontline employees in supply chains cannot be underestimated. A key consideration for frontline employees is the need to simultaneously address complex service demands and operational challenges. This requires intensive interaction with other actors across supply chains that are characterised by "…*high complexity, high task uncertainty, high task variability, high interdependence between parties and by high equivocality*" (Busse 2010; p. 46). Furthermore, since it is not practical to '*inventorize*' most service delivery and recovery requirements in supply chains, frontline employees must be in a position to, without delay, offer meaningful service and experiences to the supply chain actors with whom they interact. This view is supported by Ellinger et al.'s (2010) exposition that "*frontline employees are considered inseparable from the services they render*" (p. 80).

Frontline employees in supply chains are increasingly required to make subjective judgments regarding quantitative values (e.g., estimated delivery times, cargo weights and volumes, distances, inventory sizes, monetary costs) and to use these when making decisions under conditions of uncertainty (Marshall et al. 2018; Villena et al. 2018). This essentially means that frontline employees often have to make complex judgments and decisions in the absence of full and precise decision-relevant information. In other instances, because of the fluid nature and fast pace of the supply chain (for example, in the fashion industry), there is a need for '*fast-clockspeed*' (Fine 2000) or, in order words, quick and fast decision making. However, such circumstance frequently arises alongside contextual limitations in which frontline employees lack the necessary time to access, assess and evaluate the full range of options

and potential outcomes of their decisions. This has led frontline employees, who are generally opportunist actors (Schepers et al. 2012), to seek to cope with uncertainty by developing habitual recourse to everyday strategies of '*muddling through*' (Zinn 2008) and by engaging various kinds of decision shortcuts (Katsikopoulos and Gigerenzer 2013). Among these key decision shortcuts are '*heuristics*'.

Drawing from the literature, we opine that frontline staff will be more likely to aid their decision making by using '*heuristics*' when in complex multi-stakeholder supply chain environments. For example, Goll and Rasheed (1997) have observed that the complexity of operational environments can be a major driver for decision makers to employ cognitive simplification tools (such as heuristics) to aid their decision-making capabilities. Cognition in this instance will refer to conscious intellectual tools such as thinking and reasoning.

Heuristics are generally employed as aids to decision making because, in reality, individuals are not only limited in terms of their cognitive abilities, but are also constrained by a limited ability to engage in 'logical' or 'rational' thinking under conditions of complexity (Kang and Park 2019). Both factors, we argue, have the potential to limit effective pursuit of utility maximization. Thus, the main premise of this study is to understand the decision shortcuts, especially '*heuristics*,' employed by frontline employees and to gain insights into the consequences of such decision shortcuts. This requires a detailed assessment of the decisions that frontline employees make (Katsikopoulos and Gigerenzer 2013). In a supply chain context, this form of study has the overall objective of obtaining a better understanding of habitual decisions, such as placing orders primarily dependent on previous demand realisation (Bolton and Katok 2008), and identifying how and when to intervene to mitigate against the impact of such decisions on the efficiency of the supply chain.

The role of frontline employees in supply chains can differ greatly from frontline roles in many other industry sectors (Jeng 2018). Furthermore, despite the criticality of their role, the position of frontline employees within the supply chains of a number of organisations is quite precarious. For example, frontline employees can occupy roles, which are deemed of lower skilled and labour intensive, providing many opportunities for automation.

1.3 Heuristics

Decision-making is often challenged by 'uncertainty', 'risk' and 'complexity' (Gilovich et al. 2002; Marshall and Ojiako 2015; Marshall et al. 2018; Marshall et al. 2019a, b). To overcome these challenges, decision makers such as frontline employees often rely on heuristics (Andersson et al. 2016). Defined as a "*simple rule of thumb that leads to decisions in little time and with little information and computation*" (Katsikopoulos and Gigerenzer 2013; p. 4), heuristics can be theorised as fast, simplifying mental

strategies that support decision-makers when faced with a broader range of specified challenges or constraints. Typically, heuristics are also theorised as harnessing some combination of trust, affect and intuition in order to function (Greenberg et al. 2012), and as operating spontaneously, subliminally and swiftly under these influences to produce decision shortcuts. To appreciate why heuristics operate in this manner, it is helpful to set them within the evolutionary context of how the brain has probably developed in order to handle imminent threats.

Notably, heuristics theory aligns to what is termed dual process theory or affective intelligence doctrine to provide this explanation (Evans 2006). This corpus of psychological theory (see for example, Narayanan and Moritz 2015), contends the existence of two varying, but associated cognitive processing operating simultaneously. The first which is not in need of major memory activity (referred to as System 1) and the second (referred to as *System 2*), which does need considerable memory activity (Kahneman 2011). These risk cognitions arise suddenly and spontaneously, at least in the first instance, and within a dedicated brain system (*System 1*), as an affect-laden response honed over evolutionary time and modified through habit-forming individual experience to elicit immediate behavioural responses to imminent threats. Once such stimulation has taken place, a separate brain system (*System 2*) may modify and improve risk cognitions within conscious awareness through more laborious analysis and evaluation if such opportunity is available (Slovic 2014). Taking stock, the use of heuristics strongly implies an imbalanced reliance on the first of these two systems to produce behaviour under problem-solving circumstances that are possibly characterised by anxiety-inducing threat. Heuristic use is strongly aligned to the time and information scarcity mentioned earlier, both of which are commonly recurring constraints upon decision making within organisations.

Heuristics are widely used during decision making in organisational contexts (Del Campo et al. 2016). More so, the effectiveness and efficiency they offer managers is widely recognised (Chow 2014). This ensures that their use can be of high professional repute and of considerable academic interest, both of which share a focus on the prospects for further refining usage to optimise decision outcomes (Greenberg et al. 2012).

1.4 Heuristics and specification of context

Despite its wide use and acknowledgement, the academic and practitioner agenda on heuristics faces a particular challenge: specification of context. The importance of context as a basis for understanding heuristics use deserves careful attention. Whilst originating in the field of psychology (Tversky and Kahneman 1974), there is evidence for the literature on heuristics is becoming more nuanced between specialist management domains that, potentially, includes logistics and supply chain management (Govindan et al. 2017). Given the prevalence of information-poor and time-poor decision making within

these very broad operational and supply business contexts, heuristics-based solutions do, however, naturally attract concern for their failure to fully satisfy the informational criteria necessary for instrumental rationality (i.e. when the means are logically conjoined to the ends; Ariely 2009). Therefore, the need for a critical orientation to the subject matter, in particular, entailing careful attention to specifying the precise decision contexts within which heuristics use can be assessed and evaluated, is the main driver for the present study. This critical concern with context is commonly expressed with reference to Herbert Simon's (1990) behavioural scissors metaphor. In presenting the practical rationality of behaviour as a function of both the 'structure of task environments' and of the 'computational capabilities of the actor', the scissors metaphor invites wariness of behavioural analyses which rely too heavily on only one of these 'cutting blades'.

In Simon's (1957) 'bounded rationality' expression, the boundedness signified that there are both epistemological and temporal constraints upon rational choice and that the complexity and uniqueness of task environments render it difficult or sometimes impossible to specify prescriptive rules to guide choice. To further sketch out this representation of the behavioural reality emphasising contingent and constantly shifting decision environments, it also becomes important to appreciate that frontline employees may often use heuristics without adequate opportunity to reflect upon and learn from their usage – not even with reference to the simplifying behavioural self-assessment framework of bounded rationality itself. This insight from Simon's (1957) classic work, taken together with insight from dual process theory, arguably gets us much closer to a frontline employee-based behavioural reality for many supply chains. Specifically, that heuristics are likely to be used with very limited self-reflection, which, insofar as this is present, will typically be driven and accompanied by potential anxieties that frontline employees will seek to extricate themselves from during their decisions. Over time, such decisions may become habitual in character and, therefore, amenable to capture by researchers. Where there is a repetitive element to heuristics use, the formation of unreflective habits is clearly an important consideration, and this is indeed recognised within the literature (see for example, Marien et al. 2018).

