Differentiation strategies for defence supply chain design

Defence
supply chain
design

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Abstract

Purpose – Defence supply chains (SCs) aim at operational outcomes, and armed forces depend on them to provide availability and preparedness in peace and sustainability in war. Previous research has focussed on strategies for SCs aiming at financial outcomes. This raises the question of how suitable commercial supply chain strategies (SCSs) are for supply chain design (SCD) in defence. The purpose of this paper is to explain the constructs of SCSs that satisfy military operational requirements and to propose SCSs that are appropriate in defence.

Design/methodology/approach – This paper reports on a Delphi study with 20 experts from Swedish defence authorities. Through three Delphi rounds, two workshops and a validation round, these experts contributed to the reported findings.

Findings – The findings demonstrate that commercial SC constructs are acceptable and applicable in defence but not sufficient. An additional strategy is required to satisfy requirements on availability, preparedness and sustainability. The paper shows that different requirements in peace and war make it challenging to design suitable defence SCs and proposes eight SCSs that satisfy these requirements.

Research limitations/implications – The results emanate from the Swedish defence context and further research is required for generalisation.

Originality/value – This paper extends theory by investigating SCs aiming at operational outcomes. For managers in companies and defence authorities, it explicates how the unique issues in defence must influence SCD to satisfy operational requirements.

Keywords Delphi study, Supply chain strategies, Defence supply chain design, Military logistics

Paper type Research paper

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1. Introduction

Supply chains (SCs) are becoming increasingly complex (Purvis *et al.*, 2016), leaner, longer and more vulnerable (Christopher and Peck, 2004). Enhanced efficiency increases vulnerability to demand variability and disruptions (Purvis *et al.*, 2016), which endanger operations and deliveries (Jüttner *et al.*, 2003). Vulnerability to demand variability has prompted research on responsive SCs (Gunasekaran *et al.*, 2008), whereas vulnerability to disruptions instigated research in SC resilience (Christopher and Peck, 2004). Melnyk *et al.* (2010) suggest that future SCs must deliver varying degrees of cost-related benefit, responsiveness, security, sustainability, resilience and innovation, depending on customers' requirements. Customers determine the success or failure of SCs (Mason-Jones *et al.*, 2000a), and companies may have to sacrifice efficiency to satisfy requirements (Basnet and Seuring, 2016). However, how military customers' operational requirements should be satisfied in defence SC design (SCD) has not been sufficiently researched (Yoho *et al.*, 2013).

Efficiency is the default goal of SCD in the private sector (Basnet and Seuring, 2016), but the public sector is not profit-maximising (Wilhite *et al.*, 2013). Defence authorities such as armed forces, defence procurement agencies and defence logistics organisations generate, use or support military forces. Military logistics supports armed forces to achieve operational outcomes, not financial outcomes (Yoho *et al.*, 2013). Operational outcomes present unique SCD issues, which companies must consider (Melnik *et al.*, 2014). Furthermore, in military logistics, catastrophic events are not disruptions, they are its *raison d'être* (Martel *et al.*, 2013). Military logistics must support force generation in peace and sustain operations in war (Davids *et al.*, 2013). In such operations, "the first mile" is similar to business logistics, whereas the "last mile" is not, as the enemy may damage infrastructure and attack the SC (Glas *et al.*, 2013). Leanness and efficiency are important requirements on defence SCs in peace, but the overarching requirements in war are agility and effectiveness (Kovács and Tatham, 2009). If companies want to match military customers' unique requirements, they must design defence SCs to serve two modes: peace and war. Defence SCs must be able to work in both modes at different times but must also be able to switch rapidly between them (Sharma and Kulkarni, 2016), through activation and mobilisation. The question is which implications these unique SCD issues have for the formulation of SC strategies (SCSs) in defence.

An SCS is a response to external contingencies, such as demand variability/uncertainty, product variety, desired customer lead-time and supply uncertainty/risk (Basnet and Seuring, 2016). It is a set of prioritised competitive priorities (Schnetzler *et al.*, 2007), commonly including cost, quality, flexibility, innovation, speed, time and dependability (Chen and Paulraj, 2004). SCs must service a wide range of products and markets, and a recurrent caution is that "one size does not fit all" (Lee, 2002; Lovell *et al.*, 2005; Christopher *et al.*, 2006). SCSs must match the specific requirements of a product or a market (Fisher, 1997; Christopher *et al.*, 2006; Melnyk *et al.*, 2014) and customers' requirements (Godsell *et al.*, 2006). Researchers have proposed SCS typologies, such as efficient/responsive (Fisher, 1997), postponement/speculation (Pagh and Cooper, 1998) and lean/agile (Naylor *et al.*, 1999), which others have criticised for being too simplistic (Godsell *et al.*, 2006; Hilletofth, 2012; Basnet and Seuring, 2016). In another stream of research, authors such as Sharman (1984) and Yang *et al.* (2004) have suggested SCS continuums, using the customer-order decoupling point (CODP) position as a demarcation between different SCSs. Customised SCD in defence presupposes the inclusion of military end-users' requirements. So, which are these requirements, and what is the military perspective on commercial SCD constructs, such as external contingencies, competitive priorities and SCSs?

Researchers have investigated appropriate SCSs in different industries, such as aerospace, fashion, automotive, chemicals, electronics, food, furniture, health care, home appliances, paper and steel (Nag *et al.*, 2014) but not in defence. Functioning SCs are required

to support nations' defence and security. Considering that the total military expenditure in the world is estimated to US\$1.8tn in 2018 (SIPRI, 2019), corresponding to 2.1% of the total gross domestic product, research on defence SCSs is warranted. Indeed, Melnyk *et al.* (2014) call for more research to identify the unique SCD issues in military/defence. Furthermore, Yoho *et al.* (2013) encourage more research in defence SC resiliency and management.

