JÖNKÖPING UNIVERSITY
School of Engineering

Doctoral Thesis

Segmentation and Differentiation in Defence Supply Chain Design

– A Dynamic Purchasing Portfolio Model for Defence Procurement

Thomas Ekström

Jönköping University
School of Engineering
Dissertation Series No. 058 • 2020

JÖNKÖPING UNIVERSITY
School of Engineering

Doctoral Thesis

Segmentation and Differentiation in Defence Supply Chain Design

– A Dynamic Purchasing Portfolio Model for Defence Procurement

Thomas Ekström

Jönköping University
School of Engineering
Dissertation Series No. 058 • 2020

Doctoral Thesis in Production Systems

Segmentation and Differentiation in Defence Supply Chain Design
– A Dynamic Purchasing Portfolio Model for Defence Procurement
Dissertation Series No. 058

Published by
School of Engineering, Jönköping University
P.O. Box 1026
SE-551 11 Jönköping
Tel. +46 36 10 10 00
www.ju.se

Printed by Stema Specialtryck AB, year 2020

Trycksak
3041 0234

ISBN 978-91-87289-62-0

Acknowledgements

This dissertation marks the completion of a two-stage PhD-project. In the licentiate thesis (Ekström, 2012), I mentioned everybody who supported me during the first stage. You remain in my thoughts and you have my gratitude. These acknowledgments relate to the second stage.

I would like to thank my three supervisors, Professor Per Hilletofth, Professor Alastair Finlan (Swedish Defence University) and Dr Per Skoglund (Swedish Defence University). Without you, I could not have made this voyage into the unknown. It has been stimulating, enlightening, challenging and arduous.

I also take this opportunity to extend my gratitude to my friend and colleague, Per Skoglund, who made it possible to resume my educational journey. After my licentiate thesis, I thought that I had reached the final destination of my academic expedition, but here I am, at a new terminus. Thank you Per!

I am grateful to Professor Lauri Ojala (University of Turku, Finland) for making the dreaded final seminar an enjoyable discussion about my research and the structure and content of the dissertation. Thank you for the relaxed atmosphere you created, and for your constructive comments and suggestions.

This research would not have been possible without the participation of twenty experts from the Swedish Armed Forces, the Swedish Defence Materiel Administration (FMV), the Swedish Defence Research Agency (FOI) and the Swedish Defence University (SEDU). You have my heartfelt appreciation.

I acknowledge that the support of the Swedish Armed Forces, FMV and SEDU was a prerequisite of conducting this research. However, I would also like to emphasise that these organisations had no role in study design or in the collection, analysis or interpretation of data.

The anonymous reviewers of the appended papers provided me with several valuable insights. I learnt about the review process and used their comments and suggestions to improve the quality of the papers. I have also incorporated some of their ideas into the dissertation. Thank you very much!

As an industrial PhD candidate, I did not spend much time at the Department of Supply Chain & Operations Management at JTH. Nevertheless, I would like to thank my fellow PhD candidates in Jönköping for making me feel welcome on the few occasions that our paths crossed during PhD courses.

"No man is an island, entire of itself" (Donne, 1959). In addition to those now mentioned, many more helped me along the way. I thank you all for providing me with support and encouragement. A kind and positive word here and there makes a tremendous difference. Especially towards the end of the process.

Last, but not least, I would like to thank my family. Without the patience, understanding and support of my wife, Ulrika, and my children, Emelie, Carl, Alexander, Vilhelm and Josephine, this endeavour would have been a futile attempt at success. I am beholden to you. I also promise not to do it again.

While it may be true, as Karin Boye wrote, *"there is goal and meaning in our path - but it's the way that is the labour's worth"* (McDuff, 1994), I must confess that I am truly happy, bordering on exhilarated, to have left the way and reached my goal. Whatever the future may hold today is a good day.

Consummatum est. Forsan et haec olim meminisse iuvabit.

Roslagen, 2020-11-07

Thomas Ekström

Abstract

An important priority in the current Swedish Defence Bill is to increase the operational warfighting capability of the Swedish Armed Forces, which has implications for the defence supply chain. A recent study suggested that the Swedish Armed Forces should use segmentation of supplies and differentiation of supply chains to enable an affordable supply chain design (SCD). This raises questions regarding which segmentation model and which supply chain strategies (SCSs) the Swedish Armed Forces should use.

The purpose of this research is to design and develop a purchasing portfolio model (PPM) for defence procurement, which will be of practical use for defence authorities. The author defines a PPM as consisting of a segmentation model, tactical levers, differentiation strategies and guidance for management decisions. The research builds on a Delphi study with twenty experts from Swedish defence authorities. It addresses the operational requirements on readiness and sustainability that must be satisfied, as well as research gaps and open issues in the literature regarding PPM design and application.

The findings include several novelties. The author proposes a dynamic PPM, including an innovative two-stage segmentation model, with a precursor and a two-dimensional model. The latter merges sixteen elements into one square and three other segments. Another originality is that the PPM is *both* prescriptive *and* serves as a catalyst for in-depth discussions. The author also develops guidance for management decisions, including twelve tactical levers, and eight SCSs to differentiate treatment of the supply segments.

The research contributes to theory by combining constructs from the purchasing and supply management (PSM) literature and supply chain management (SCM) literature, and applying them in the context of military logistics, including defence procurement. It contributes to practice by developing a PPM that is relevant to practitioners in defence procurement and satisfies the operational requirements of the Swedish Armed Forces. It also contributes to methodology by investigating how researchers can use two panels in Delphi studies to enhance research validity.

Keywords: purchasing portfolio model, segmentation and differentiation, segmentation model, supply chain strategy, military logistics, defence procurement, defence supply chain design, modified Delphi study.

Sammanfattning

Att öka den operativa krigföringsförmågan har hög prioritet i den nuvarande försvarspolitiska inriktningen, vilket har implikationer för militära försörjningskedjor. I en färsk studie rekommenderas Försvarsmakten att utnyttja segmentering av förnödenheter och differentiering av försörjningskedjor för att möjliggöra utformning av försörjningskedjor till ett överkomligt pris. Detta föranleder frågor avseende vilken segmenteringsmodell och vilka försörjningsstrategier som Försvarsmakten bör använda.

Syftet med denna avhandling är att utforma och utveckla en portföljmodell för försvarsanskaffning som är praktiskt användbar för försvarsmyndigheter. Enligt författarens definition inkluderar portföljmodellen en segmenteringsmodell, taktiska hävstänger, differentieringsstrategier och vägledning för ledningsbeslut. Forskningen bygger på en Delphistudie med tjugo experter från försvarsmyndigheterna. Studien hanterar de operativa kraven på tillgänglighet, beredskap och uthållighet, samt forskningsgap och öppna frågor i litteraturen avseende utformning och användning av en sådan modell.

Resultaten innefattar flera nyheter. Författaren förslår en dynamisk portföljmodell för försvarsanskaffning, inklusive en segmenteringsmodell i två steg, ett försteg och en tvådimensionell modell. Den senare slår samman sexton element till ett kvadratiskt och tre andra segment. En annan originalitet är att portföljmodellen är både preskriptiv och en katalysator för djuplodande diskussioner. Författaren utvecklar också vägledning för ledningsbeslut, inklusive tolv taktiska hävstänger och åtta differentieringsstrategier.

Forskningen bidrar till teorin genom att kombinera koncept från inköps- och affärslogistiklitteraturen, samt applicera dessa i den militära logistik- och försvarsanskaffningskontexten. Den bidrar till praktiken genom att utveckla en portföljmodell som är relevant för praktiker inom försvarsanskaffning och tillfredsställer Försvarsmaktens operativa krav. Den bidrar också till metodutveckling genom att undersöka hur forskare kan utnyttja två paneler i Delphistudier för att förbättra forskningens validitet.

Nyckelord: portföljmodell, segmentering och differentiering, segmenteringsmodell, försörjningsstrategi, militär logistik, försvarsanskaffning, utformning av militära försörjningskedjor, modifierad Delphistudie.

List of appended papers

Paper 1

Towards a purchasing portfolio model for defence procurement – A Delphi study of Swedish defence authorities

Thomas Ekström, Per Hilletofth & Per Skoglund

Work distribution: Ekström, Hilletofth and Skoglund initiated the paper. Ekström conducted literature reviews. Ekström designed the study, with the support of Hilletofth and Skoglund. Ekström collected the data. Ekström analysed the data, with the support of Hilletofth and Skoglund. Ekström wrote the paper, with the support of Hilletofth and Skoglund.

Paper 2

Differentiation strategies for defence supply chain design

Thomas Ekström, Per Hilletofth & Per Skoglund

Work distribution: Ekström, Hilletofth and Skoglund initiated the paper. Ekström conducted literature reviews. Ekström designed the study, with the support of Hilletofth and Skoglund. Ekström collected the data. Ekström analysed the data, with the support of Hilletofth and Skoglund. Ekström wrote the paper, with the support of Hilletofth and Skoglund.

Paper 3

Guidance for management decisions in the application of a dynamic purchasing portfolio model for defence procurement

Thomas Ekström, Per Hilletofth & Per Skoglund

Work distribution: Ekström, Hilletofth and Skoglund initiated the paper. Ekström conducted literature reviews. Ekström designed the study, with the support of Hilletofth and Skoglund. Ekström collected the data. Ekström analysed the data, with the support of Hilletofth and Skoglund. Ekström wrote the paper, with the support of Hilletofth and Skoglund.