Heuristics are very commonly theorised as habits of mind for dealing with familiar and recurring problems. This infers less anxiety and more enthusiasm within the emotional experiences accompanying their use. Looking from this perspective, a well-known general concern is that habitual use of heuristics within repeating decision contexts can produce systematically biased judgements (Tversky and Kahneman 1974). Furthermore, the literature observes that some heuristics are also considered as a bias (Tversky and Kahneman 1982) and this has presaged ongoing dispute as to how these two very closely related concepts ('heuristics' and 'biases') are best differentiated. In some research, such as Busenitz and Barney (1997), the two terms are constantly juxtaposed as substitution instances. Perhaps the most compelling case for using the term 'bias' alone is where uses of heuristics produce erroneous estimates

that exhibit overconfidence (Liu et al. 2018). In other words, not only can individuals make systematically erroneous judgments as a result of using heuristics, but his/her conviction that the judgment is accurate can be deemed a 'bias' because its perceived veridicality is skewed by a subjective belief.

To summarise, it can be argued that effective use of heuristics hinges on recognising uncertainty, which is often represented as variability (see Flynn et al. 2016). Furthermore, much literature recognises that such uncertainty is prevalent within supply chains (Gadde and Wynstra 2018).

1.5 The research question

Taking stock, the present study regards the frontline employee as being largely responsible for daily management decisions of various kinds that have substantial implications across the supply chain. The literature indicates that for frontline employees (at the lowest competent level) to be able to proactively respond to customer needs, supply chain organisations must be willing to create the right conditions that allows for delegation of the necessary discretional decisional authority. Such authority may allow frontline employees to shape the nature and context of decisions they make on behalf of the organisation (Ellinger et al. 2010). However, it is anticipated that in naturalistic organisation contexts these decisions may often be impugned by the bias that can result from 'bounded rationality'. This is because 'bounded rationality' elicits a reliance on heuristic that then become a rough and broadly applied practice-based principle that emerges behaviourally within the near-chaos of everyday non-routine frontline employee experience. However, there is little research that has specifically focused on heuristic and overconfidence among frontline employees of supply chain organisations. Yet, their use of heuristics may be regularly repeated and, therefore, 'prevalent' within their workaday lives. Thus, in light of calls for an increase in studies exploring the decisions made by supply chain employees (see, Katsikopoulos and Gigerenzer 2013), we present a study that addresses the following research question:

How prevalent are heuristics and overconfidence bias in the decision making of frontline employees within complex multi-stakeholder supply chain organisations?

2. Review of the literature

2.1 The anchoring heuristic

Research on biases in subjective judgments in supply chains is widespread (see for example, Arvan et al. 2019). Originally applied to judgment under uncertainty by Tversky and Kahneman (1974), the anchoring and adjustment heuristic is seen to be one of the most widely recognised cognitive heuristics (Furnham and Boo 2011).

The anchoring and adjustment heuristic refers to a decision maker's propensity to make judgements that are biased toward an initial reference point that is typically of an ambiguous or questionable nature (Cheek and Norem 2017). Whilst much anchoring research has focused on probability estimation and general knowledge, its effect is deemed to be observed across a variety of decision domains such as economic valuation (Northcraft and Neale 1987), consumer purchasing (Bergman et al. 2010), strategic acquisition (Malhotra et al. 2015) and judicial opinions (Englich et al. 2006). A review of the literature suggests that there are a number of different factors that can impact upon the anchoring heuristic (Furnham and Boo 2011). These include, for example, emotions and mood – whereby actors in a sad mood are more likely to be vulnerable to anchoring when compared to others who are in a happy mood (Englich and Soder 2009). This may be because when individuals are sad, they expend more effort processing information and, therefore, may be more likely to identify information that can become anchors. Relatedly, the anchoring effect can be experienced by those with high level of knowledge (and by implication, expertise) because they may readily identify more anchors (Englich and Soder 2009). For example, Englich et al. (2006) found evidence of the anchoring heuristic among judges with very high level of expertise. Again, it can be inferred that those with high levels of expertise (such as judges) will engage in decisional comparisons prior to reaching their own decisions. Inevitable, this activates anchor-laden bias.

In addition to emotions, mood and knowledge (expertise), other factors that can impact upon the anchoring heuristics includes national culture (Czerwonka 2017), information processing and thinking styles (Wegener et al. 2001), motivation to arrive at the appropriate judgment (Wegener et al. 2010), individual actor differences (e.g., personality; Brandstatter 1993), and cognitive intelligence (Bergman et al. 2010). Most interestingly, research appears to suggest that the anchoring heuristic influences judgments even where the decision-maker is aware that it may produce bias (Gilovich et al. 2002) and when clear incentives for effective decision making exist (Epley and Gilovich 2005). More specifically, Epley and Gilovich (2005) found that responses to externally provided anchors were not influenced by forewarnings of the impacts that the anchoring cue may have. Even when providing participants with the correct information some time prior to their decision, studies have shown that individuals still exhibited the anchoring effect (Caputo 2014). In the present study, we focus on two aspects of anchoring: (i) the presence of insufficient adjustment and (ii) the resulting inaccuracies for both conjunctive and disjunctive events.

2.1.1 Anchoring as insufficient adjustment: The anchoring bias implies a cognitive process where decision makers rely (anchor) on informational reference points that come to mind. In their study of forecasting as a key ingredient in supply-chain planning, Fildes et al. (2009) draw attention to widespread

supply chain management practice whereby computerised forecasting systems will produce initial forecasting estimates to serve as anchors. Human judgments are then made which adjust the estimates thereby varying forecasting accuracy. They highlight a need for larger (cf. smaller) and negative (cf. positive) adjustments in order to succeed in improving forecasting accuracy. The observed tendency for smaller adjustments over larger adjustments is also claimed by Furnham and Boo (2011), who articulate it as one of 'insufficiency of adjustment'.

Similarly, the purported general tendency for negative adjustments to be better is located within supply chain management practice by Niranjan et al. (2011). Looking at the supply chain management practices of a components manufacturer, they explain that simple calculations of mean demand are commonly used as anchors for inventory ordering. They propose a 'correction model' to explain the commonplace over ordering which often then ensues. This correction model considers how ongoing adjustments can often only be understood with reference to reflexivity between buyers and sellers (e.g. where over ordering becomes reactive against perceptions of supplier tendencies towards short supplying). Croson et al. (2014) have similarly emphasised that coordination risk between buyers and sellers in supply chains can profoundly affect order stability along supply chains. They draw on earlier work by Sternman (1989) cautioning that poor anchoring and adjustment is often precipitated when supply chain participants are insensitive as to how their decisions will be perceived by other supply chain participants. It is further worth noting Sterman's (1989) conclusion that over ordering, commonly leading downstream to bullwhip effects will very commonly have its origins in underestimation of inventory ordered but not delivered. In other words, positive adjustments towards over ordering may often occur in circumstances of time and information poverty associated with relatively fast-moving and heterogeneous inventory pipelines that are characterised by coordination risk and uncertainty.

Malhotra et al. (2015) draw on lay epistemic theory to further clarify what adjustments can entail in simple individual psychology terms, reminding us in particular that anchors can also very commonly involve human selectivity. They conceive of initial anchoring as occurring through epistemic sequences of confirmatory selective searches for some tangible datum. Selection then brings epistemic closure, entailing that further specific (and perhaps more relevant) information can be underestimated or excluded altogether. Generally, the salience of the chosen reference point (Wilson et al. 1996) and its perceived consonance with the focal task (Strack and Mussweiler 1997), combine to determine whether it will serve as an anchor. Misperceptions in either or both can then be viewed as sometimes precipitating poor judgment (Goodwin and Wright 2014).