This paper bridges the gaps in the literature regarding defence SCD. The purpose is to explain the constructs of SCSs that satisfy military operational requirements and to propose SCSs that are appropriate in defence. To formulate suitable SCSs, the study must establish the operational requirements, or unique defence SCD issues, and determine if commercial SCD constructs are acceptable, applicable and sufficient in defence. This paper operationalises the purpose through the following research questions:

RQ1. How acceptable, applicable and sufficient are commercial SCD constructs in defence?

RQ2. Which SCSs satisfy defence authorities' operational requirements?

Based on a Delphi study, this paper extends SC management (SCM) and military logistics theory and military logistics practise, as follows. Firstly, it investigates the acceptability, applicability and sufficiency of commercial SCD constructs in Swedish defence. Secondly, it examines unique defence SCD issues and proposes SCSs that will satisfy them. Thirdly, it provides defence authorities with instruments to formulate and convey requirements to industry.

The paper is organised as follows. Section 2 reviews the related literature on military logistics and SCSs. Section 3 presents the methodology. Next, Sections 4 and 5 present and discuss the findings. Finally, Section 6 explicates theoretical contributions, practical implications and limitations and proposes further research.

2. Literature review

2.1 Military logistics

The operational purpose of military logistics is to ensure that the elements of military capability come together at the right place and time and in the right configuration (Swartz and Johnson, 2004). Military capability is the ability to achieve a specified objective, which can be to win a war. It depends on force structure, modernisation, readiness and sustainability, where the two latter reflect how quickly and for how long military forces are usable (Moore *et al.*, 1991). Consequently, in military logistics, sustainability has a rather different meaning than in business logistics. The supply dimension of military logistics involves procuring, storing and distributing supplies to bridge the discrepancy between production and consumption (Hauk, 1964) or to ensure readiness and sustainability. Readiness consists of operational readiness, "ready for when", and mobilisation readiness, "ready for what" (Betts, 1995, p. 216), otherwise known as availability and preparedness. Availability and preparedness are military units' abilities to be committed to an activity without forewarning or after mobilisation. Sustainability is the ability to maintain the necessary level of combat power for the duration required to achieve objectives.

Compared to business logistics, military logistics faces a number of particular challenges. Whereas an error in business logistics can lead to a loss of profit, in military logistics, it can result in death or injury (Yoho *et al.*, 2013). Furthermore, military logistics operates at three different levels of activity: peace, mobilisation and war (McGinnis, 1992). The logistics support for a country's armed forces is frequently required to operate in cost-efficient mode during peace but must be prepared to transition into war, in which effectiveness is paramount (Kovács and Tatham, 2009). Consequently, there is a dual

premise in defence SCD. In peace, defence SCs must satisfy requirements on availability and preparedness. In war, they must satisfy requirements on sustainability.

2.2 Supply chain strategies

An SC consists of all activities that manufacturers and distributors perform to create value, including purchasing, manufacturing and distribution (Chen and Paulraj, 2004; Hilletoft, 2009). An SCS specifies how a company enhances performance through competitive priorities, such as quality, flexibility, innovation, speed, time and dependability (Chen and Paulraj, 2004). Researchers have divided SCSs into efficient and responsive, which many equate with lean and agile (Selldin and Olhager, 2007; Basnet and Seuring, 2016). Companies that select low-cost, high quality and/or short delivery time as its competitive priorities should select a lean SCS, whereas with a focus on flexibility, an agile SCS is the best choice (Qi *et al.*, 2017).

SCs perform physical and market mediation functions, where the physical mediation involves production, storage and distribution and market mediation matches supply with demand (Fisher, 1997; Aitken *et al.*, 2005). Successful companies have realised that the right SCS is dependent on customer-orientation and on demand and supply variability (Lee, 2002). SCSs must be context-specific (Melnyk *et al.*, 2014) and develop the optimum solution for a particularly competitive environment (Godsell *et al.*, 2006). A differentiated SCS is one way that companies can be responsive to variable demand and maintain SC efficiency, and researchers have proposed several typologies to assist companies in selecting a suitable SCS (Hilletoft, 2009). Most typologies, exemplified in Table 1, are two-by-two matrices, with different dimensions and values. They determine segmentation by product-related, customer-related, supply-related or geography-related factors (MacCarthy *et al.*, 2016). These typologies have in common that they present a discrete choice of one suitable SCS, in a set of two or four. At least one SCS emphasises efficiency/leanness, whereas the others are market mediation SCSs (von Falkenhausen *et al.*, 2019). In another stream of research, scholars such as Yang *et al.* (2004) use postponement and CODP-positioning to construct strategy continuums. These continuums have in common that they use constructs from the typologies to propose market mediation strategies after the CODP (von Falkenhausen *et al.*, 2019) and allow customised SC solutions, dependent on a unique situation. This paper distinguishes between these two waves of contributions as strategy typologies and continuums.