Paper 4

The Delphi Technique – Limitations and possibilities

Thomas Ekström

Work distribution: Ekström initiated the paper, conducted literature reviews, designed the study, collected and analysed the data and wrote the paper.

Table of content

List of figures

List of tables

List of abbreviations and acronyms

ATO: Assemble-to-order
AUS: Australia
BTO: Buy-to-order
CAPDEV: Capability development
CODP: Customer order decoupling point
DE&S: Defence Equipment & Support (UK MoD DPA)
DLO: Defence logistics organisation
DMO: Defence Materiel Organisation (AUS DoD DPA)
DoD: Department of Defense (AUS, US)
DPA: Defence procurement agency
ECTS: European Credit Transfer System
ETO: Engineer-to-order
EU: European Union
FMV: Försvarets Materielverk (SE Defence Materiel Administration) (SE DPA)
FOI: Totalförsvarets Forskningsinstitut (SE Defence Research Agency)
IPT: Integrated project team
JFC: Joint Forces Command (SE Armed Forces' Headquarters)
JTH: Jönköpings Tekniska Högskola (Jönköping University, School of Engineering)
MoD: Ministry of Defence (SE, UK)
MTF: Make-to-forecast (same as MTS)
MTO: Make-to-order
MTS: Make-to-stock (same as MTF)
NATO: North Atlantic Treaty Organisation
NPM: New public management
OPP: Order penetration point
PPM: Purchasing portfolio model
PSM: Purchasing and supply management
PTO: Packaging/labelling-to-order
PTS: Procure-to-stock
RQ: Research question
SCD: Supply chain design
SCM: Supply chain management
SCRM: Supply chain risk management

SCS:	Supply chain strategy
SE:	Sweden / Swedish
SEDU:	Swedish Defence University
SIPRI:	Stockholm International Peace Research Institute
SPA:	Sourcing portfolio analysis
STO:	Shipment-to-order
STS:	Ship-to-stock
TPS:	Training and Procurement Staff (SE Armed Forces' Headquarters)
UK:	United Kingdom
US:	United States

1. Introduction

The first chapter introduces the reader to a practical research problem (Section 1.1), the research context and system in focus (1.2), the status of knowledge in three relevant research fields (Section 1.3) and the purpose and research questions of the presented research (Section 1.4). It also clarifies the scope and delimitations of the research (Section 1.5). In addition, it guides the reader regarding the abbreviations, acronyms and definitions used in the dissertation (Section 1.6) and outlines the dissertation (Section 1.7).

The following quote intends to illuminate the quandary that the dissertation seeks to address.

> *"Many of the requirements for organisations and personnel that are herein stated as necessary to logistic effectiveness and efficiency in wartime may be considered to be too costly for our peacetime establishment. This is a matter in which official opinion and decisions will vary in accordance with the degree of apprehension to our national security which may exist at any particular time. Regardless of what the decisions may be it is still important that the military professional have a clear idea of the manner in which various deficiencies affect our combat strength. In particular, the professional should not fall a victim to the facile assumption that combat strength can be increased by the simple expedient of arbitrary reductions in logistics forces. There is an important distinction between the rigorous elimination of waste or unwarranted luxury, and the mirage of false economy. The first is merely the application of a strict logistic discipline. The second is the delusion based upon a failure to understand the nature and magnitude of the logistic base on which the combat forces must rest before they can begin to fight. High military commanders may be called upon to accept many arbitrary and unsound political decisions but they themselves must not fall into the trap of self-deception".*
>
> *Eccles (1959, pp. 320-321)*

This insightful declaration by Henry Effingham Eccles, who was a Rear Admiral in the United States (US) Navy, eloquently sets the scene for the reported research. The current pandemic further highlights the dilemma. How much of the society's resources are governments prepared to allocate to preparedness against disruptions such as war, terrorism, natural disasters and

pandemics? In light of most nations' inabilities to meet the requirements of the Covid-19 pandemic satisfactorily, the answers in many countries probably is "not enough". The fact that the Swedish Government (2020) recently commissioned FOI, the Swedish Defence Research Agency (DRA), to analyse the national supply preparedness, underpins the importance and timeliness of the research reported in this dissertation.

Collective preparedness in societies is similar to insurance policies for individuals and companies. Individuals, companies and governments must weigh costs for insurance, or preparedness, against risks, where the latter includes both the probability of occurrence of contingencies and the potential impacts of such eventualities. This research addresses a significant portion of the national preparedness, which is the logistical element of military preparedness (Section 2.6.1), and deals specifically with how segmentation of supplies and differentiation of supply chain strategies can play an instrumental part in the creation of military preparedness and, ultimately, operational capability (Section 2.6.1).

1.1. Research background

As stated by Eccles (1959, pp. 320-321), in peace-time military logistics there is an intricate balancing act that must be performed to remain on the right side of justifiable cost-efficiency initiatives and undiscriminating cost-reduction undertakings. This balancing act has become even more complex in recent years, with the introduction of private sector approaches, resources and services into military logistics, to enhance efficiency.

> *"The defence procurement and logistic environment is now more commercial. Commercial approaches, particularly the purchase of services, may work well in a benign (home base) environment. However, when on deployed operations, whilst there is a business imperative for the purchase of services or more accurately services providers, there are also operational imperatives that cannot be compromised. This requires careful balancing of the risk of failure against the benefits of the use of service providers."*
>
> *Moore (2000, p. 947)*

Dr David Moore, previously the Director of the Centre for Defence Acquisition at Cranfield University in the United Kingdom (UK), elucidates

that, at the end of the day, operational risk-taking stands against the potential benefits of private sector involvement (Moore, 2000, p. 947).

During the Cold War, governments in the West considered the military threat to be high, and many countries accordingly had national defence forces standing in preparedness for a third World War. Like many of its counterparts, the Swedish defence logistics system of the Cold War pre-stored supplies in sufficient volumes and quantities to meet the operational requirements (Section 2.6.1). These systems were characterised by "Just-in-Case" (Cusick and Pipp, 1997), which means that they used strategies similar to contemporary commercial supply chain strategies (SCSs) such as speculation (Pagh and Cooper, 1998), responsiveness (Fisher, 1997; Lee, 2002), agility (Lee, 2002; Christopher *et al*., 2006) and resiliency (Christopher and Peck, 2004).

The Swedish Armed Forces dispersed and prepositioned much of its pre-stored supplies in or near envisioned areas of operations to minimise the requirements on distribution in higher levels of preparedness and conflict, and thus further meet the operational requirements. The catchwords of the day were preparedness and self-sufficiency, and the storage principle was dispersion of supplies. Legislation, supplemented with commercial contracts, governed the relations between the defence authorities and the private sector suppliers, which largely were domestic. In accordance with law, the government could enforce particularly important private sector suppliers to continue to deliver goods and services to the Swedish Armed Forces in higher levels of preparedness. The defence logistics system of the Cold War shared characteristics with the agile paradigm, as described by Naylor *et al*. (1999).

After the Cold War, the military threat was considered to be nigh on non-existent, and many Western governments, including Sweden, directly or indirectly capitalised on the peace dividend (Humphries and Wilding, 2001), downsized the defence forces, transformed them into expeditionary forces, and deployed them on peace support operations. Between 1990 and 2010, the Swedish defence logistics system was to an ever-increasing extent managed in accordance with the principles of new public management (NPM).

NPM involves increasing competition, utilising private sector management practices, striving to reduce costs, and enhancing standards of performance (Hood, 1995). The logistics system was accordingly characterised by the implementation of Japanese production philosophies, such as Just-in-Time,

using strategies similar to commercial SCSs such as postponement (Pagh and Cooper, 1998), efficiency (Fisher, 1997; Lee, 2002) and lean (Christopher *et al.*, 2006). In addition, as investigated by Ekström (2012), governments explored and implemented new public private business models (Grimsey and Lewis, 2004, p. 54), such as public private partnerships (Parker and Hartley, 2003) and outsourcing (Dickens Johnson, 2008) to enhance efficiency even further in the public defence sector. Capitalisation of the peace dividend (Humphries and Wilding, 2001) was at the centre of political attention, and the principle for storage was accordingly centralisation.

The political rhetoric embraced expressions such as "doing more with less" and "faster, cheaper, better", which can be interpreted as the implementation of six sigma and/or lean management approaches (Christopher, 2000; Stock *et al.*, 2010). As one of the consequences of NPM in Sweden, commercial contracts governed the relations between the defence authorities and the private sector suppliers, even if the legislation from the Cold War was still in existence, and the government can to this day enforce it in higher levels of preparedness. The defence logistics system of the Post-Cold War era shared characteristics with the lean paradigm, as described by Naylor *et al.* (1999).

Presently, the Swedish Armed Forces experiences yet another transformation, because of a renewed political interest in national defence. After the disquieting developments in Russia, Georgia and Ukraine in recent years, the Swedish political assessment is that there is a tangible military threat, and the government is consequently transforming its defence forces once more.

The most important priority in the current Swedish Defence Bill is to increase the operational warfighting capability of the Swedish Armed Forces and to ensure the collective force of the Swedish Total Defence (Swedish MoD, 2015, p. 1), which has a significant impact on the logistics system. The Swedish Armed Forces must consequently re-design its logistics system to support an increased level of ambition regarding the operational warfighting capability, by meeting intensified operational requirements on readiness (Section 2.6.1) and sustainability (Section 1.6 and Section 2.6.1). The lean paradigm is not responsive and resilient enough in times of war. However, the agile paradigm is not affordable in times of peace. So, how should the Swedish Armed Forces design an affordable logistics system that meets the operational requirements, in peace as well as in war?