However, the causes of poor judgment do not end there. Even when anchors are rated by decision-makers as irrelevant or implausible, the decision-makers may still prioritize information deemed consistent with the anchor (Goodwin and Wright 2014). Providing some counter-balance against the

suggestion that anchoring may often entail uncritical use of anchors, studies by Ariely et al. (2003) and Bergman et al. (2010) have found the strength of anchors to be largely dependent on their assessed applicability. This application effect seems to be independent of the anchor's perceived level of plausibility (Furnham and Boo 2011). Accordingly, why individuals consciously incorporate implausible anchors into their judgements remains of interest. A common explanation is that decision makers deem anchors as 'hints' in circumstances where there is pessimism over prospects for further information acquisition (Wegener et al. 2010). However, this simplifying line of argument has been questioned within studies that point to the persistence of anchored judgements even when decision makers are forewarned of the operative anchoring cue and its negative effects (Epley and Gilovich 2005). Another argument is that the process of adjustment is resource consumptive. Consequently, any obstacles encountered, which lead the decision-maker to question whether to persist with or deepen their information search, can cause early termination of adjustment. This can lead to the anchor's persistence or even its further reinforcement (Gilovich et al. 2002).

2.1.2 Anchoring within conjunctive and disjunctive events: Tversky and Kahneman (1974) found the anchoring heuristic was present when individuals evaluated both conjunctive (events that occur in conjunction with another) and disjunctive events (events that occur independently). For conjunctive events, each of the likely elementary events must occur for the overall undertaking to succeed (Barbosa and Fayolle 2007). For example, in supply chains, when considering the launch of a new supply route, its success will depend on the success of several individual endeavours, which are all connected with one another. When evaluating the probability of failure within a whole supply chain system, the probability of a failure of the system typically remains low if one only component of that system fails.

While the failure of one of the elementary elements of a supply chain may typically be containable (and not affect the entire supply chain), there can be circumstances in which failure in one component causes failure across the entire structure. This can be due to the integrated and fragile nature of certain supply chains (Caniato et al. 2012). Hence, there can be disjunctive events in supply chains and these can lead to the collapse of the entire system.

2.1.3 Susceptibility to the anchoring heuristic (expertise and knowledge): A further cautionary point from the literature is an expectation that not all frontline employees will be influenced equally by the same anchoring cues due to individual differences (Teovanovic 2019). Hence, we focus on the influence of expertise and knowledge on heuristic use as a means of assessing the effect of individual differences.

Studies suggests that the soft skills and experiences of supply chain actor's impact not only on individual performance, but also on firm performance (Essex et al. 2016). An important subdomain of

heuristics research considers how levels of knowledge and expertise can influence a manager's susceptibility to the anchoring heuristic. Chapman and Johnson (1994) suggest that when individuals have high certainty about an answer and, therefore, are considered knowledgeable, they experience smaller anchoring effects. This is supported by Wilson et al. (1996) who found that the anchoring effect occurred only among people low in knowledge. They explained this in terms of experts being more skilled and able to retrieve veridical information that helps to answer questions. Some further evidence for delineating this expert advantage comes from previously mentioned research by Englich and Soder (2009), which emphasised the mood independence of information processing among experts (but not non-experts). Furthermore, Pedersen et al.'s (2018) finding that personal characteristics such as work experience (and by implications, expertise) play a significant role in conditioning discretionary judgements made by frontline employees is of broader interest because the development of such mood independence is set within broader contexts of organisational experience.

The question of how expertise might influence anchoring remains unsettled (Teovanovic 2019). Some literature suggests that those with relatively high levels of expertise are less susceptible to anchoring (Furnham and Boo 2011). Whereas, Englich et al. (2006) did not find this, and Northcraft and Neale (1987) found that higher levels of expertise were not protective against anchoring. Similarly, studies by Englich et al. (2006) found that individuals with high levels of expertise anchored their judgements regardless of the perceived relevance and importance of the information anchor. To reiterate, the original proposition by Tversky and Kahneman (1974) was that the reliance on the *anchoring* heuristic was not inverse to expertise. However, it is also apparent from the above discussion that there are mixed findings on this question and, therefore, that there is a need for further research. We suggest, consistent with the weight of the extant evidence, that it is more likely that frontline employees with higher (cf. lower) levels of expertise will be less susceptible to the anchoring heuristic.

2.2 Overconfidence bias

Drawing from Fischhoff et al. (1977; p. 552), we define 'overconfidence' as the extent to which an individual frontline employee exaggerates his/her evaluation of what he/she knows is correct. Overconfidence is conceptually distinct from the over/under-estimations that are associated with the anchoring-and-adjustment heuristic. Specifically, overconfidence describes an individual's degree of belief that his/her judgment is more accurate than the actual level of accuracy. By contrast, over/under-estimation describes a miscalculation, but does not relate to a degree of belief regarding accuracy. Factors that can impact upon overconfidence includes national culture (Feng et al. 2011; Antonczyk and Salzmann 2014; Moore et al. 2018), experience and professionalism (Hansson et al. 2008; Menkhoff et al. 2013), and level of education (Mishra and Metilda 2015). The literature has also found evidence of

overconfidence in both un-experienced and highly experienced supply chain managers (Ancarani et al. 2016) and frontline employees (Hoffman and Burks 2017). Edward and Schoemaker (1992) claims that "*Overconfidence persists in spite of experience because we often fail to learn from experience*" (p. 10).

The evidence relating to frontline employees is mixed. For example, Hoffman and Burks (2017) found that truck drivers in freight organisation systematically over predicted the level of their productivity (which the authors termed, 'overconfidence'). On the other hand, Hallin et al. (2009) found that senior managers and executives exhibited overconfidence in their judgments while frontline employees exhibited under-confidence. Drawing from literature (see Bendoly et al. 2010), the potential negative consequences of overconfidence among frontline employees of supply chain organisations are that there can be a risk of underestimation, poor choice of appropriate risk mitigation strategy, and an underestimation of demand variance.

It is posited that the perceived value offered by the overconfidence bias can be subtle among frontline employees in supply chains (Liu et al. 2018). For example, it can relate to a need for some task complexity reduction and projection of certainty. It may also relate to the maintenance by frontline employees of viable professional identity and positive mental attitude through self-appraisals of competence in relation to professional knowledge and control exerted within tasks. Complex and heterogeneous psychological benefits such as these may be reflected to varying extents in studies that reveal individual supply chain actors' exhibit deeply rooted overconfidence in their beliefs and judgments (Liu et al. 2018). In the literature, overconfidence can often reflect the discretionary powers of an individual actor (Zimmermann et al. 2018).

To theorise the prevalence of overconfidence, Ancarani et al. (2016) draw attention to the need for discretionary power wherever there is uncertainty. More specifically, they report overconfidence as leading to less caution amongst individual supply chain actors and, therefore, it increases the costs of managing inventories. Such actors are often simultaneously overconfident about estimation accuracy and information accuracy. Therefore, again drawing from the literature (Goncalves and Castaneda 2018), overconfidence may lead frontline employees of supply chain organisations to abandon and reduce the use of proper mechanisms to select, evaluate and monitor demand trends. It may also lead to either mistaken assumptions that random samples match representatively to the primary attributes of processes or frontline employees engaging in demand chasing irrespective of cost conditions. Overconfidence aligned to trust in systems, people or information sources, constitutes an internally diverse area of study in its own right. For example, trust in 'experts' can lead to frontline employees adopting managerial practices which are fundamentally incorrect (Kaufmann et al. 2012). It is also important to highlight that the extant literature on the relationship between overconfidence and recognition incentives for accuracy suggest little or no significant impact of one on the other. For example, Tversky and Kahneman (1974)

offered accuracy incentives for correct confidence intervals and observed they had little effect. Similarly, Fischhoff et al. (1977) observed significant overconfidence even when participants were willing to stake money on the validity of their judgements. In a more practical example, it is worth mentioning that even when the financial consequences (and therefore incentives) are considerable, overconfidence still remains prevalent in decisions (see for example, Doukas and Petmezas 2007).