2.2.1 Strategy typologies. Fisher (1997) took segmentation and differentiation into SCM and asserted that mismatches between products and SCs are the causes of problems afflicting SCs. As a remedy, Fisher introduced innovative and functional products, requiring responsive and efficient SCs, and produced a typology that has become a cornerstone in SCD (Perez-Franco *et al.*, 2016). Since Fisher's seminal contribution, authors have proposed extensions and modifications. Lee (2002) expands Fisher's model with supply uncertainties and proposes two additional SCSs, risk-hedging and agile. Introducing value density and throughput, Lovell *et al.* (2005) propose a generic framework, including centralised and decentralised storage. Naylor *et al.* (1999) introduce leanness and agility from manufacturing into SCD. Building on these ideas, Mason-Jones *et al.* (2000b) and Aitken *et al.* (2005) introduce competitive priorities, and the concepts of market-qualifiers and order-winners. Roh *et al.* (2014) update these contributions and add innovative features as an order-winning criterion. In a series of contributions, Christopher (2000), Christopher *et al.* (2006) and Christopher *et al.* (2009) explore the combination of leanness and agility with external contingencies, for example, duration of life cycle, delivery lead-time, volume, product variety and variability in demand, supply or process. Based on production-to-delivery-ratio and

Author(s) (Year)	Dimensions	Values	Segments/Strategies/Competitive priorities
Fisher (1997)	Product	Functional, Innovative	Mismatch*, Match*, Match*, Mismatch*
	Supply chain	Responsive, Efficient	
Pagh and Cooper (1998)	Logistics	Speculation, Postponement	Manufacturing postponement**, Full postponement**, Full speculation**, Logistics postponement**
	Manufacturing	Postponement, Speculation	
Naylor <i>et al.</i> (1999)	Demand for variability in production	Low, High	Leanness**, {}, {}, Agility**
	Demand for variability of products	Low, High	
Mason-Jones <i>et al.</i> (2000a)	Market	Qualifiers, Winners	Quality/Lead-time/Service level***, Cost***, Quality/Cost/Lead-time***, Service level***
	Supply	Lean, Agile	
Christopher (2000)	Volume	Low, High	{}, Lean**, Agile**, {}
	Variety/ Variability	Low, High	
Lee (2002)	Demand uncertainty	Low, High	Risk-hedging**, Agile**, Efficient**, Responsive**
	Supply uncertainty	Low, High	
Olhager (2003)	Production-to- delivery(P/D)- ratio	$P/D < 1$, $P/D > 1$	MTO/(ATO)/MTS**, MTS** (make-to-stock), MTO** (make-to-order), ATO** (assemble-to- order)
	Relative demand volatility	Low, High	
Aitken <i>et al.</i> (2005)	Market	Market-qualifiers,	Quality/Reliability***, Price***, Quality/ Reliability***, Lead-time***
	requirements	Order-winners	
	Supply chain focus	Lean supply, Agile supply	
Lovell <i>et al.</i> (2005)	Value-density	Low, High	Generic framework. Specific SCD depends on detailed examination of business case.
	Throughput	Low, High	
Christopher <i>et al.</i> (2006)	Demand	Predictable,	Lean (continuous replenishment)**, Agile (quick response)**, Lean (plan and execute)**, Leagile (postponement)**
	characteristics	Unpredictable	
	Supply	Short lead-time,	
	characteristics	Long lead-time	
Vonderembse <i>et al.</i> (2006)	Product type	Standard, Innovative, Hybrid	Lean** for standard, Agile** for innovative (introduction, growth), Hybrid/Lean** for innovative (maturity, decline), Hybrid** (postponement) for hybrid
	Product life cycle	introduction, Growth, Maturity, Decline	
Roh <i>et al.</i> (2014)	Market	Order-qualifiers,	Quality/Lead-time/Service level***, Cost***,
	requirements	Order-winners	Quality/Lead-time/Cost/Service level***,
	Supply chain focus	Lean supply, responsive supply	Innovative features***

Notes: *Segments; **Strategies; ***Competitive priorities; {} = empty set

Table 1.
Select strategy
typologies

relative demand volatility, Olhager (2003) proposes CODP-based SCSs. Vonderembse *et al.* (2006) expand previous contributions by introducing the product life cycle and more than two values for each dimension. Table 1 summarises a selection of strategy typologies. The selection is not exhaustive but incorporates all SCD constructs of interest to the study. It includes seminal contributions, for example, Fisher (1997), and extensions, for instance, Lee (2002). It also exemplifies other perspectives on strategy typologies, such as Olhager (2003) and Lovell *et al.* (2005).

With the exception of Vonderembse *et al.* (2006), the contributions in Table 1 are two-by-two matrices, with two dimensions, two values each and four segments. However, two models (Naylor *et al.*, 1999; Christopher, 2000) are dichotomies, whereas the others are quadripartites. Vonderembse *et al.* (2006) propose a three-by-four matrix but merge the segments and provide a selection of four strategies. Empirical research to test these typologies has been mixed, inconclusive or negative (Perez-Franco *et al.*, 2016; Basnet and Seuring, 2016). Testing Fisher's model, Selldin and Olhager (2007) find that a match between products and SCs do not necessarily outperform mismatches.

2.2.2 Strategy continuums. Researchers have criticised strategy typologies for being too simplistic (Godsell *et al.*, 2006; Hiltefth, 2012; Basnet and Seuring, 2016). As customers may require different degrees of responsiveness (Collin *et al.*, 2009), researchers should present strategies in a continuum (Basnet and Seuring, 2016). Even if the typologies in Table 1 present discrete choices, some authors discuss continuums. Naylor *et al.* (1999) conclude that lean and agile are complementary strategies and that companies should strive for "leagility", by combining lean and agile in a total SCS through an appropriate CODP-positioning. One of the SCSs proposed by Christopher *et al.* (2006) is leagile, which is a continuum. Olhager (2003) propose a subset of a strategy continuum.