The challenges facing defence authorities have parallels in the private sector: the cost versus control dilemma in outsourcing, requirements for resilience, and reduced product life cycles (Yoho *et al.*, 2013). However, defence authorities are cost minimising, not profit-maximising (Wilhite *et al.*, 2014), and military logistics supports armed forces to achieve operational outcomes, not financial outcomes (Yoho *et al.*, 2013), possibly in a hostile environment, where supply chains are likely targets (Glas *et al.*, 2013).

A study by FMV (2016), the Swedish Defence Materiel Administration (Defence Procurement Agency, DPA), recommended the Swedish Armed Forces to develop differentiated SCSs, based on operational requirements. The rationale is that if operational requirements are not satisfied in supply chain design (SCD), this may cause substantial time-delays for military-specific supplies, with significant operational consequences. The study also suggested using the logistics principle of segmentation and differentiation (Norrman and Henkow, 2014), which involves classification of supplies into homogenous segments, and deciding on appropriate SCSs for each segment. Considering that purchasing portfolio models (PPMs) provide differentiated strategies for diverse product segments (Turnbull, 1990), they may be useful also in defence procurement (purchasing). However, Luzzini *et al.* (2012) state that the overarching framework must be tailored to include domain-specific content.

If defence authorities are going to differentiate supply chains based on segmentation, they require an appropriate segmentation model. The question is which one. An existing model, with or without adaptations, or a newly developed one? The defence authorities also require suitable differentiation strategies to connect to the various segments in the model. Another question is therefore if the commercial SCSs proposed in the literature are suitable also in the public defence sector. Finally, to decide on differentiation of supply chains based on segmentation of supplies, the defence authorities also require an appropriate methodology. This research addresses these questions and seeks to establish suitable answers.

A recent Swedish Government Inquiry proposed that the public and private defence sectors must introduce new forms of long-term cooperation to prepare Sweden for war (Swedish MoD, 2019, p. 14). This is consistent with an underlying assumption of this research, which is that one way of finding affordable supply chain solutions that satisfy operational requirements is to involve the defence industry in the design and operation of defence supply

chains. However, in line with the cautions provided by Eccles (1959, pp. 320-321) and Moore (2000, p. 947), such solutions must include a balance between operational risk-taking and economic efficiency. In addition, as clearly stated by the current Swedish Defence Bill, increasing the operational warfighting capability of the Swedish Armed Forces is presently the most important priority (Swedish MoD, 2015, p. 1), which should give capability supremacy compared to efficiency, and preclude operational risk-taking. However, as of yet, the politicians have been reluctant to match the increased ambition regarding defence with appropriately increased defence budgets.

1.2. Research context and system in focus

The Swedish defence sector is the context for the research presented in this dissertation and the system in focus is a generic Swedish defence supply chain. This section describes the research context, the system in focus and provides definitions and explanations of the key concepts concerning the Swedish defence sector. These concepts are central to the presented research and used throughout the dissertation and the appended papers. Figure 1.1 illustrates the interrelatedness of these concepts.

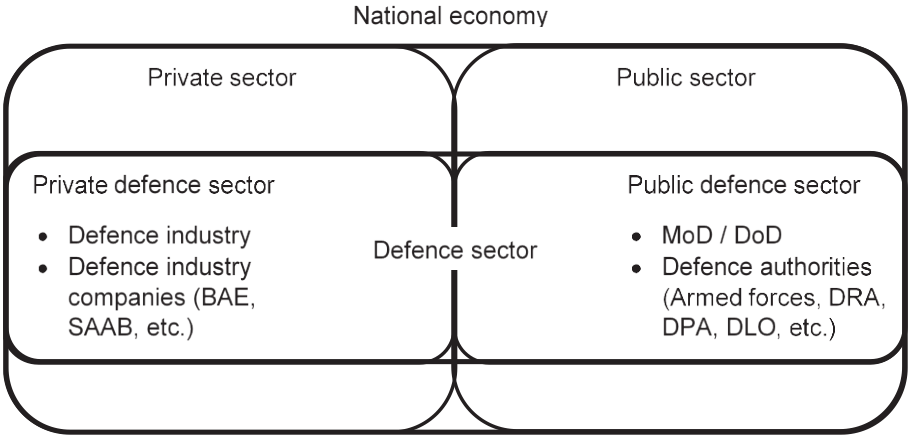


Figure 1.1: Decomposition of the national economy into private, public and defence sector.

The Swedish defence sector is characterised by a small country perspective, non-alignment, neutrality, advanced domestic defence industry and the

interdependency of the private and public defence sectors. Because of the Swedish century-long history of non-alignment in peace and neutrality in war, the Swedish defence industry has a long tradition of developing advanced equipment, including fighter aircraft, combat vehicles and submarines, to the Swedish defence. Laws and regulations severely restrict the Swedish defence industry's opportunities to export, which reinforces its dependency on the domestic market.

Deregulations, mergers and acquisitions, globalisation, and reductions in defence expenditure have changed the Swedish defence industry landscape over the past few decades. First, the government privatised government-owned defence equipment manufacturers. Then mergers and acquisitions resulted in fewer and larger companies. Later, multinational conglomerates acquired several of these companies. Today, the defence industry in Sweden is thus a better label than the Swedish defence industry. British BAE and Swedish SAAB currently dominate the defence industry in Sweden.

After the ending of the Cold War, politicians gave national defence and having a domestic defence industry a low priority. Prime Minister Fredrik Reinfeldt manifested the political disinterest in 2013, when he referred to defence (of Sweden) as an *"area of special interest"* (to the Swedish Armed Forces), rather than of general interest to the nation (Reinfeldt, 2013). Since 2015, with the current Defence Bill, this perspective on matters of national defence is rapidly changing. Defence budgets are increasing and the importance of having a domestic defence industry is not only realised, but also emphasised.

Nations organise their public defence sectors differently. In Sweden, the Armed Forces, FOI and FMV are independent authorities under the Swedish Ministry of Defence (SE MoD), whereas FMLOG, the Swedish defence logistics organisation (DLO), is part of the Armed Forces. In for instance the UK, the corresponding organisations are all parts of the UK MoD. Laws and regulations, such as the Swedish law regarding public procurement, restrict the activities of the defence authorities, particularly in defence procurement.

Figure 1.2 depicts a generic Swedish defence supply chain, which is the system in focus for the research presented in this dissertation. FMV is responsible for acquiring major equipment (Class VII, Table 2.2), and the Swedish Armed Forces Headquarters (SwAF HQ) is responsible for acquiring all other supplies. Industry produces, and, depending on buyer and contract, delivers supplies to FMV, FMLOG, or directly to military units, via a

handover point. Industry includes both the defence industry, which provides military-specific supplies, and other industries, which provide market-generic supplies. In peace, FMV, FMLOG, or industry, deliver supplies to permanent bases to ensure readiness. In war, they deliver replacement supplies to temporary bases, or areas of operations, to ensure sustainability.

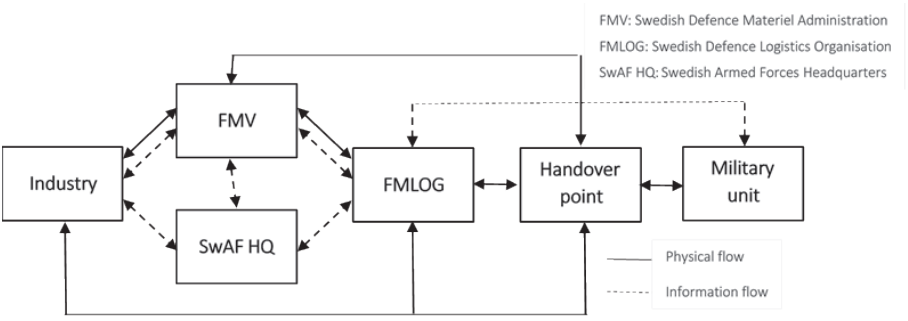


Figure 1.2: System in focus – A generic Swedish defence supply chain (Ekström, 2020a).

This dissertation uses the following terms with the presented explanations:

Defence authority: Independent authority under a nation's Ministry of Defence (MoD). Examples include Armed Forces, and supporting agencies such as DRAs, DPAs and DLOs.

Defence industry: The sum of all private sector organisations that entirely, or primarily, produce military-specific supplies and support to the public defence sector. The defence industry is characterised by its dependency on the domestic public defence sector, both for developing new systems and for providing an initial market.

Defence sector: That part of the national economy, which consists of the private defence sector and the public defence sector.

Private defence sector: That part of the private sector, which consists of organisations that entirely, or primarily, produce military-specific supplies and support to the public defence sector.

Private sector: That part of the national economy, which consists of organisations that individuals and companies own and operate, to provide profit to its owners.

Public defence sector: That part of the public sector, which consists of organisations that the Government owns and operates, to provide defence and security to its citizens.

Public sector: That part of the national economy, which consists of organisations that the Government owns and operates, to provide public goods, services and infrastructure to its citizens.

To some extent, the decomposition presented in Figure 1.1 and explained in this section is a simplification of a more multifaceted reality. Deviations from these explanations include cases where governments own business operations that sell goods and services, for profit, in the marketplace. In some countries, but not in Sweden, this includes defence industry companies, which produce and market military equipment. Moreover, taxpayers finance privately owned companies, such as schools, hospitals and prisons, to deliver public goods and services. Nevertheless, the dissertation uses the presented explanations, since the author deem them sufficient for the presented research.