Studies consistently suggest that the overconfidence bias is evident across a range of supply chain actors (Ancarani et al. 2016; Hoffman and Burks 2017). Generally, individuals with perceived expertise have regularly shown overconfidence (Erceg and Galic 2014), and this bias has also be shown to manifest as an overestimation of personal skills in particular domains (Doukas and Petmezas 2007). Moreover, work by Tetlock and Gardner (2015) has drawn attention to overconfidence as a factor that explains why individuals with higher (cf. lower) levels of expertise often make poorer forecasts across diverse domains. One possible general explanation as to why individuals with higher levels of expertise often make poorer forecasts is because they mistakenly see themselves as less susceptible to overconfidence (Furnham and Boo 2011).

Drawing from Erceg and Galic (2014), we now explore the two predominant paradigms within which overconfidence studies have tended to focus: (i) confidence in binary decisions and (ii) interval prediction formats.

2.2.1 Overconfidence as mis-calibration ('mis-calibration'): Much of the evidence on overconfidence comes from calibration studies (Ancarani et al. 2016). These studies involve researchers providing a series of questions and providing two alternative answers for each question. The respondent chooses one answer and expresses confidence on a probability scale on the correctness of their responses (Erceg and Galic 2014). Researchers then assess whether a mis-calibration exists. In order words, they assess whether there is a difference between the accuracy and self-assigned probability that the response is correct (Skala 2008). Well-calibrated probability judgements will closely match their accuracy (Ji and Kaulius 2013).

2.2.2 Overconfidence within intervals ('over-precision'): The literature shows that overconfidence elicits preferences for overly narrow confidence intervals (Goodwin and Wright 2014). Hence, it seems reasonable to suggest that supply chain actors may be overconfident about the chances that their estimated ranges include the true value. Interestingly, the creation of such overly narrow intervals can be explained in part through an interaction between overconfidence and the anchoring heuristic (Tversky and Kahneman 1974). This is because individuals start with an initial value and anchor to it, which often has the effect of squeezing intervals to become too narrow to include the correct value (Goodwin and

Wright 2014). Therefore, heuristics may operate in conjunction with one another. Moreover, the theoretical simplification afforded by studies on individual heuristics, while often very necessary, can easily detach from complex behavioural reality within organisations that exists in the absence of careful attention to the psychological processes and broad social contexts in which they are used.

3. The study

3.1 Research methods

Our study sought to assess the extent to which, in operational settings, the anchoring heuristic and overconfidence bias led to inaccurate judgments among frontline employees of complex multi-stakeholder supply chain organisations. As there is currently a paucity in validated empirical knowledge on this topic, we employ a case study as our research tool. Case studies are a well-recognised means of undertaking exploratory studies focused on the development of newer understandings within operations management (Barratt et al. 2011). The utilisation of single case studies to build knowledge in operations management is increasingly becoming popular in the literature (Ketokivi and Choi 2014). To ensure that the earlier stated research question (*How prevalent are heuristics and overconfidence bias in the decision making of frontline employees within complex multi-stakeholder supply chain organisations?*) was adequately addressed, we selected for investigation, as case organisation, a United Kingdom (UK) based freight forward and materials handling company (*Organisation 'A'*).

3.2 The case organisation

The organisation is structured into three main divisions: operations, sales and accounts. It maintains nine offices worldwide spanning four continents. Its headquarters and largest office is located in the UK.

Organisation 'A' can be described as a 'complex multi-stakeholder organisation' in that it caters not only for multiple, diverse and heterogeneous stakeholder service needs, but these service needs are contradictory in some cases and contested between its diverse customers. The implication of this being that frontline employees face major challenges when seeking to articulate service templates, which are coherent and compatible to both the organisation's institutional structures and the institutional structures of its customers. Being a complex multi-stakeholder organisation also means that the manner in which its frontline employees respond to challenges posed by individual customer needs will differ significantly and be partially based on the employee's creativity.

3.3 Choice of Organisation 'A'

Our choice of the case organisation was also based on the following reasons. *First*, the organisation is widely recognised as an industry leader in the provision of supply and logistics services. For this reason,

it has developed meaningful best practices from lessons learned, which have then been used to support theory building/testing (Siggelkow 2007), and enhance managerial practice (Barratt et al. 2011). *Second*, our decision to conduct the study within the specific case was also because the organisation regularly dealt with complex problems that required creative solutions. Jeng (2018) had opined that supply chain firms were in need of frontline employees who were creative. In this context, creativity implies having the "*...the ability to produce work that is both novel (i.e., original, unexpected) and appropriate (i.e., useful, adaptive concerning task constraints)*" (Sternberg et al. 2002; p. 3). Most importantly, Jeng's (2018) research showed that complexity had a direct impact on the creativity of frontline supply chain employees, and that this impact was more pronounced in supply chain organisations that provided a variety of services than those that provided standardized services. Furthermore, we were aware that some literature suggests the creative decisions of individuals is generally not strongly driven by objective costs and benefits assessments of their decisions. Instead, what appears to matter more to those involved in creative endeavours is the immediate context of creativity. In effect, those involved in creativity may often use mental shortcuts in their decision-making (Bechtold et al. 2015).

3.4 The survey instrument

The survey instrument consisted of twenty-seven open and closed questions sub-divided into five sections (see Appendix 1 for full survey instrument). Overall, question structures were varied to support the exploration of different elements of the heuristics/biases potentially associated with specific actor decisions. Survey instruments of this nature have been one of the most common methodological approaches used to assess the extent to which individuals employ heuristics when making decision-relevant judgments (e.g., Tversky and Kahneman 1974; Gilovich et al. 2002; Goodwin and Wright 2014). The five sections of our questionnaire are now explained.

The *first* section of the questionnaire, drawn from Tversky and Kahneman (1974), contained questions enquiring if a value is perceived to be higher or lower than a given anchor, followed by a request for an absolute estimate of the same value. This question structure has been employed in prior studies exploring economic behaviour (Bergman et al. 2010) and legal judgements (Englich et al. 2006). Specifically, the external provision of an anchor is often an integral part of activating both psychological components of the 'anchoring *and* adjustment heuristic'. Indeed, extant research in this field has not typically concerned itself with how people select anchors simply because, in naturalistic contexts, these anchors generally come from external sources.

To fit the context of this study (supply chain management), numerical figures related to the industry, such as air distance within commonly used flight routes, were incorporated into the questions in the first section. The vast majority of studies analysing insufficient adjustment have used an approach

where a low anchor is provided to some participants and a high anchor to others; the objective being to polarise results from the same question (Caputo 2014). However, due to the target sample (all frontline employees within the case organisation) being relatively small, this comparative approach was deemed inappropriate. Instead, we provided the same anchor to all respondents for each decision problem (rather than varying the anchors among the small numbers of respondents for each decision problem). The questions in this section were deliberately designed so that the anchor provided diverged at least 40%, either upwards or downwards from the correct answer. As such, we deemed that respondents (employees) who provided an answer within a range between 20% below and 20% above the given anchor were to have exhibited insufficient adjustment. For example, in the first question, the anchor provided for the cargo volume (metric tonnes) at Heathrow (LHR) during 2017 was 1,000,000, with the correct answer being 1,700,000. Thus, responses of between 800,000 and 1,200,000 were to be considered as insufficiently adjusted from this anchor.