The CODP is an important construct in SCD, and its positioning is a strategic decision (Olhager, 2003; Yang and Burns, 2003). It primarily relates to the competitive priority delivery speed (Olhager, 2003) and SCD should position it based on which lead-time that is acceptable to the customer (Naylor *et al.*, 1999). Sharman (1984) introduces it into logistics and proposes five strategies, sell from stock (make-to-stock [MTS]), sell semi-customised system from stock, assemble and sell from stock of parts, make-to-order (MTO) and design and MTO. Authors have since re-labelled and extended, by introducing more CODPs and combining it with strategy typologies. Naylor *et al.* (1999) describe five CODP-based SCSs, buy-to-order (BTO), MTO, assemble-to-order (ATO), MTS and ship-to-stock. Olhager (2003) define four CODP-related SCSs, MTS, ATO, MTO and engineer-to-order (ETO). Building on the standardisation–customisation continuum (Lampel and Mintzberg, 1996), Yang and Burns (2003) propose an integrated framework, dividing speculation and postponement and standardisation and customisation. They define seven SCSs based on the CODP-position, make-to-forecast (MTF/MTS), shipment-to-order (STO), packaging/labelling-to-order (PTO), ATO, MTO, BTO and ETO. Yang *et al.* (2004) combine the framework proposed by Yang and Burns (2003) with three additional spectra, lean–leagile–agile, globalisation–localisation–localisation and centralisation–decentralisation. Table 2 illustrates select strategy continuums.

The extreme points in these spectra are pure postponement (ETO) and pure speculation (MTF). ETO enables pure customisation, agility and responsiveness but entails extensive lead-times. MTF facilitates pure standardisation, leanness and efficiency but involves increased costs for storage and risk-taking regarding misjudged future demand, depreciation and obsolescence. In between these extremes, there are five hybrid strategies, representing postponement of one, or more, of the activities that manufacturers and distributors must perform. The hybrid strategies, BTO, MTO, ATO, PTO and STO, are

Table 2.

Select strategy
continuaums

SCS	CODP-position	Push-pull boundary	Postponement- Speculation	Agile-leagile- lean	Customisation- standardisation
ETO	Before design	Engineering (pull-only)	Pure (full) postponement	Agile (responsive)	Pure customisation
BTO	Before purchasing	Purchasing	Purchasing postponement	Leagile	Tailored customisation
MTO	Before manufacturing	Manufacturing	Manufacturing postponement	Leagile	Tailored customisation
ATO	Before assembly	Assembly	Assembly postponement	Leagile	Customised standardisation
PTO	Before packaging	Packaging	Packaging postponement	Leagile	Customised standardisation
STO	Before distribution	Distribution	Logistics postponement	Leagile	Segmented standardisation
MTF	After distribution	Storage (push- only)	Pure (full) speculation	Lean (efficient)	Pure standardisation

Sources: Lampel and Mintzberg (1996), Fisher (1997), Pagh and Cooper (1998), Yang and Burns (2003), Yang *et al.* (2004), Christopher *et al.* (2006)

leagile, enabling varying degrees of customisation/standardisation, agility/leanness and responsiveness/efficiency. All activities that take place prior to a customer order is speculation by the manufacturer, involving risk-taking. The CODP-positioning thus separates decisions under uncertainty from decisions under certainty, speculation from postponement and push from pull and impacts costs, lead-times and risk-taking. Strategy continuaums raise the question, “at what point or combination of points in the SC postponement provides the greatest overall benefit” (Boone *et al.*, 2007).

2.2.3 Supply chain design constructs. Strategy typologies and continuaums share constructs, such as external contingencies, competitive priorities and SCSs. External contingencies are the product/market requirements in SCD (Basnet and Seuring, 2016). Christopher *et al.* (2009) propose five external contingencies: duration of life cycle, delivery lead-time, volume, product variety and variability in demand, supply or process. Basnet and Seuring (2016) condense the 14 most frequent contingencies in the literature into 4: demand variability/uncertainty, product variety, desired customer lead-time and supply uncertainty/risk. When a company focusses on the end-user, it must consider all competitive priorities, such as service, quality, cost and lead-time (Naylor *et al.*, 1999) and make trade-offs between contesting competitive priorities (Basnet and Seuring, 2016). Table 3 summarises the commercial SCD constructs that this paper investigates in defence and exemplifies definitions.

3. Research methodology

RAND developed the Delphi method in the 1950s (Dalkey and Helmer, 1963). The method is iterative, allows anonymous collaboration between experts (Okoli and Pawlowski, 2004) and includes gathering opinions from experts, synthesising and statistically summarising opinions and providing feedback. It is applicable in most areas (Linstone and Turoff, 2002, p. 3) and appropriate when expert opinions are the only available source of information. As this study is on defence SCD, an area with insufficient academic knowledge and where expert opinions and proven experience are the primary sources of information, the researchers selected the Delphi method.