1.3. Research motivation

> *"Successful problem solving requires finding the right solution to the right problem. We fail more often because we solve the wrong problem, than because we get the wrong solution to the right problem."*
>
> *Russell Ackoff (1974, p. 8)*

The above quote by Dr Russell Ackoff, a pioneer in the fields of operational research, systems thinking and management science, illustrates the importance of research relevance. Hence, problem formulation, which entails to structure the problem area and to produce the necessary insights to describe the research problem, is essential when formulating relevant research questions (RQs), to ensure research relevance, or to minimise the risk of a knowledge production problem, which is the problem of *"lost before translation"* (Shapiro *et al.,* 2007). Rosenhead (1989) defines problem structuring as *"the identification of those factors and issues which should constitute the agenda for further discussion and analysis"*.

1.3.1. Military logistics

While companies in the private sector exist to increase the wealth of their shareholders, making efficiency the default goal of SCD in the private sector (Basnet and Seuring, 2016), public sector organisations are not profit-maximising entities (Wilhite *et al.*, 2014). Defence authorities such as armed forces, DPAs and DLOs exist to generate, use and/or support military forces. Military logistics is about supporting the armed forces to achieve operational outcomes, not financial outcomes like in the private sector (Yoho *et al.*, 2013). Operational outcomes present unique SCD issues, which companies must consider (Melnyk *et al.*, 2014). Furthermore, in military logistics, catastrophic events are not disruptions, they are its *raison d'être* (Martel *et al.*, 2011).

In peace, military logistics must support military forces on training, exercises and other activities for force generation, whereas in war, military logistics must support the use of force on operations (Davids *et al.*, 2013). In such operations, "the first mile" is similar to business logistics, whereas the "last mile" is not, since the enemy may damage infrastructure and attack the supply chain (Glas *et al*., 2013). Defence supply chains must be able to work in both modes, peace and war, at different times, but it must also have the ability to switch between them at short notice (Sharma and Kulkarni, 2016), through activation (Section 2.6.1) and mobilisation (Section 2.6.1).

The customer requirements of the public defence sector are examples of the unique design issues that companies must consider when non-traditional outcomes are the objective of a supply chain (Melnyk *et al.*, 2014). While leanness and efficiency are important requirements on defence supply chains in peace, the overarching requirements in war are on agility and effectiveness (Kovács and Tatham, 2009). Companies in the defence industry should consequently design defence supply chains to serve two modes: peace and war. The question is which implications these unique SCD issues have for the formulation of SCSs in defence.

Functioning supply chains are required to support nations' defence and security. Considering that the total military expenditure in the world is estimated to US$1.8 trillion in 2018 (SIPRI, 2019), corresponding to 2.1% of the total gross domestic product in the world, research on defence SCSs is warranted. However, as of yet, studies on SCD in the defence sector are absent in the literature. Since military logistics represents more than half of nations'

defence budgets, this absence of research is unexpected and Yoho *et al.* (2013) consequently encourage more research in defence logistics in general, and, among other topics, especially call for more research in military supply network resiliency and management.

Rutner *et al*. (2012) regard the military logistics increased dependency on civilian logistics providers as an opportunity to benefit from a knowledge diffusion. In addition to this knowledge transfer between practitioners in logistics, a premise of this research is that military logistics may also have the opportunity to take advantage of research in purchasing and supply management (PSM), business logistics and supply chain management (SCM). Furthermore, Melnyk *et al.* (2014) specifically call for more research to identify the unique SCD features, as well as the underlying factors, in, for example, the defence sector.

1.3.2. Purchasing and supply management

The view on purchasing differ between the public and private sectors. In the public sector, decision-makers perceive defence procurement (purchasing) as a supporting function. In the private sector, purchasing has evolved into a strategic function (Persson and Håkansson, 2007), which can give competitive advantage (Chen *et al.*, 2004), since it enables high quality, large variation, low cost and fast delivery (Drake *et al.*, 2013).

A prerequisite of strategic purchasing is differentiated relationships with suppliers (Gelderman and van Weele, 2005), which necessitates classification (Lilliecreutz and Ydreskog, 1999). Strategic purchasing consequently requires segmentation and differentiation (Dyer *et al.*, 1998), and academics have developed PPMs, as well as numerous segmentation models, to classify supplies and select suitable supply chains (Hilletofth, 2009).

Kraljic (1983) introduced PPMs into PSM, and practitioners commonly use such models (Drake *et al.*, 2013). However, academics have raised two major concerns with extant models. The first concern entails a longstanding debate about developing such models (Ramsay, 1996; Olsen and Ellram, 1997; Nellore and Söderquist, 2000; Dubois and Pedersen, 2002; Gelderman and van Weele, 2005; Lovell *et al.*, 2005; Persson and Håkansson, 2007; Jarzabkowski and Kaplan, 2008; Cox, 2015; Rezaei *et al.*, 2015; Hesping and Schiele, 2016). One aspect of the appeal and success of PPMs is simplicity.

They are easy to understand and give practical guidelines (Dubois and Pedersen, 2002), but the simplicity has been a source of critique. PPMs have been criticised for having only two dimensions (Dubois and Pedersen, 2002; Lovell *et al.*, 2005; Rezaei *et al.*, 2015; Hesping and Schiele, 2016), selection of dimensions (Nellore and Söderquist, 2000), and for values of dimensions (Ramsay, 1996; Olsen and Ellram, 1997; Gelderman and van Weele, 2005).

PPMs have also suffered criticism regarding application. Researchers have discussed if PPMs should be prescriptive, or serve as catalysts for discussions among stakeholders (Gelderman and van Weele, 2003; Jarzabkowski and Kaplan, 2008) and if they should have segment-generic or purchase-specific strategies (Hesping and Schiele, 2015). Scholars also discuss strict or pragmatic application (Gelderman and van Weele, 2003; Hesping and Schiele, 2015), and static or dynamic application (Persson and Håkansson, 2007; Cox, 2015; Hesping and Schiele, 2015). There are consequently several open design and application issues regarding PPMs in the literature.

The second concern is regarding theory and practice, where researchers have noticed a discrepancy (Gelderman and van Weele, 2003; Krause *et al.*, 2009; Monczka *et al.*, 2011; Cox, 2015). Practitioners use strategies from adjoining segments, to move from a difficult position to a more favourable one (Gelderman and van Weele, 2003; Monczka *et al.*, 2011), and exchange dimensions, depending on the decision-situation (Krause *et al.*, 2009). Cox (2015) argues that the fault lies with theory.

What is required is a PPM that is theoretically sound and practically relevant. So how should academics develop such a model? Experienced practitioners stress that there is no simple blueprint for model application, and that it requires critical thinking and sophistication of the purchasing function (Gelderman and van Weele, 2005). This dissertation proposes that involvement of practitioners in model development, including the establishment of rules for design and application, would narrow the gap between development and application.

1.3.3. Supply chain management

The importance of SCSs in SCM is undisputed (Perez-Franco *et al.*, 2016) and the development of a successful SCS is critical to a company's competitive success (Narasimhan *et al.*, 2008). A SCS is a response to external

environment 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).

Supply chains 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). Companies should therefore customise SCSs to match the customers' requirements (Aitken *et al.*, 2003; Hilletofth, 2009). In a perfect world, SCD should begin with the customer and move backwards, rather than the traditional forwards from the manufacturer, but the enticement in SCD is to focus on efficiency rather than effectiveness (Christopher *et al.*, 2006).

Researchers have observed that modern supply chains are becoming increasingly complex (Purvis *et al.*, 2016), leaner, longer due to globalisation, and thus more vulnerable to disruptions (Christopher and Peck, 2004). Companies have enhanced supply chain efficiency through inventory reduction, outsourcing and global sourcing, which has led to increased vulnerability to demand variability, as well as to war, terrorism and natural disasters (Purvis *et al.*, 2016). Disruptions have demonstrated that this vulnerability has direct effects on a company's ability to continue operations and deliver products to its customers (Jüttner *et al.,* 2003).

The vulnerability to demand variability of efficiency-based, cost saving supply chains has prompted researchers to explore responsive supply chains, which are capable of reacting quickly and cost-effectively to changing market requirements (Gunasekaran *et al.*, 2008). The vulnerability to disruptions such as war, terrorism and natural disasters has instigated research in supply chain resilience, which is the ability of the supply chain to return to its original state, or move to a new, more desirable state after being disturbed (Christopher and Peck, 2004). Melnyk *et al*. (2010) suggest that future supply chains must deliver varying degrees of cost-related benefit, responsiveness, security, sustainability, resilience and innovation, depending on customers' requirements.

Customers ultimately determine the success or failure of supply chains (Mason-Jones *et al*., 2000a) and companies may have to sacrifice efficiency to satisfy their customers' requirements (Basnet and Seuring, 2016). However, how military customers' operational requirements should be satisfied in defence SCD has not been sufficiently researched (Yoho *et al*., 2013).

In the literature, many authors present the strategy decision-making situation as discrete choices and propose SCS typologies, such as efficient/responsive (Fisher, 1997), postponement/speculation (Pagh and Cooper, 1998) and lean/agile (Naylor *et al*., 1999). Other researchers have criticised such typologies 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) advocate hybrid solutions, or SCS continuums, using the customer order decoupling point (CODP) position as a demarcation between different SCSs.