Questions within the *second* and *third* sections of the questionnaire employed *conjunctive* or *disjunctive* events respectively. Again, these questions were rooted in the works of Tversky and Kahneman (1974) and were primarily focused on determining whether an anchoring bias existed for these two different types of events. In other words, the questions assessed the accuracy of the respondents' judgments to determine if, consistent with the anchoring-and-adjustment heuristic, over/under-estimations were evident. If such over-/under-estimations existed, this would provide evidence that the respondent's probability estimates were inaccurately 'anchored' too close to the probabilities provided for the constituent events. These questions were not intended to determine if respondents believed, consistent with overconfidence, that their judgments were more accurate than the actual level of accuracy. Hence, the general purpose of the questions in the second and third sections was to examine the possible overestimation of conjunctive events and, conversely, the underestimation of disjunctive events.

The *fourth* section of the questionnaire was framed against earlier studies by Russo and Schoemaker (1992). This section of the questionnaire asked respondents to produce a lower and upper bound around an estimate in order to build 90% confidence that their response captures the correct quantity. Percentages were calculated for correct and incorrect estimates. Overconfidence was deemed present when less than the target percentage (90%) of ranges included the correct value (Block and Harper 1991). On this premise, only 10% of the responses were expected to reside within the correct ranges.

The final (*fifth*) section of the questionnaire adopted question structures previously employed in the literature to assess calibration (Ji and Kaulius 2013; Paluch 2012). Respondents were asked questions followed by a confirmatory question on the respondent's confidence that his/her original response was

correct. The responses were then checked for mis-calibrations. Drawing from Pulford (1996), scores were categorised from under confident (negative) to over confident (positive).

In all cases, the questionnaire was in English. Despite the questionnaire also being distributed in offices where English was not the lingua franca (Turkish and Arabic are the main languages of Turkey and the United Arab Emirates, respectively), the decision to prepare only an English language version was made for two reasons. Firstly, English is the business lingua franca of the case organisation. Secondly, the authors were keen to maintain grammatical, idiomatic, and syntactical equivalence for all respondents.

4. Piloting, sampling and data analysis

The first draft of the questionnaire was piloted with two frontline employees (who were not part of the subsequent sample). Feedback led to some minor modification and then re-administration to the two respondents for checking. We then made some final adjustments to the survey instrument (questionnaire).

Data gathering commenced with the administration of the survey instrument via email in August 2018. Respondents were drawn from an employee list provided by the organisation's management team. The questionnaires were sent only to employees that *Organisation 'A'* had designated as 'frontline'. The sample were drawn from all of the organisation's nine operational offices spread across the United States, United Kingdom, Turkey and the United Arab Emirates. No incentives were offered to respondents.

Completed questionnaires were received from forty-seven respondents. Seven were discarded due to critical missing information. This left 40 usable questionnaires split geographically as follows: UK ($n = 17$), US ($n = 6$), UAE ($n = 9$) and Turkey ($n = 8$). Two categories of experience level were those designated as (1) 'non-experts' due to accrual of '*less than five years*' ($n = 18$), and (2) 'experts' with '*five years or more*' ($n = 22$). Twenty-two respondents were from the Operations Department, thirteen were from Sales, and five were from Accounts. In order to ensure the questionnaire could be completed in a reasonable amount of time, we elected not to obtain any sociodemographic data (e.g., age, gender) from our respondents that would be superfluous to our research aims and hypotheses. Data analysis was undertaken utilising a combination of descriptive statistics and a series of Chi-squared tests using IBM SPSS Statistics.

5. Findings

*5.1 Descriptive overview of the questionnaire responses*

Questions *Q1* through to *Q6* focused on sufficiency in adjustment. Whilst some respondents did show some anchoring in their responses, this was not at a rate sufficient to be attributable to the anchoring

heuristic. At an aggregate level, under a third of responses (30%) fell into the anchored boundaries, equating to 36/120. Hence, *the findings did not appear conclusive in showing that frontline employees in this supply chain organisations presented insufficient adjustment.*

Questions *Q7*, *Q8* and *Q9* focused on anchoring within conjunctive events. The questions were framed for an overestimation assessment. For each question, a plausible range was presented near to the answer considered to be sufficiently accurate for the purposes of this study. Plausible ranges were determined using five percent segments; 70-75% for *Q7*, 80-85% for *Q8* and 50-55% for *Q9*. The responses were assessed for under/overestimation against the plausible range. For *Q7*, 75% of respondents answered above the correct probability and outside the plausible range. For *Q8* this figure was 70% and for *Q9* it was 73%. In terms of mean response, for *Q7* was 11.34% higher than the correct answer. For *Q8* this figure was 3.86% and for *Q9*, 15.31% higher. We also found that the range of answers and standard deviation for each question were high. For *Q7*, answers ranged from 50-100% (*SD*= 13.65). For *Q8,* answers ranged from 55-100% (*SD*=8.129) and for *Q9,* responses ranged from 25-95% (*SD*=21.702). *Thus, it appeared that frontline employees in this supply chain organisations were overestimating probabilities when framed in a conjunctive manner.*

Questions *Q10*, *Q11* and *Q12* were aimed at identifying the extent to which respondents anchored within disjunctive events. The questions were framed in a disjunctive manner in order to assess possible underestimation of probabilities. Plausible ranges (38-43% for *Q10*, 15-20% for *Q11* and 25-30% for *Q12*) were used for sufficient accuracy, again based on five percent segments surrounding the correct answer. The data showed that for *Q10*, *Q11* and *Q12*, 58%, 70% and 78% of respondents, respectively, estimated below the correct probability *and* outside of the plausible ranges. Arguably, *Q11* provided a less convincing indication of underestimation, in comparison to *Q10* and *Q12*. The reason for this could relate to the differing numbers of responses to these questions. Eight respondents answered 50% in *Q10*, eleven responded 18% in *Q11*, and ten responded 30% in *Q12*. Hence, the estimates placed respondents within a plausible region for *Q11* and *Q12*, but not for *Q10*. Potentially, this explains the substantial difference between the number of plausible responses within these questions, and why *Q11* produced a smaller comparative underestimation. Figure 1 shows the comparison between the correct answers and the mean responses given. The mean response for *Q10* was 19.37% lower than the correct answer. For *Q11* this figure was 2.2% and for *Q12*, 7.1%. As expected, *Q11* was closer, yet all three again showed an element of underestimation. Answers ranged from 1-50% for *Q10* (*SD*=17.340), 3-50% for *Q11* (*SD*=10.711) and 3-50% for *Q12* (*SD*= 10.703). The standard deviation was slightly more consistent when analysing disjunctive events as opposed to conjunctive, with the mean response also nearer to the correct answers at an aggregate level.

Figure 1- Correct Answers versus Mean Response (*Q10-Q12*)
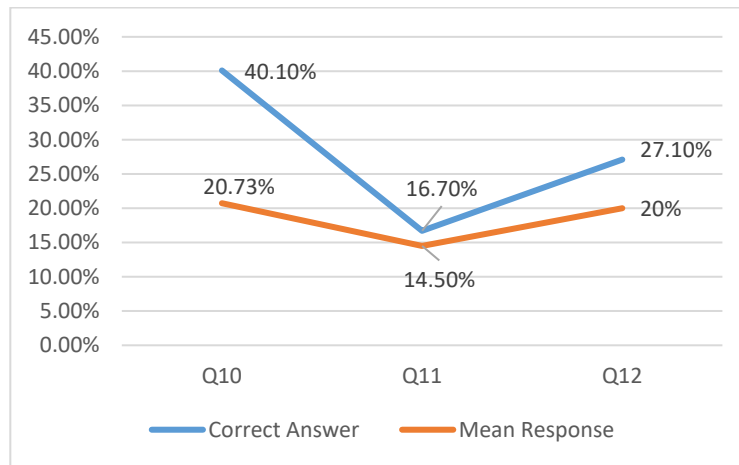
These results indicate that frontline employees in this supply chain organisations may underestimate probabilities when framed in a disjunctive manner. These findings are congruent with findings in similar studies (see Barbosa and Fayolle 2007).