Table 3.
Commercial SCD
constructs and select
definitions

Commercial SCD constructs	Select definitions
CODP	Separates forecast and order-driven activities (Mason-Jones <i>et al.</i> , 2000b)
Competitive priorities	Manufacturers' choice of tasks or key competitive capabilities (Chen and Paulraj, 2004)
Cost	Logistics costs, infrastructure, inventory (Schnetzler <i>et al.</i> , 2007)
Delivery/Lead-time	Delivery-times, high fill rate (Schnetzler <i>et al.</i> , 2007)
Dependability	Punctuality, delivery reliability rate (Schnetzler <i>et al.</i> , 2007)
Flexibility	Managing changes and uncertainties (Schnetzler <i>et al.</i> , 2007)
Quality	Meeting higher customer demands (Schnetzler <i>et al.</i> , 2007)
External contingencies	Product/market requirements (exogenous variables) in SCD (Basnet and Seuring, 2016)
Demand variability/uncertainty	The inability to forecast product demand accurately (Basnet and Seuring, 2016)
Desired customer lead-time	The importance placed by the customer on quick delivery (Basnet and Seuring, 2016)
Product variety	Products may be characterised as standardised (low variety) or customised (high variety) (Basnet and Seuring, 2016)
Supply uncertainty/risk	Disruptions by various causes, such as natural disasters, yield losses, quality issues, etc. (Basnet and Seuring, 2016)
SC strategies	Specifies how a company can achieve its competitive advantage through its competitive priorities (Qi <i>et al.</i> , 2011)
Agility	The ability to respond rapidly to unpredictable changes in demand or supply (Christopher and Peck, 2004)
Efficiency	Distinguished by longer production lead-times, high set-up costs and larger batch sizes that allow the efficient firm to produce at a low unit cost but often at the expense of market responsiveness (Randall <i>et al.</i> , 2003)
ETO, BTO, MTO, ATO, PTO, STO, MTF/MTS	Involves postponement of design (ETO), purchasing (BTO), manufacture (MTO), assembly (ATO), packaging (PTO) and/or shipment (STO) or pure speculation (MTF/MTS) (Yang <i>et al.</i> , 2004)
Full (pure) postponement	Both manufacturing and logistics activities are customer order initiated (Pagh and Cooper, 1998)
Full (pure) speculation	Based on forecasts involves full speculation of all manufacturing and logistics activities (Pagh and Cooper, 1998)
Leagility	Judicious selection and integration of appropriate aspects of lean and agile (Christopher <i>et al.</i> , 2006)
Leanness	Means developing a value stream to eliminate all waste, including time, and to ensure a level schedule (Naylor <i>et al.</i> , 1999)
Logistics postponement	Direct distribution of finished goods from centralised inventory (Pagh and Cooper, 1998)
Manufacturing postponement	Final manufacturing activities performed downstream in the SC (Pagh and Cooper, 1998)
Responsiveness	Distinguished by short production lead-times, low set-up costs and small batch sizes that allow the responsive firm to adapt quickly to market demand but often at a higher unit cost (Randall <i>et al.</i> , 2003)
Risk-hedging	Aimed at pooling and sharing resources to enable risk sharing in supply disruption (Lee, 2002)

The Delphi method has been critiqued for lacking scientific rigour and for questionable application (Sackman, 1974), which has led to epistemological debate (Hasson and Keeney, 2011) and practical guidelines, such as Worrell (2013). This paper describes a modified, conventional Delphi in line with Worrell (2013) and demonstrates trustworthiness in line with Skulmoski *et al.* (2007). The study included a literature review to identify seeds, a three-

round Delphi study, with workshops to review and extend the findings (Melnyk *et al.*, 2009), and strategy formulation.

The researchers conducted the Delphi study in six steps: panel selection, introduction, Delphi rounds 1–3 and workshops. The study invited 45 practitioners from the Swedish Armed Forces (SwAF) and the Swedish Defence Materiel Administration (FMV), and researchers from the Swedish Defence Research Agency (FOI) and the Swedish National Defence University (SEDU). The 25 experts who accepted the invitation represent different perspectives (Melnyk *et al.*, 2009) and have experience in excess of 20 years. Five experts left the study before the first round. The final panel consisted of 12 experts from the SwAF, 4 from FMV and 2 researchers each from FOI and SEDU. The panellists had no knowledge of the number or identity of participants. The researchers distributed written information to each panellist, presenting the study, its background and objective and summarising the Delphi method. The response rates in the three rounds were 100%, 85% and 75%.

In the first round, the panellists answered 12 questions concerning the acceptability and applicability of commercial SCD constructs in defence on a five-level Likert scale, ranging from “strongly disagree” to “strongly agree”. They could justify answers, motivate abstainment and comment on omitted issues, in free text. For each round, the researchers compiled and analysed answers to determine whether to alter, delete or add questions. No insights motivated changes for the second round. In the second round, the panellists received a compilation of answers, including most frequent answers, means, justifications and motivations, which enabled them to change answers based on this information. The few revisions reinforced the most frequent answers and reduced means but did not provide new insights. The study thus changed the format for the third round and asked the panellists to answer “Yes”, “No” or “I don’t know”. For most questions, Round 3 led to consensus. However, for some questions, there was bipolarity, which researchers and panellists addressed during the workshops. The workshop participants also discussed if and how the investigated constructs could describe previous logistics systems in the SwAF. The second workshop used the results of the first as input, allowing discussions to commence on a higher level of understanding.

After the workshops, the researchers formulated eight SCSs, based on the literature and the study’s results, and distributed them to the panel for validation and comments. There was consensus that the eight SCSs are acceptable, applicable and sufficient to satisfy the Swedish defence authorities’ operational requirements.

4. Research results

The purpose of this paper is to explain the constructs of SCSs that satisfy military operational requirements and to propose SCSs that are appropriate in defence. This section establishes the operational requirements, determines acceptability, applicability and sufficiency of commercial SCD constructs (*RQ1*) and proposes acceptable, applicable and sufficient defence SCSs (*RQ2*).

4.1 Operational requirements

The researchers asked the panellists if the study should base defence SCSs on commercial or operational goals. In the first round, there was a consensus regarding using operational goals. One panellist stressed the importance:

For us as a buyer it is important that the right product, with the right quality, is delivered in time to serve our purpose. Unfortunately, I have found that the suppliers often fail in this regard.

Another panellist noted, “It is only reasonable to base it on factors that are important to us if it is going to be useful to us”.

During the workshops, the panellists agreed that the study should operationalise the SwAF’s unique SCD issues through operational requirements on logistics, derived from Sweden’s Defence Policy ([The Swedish MoD, 2015](#)). It specifies the operational outcome that the SCs must contribute to in terms of availability, preparedness and sustainability. The SwAF’s main task in peace is to maintain availability and preparedness ([The Swedish MoD, 2015](#), p. 6), and the government differentiates these requirements between military units. There are three values for availability: immediately, within three months or within six months, and three for preparedness: mobilisation within hours, days or within one week. These requirements provide a starting point for the requirements on sustainability. The requirements on availability and preparedness provide a few days of supplies. The requirements on sustainability involve a flow of replacement supplies throughout an operation.