Selection of an appropriate SCS is dependent on understanding the characteristics of product type, marketplace requirements and management challenges (Mason-Jones *et al.*, 2000a). SCD is consequently context sensitive (Melnyk *et al.*, 2014). To avoid sub-optimisation in the supply chain, Christopher *et al.* (2006) request holistic SCM, in which companies' overarching objectives drive supplier selection, facility localisation and distribution decisions.

Researchers have conducted studies to investigate appropriate SCSs in different industries. Nag *et al.* (2014) found examples of such studies in aerospace, fashion, automotive, chemicals, electronics, food, furniture, healthcare, home appliances, paper, and steel. However, so far, similar studies are absent concerning defence. Customised SCD in defence presupposes the inclusion of the military end users' requirements. So, which are these requirements, and what is the military perspective on commercial SCD-constructs, such as contingency variables, competitive priorities and SCSs?

1.4. Research purpose and research questions

To address the practical problem described in the research background (Section 1.1) and the research gaps outlined in the research motivation (Section 1.3), the purpose of the research presented in this dissertation is to design and develop a purchasing portfolio model (PPM) for defence

procurement, which will be of practical use for defence authorities. Building on Gelderman (2003, p. 21), this dissertation defines a PPM as a tool that combines two or more dimensions into a set of heterogeneous segments, and recommends different tactics and strategies for these segments (Section 2.3.1). Accordingly, a PPM consists of a segmentation model, tactical levers, differentiation strategies and guidance for management decisions, which leads to the following RQs.

There are several open PPM design issues (Section 2.5.2) in the PSM literature. To develop a PPM for defence procurement, the research must address these issues in the defence context. In addition, researchers should tailor PPMs to include domain-specific content. However, previous research has predominantly focused on PPMs for profit-maximising companies in the private sector. The research must consequently establish which domain-specific requirements that must be satisfied in the defence context. Defence procurement is organised differently by nations. In Sweden, two defence authorities, FMV and the Swedish Armed Forces, are directly involved in the procurement of supplies and the PPM should be relevant to both. Hence, this dissertation formulates the first research question (RQ1) as:

> RQ1: Which segmentation model design satisfies the practical relevance requirement of defence authorities?

Answering RQ1 encompasses investigation of to which extent existing segmentation models satisfy defence authorities' operational requirements. Depending on the outcome of this investigation, it will also involve adaptation of an existing model, or the development of a new one. In either case, this will include establishing which design rules that satisfy defence authorities' requirements. As part of this investigation, answering RQ1 also includes finding out defence procurement practitioners' perspectives on the open design issues in the PSM literature. In addition, to ensure that the segmentation model actually is of practical use to defence authorities, answering RQ1 also necessitates the involvement of practitioners in design, development and validation of the model. The answer to RQ1 will consist of a set of design rules, as well as a segmentation model.

In the PSM literature, extant PPMs have an inbound logistics perspective and use strategies that seek to enable buyers to exploit power-positions vis-à-vis suppliers. In this research, what is required are strategies from an outbound

logistics perspective, which enables military buyers to satisfy the operational requirements of the end users. The SCM literature has many examples of such strategies. However, they are SCSs proposed for different industries in the private sector, but not for the defence sector. Previous research has consequently not established how suitable commercial SCD-constructs (Section 2.6.3) are in the public defence sector. The research must therefore establish the acceptability, applicability and sufficiency of these constructs in defence. In addition, researchers have yet to address the unique defence SCD issues. Different defence authorities, such as DPAs, DLOs and armed forces, conduct defence procurement. However, the operational requirements, which must be satisfied in defence SCD, are those of armed forces. Therefore, this dissertation formulates the second research question (RQ2) as:

> RQ2: Which supply chain strategies satisfy the operational requirements of armed forces?

Answering RQ2 requires investigation of the unique design issues, or operational requirements, in defence SCD. It also involves establishing how acceptable, applicable and sufficient commercial SCD-constructs from the SCM literature are in defence. The answer to RQ2 will consequently comprise a set of operational requirements; acceptability, applicability and sufficiency of commercial SCD-constructs in defence SCD; and a set of defence SCSs.

There are several open PPM application issues in the PSM literature, which the research must address in the defence context. Furthermore, hitherto, researchers have proposed PPMs and guidance for management decisions for private sector companies, while neglecting public sector authorities. This dissertation formulates the third research question (RQ3) as:

> RQ3: How can guidance for management decisions be formulated to ensure practical relevance of a PPM for defence procurement?

Answering RQ3 embraces investigation of which application rules that satisfy defence authorities' requirements. Analogous with RQ1, as part of this investigation, answering RQ3 includes finding out the defence procurement practitioners' perspectives on the open PPM application issues (Section 2.5.2) in the PSM literature. Similar to RQ1, a prerequisite of answering RQ3 is the involvement of practitioners from the defence authorities. The answer to RQ3 will include a set of application rules, tactical levers and a guidance for management decisions in the application of a PPM for defence procurement.

1.5. Research scope and delimitations

The scope of this dissertation is designing and developing a PPM that is useful for defence authorities. The conducted research is a sequel to the study by FMV (2016), which recommended the Swedish Armed Forces to develop differentiated SCSs based on operational requirements and to use the logistics principle of segmentation and differentiation. The focus of this research is consequently not on defence procurement *per se*, but on the impact that procurement has on armed forces' operational capabilities, through SCD. Accordingly, the literature review builds on previous research in the areas of military logistics, and, first and foremost, PSM and SCM, rather than, say, public procurement or defence acquisition (procurement). This choice is further motivated in Section 2.1.

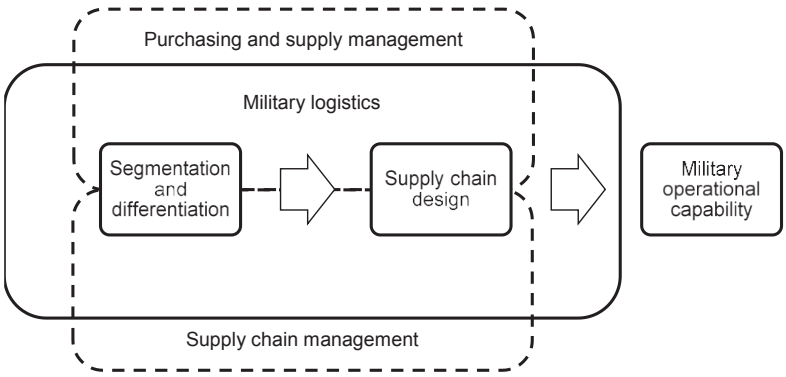


Figure 1.3: Connection between central constructs and areas of theory.

Regarding military logistics, the scope of this research is primarily the supply function, while excluding the other elements of military logistics (Section 2.2.4). Furthermore, the scope is limited to proposing a PPM for defence procurement, including a segmentation model, tactical levers, differentiation strategies and guidance for management decisions. Implementation of the model must address various forms of cooperation between the defence authorities and the defence industry. However, even if the proposed SCSs imply such cooperation, buyer-supplier relationships are not included in this research.

Figure 1.3 schematically illustrates the connection between the central constructs and the areas of military logistics, PSM and SCM. The underlying

premise of the research is that military logistics has a significant impact on military operational capability. Furthermore, building on the study by FMV (2016), another fundamental aspect of the research is the idea that segmentation and differentiation influences SCD. In addition to these central constructs of the research, Figure 1.3 also depicts how the areas of military logistics, PSM and SCM relate to these constructs. Chapter 2 further elaborates on these relationships.

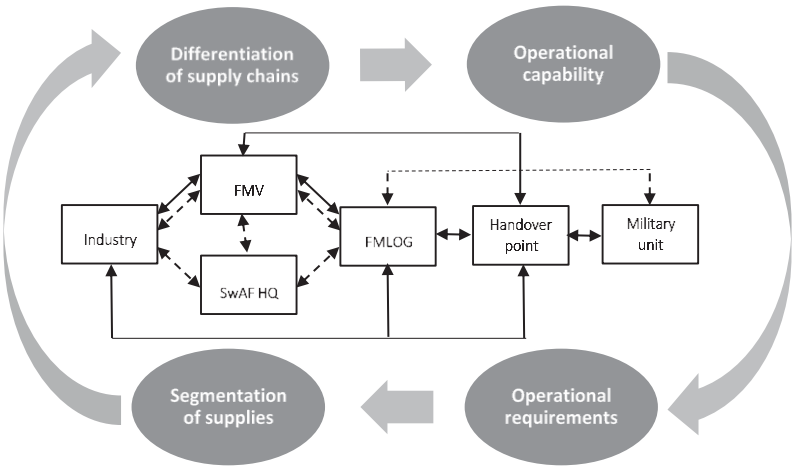


Figure 1.4: Overarching research idea and system in focus.

Section 1.2 describes the system in focus, a generic Swedish defence supply chain. As illustrated in Figure 1.3, the objective of such a defence supply chain is to support generation and use of military operational capability. The following statements constitute a summary of the overarching research idea. Operational requirements operationalise the logistical implications of military operational capability. Operational requirements are suitable as input to a model that classifies military supplies into heterogeneous segments which users should treat differently. Differentiated SCSs are required as part of this treatment and can contribute to the satisfaction of the operational requirements and, ultimately, the creation and sustainment of operational capability. Figure 1.4 illustrates the research idea and the system in focus.