Questions *Q13* through *Q17* sought to identify the extent to which frontline employees in supply chain organisations utilise over-precise intervals in their judgements. Addressing this objective required assessing, as a measure of overconfidence bias, whether respondents would be over-precise in their range estimations. The questions were framed using a 90% confidence interval, implying that only 10% of responses were expected to encompass the correct responses within their specified ranges. Three different measures were used, namely air distance, sea distance and cargo capacity. Table 1 below illustrates the findings from each of the questions.

Table 1 - The proportion of respondents who demonstrated overconfidence via the use of over-precise intervals in judgements of air distance, sea distance and cargo capacity

Question No.	Question Type	Incorrect Ranges		
		Ideal	*Actual*	*Number of respondents*
13	Air Distance	10%	75%	30
14	Air Distance	10%	82.5%	33
15	Sea Distance	10%	75%	30
16	Sea Distance	10%	77.5%	31
17	Cargo Capacity	10%	75%	30
Total		10%	77%	154/200

Our findings suggest that across all five questions (Q13 to Q17) with the three different measures, overconfidence was exhibited. This claim can be made because for each of the questions, a minimum of thirty respondents (75% of the sample) responded with range estimations that did not contain the correct value. When aggregated, this suggests that 154/200 (77%) of ranges given failed to include the true value.

Q18 through to Q27 allowed us to explore mis-calibration (difference between the accuracy and assigned probability that the response is correct) between the confidence of frontline supply chain managers in their response and the accuracy of those responses. A bias score was produced for each respondent to determine the extent of their under or over confidence (in effect, their mis-calibration). At an aggregate level, the mean bias score was 21.3%, indicating a high level of overconfidence. This mis-calibration highlights that on average, respondents were 79.3% confident of the correctness of their answers, while in reality they were only correct 58% of the time. More specifically, across all five questions (Q18 to Q27), overconfidence was exhibited. Furthermore, when respondents were categorised against five categories: '*High Underconfidence*' (bias score of above -15), '*Slight Underconfidence*' (between -5 and -15), '*Accurate*' (between -4.99 and +4.99), '*Slight Overconfidence*' (between +5 and +15) and '*High Overconfidence*' (above +15), we found that an overwhelming majority of respondents, 65% (26/40) exhibited overconfidence. *In effect, frontline employees in supply chain organisations exhibited considerable overconfidence in their judgements*. Out results are consistent with previous literature (e.g., Ancarani et al. 2016).

5.2 Inferential analysis

In our review of the literature on susceptibility to the anchoring heuristic, we suggested that expertise and knowledge might influence the anchoring heuristic. To explore this hypothesis in more detail, three anchoring measures ('*insufficient adjustment*', '*conjunctive scenarios*', and '*disjunctive scenarios*') were assessed against the two designated experience groups identified earlier in the study ('*less than five years*' and '*five years or more*'). A chi-squared test for independence was statistically significant [$\chi^2 = 9.755$, *df* = 1, *p* = 0.002], suggesting that the experience of frontline employees in supply chain organisations was a significant factor impacting anchoring susceptibility. More specifically, the results suggested that a significant positive relationship existed between frontline employees with higher expertise and judgments that were closer to the provided anchor. However, in terms of the second measure, '*conjunctive scenarios*', the results from the chi-squared test were not statistically significant, [$\chi^2 = 0.426$, *df* = 2), *p* = 0.081]. This was also the case when assessing '*disjunctive scenarios*' where, again, the results from the chi-squared test were not statistically significant in terms of differences in experience level [$\chi^2 = 2.524$, *df* = 2), *p* = 0.283]. Hence, although our findings did not allow us to

conclusively reject or accept a hypothesis that in supply chain organisations, frontline employees with higher (cf. lower) expertise/experience are less susceptible to the anchoring heuristic, we were able to make two conclusions. That is, in supply chain organisations (i) frontline employees with higher (cf. lower) expertise may be more susceptible to judgmental bias as a result of anchoring and (ii) expertise may not influence the extent to which frontline employees are susceptible to judgmental errors for conjunctive or disjunctive events.

In order to examine our earlier literature-driven hypothesis that the overconfidence bias may be evident across a range of supply chain management professional groups, two overconfidence measures ('*confidence in binary decisions*' and '*interval prediction formats*') were assessed against the two experience groups ('*less than five years*' and '*five years or more*'). The chi-squared test results [χ^2 = 2.520, *df* = 1, *p* = 0.112] were not statistically significant, suggesting no grounds for confidently positing that *overconfidence within intervals ('over-precision')* differed on experience levels of individual frontline supply chain employees. In terms of *overconfidence as mis-calibration ('mis-calibration'),* chi-squared test for independence [χ^2 = 1.28, *df* = 1, *p* = 0.257] was not significant, thus rejecting our hypothesis.

Although we had not put forward any hypothesis on the possible impact of location and national culture on the anchoring heuristics and the overconfidence bias, we did undertake such an examination. Thus, to explore a possible relationship between employee location and the anchoring heuristic, three anchoring measures ('*insufficient adjustment*', '*conjunctive scenarios*', and '*disjunctive scenarios*') were assessed against the four locations covered in the survey ('*Turkey*', '*UAE*', '*UK*' and '*US*'). Chi-squared test for each measure were not statistically significant; '*insufficient adjustment*': [χ^2 = 1.184, *df* = 1), *p* = 0.277]; '*conjunctive scenarios*': [χ^2 = 3.128, *df* = 2, *p* = 0.209]; '*disjunctive scenarios*': [χ^2 = 4.240, *df* = 2, *p* = 0.120]. In sum, we were unable to deduce any evidence from our data that the location of frontline employees of supply chain organisations had any particular impact on susceptibility to the anchoring heuristic. However, when the two overconfidence measures ('*confidence in binary decisions*' and '*interval prediction formats*') were assessed against the four locations ('*Turkey*', '*UAE*', '*UK*' and '*US*'), Chi-square test results were statistically significant [χ^2 = 24.48, *df* = 1, *p* < .0001]. This suggested that the level of *overconfidence within intervals ('over-precision')* differed depending on location ('*Turkey*', '*UAE*', '*UK*' and '*US*') of respondents. Although being the case, in terms of *overconfidence as mis-calibration ('mis-calibration'),* chi-squared test did not show significant differences [χ^2 = 0.105, *df* = 1), *p* = 0.746]. Thus, while over-precision differed significantly between office locations, mis-calibration did not.

6. Discussion

Virtually every activity undertaken across a supply chain will involve some aspect of human decision-making. For this reason, the ability of practitioners and scholars to develop deep insight into the decision making of those at the frontline of customer engagement and service delivery in supply chains is important to the optimization and efficiency of supply chains. In particular, having such an understanding will support practitioners and scholars to successfully predict with greater efficiency and accuracy the decisions those frontline employees are likely to make – but perhaps most importantly, such an understanding will inform how best to react to and influence such decisions.