4.2 Acceptability, applicability and sufficiency of commercial supply chain design constructs

This study introduces commercial SCD constructs into Swedish defence. For many panellists, it provided the first encounter with an alien terminology, even if phenomena were familiar. For some constructs, there was initial resistance. The following comments illustrate attitudes regarding CODP. “I don’t think that CODP is relevant in military logistics”. “I guess it’s OK, but CODP is a new concept to most of us in the SwAF, and may cause confusion for many”. “Military terminology should be used”. However, some saw potential. “The concept is very suitable. It could provide a switching point in a flow from strategic, via operational and tactical, to the combat level”. Acceptance increased during the study, and by the third round, a qualified majority accepted the CODP as applicable in defence SCD. During the workshops, there was consensus that it is a useful construct to differentiate defence SCs, and that the study should use the CODP to propose defence SCs. This means that the panellists require a strategy continuum rather than a typology.

For each SCD construct in [Table 3](#), the study asked the panellists to answer if they are acceptable and applicable for defence SCD. [Table 4](#) summarises the results from Round 3 and the workshops and exemplifies comments from the initial rounds. The comments demonstrate diverging opinions in the study’s early stages. However, for most questions, by Round 3, there was agreement that the investigated constructs are acceptable and applicable for defence SCD. The notable exceptions were the questions related to postponement and speculation. “Postponement feels relevant, but speculation gives a feeling of gambling”. “Entirely civilian concepts, with few connections to military activities”. “It doesn’t seem likely that these concepts contribute to the overarching objective; to win the war”. However, some panellists were positive. One stated, “Both terms are required to handle different supply classes”, and another that “They are needed to design military SCs”. One panellist observed, “Speculation from a civilian perspective could be security-of-supply from a military perspective”. Some positive comments came with a constraint, “The names should be militarised if these strategies are going to be used in the SwAF”.

During the workshops, the participants discussed the logistics systems that supported the national defence during the Cold War and the expeditionary forces after the Cold War. They concluded that the commercial SCD constructs are useful to describe these systems. Agility, responsiveness, safety stock, speculation and decentralisation describe national defence logistics. Leanness, efficiency, pooling and sharing, postponement and centralisation describe expeditionary logistics. The participants agreed that all investigated constructs are acceptable and applicable in defence SCD. However, they also agreed that the

Commercial SCD constructs	Acceptable and applicable?		Examples of panellists' Comments in Delphi rounds 1 and 2
	Delphi round 3	Workshops	
CODP	Yes (Qualified majority, >2/3)	Yes (Consensus)	"New, unnecessary, civilian, complicated concept, but, it is clearly useful"
Competitive priorities (Quality, Lead-time, Service-level, Cost)	Yes (Consensus)	Yes (Consensus)	"Service-level is a suitable dimension, but cost is subordinate to other parameters when it comes to assessing our operational capability". "Focus should be on the customer's requirements". "The service-level is important and must be allowed to cost". "Yes, because there is an inherent trade-off between these factors, which should be made visible". "These dimensions are closely related to the SwAF ability to deliver operational effect. If quality, lead-time and service-level are substandard, the ability to deliver operational effect decreases. Cost is the means to regulate the other three to the right balance". "These are important terms that deserve to be introduced in defence in earnest"
Efficiency, Responsiveness	Yes (Qualified majority, >2/3)	Yes (Consensus)	"Options such as these are essential in defence SCD". "Can be difficult to realise the flexibility that is required to be efficient in peace and responsive in war. If we can define differentiated SCs for different supply segments, which are suitable for both states and usable in operational planning and for peace-time storage, these strategies could be appropriate for defence SCs". "Efficiency may be prevailing for routine supplies, but responsiveness should apply for our more important supplies"
ETO, BTO, MTO, ATO, PTO, STO, MTS	Yes (Majority)	Yes (Consensus)	"It could be advantageous to postpone certain manufacturing activities for some supplies". "Military SCs must be dynamic, flexible and adaptable. A combination of different strategies is appropriate"
Functional, Innovative products	Yes (Qualified majority, >2/3)	Yes (Consensus)	"Provides a rationale for which choices that can, and must, be made". "Not in a military SC". "Difficult to sort out which supply that belongs to which category, since this may change in different phases"

(continued)

Table 4.
Results from the
Delphi study

Table 4.

Commercial SCD constructs	Acceptable and applicable?		Examples of panellists' Comments in Delphi rounds 1 and 2
	Delphi round 3	Workshops	
Lean, Agile	Yes (Qualified majority, >2/3)	Yes (Consensus)	"Yes, but not puritanically implement one strategy for the entire SC. For resupplying at the strategic and operational levels, lean may be appropriate, but closer to the military units, agile is probably more suitable". "Depends on where you are in the SC". "Modern terminology in a traditional context, but, yes"
Manufacturing postponement, Full postponement, Full speculation, Logistics postponement	No (Majority)	Yes (Consensus)	"They are all required to handle different products". "I am sceptic regarding the terminology, but I think that the strategies as such are useful". "New terminology for already existing military activities. It should be 'militarised' so that personnel in the SwAF understand"
Postponement, Speculation	Yes = No (Bipolarity)	Yes (Consensus)	"I guess the strategy as such is OK, but I am a bit sceptic regarding the term 'speculation'"
Predictability, Lead-time	Yes (Consensus)	Yes (Consensus)	"Essential for a well-functioning military logistics". "Enhances logistics planning activities". "I find it difficult to associate the presented concepts with the requirements of a defence SC". "The significance of these words in themselves points towards the conclusion that these are obvious dimensions to take into consideration"
Push, Pull	Yes (Consensus)	Yes (Consensus)	"They are both required, since consumption of some supplies can be calculated, whereas the demand for other supplies simply occurs". "Classical terms in the military". "Can be applied to different levels in the SC"
Risk-hedging, Agile, Efficient, Responsive	Yes (Consensus)	Yes (Consensus)	"Efficiency is subordinate in crises and war, but extremely important in peace for functional products". "The complexity of military logistics require many different SCSs that can work together". "My concern is that efficiency is allowed to supersede operational requirements on preparedness"

researchers should develop a CODP-based strategy continuum for defence SCD, as a strategy typology would not be sufficient.