The research results build on a Delphi study conducted in the Swedish defence context, with participation of twenty experts from the Swedish defence

authorities. The author developed and validated the proposed PPM in close cooperation with these practitioners and it promises to be of practical use to them. To determine generalisability and transferability (Section 3.10.2) of the results, additional studies are required (Section 6.1.2). Nevertheless, the results are likely to be of interest to practitioners in both the public and private defence sectors, both inside and outside Sweden, and probably also to procurement practitioners in the wider public sector, as well as to non-governmental organisations dealing with preparedness and crisis management (Section 6.1.1).

The PPM will provide defence authorities with an instrument that integrates operational requirements with market capabilities and operational consequences. For practitioners outside Sweden, the model may require adaptation regarding operational requirements. The model will also enable defence industry to enhance its ability to understand the operational requirements of the defence authorities. Outside the defence sector, and after some adaptation of the proposed model, public and non-governmental organisations dealing with preparedness and crisis management, including humanitarian logistics and disaster relief aid, may have use of a PPM that includes their operational requirements.

1.6. Acronyms, definitions and explanations

The military domain has a certain notoriety for excelling in the use of acronyms. However, academic areas such as PSM and SCM are also abundant with acronyms. This dissertation utilises its fair share of abbreviations and acronyms, from both the military and commercial sectors. The author explains the abbreviations and acronyms when they first occur in the text, and lists them, with interpretations, immediately after the list of tables.

Furthermore, all sectors of society have their own languages, with specialised nomenclature. Areas such as military logistics, PSM and SCM use particular terminology and concepts, frequently without universally accepted definitions or explanations. A complication in this regard is that the military and commercial sectors recurrently use the same terms, but with different meanings. In this dissertation, there are two such deceptive similarities. With the exception of references to the SCM literature (Section 1.3.3, Section 2.4 and Section 2.5.3), this dissertation uses “sustainability” with the military

logistics interpretation (Section 2.6.1), not with the meaning commonly used in other sectors of society. This dissertation uses the military hierarchical levels; strategic, operational and tactical (Section 2.2.2). This is different from the hierarchy strategic, tactical and operations, used in the commercial sector.

This dissertation uses several terms, concepts and constructs from military logistics, PSM and SCM. The author presents definitions and explanations of the most important of these in Section 2.6. For some of the most important military terms, the author also provides references to Section 2.6.1, when they first occur in the text. Additionally, Section 1.2 provides definitions and explanations of the terminology associated with the research context, the Swedish defence sector.

This dissertation proposes a *dynamic* PPM for defence procurement. The literature discusses dynamic application both in terms of repositioning in the segmentation model immediately after segmentation and in terms of repositioning after developments in the external environment that require repositioning. In the appended Paper 1, the authors make a distinction between the two varieties and refer to the first as interactive and the second as dynamic (Section 4.2.2). This dissertation does not make this distinction. The proposed dynamic PPM is dynamic in both interpretations of the word.

1.7. Dissertation outline

This compilation dissertation comprises six chapters and four appended papers. The structure and content of the main text is as follows:

Chapter 1. Introduction: Introduces the reader to the research background, context, motivation, purpose and clarifies the scope of the presented research. Guides the reader regarding the abbreviations, acronyms, definitions and explanations used in the dissertation, and outlines the dissertation.

Chapter 2. Frame of reference: Identifies relevant areas of theory and relates them to the RQs. Summarises previous research in military logistics, PSM and SCM. Identifies open issues and gaps in extant theory. Identifies, defines and explains key theoretical constructs.

Chapter 3. Research methodology: Positions the author regarding theory building and research paradigm. Explains and motivates research approach

and strategy. Presents the research process, research design, data collection and analysis, and model development. Discusses research rigour and ethics.

Chapter 4. Findings from the appended papers: Presents an overview of the appended papers. Summarises the findings and contributions of the appended papers.

Chapter 5. Discussion on findings: Discusses the findings from the appended papers and relates them to the previous literature. Reflects on the selected research design.

Chapter 6. Conclusions, contributions and future research: Presents the main conclusions, including theoretical and methodological contributions. Establishes implications for practitioners and researchers. Establishes limitations and proposes ideas for further research concerning the dynamic PPM for defence procurement and on the Delphi technique.

2. Frame of reference

This chapter summarises theories and previous research that is of relevance to the research presented in this dissertation. The first section explicates how and why the author identified and selected theoretical areas for the frame of reference and how these areas relate to the research questions (Section 2.1). A distinguishing trait of military logistics is that armed forces document organisational knowledge in doctrines and experienced practitioners document individual knowledge in books, whereas academics to a much lesser extent publish research in peer-reviewed journals (Yoho *et al*., 2013). Consequently, the summary of knowledge regarding military logistics (Section 2.2) relies heavily on doctrinal documents and books. The other areas of interest to this research are how researchers in PSM (Section 2.3) and SCM (Section 2.4) have contributed to the knowledge regarding segmentation and differentiation. The chapter concludes by accumulating open issues and gaps in extant theory (Section 2.5) and compiling, defining and explaining the key theoretical constructs of interest to this research (Section 2.6).

2.1. Identification of relevant areas of theory

Table 2.1 decomposes the research purpose (Section 1.4) into three distinct parts and connects the different parts to relevant areas of theory. Using the PPM definition (Section 2.3.1), Table 2.1 also connects the PPM components to theory.

Researchers primarily discuss PPMs in the PSM literature, which makes PSM a natural starting point to include in the frame of reference. Furthermore, this research aims to develop a PPM for defence procurement. By the definition adopted in this research (Section 2.2.1); defence procurement is a part of military logistics, which means that military logistics must also be included in the framework.

The consequences of application of the model will manifest itself in defence procurement practice, but also in its impact on defence SCD and supply chain operations. As stated in Section 1.5, the focus of this research is not on defence

procurement *per se*, but on the impact that procurement has on armed forces' operational capabilities, through SCD. This reinforces the necessity of including military logistics in the framework. The SCM literature frequently discuss SCD, which motivates including also SCM in the framework.

Table 2.1: Decomposition of research purpose and identification of relevant areas of theory.

Research purpose	Relevant areas of theory
design and develop a PPM*	PSM
for defence procurement	Defence procurement (Military logistics)
which will be of practical use for defence authorities	Military logistics (defence supply chain design), SCM
* segmentation model	PSM, SCM
* tactical levers	PSM, SCM
* differentiation strategies	SCM
* guidance for management decisions	PSM

Both the PSM and SCM literature discuss segmentation models and tactical levers, which underpins the requirement for including these areas in the framework. Moreover, while researchers predominantly discuss PPMs in the PSM literature, from the inbound logistics perspectives of buyers, other researchers regularly discuss segmentation models and differentiation strategies in the SCM literature, from the outbound logistics perspectives of suppliers. The latter perspective is in line with the operational requirements addressed in this research, which further motivates including SCM in the framework. Finally, researchers discuss guidance for management decisions in the application of PPMs in the PSM literature.

This dissertation addresses three research questions:

> RQ1: Which segmentation model design satisfies the practical relevance requirement of defence authorities?
>
> RQ2: Which supply chain strategies satisfy the operational requirements of armed forces?
>
> RQ3: How can guidance for management decisions be formulated to ensure practical relevance of a PPM for defence procurement?

As demonstrated in Table 2.1, researchers discuss segmentation model design in both the PSM and SCM literature. In addition to segmentation model design, RQ1 also includes practical relevance from the point of view of

defence procurement, which by this dissertation's definition is part of military logistics. Addressing RQ1 consequently involves using theory from PSM, SCM and military logistics, which Figure 2.1 illustrates.

RQ2 involves the investigation of SCSs in the context of military logistics, which means using theory from SCM and military logistics. Figure 2.1 illustrates the relevant intersection for RQ2.

To the extent that the literature includes complete PPMs, as this dissertation defines them, the PSM literature is the source for the related discussion on guidance for management decisions. Figure 2.1 illustrates the juncture between PSM and military logistics, which is required to address RQ3.

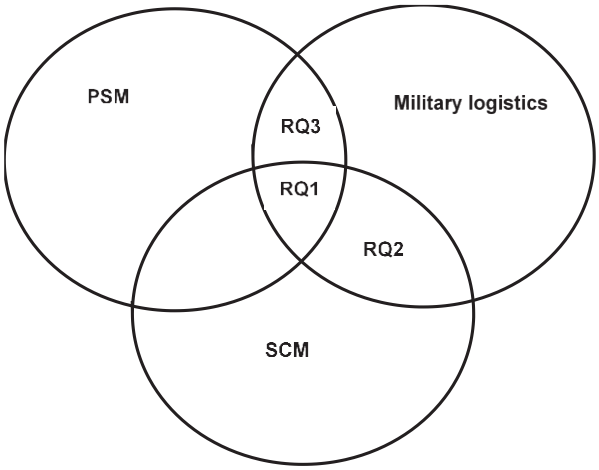


Figure 2.1: Frame of reference and research questions.

Figure 2.1 illustrates how the frame of reference relates to the research questions. However, some of the tactical levers required for the guidance for management decisions emanate from the SCM literature, rather than the PSM literature. This means that regarding tactical levers, RQ3 shares the same space as RQ1 in Figure 2.1.

2.2. Military logistics

Military logistics is *"the bridge between our national economy and the actual operations of our combat forces in the field"* (Eccles, 1959, p. 10) and it is *"a system established to create and sustain the military capability"* (Peppers,

1988, p. iv). Compared to business logistics, military logistics faces a number of particular challenges. Whilst an error in a business logistics context can lead to a loss of profit or even to the demise of an organisation, a similar failure in the military domain can result in death or injury (Yoho *et al*., 2013).