Results from the present study provide detailed insights into how frontline employees in supply chain organisations may often engage with specific forms of anchoring ('*insufficient adjustment*', '*conjunctive scenarios*', and '*disjunctive scenarios*') and overconfidence (e.g., *'over-precision'*). These findings may plausibly inform future development within supply chain management heuristics research for a range of more narrowly specified decision contexts. Specifically, evidence from the present study suggests that these frontline employees: (i) overestimate probabilities when framed in a conjunctive manner (ii) underestimate probabilities when framed in a disjunctive manner and (iii) exhibiting considerable overconfidence in their judgements. While employee expertise was not found to influence susceptibility to anchoring or overconfidence, the results indicated that geographic location might. Therefore, our findings suggest that geographical differences could be worth exploring as contextual variables affecting the presence and strength of decisional biases.

Our findings surface a number of other potential factors leading to the prevalence of the anchoring heuristic and overconfidence bias among frontline employees in supply chain organisations. For example, in relation to our finding that these employees overestimated probabilities when framed in a conjunctive manner, this may have been because the respondents summed or multiplied the percentages for each of the individual events in the conjunction to arrive at higher numbers. Indeed, research by Dawson et al. (2014) shows that individuals often sum or even multiple the probabilities associated with individuals events when trying to determine the overall probability associated with a combination of those events. Relatedly, a plausible explanation for our finding that frontline employees underestimated probabilities when framed in a disjunctive manner is that they treat each event as having a separate effect on the overall supply chain and, therefore, fail to recognise the accumulative influence on the overall probability (Tversky and Kahneman 1974). Hence, employees working on the frontline of supply chains may benefit from inversely framing conjunctive risks when communicating (i.e. 3% chance of failure instead of 97% chance of success). Relatedly, earlier studies by Doyle (1997) and Keller et al. (2006) suggest that individuals prefer probability information to be presented in disjunctive rather than conjunctive terms. However, it is interesting to note Visschers et al.'s (2009) opinion that the findings from both Doyle (1997) and Keller et al. (2006) are not conclusive. Therefore, our contention is that the

use of risk modelling approaches such as fault trees and event tree, which can better facilitate the comprehension of conjunctive and disjunctive events, could help to reduce the effect of biases introduced when such employees are assessing supply chain risks.

7. Conclusions

In this paper, an experimental survey was undertaken within a UK-based freight forward and materials handling company in order to examine the extent to which the anchoring heuristic and overconfidence bias were evident among frontline employees. Our study surfaced a number of useful findings and valuable insight into the use of these heuristics in complex multi-stakeholder supply chain decision making. For example, we found that frontline employees in supply chains specifically (i) *overestimate* probabilities when framed in a conjunctive manner (ii) *underestimate* probabilities when framed in a disjunctive manner and (iii) exhibit considerable overconfidence in their judgements. Thus, in terms of theoretical implications, by explicitly assessing judgmental biases of frontline employees in complex multi-stakeholder supply chain environments against designated measures (i.e., '*insufficient adjustment*', '*conjunctive scenarios*', and '*disjunctive scenarios'* in the case of anchoring and *'over-precision'* in the case of overconfidence), our study paper opens a new area of discourse in relation to not only frontline employee literature, but supply chain operations literature as well. Although it appears that the wider operations management literature does appreciate the nature of peculiarities that characterizes the nature of the decisional interaction between complex multi-stakeholder supply chain organisations and their stakeholders, our study is the first to focus exclusively on the frontline context.

Our findings also have practical implications for supply chain organisations. The main premise of the extant literature is that within complex multi-stakeholder supply chain environments, there appears to be demands for decisional shortcuts (see Merlo et al. 2008), that simultaneously (i) provide very quick and almost immediate solutions (Merlo et al. 2008) and (ii) make minimal demands for information (Swieringa et al. 1976). However, not being able to understand the nature and limits of these decisional shortcuts and associated biases will arguably degrade the efficiency and effectiveness of supply chains. Ultimately, this will lead to increases in transaction costs. When considered in conjunction with the findings of our study, this all points towards the indispensable need for frontline supply chain employees to be (i) more aware of these shortcuts (ii) capable of identifying the very specific conditions that can elicit judgmental biases and (iii) critical in the use of heuristics. However, despite the appeal to employ these decisional shortcuts ('heuristics'), there is a need for vigilance regarding its impact on operational activities. Thus, we also call upon managers in supply chain organisations to be cautious about the use and potential unintended consequences of the anchoring heuristic. This vigilance arises in a number of circumstance.

First, there is a need to acknowledge that heuristics may provide frontline supply chain employees with (i) no solution - if its rules are vague, or (ii) solutions which are not useful – if its rules are complex. Thus, heuristics need to be construed in a manner that is neither vague nor too complex for its use to be fully appreciated (Merlo et al. 2008). This is especially poignant for novice frontline employees. Hence, despite our study finding limited impact of expertise on the anchoring effect, there are strong views expressed in the literature (see Kaustia et al. 2008). Specifically, that expertise has such a significant impact on bias to warrant a call for managers to implement training programmes that educate novice frontline employees to become aware of this heuristic. The *second* need for vigilance relates to the potential to use (incorrectly) a heuristic in domains within which it was not framed originally (see Merlo et al. 2008). Gigerenzer (2004) notes that to an extent, all heuristics are domain specific (that is, engaged to address specific categories of problem). Yet, we are aware that individuals have on occasions employed heuristics while not being fully aware that to do so would be 'irrational' (Denes-Raj and Epstein 1994). Thus, *not* paying particular attention to its original framing domain is likely to enhance their *in*effective use as a decision tool (Dane and Pratt 2007). This has implications for frontline supply chain employees evaluating either conjunctive or disjunctive.

The finding that frontline supply chain employees exhibited considerable overconfidence in their judgements also has implications for management. Studies by Bolton et al. (2012) compared how students and experienced procurement managers solved the newsvendor problem - finding that classroom-based education served as an effective form of learning. Similarly, Marinova et al. (2017) opined on the importance of learning among frontline employees, and suggested this was best achieved through *repeated* and *timely* feedback. This process is likely to be more beneficial if such education is augmented with training that is undertaken within a 'real' operations setting.

As with all research, this study was not without its limitations. *First*, the study took the earlier conceptual position that mainly construed heuristics as a liability. Yet, several studies show that there are conditions where heuristics serve to efficiently elicit accurate judgments and facilitate sound decision-making. Hence, researchers could aim to explore the potential prevalence and benefits of these heuristics in the supply chain context and, as was the case with the present study, to develop fine-grained insights into the precise conditions under which these heuristics may be at their most beneficial. *Second*, while our study employed stimulus materials concerning only the supply chain context, our use of questionnaire-based scenarios could arguably, lack some degree of ecological validity. We have assumed for purposes of our research that the forty employees studied are all heavily immersed, albeit to varying extents and in varying functional capacities, in operational decision-making involving planning and purchasing (as discussed in section 2.1.1) aimed at ensuring leanness and efficiency of supply chains. This is the basis on which their participation in the study was sought. Our use of hypothetical decision

problems further assumes that this professional experience will have resolved as professional habits which the hypothetical decision problems can capture and permit to be expressed as statistical generalisations. This limitation does of course entail that the findings of this study may not necessarily hold true for every frontline supply chain employee and every type of heuristics. This is a point for future studies, especially noting that the sample was small which could potentially have an outsized influence of cultural bias. In effect, despite the fact that case experiment was designed with the aim of closely approximating the decisional challenges found in typical supply chain environments, less than careful attempts to generalize the findings, especially in domains, which a particular heuristic was not originally framed, certainly needs to be eschewed. Therefore, future studies should be directed at examining similar literature-driven hypotheses utilising data gathered in a more naturalistic context. *Third*, we elected to provide all of our respondents with the same anchors, rather than following the conventional approach of using higher and lower anchors. Consequently, our results only provide a measure of whether or not the respondent's adjustments were insufficient, rather than determining the extent to which different anchors cause deviations from the correct answer. Understanding the extent of the deviations could be important for identifying the circumstances under which the greatest margin for error may exist. Hence, future studies could provide different anchors to different groups of respondents to determine the magnitude of influence that anchors can play in judgments among supply chain professionals.