4.3 Acceptable, applicable and sufficient defence supply chain strategies

The panellists concluded that the SCSs in [Table 2](#) are acceptable and applicable in defence SCD. Accordingly, a spectrum of seven CODP-based SCSs are available to ensure that supply meets demand. However, not all SCSs are applicable for all operational requirements. In addition, they are not sufficient. For these panellists, the importance of lead-time is paramount from an operational perspective. SCD must position the CODP so that the expected lead-time from order to delivery is within the operational requirements' limits. If defence authorities cannot accept the risk that suppliers fail to deliver on time, they must procure and store supplies in-house to guarantee the satisfaction of all operational requirements. This paper defines this alternative as pre-storage or procure-to-stock (PTS) and proposes eight SCSs that are acceptable, applicable and sufficient in defence SCD. The first seven SCSs use names from the literature, from a supplier's perspective. However, ETO, BTO, MTO, ATO, PTO, STO and MTS work equally well from a buyer's perspective, as buyers can contract suppliers to differentiate SCSs to satisfy their requirements. ETO is applicable for capability development (CAPDEV), which involves the development of new, technically advanced systems but not for operational requirements. Depending on lead-time, BTO, MTO, ATO, PTO, STO and MTS may be expedient to satisfy some operational requirements but not all. PTS is applicable for all operational requirements and may be necessary to satisfy immediate availability and preparedness and to ensure sustainability until industry commences delivering replacement supplies. However, in addition to costs for procurement, operations, maintenance, infrastructure, distribution and personnel, PTS involves risk-taking regarding depreciation and obsolescence and should be used restrictively. To minimise lead-times, defence authorities should combine PTS with pre-positioning, close to planned locations for activation and mobilisation for supplies required for immediate availability and preparedness and close to envisioned areas of operations for supplies required for sustainability. [Table 5](#) matches CAPDEV and the SwAF's operational requirements with the proposed SCSs.

The lead-time from order to delivery for military-specific supplies ranges from hours to years, depending on supply class and SCS. The point in time at which the SwAF require replacement supplies depends on consumption patterns, which in turn depend on time, activity, chance or a combination. Consequently, [Table 5](#) is illustrative not prescriptive. It is not a decision-making tool but serves as an illustration of which SCS that may be applicable. Prior to any decisions, defence authorities must analyse the different supply classes and, in some cases, individual supply items, to determine applicable SCSs, for each operational requirement. For a specific supply item, a combination of SCSs will probably be required to satisfy all requirements. In addition to matches and mismatches, which are certainties, [Table 5](#) includes potential matches, which are uncertainties. Potential matches illustrate that a certain combination of operational requirement and SCS may be a match, depending on lead-time and consumption pattern.

5. Discussion

The purpose of this paper is to explain the constructs of SCSs that satisfy military operational requirements and to propose SCSs that are appropriate in defence. *RQ1* asks how acceptable, applicable and sufficient commercial SCD constructs, such as external contingencies, competitive priorities and SCSs, are in defence. The study concludes that all investigated constructs are acceptable and applicable but not sufficient. Even if the

Table 5.
Operational
requirements versus
proposed supply
chain strategies

Operational requirements	Proposed supply chain strategies							
	ETO	BTO	MTO	ATO	PTO	STO	MTF	PTS
CAPDEV	Match	Match	Match	Match	Match	Match	Match	Match
Availability immediately	Mismatch	Mismatch	Mismatch	Mismatch	Potential match	Potential match	Potential match	Match
Availability within three months	Mismatch	Potential match	Potential match	Match	Match	Match	Match	Match
Availability within six months	Mismatch	Potential match	Potential match	Match	Match	Match	Match	Match
Preparedness (mobilisation within hours)	Mismatch	Mismatch	Mismatch	Mismatch	Potential match	Potential match	Potential match	Match
Preparedness (mobilisation within days)	Mismatch	Mismatch	Mismatch	Mismatch	Potential match	Potential match	Potential match	Match
Preparedness (mobilisation within one week)	Mismatch	Mismatch	Potential match	Potential match	Potential match	Potential match	Potential match	Match
Sustainability	Mismatch	Potential match	Potential match	Potential match	Match	Match	Match	Match

constructs are acceptable and applicable, the findings indicate that in defence, operational requirements have different implications for competitive priorities in peace, mobilisation and war. Aitken *et al.* (2005) suggest that market-qualifying and order-winning characteristics may change as a function of the product life cycle. The findings indicate that a better distinction in defence SCD is between peace, mobilisation and war. To satisfy requirements on availability and preparedness, quality, lead-time, flexibility and dependability are market qualifiers, but the cost is the likely order-winner, which means that SCs should be lean (Aitken *et al.*, 2005; Kovács and Tatham, 2009). For sustainability, lead-time is all-important or the order-winner. In such cases, SCD should position the CODP based on which lead-time that is acceptable to the customer (Naylor *et al.*, 1999), which is likely to be close to the final goods inventory (Olhager, 2003), and the SC should be agile (Aitken *et al.*, 2005; Kovács and Tatham, 2009). Basnet and Seuring (2016) conclude that demand variability/uncertainty, product variety, desired customer lead-time and supply uncertainty/risk represent the essential contingencies in SCD. The findings indicate that in defence, the values will change between peace, mobilisation and war. Demand variability/uncertainty will go from low to high, desired customer lead-time will go from subordinate to cost, to all-important, and supply uncertainty/risk will increase in war. Defence SCD must consider these unique issues when selecting appropriate SCSs. This dynamic epitomises the defence SCD-dilemma, which companies and authorities must resolve. Lean and efficient in peace and agile and effective in war.