2.2.1. Definitions

There are numerous definitions of what military logistics is, ranging from succinct to comprehensive, and formulated from different perspectives. Van Creveld (1977, p. 1) defines military logistics from an operational perspective:

> *"Logistics is the practical art of moving armies and keeping them supplied."*

The purpose of military logistics in this sense is to ensure that the material elements of combat capability come together at the right place and time and in the right configuration to be useful (Swartz and Johnson, 2004). Military logistics consequently determines what military forces can be delivered to an operational theatre, the time it will take to deliver that force, the scale and scope of forces that can be supported once there and the tempo of operations (Uttley and Kinsey, 2012, p. 401).

Kress (2002, p. 7) states that logistics has to do with the inputs, including means and resources, of a production process, which is called combat or military operation, and consequently defines logistics as:

> *"Logistics is a discipline that encompasses the resources that are needed to keep the means of the military process (operation) going in order to achieve its desired outputs (objectives). Logistics includes planning, managing, treating and controlling these resources."*

Modern military logistics involves a wide range of activities and services required to support operations. It is the bridge between defence industry and deployed forces, and the North Atlantic Treaty Organisation (NATO, 2012, p. 20) therefore, from a life cycle perspective, defines logistics as:

> *"Logistics is the science of planning and carrying out the movement and maintenance of forces. In its most comprehensive sense, the aspects of military operations which deal with: design and development, acquisition, storage, transport, distribution, maintenance, evacuation, and disposal of materiel; transport of personnel; acquisition or construction, maintenance, operation, and disposition of facilities; acquisition or furnishing of services; and medical and health service support."*

Consequently, military logistics embraces a much broader spectrum of acquisition, support and disposal challenges than storage and distribution of supplies (Yoho, 2013). In essence, military logistics *"exists to support combat forces"* (Foxton, 1994, p. 11) and the supply dimension of military logistics has to do with acquiring, holding and moving supplies to bridge the time and place discrepancy between production and consumption (Hauk, 1964), in other words to ensure readiness and sustainability. In short, the logistic capabilities limit the size of armed forces that a nation can employ in combat operations (Prebilič, 2006).

In line with Skoglund (2012, p. 21), this dissertation uses the all-embracing definition established by NATO. As demonstrated by this definition, defence acquisition, or procurement (Section 2.2.6), is an important part of contemporary military logistics.

2.2.2. Strategic, operational and tactical logistics

Military logistics comprises strategic, operational and tactical logistics (Kress, 2002, p. 17). Through strategic logistics, armed forces make long-term defence related decisions. These decisions concern military infrastructure, technology, defence related industry, storage and resources for transportation. Strategic logistics is mostly utilised in peace and an important factor is therefore efficiency (Kress, 2002, p. 42).

Tactical logistics relate to the on-going combat. This level of military logistics supports military units with supplies. Armed forces measure tactical logistics in terms of effectiveness, since the dominant factor at the tactical level is the effect of the action, not its cost (Kress, 2002, pp. 42-43). The aim of logistics at the tactical level is to deliver the right supplies and maintenance, in the right quantities and at the right time to the units.

Between the strategic and tactical logistical levels lies operational logistics, which relates to a theatre of operations. The task of operational logistics is to set up a logistics system in the theatre of operations, operate the system and to predict, analyse and prioritise future requirements for logistical efforts. The logistical system at the operational level is a network of supply chains. Along these supply chains, the logistics function transports supplies, support and troops to the units that are engaged in military action.

2.2.3. Peace, mobilisation and war

Military logistics operate at three different levels of activity: peace (typified by stagnation), mobilisation (typified by desperation) and war (typified by operations) (McGinnis, 1992), which are closely interconnected. The logistical systems in place in peace is claimed to be a result of national security policy and thus the type and range of contingencies that the state chooses to prepare for, since they affect the support requirements needed to conduct such operations at the desired tempo (Erbel and Kinsey, 2018). However, in peace governments are not necessarily inclined to provide the required financing, especially if politicians presume that there is a peace dividend to reallocate to other sectors of the society (Humphries and Wilding, 2001).

The logistics support for a country's armed forces is frequently required to operate in a cost-efficient mode during peacetime, but must nonetheless be prepared for mobilisation and, ultimately, war, in which effectiveness is paramount and cost a secondary consideration (Kovács and Tatham, 2009). Consequently, there is a dual premise in defence SCD. In peace, the defence supply chain must ensure that military units in their permanent bases have sufficient supplies to fulfil requirements on readiness. In higher levels of conflict, including war, the defence supply chain must deliver supplies to fulfil requirements on sustainability, which involves securing continuous flows of supplies to military units in temporary bases or in areas of operations. In other words, the public defence sector must design supply chains that are cost-efficient in peace, when the system is dormant, but also effective in war, when the system is activated (Kovács and Tatham, 2009). In peace, expenditures to achieve and maintain readiness and sustainability typically include training, maintenance and stockpiling of supplies (Moore *et al*., 1991).

Thus, military logistics depends on whether a country is in a state of peace, crisis or war. In peacetime, the primary focus of military logistics is strategic logistics, including acquisition, storage and maintenance of materiel. Peacetime logistics also includes logistical planning for different types of military contingencies. Peacetime military logistics shows several similarities with business logistics. However, there are also significant dissimilarities. The fundamental difference lies in the fact that the peacetime form of military logistics must have a preparedness to transform into wartime military logistics at relatively short notice, through activation or mobilisation. The potential transformation of peacetime military logistics to its wartime counterpart exerts

a strong influence on the peacetime variety of military logistics. Thus, the focus of peacetime logistics is on strategic materiel, production, storage, maintenance, education and training, and preparations for military operations.

In case of war, the focus of military logistics shifts. The activities of peacetime military logistics, such as acquisition, distribution, storage of ammunition and spare parts, must continue also in times of war. However, in crises and war, military logistics must focus on operational and tactical logistics, and primarily deal with strategic lift and operative regrouping of military units, maintenance, medical attendance, storage and flow of supplies, such as equipment, spare parts, ammunition and fuel.

2.2.4. The defence supply chain

Military logistics consists of several functions. Foxton (1994, p. 11) identifies five generic functions, found in most armed forces: supply, transportation and movements, maintenance and repair, medical services, and smaller functions, including post. This is in line with the Swedish Armed Forces (2020) subdivision of military logistics. The supply function is the focus of this dissertation.

Military logistics has always confronted three basic logistical alternatives: obtain the necessary resources on the battlefield, carry the necessary resources with the troops, and/or transport the necessary resources from the rear area to the troops in the battlefield (Kress, 2002, p. 10). Throughout history, logistical considerations, for example regarding where armed forces could obtain necessary resources, dictated the planning and execution of military operations (Van Creveld, 1977, pp. 7-8).

Modern military logistics must be a combination of all the three logistical alternatives (Kress, 2002, pp. 14-15). The first alternative includes being partly dependent on the resources of host nation support. Armies partly utilise the second alternative by bringing supplies with the units. The third alternative is, however, the only alternative that can support a modern military unit over time. Regardless of the mission, armed forces cannot perform their tasks over time if the logistical function does not guarantee a continuous flow of essential resources, at the right speed and at the right time, in other words an appropriate supply chain.

The defence supply chains, or defence supply network, must distribute different types of supplies, from a large number of suppliers and in-house storage facilities, to numerous types of military units, in various domains and environments, and in multiple scenarios, while satisfying multiple operational requirements. The armed forces of any nation is dependent on a large variety of supplies, military-specific as well as market-generic, and different nations and organisations have different ways of classifying supplies.

Table 2.2: US classification of supplies (US DoD, 2010).

Class	Supply
I	Rations and gratuitous issue of health, morale, and welfare items.
II	Clothing, individual equipment, tentage, tool sets, and administrative and housekeeping supplies and equipment.
III	Petroleum, oils, and lubricants.
IV	Construction materials.
V	Ammunition.
VI	Personal demand items.
VII	Major end items, including tanks, helicopters, and radios.
VIII	Medical.
IX	Repair parts and components for equipment maintenance.
X	Nonstandard items to support non-military programs such as agriculture and economic development.

In line with Skoglund (2012, p. 53), this dissertation uses the US classification system, since it provides a granulation that is well suited to illustrate the complexity of the defence supply network. As illustrated in Table 2.2, it divides supplies into ten classes, which are based on their respective requirements for procurement, packaging, storage, handling and transportation, where the requirements may emanate from the areas of safety, environmental, size, hazard category, end use, shelf life, etc.

For each of these supply classes, the logistics system must provide individual soldiers and military units with an initial allowance, in accordance with tables of organisation and equipment, as well as in line with standing operational plans, to ensure readiness. For many of these classes, such as Class I, the initial allowance will give soldiers and military units a limited number of days of supply.

After depletion of the initial allowance, soldiers and units will become dependent on a more or less continuous flow of resupplies from storage facilities, or directly from suppliers, to ensure sustainability, which is necessary to maintain operational capability. The point in time when the

military units have consumed the initial allowance, and thus require resupply, varies for different supply classes. The consumption patterns are quite dissimilar and present various challenges for the supply network. As an example, soldiers will consume sustenance and water at an approximately uniform rate, irrespective of local changes in combat or terrain conditions. Consequently, the consumption of Class I items is related to time and the consumption rate is easily calculated. For other supply classes, such as fuel, ammunition and spare parts, the consumption rate may depend on time, activity, chance, or a combination of these factors, which means that predictions of consumption will become more complicated. Therefore, military logisticians must be well aware of planned and current operations to predict the consumption and design the logistics system accordingly.