The *fourth* limitation of the paper is that although it is now well documented in the literature that cross-national differences affect various aspects of judgment and decision making (Cui et al. 2013), including overconfidence (see for example, Feng et al. 2011; Antonczyk and Salzmann 2014; Moore et al. 2018), our study did not examine the impact of such cross-national differences on the anchoring heuristic and overconfidence bias. Our study also did not investigate the impact of possible individual differences. Prior studies by Moritz et al. (2013, 2014) and Narayanan and Moritz (2015), for example, point out that individual heterogeneity may explain some of the differences in decision-making performance. More specifically, the outcome of their studies led to suggestions that one way of ensuring efficiencies in supply chains was to assign practitioners with higher-level cognitive reflection tendencies (in order words, the ability to override an instinctive response and engage in additional reflection in order to establish a correct response – see Frederick 2005) to deal interface with customers susceptible to stable but random demand. For this reason, future studies could focus more on the area of framing and the communication of complex problems with a view to identifying how these approaches could be designed in a sensitive manner that minimizes inter-individual and/or cross-national differences in the forms of anchoring and overconfidence that we identified as being prevalent among frontline employees in supply chain organisations.

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Appendix: The Questionnaire

Part One
Background Information:
How long have you worked for Organisation 'A'?

Less than 1 year (≤) 1year	Greater than 1 year (≥), but less than (≤) 3 years
Greater than 3 years (≥), but less than (≤) 5 years	Greater than (≥) 5 years

Have you worked at another company within the industry? If no, leave blank. If yes, how long for?

Less than 1 year (≤) 1year	Greater than 1 year (≥), but less than (≤) 3 years
Greater than 3 years (≥), but less than (≤) 5 years	Greater than (≥) 5 years

What office are you located at?

United Kingdom	Turkey
United States	United Arab Emirates

Which department do you work in, or most closely work with?

Sales	Accounts
Operations	Other

Part One
1) During 2017, was Heathrow's (LHR) cargo volume higher or lower than 1,000,000 metric tonnes?

Higher
Lower

2) Estimate Heathrow's cargo volume (in metric tonnes) during 2017.

3) X has offices located across the world. One of the overseas offices is located in Lagos, Nigeria. Is the population of Nigeria higher or lower than 110m?

Higher
Lower

4) Estimate the population of Nigeria to the nearest million.

5) Is the air distance between LHR and HKG (London Heathrow Airport- Hong Kong International Airport) higher or lower than 10,000 miles/16,093 kilometres?

Higher
Lower

6) Estimate the air distance between LHR and HKG in miles or kilometres (please specify).

Part Two

7) X is aiming to develop a new internal communication system between offices located around the world for use during urgent circumstances. For it to function properly, each of the 10 relay centres needed must be operational, with each centre having a 97% chance of being operational at any given time. You are about to send a message using the system. Estimate the probability (%) of the message successfully reaching its destination.

8) A customer has recently begun using the services of X due to being unhappy elsewhere. This customer specialises in urgent deliveries and is expecting to have 13 heavy cargo items that need to be transported in the next 5 months. You think that as it is urgent, you could suggest using air freight as the supplier you have in mind is very reliable, attributing a 99% chance of a smooth process for each load. The customer agrees and asks for you to estimate the possibility that all of the loads will reach their destination without an issue. What is the probability (%) of this occurring?

9) X are attempting to diversify by expanding their business. Warehousing is now being offered as a service to customers and this is being funded by the main transport operations. You are assessing whether future circumstances in the logistics industry may inhibit the financing of this new business. You attribute an 85% chance that each of the following circumstances will remain favourable (or at least relatively stable) over the next year.

The demand for transport services.
The projected traffic volume (or capacity freight) available.
The cost of transport services.
The tax and fare costs across relevant areas.

What is the probability (%) that all of these circumstances will remain favourable, or at least stable?

Part Three

36

10) You are currently dealing with 10 customers who supply a large amount of business to the company. Each of these customers have a 5% chance of leaving for a competitor in the next year, based on previous data. Estimate the probability (%) that at least one of these customers will do so (assuming that chance of one customer leaving is independent of other customers' decisions).

11) There is roughly a 3% chance for each of the following circumstances to occur during a job:

Cargo is held at customs for an undisclosed reason.
Cargo becomes damaged during transit.
There has been an incorrect declaration on the customs document.
The collecting vehicle breaks down.
Freight gets bumped from a flight due to unavailable space.
Delay in the packing process.

What is the probability (%) that at least one of these events occur?

12) X are proposing an innovative new venture in which drones are being considered for transporting goods locally. They wish to begin trial operations as quick as possible to try and capture an early-adopter market. There are numerous risks involved, and if any of the following occur, the project will be delayed. You attribute roughly a 10% chance to each of these events.

Failure to receive regulatory approval.
Failure to receive the appropriate funding.
Supplier failing to produce an adequate number of prototypes.

What is the probability (%) that at least one of these events occur?

Part Four

For the following routes, please give your best estimates of the air distance (airport to airport), in miles or kilometres (please specify), between the starting and finishing location. For the same routes, please also place a lower and upper bound around your estimate so that you are 90% confident the range will include the correct quantity:

For example, I believe that the distance from Central London to Southampton is 85 miles. I am 90% confident that the true value will be between 60 miles (lower bound) and 110 miles (upper bound).

Route	Estimate (please specify miles or KM)	Lower Bound	Upper Bound
13) LHR-IAH (London Heathrow - Houston, USA)			
14) IST-DMM (Istanbul, Turkey- Dammam, Saudi Arabia) 1561 miles			

For the following routes, please give your best estimates of the sea distance (port to port), in miles or kilometres, between the starting and finishing location. For the same routes, please also place a lower and upper bound around your estimate so that you are 90% confident the range will include the correct quantity:

Route	Estimate (please specify miles or KM)	Lower Bound	Upper Bound
15) Port of Southampton (Southampton, UK) - Port of Jebel Ali (Dubai, UAE)			
16) Port of Houston (Houston, USA) - Tin Can Island Port (Lagos, Nigeria)			

17) Please estimate the maximum weight capacity of a Boeing 747-400 freight (cargo only) aircraft and specify which unit of measurement you have chosen (e.g. kilograms or pounds). Please also place a lower and upper bound around your estimate so that you are 90% confident the range will include the correct quantity:

Estimate (please specify miles or KM)	Lower Bound	Upper Bound

Part Five

18) Each year, a Corruption Perceptions Index is produced to create a world ranking. Out of the following countries, which do you believe to be ranked the most all-round corrupt in 2017?

Nigeria
Iraq

19) How confident are you that your answer above is correct? (50-100%).

20) According to INCOTERMS, who pays the Vessel Loading Charges during the FCA (Free Carrier) mode of transport?

Buyer
Seller

21) How confident are you that your answer above is correct? (50-100%).

22) According to INCOTERMS, who pays the Destination Terminal Charges during the DAP (Delivered at Place) mode of transport?

Buyer
Seller

23) How confident are you that your answer above is correct? (50-100%).

24) Which of the following is the VGM (Verified Gross Mass) of a container carried out by?

Shipping Line
Port

25) How confident are you that your answer above is correct? (50-100%).

26) Which of the following does the VGM (Verified Gross Mass) process apply to?

Tank
Wide-body

27) How confident are you that your answer above is correct? (50-100%).