RQ2 asks which SCSs satisfy defence authorities' operational requirements. In line with Hilletofth (2012) and Basnet and Seuring (2016), the panellists find strategy typologies too simplistic for their requirements and determine that defence authorities must develop a strategy continuum, based on CODP-positioning. This paper proposes eight SCSs that are acceptable, applicable and sufficient for defence SCD. Seven are in line with suggestions in the literature, such as Yang *et al.* (2004). The eighth is a complement, as SCs may not always be able to satisfy operational requirements, in which case defence authorities must pre-store supplies, using the PTS strategy. The answer to which SCS to select, or at what point in the defence SC the CODP delivers the maximum advantage (Boone *et al.*, 2007), is that it depends. Armed forces require various supply classes, including market-generic and military-specific, with lead-times ranging from hours to years. In addition, consumption patterns depend on time, activity, chance or a combination, which means that for some supply classes, demand is unpredictable. Depending on supply class and which operational requirement that is to be satisfied, different SCSs will be applicable. This means that a dynamic application of SCSs is required in defence SCD. Contrary to most commercial SCs, for a particular supply item, it is likely that several SCSs are required to satisfy the different operational requirements. PTS satisfies all operational requirements but is costly and associated with financial and technical risk-taking. Defence authorities must thus identify the optimal mix of SCSs, which satisfies operational requirements at minimum cost and technical risk, without unwarranted operational risk-taking. To select appropriate SCSs, defence authorities' will require a segmentation model, which classifies supplies based on operational requirements.

For every SCS proposed in this paper, variants are possible. An SCS is a configuration of decisions regarding sourcing, capacities, manufacturing and distribution (Hilletofth, 2009). The eight SCSs position the CODP at various points in the SC, thus postponing different process-related decisions, but there are other issues to consider. These include customisation/standardisation of products, centralisation/decentralisation of production, globalisation/localisation of sourcing, storage and distribution, strategic inventories other than at the CODP, strategic capacity positioning, transportation modes and SC relationships

(Yang *et al.*, 2004; MacCarthy *et al.*, 2016). Defence authorities can complement the eight SCSs by contracting suppliers to reduce lead-times, with measures such as storing raw materials, components or sub-systems, decentralising production, localising sourcing, storage and distribution and/or increasing capacities. Such measures must also be included in the analysis required to identify the optimal mix of SCSs for all supply classes and all operational requirements. In addition, defence authorities can use performance-based logistics (PBL) to contract suppliers to deliver availability of supplies rather than traditional, transaction-based contracts.

6. Conclusions, implications and further research

6.1 Conclusions

To explain the constructs of SCSs that satisfy operational requirements, this paper investigates the acceptability, applicability and sufficiency of commercial SCD constructs in the Swedish defence and concludes that they are acceptable and applicable but not sufficient. The findings indicate that defence authorities prefer strategy continuums to typologies, as continuums are better suited to meet their requirements. Furthermore, an additional SCS is required. As well as proposing seven strategies from the literature (Yang *et al.*, 2004), this paper proposes a complementary strategy for pre-storage, procure-to-stock (PTS).

6.2 Implications

The results presented in this paper have implications for managers in companies and defence authorities. For companies, this paper emphasises that defence authorities' operational requirements are different in peace, mobilisation and war and that they can develop SCSs accordingly. For defence authorities, it exemplifies how they should formulate their unique SCD issues and articulate their requirements on SCD. PTS is a match for all operational requirements but unaffordable to implement as the only SCS and associated with financial and technical risk-taking. Defence authorities should use it restrictively, when it is required to avoid operational risk-taking.

6.3 Future research

This paper proposes eight generic SCSs that are acceptable, applicable and sufficient in defence SCD but does not answer the question when to use which strategy. SCSs are one element of purchasing portfolio models (PPMs), where the others are a segmentation model and guidance for management decisions. This paper suggests that future research completes a PPM for defence procurement by developing the remaining elements. It would also be interesting with further research regarding variants of the generic strategies, such as PBL.

Researchers such as Mason-Jones *et al.* (2000b) and Aitken *et al.* (2005) have explored the concept of market-qualifiers and order-winners in the private sector, where commercial outcomes are important. It would be interesting to explore these concepts in the public sector, where operational outcomes are the focus. The results from this study indicate that in defence, there may be different sets of market-qualifiers and order-winners for peace, mobilisation and war, and it would be of interest to do further research on this topic.

Glas (2017) discusses the issues of the preferred customer, customer attractiveness and preferential treatment of military customers in peace. This paper suggests that defence SCD must take into consideration that suitable competitive priorities, and hence SCSs, are different in peace, mobilisation and war. It would be interesting to investigate preferential

treatment in higher levels of conflict and preparedness, when military customers may stand against each other, and any consequences that this may have for SCD.

The results presented in this paper comes from a Delphi study in the Swedish defence. To determine generalisability, additional studies are required. This paper suggests that researchers conduct studies with other methods and stakeholders, in other contexts, including different national perspectives. In particular, this paper invites researchers to explore the validity of the eight proposed SCSs in other defence settings.

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