To add to the complexity, many of these supply classes are military-specific, whereas others encompass both military-specific and market-generic supply items. Market-generic supply items, such as sustenance, may be readily available off-the-shelf. In contrast, military-specific supply items limit the number of potential suppliers quite significantly, and may involve lead times ranging from months, or even years, for ammunition, mines and explosives (Class V items), to several years for major equipment (Class VII items).

The supply chains required for these disparate supply classes each have its unique characteristics, with different types of suppliers, lead times, costs involved, limitations regarding storage and distribution, etc. They will also look dissimilar depending on which operational requirement they satisfy. To satisfy requirements on readiness, supplies must both be pre-stored and prepositioned, or have lead-times from external suppliers measured in days. The requirements on sustainability means that the supply chains must, for at least certain supplies, ensure a more or less continuous flow of supplies for the duration of an operation. Depending on lead times, external suppliers will be the main source for most of these supplies.

2.2.5. Operational capabilities and operational requirements

The US DoD (2010) defines military capability as the ability to achieve a specified wartime objective, which can be to win a war or a battle, or to destroy a target set. It rests on four pillars: force structure, modernisation, readiness and sustainability (Moore *et al*., 1991). Force structure is the numbers, size and composition of the units that comprise the defence forces, whereas

modernisation is the technical sophistication of forces, units and equipment (US DoD, 2010). Readiness and sustainability reflect how quickly and for how long military forces are usable, and govern the degree to which a nation can exploit the other pillars in war (Moore *et al*., 1991).

Military logistics, including defence acquisition, is required to produce the force structure, as well as ensuring modernisation, readiness and sustainability. In military logistics, the operational requirements on readiness and sustainability have specific meanings, which differ significantly from other contexts. However, there are no universal, uncontested terminology and definitions in this area. This dissertation uses the definitions and explanations presented in Section 2.6.1. Regarding readiness, there is a distinction between "ready for when", operational readiness, and "ready for what", mobilisation readiness (Betts, 1995, p. 216), or availability and preparedness.

Until recently, the Post-Cold War era was characterised by times of austerity in the defence sector, and for reasons of affordability, the Swedish government has differentiated the requirements on availability and preparedness so that they are dissimilar for diverse military units. The requirements on availability and preparedness both entail that a military unit must have access to, in their permanent bases, supplies for the initial phase of an operation, which means that a specified number of days of supply is required.

The Swedish government specifies the operational outcome that the logistics system must contribute to in terms of availability (operational readiness), preparedness (mobilisation readiness) and sustainability. The main task of the Swedish Armed Forces is explicitly to maintain availability of capabilities in peace and maintain preparedness for a raised alert or war (Swedish MoD, 2015, p. 6). In accordance with the Swedish Defence Policy, there are three possible values for the requirement on availability: immediately, within three months, or within six months. The Swedish Defence Policy also defines three levels of preparedness: mobilisation within hours, days, or within one week. The latter may give some respite for acquisition of easily accessible supplies.

The requirements on availability and preparedness stipulate the point in time when a military unit should be ready to participate in an operation, after activation or mobilisation. These requirements also provide a starting point for the requirement on sustainability. However, in addition to a starting point, the requirement on sustainability also has a duration. It involves a continuous flow of supplies for the duration of a firefight, battle, operation, campaign or

war. The point in time when this flow can start varies between different types of supply, and depends on the lead-time for production and distribution.

2.2.6. Defence procurement

Because of Post-Cold War budgetary reductions in the defence sector, privatisation and outsourcing have become familiar terms in military logistics (Cardinali, 2001), and competencies and capacities of the private sector are now at the heart of logistics delivery to the armed forces (Louth, 2015). Defence authorities contract private sector engagement through defence procurement. Defence procurement refers to the activities required to provide a country's national security, which is the final output of the defence production/value chain (Markowski *et al*., 2010, pp. 12-14). Some authors, such as Markowski *et al*. (2010, p. 12) intentionally use defence procurement and defence acquisition interchangeably. Other authors, for example Lawrence (2009, p. 155), are adamant that defence procurement is a subset of defence acquisition. Ekström (2012, pp. 93-101) provides a summary of this controversy. However, in line with Markowski *et al*. (2010), this dissertation uses defence procurement and defence acquisition as synonyms.

Defence procurement of military supplies is organised differently by nations. In some countries, a single, specialised organisational unit is responsible. Other countries disperse the responsibility for defence procurement between larger organisational elements such as the services. Some countries have delegated the responsibility to a detached specialised procurement agency. The latter is the case in the UK (the Ministry of Defence, Defence Equipment & Support, MoD DE&S), Australia (the Australian Defence Materiel Organisation, DMO) and in Sweden (the Swedish Defence Materiel Administration, FMV). However, whereas DE&S and the British Armed Forces are both parts of the UK MoD, in Sweden, FMV is an independent public authority under the Swedish MoD, just like the Swedish Armed Forces. Consequently, unlike commercial firms, some countries, such as Sweden, has a single purchasing department that is external from the Armed Forces, a DPA.

2.3. Purchasing and supply management

2.3.1. Purchasing portfolio models

PPMs trace their origins back to the portfolio models introduced in finance by Markowitz (1952) and his pioneering portfolio theory for the management of equity investments has been instrumental for applications in other fields and disciplines (Turnbull, 1990). Prior to segmentation models, ABC analysis (or Pareto analysis) was the only tool for differentiating between important and less important purchases (Gelderman and van Weele, 2005).

In 1983 Kraljic, in his seminal paper *"Purchasing must become supply management"* (Kraljic, 1983) took segmentation into the field of PSM with the purchasing portfolio matrix. Since then, a key focus of the purchasing literature has been on finding ways to classify various purchases to help buyers manage large portfolios (Terpend *et al*., 2011), and scholars have proposed a number of models as guidance (Hilletofth, 2012). PPMs provide differentiated strategies for diverse product segments (Turnbull, 1990) and researchers and practitioners frequently describe PPMs as appreciated instruments for developing differentiated purchasing and supplier strategies (Gelderman and van Weele, 2005). However, for application in new contexts, PPM designers must tailor the overarching framework to include domain-specific content (Luzzini *et al.*, 2012).

Building on Gelderman (2003, p. 21), this dissertation defines a PPM as a tool that combines two or more dimensions into a set of heterogeneous segments, and recommends different tactics and strategies for these segments. Accordingly, a PPM consists of a segmentation model, tactical levers, differentiation strategies and guidance for management decisions. Based on this definition, most contributions in the PSM and SCM literature are segmentation models, differentiation strategies or a combination, whereas few contributions are complete PPMs (Luzzini *et al*., 2012).

Kraljic (1983) proposes a methodology in four phases, classification, market analysis, strategic positioning, and action plans. Olsen and Ellram (1997) propose a similar approach in three steps, analyse the company's purchases, analyse the supplier relationships, and develop action plans. Svensson (2004) proposes a process in four phases, analysis of business environment, analysis of relationship criteria, selection of relationship strategy, and managerial

decision of relationship strategy. Based on severe critique of extant models, regarding rigour, robustness and application, Cox (2015) advocate a more complex, dynamic approach, the sourcing portfolio analysis (SPA). In SPA, the methodology includes criticality analysis, static power positioning and sourcing strategies, dynamic power positioning and sourcing strategies.

2.3.2. Segmentation models

Supply chains have to service a very wide range of products and markets, and a recurrent caution in selection of suppliers and supply chains is that "one size does not fit all" (Christopher *et al*., 2006; Dyer *et al*., 1998; Lee, 2002; Lovell *et al*., 2005). The underlying logic behind segmentation models is the idea of specialisation and differentiation. *"The approach to different segments is specialized in the sense that it is aligned to the needs of the particular segment, and it is differentiated in the sense that the segments represent different managerial approaches"* (Persson and Håkansson, 2007).

Utilisation of segmentation models presupposes that effective SCM requires choosing a type of relationship appropriate to product and market conditions and adopting management practices to that relationship (Bensaou, 1999). Scholars have proposed a number of classification models to guide the choice of SCSs (Hilletofth, 2012). Factors that influence supply chain segmentation are product, market, source or geographic/commercial environment specific (Lovell *et al*., 2005). According to Johansen *et al*. (2012), the dominant focus in supply chain segmentation has hitherto been on products, but with an emerging interest on customer needs and market characteristics as ground for segmentation.

Since the introduction of the Kraljic model, a large number of scholars have contributed to the research on PPMs. Scholars have identified several advantages and disadvantages with such models, thus revealing considerable divergence in opinion on the merits of portfolio models (Gelderman and van Weele, 2005). This dissertation identifies three waves of contributions, and refers to them as "traditionalists", "revisionists" and "post-revisionists", respectively. In each of these waves, the dissertation identifies open issues in the academic debate, and categorises them as design and application issues.

2.3.2.1. Traditionalists

Many scholars have made extensions and modifications to Kraljic's original approach (Rezaei *et al*., 2015). They have proposed new dimensions, values for these dimensions, names for segments, and strategies and tactics for these segments. However, these contributions, exemplified in Table 2.3, have in common that they mostly build on the portfolio matrix proposed by Kraljic (1983), and there are more similarities than differences in comparison to the original Kraljic matrix (Gelderman and van Weele, 2005). In fact, most approaches to supplier segmentation in the extant literature are extensions of the Kraljic approach (Rezaei and Ortt, 2013). These contributions are traditional two-dimensional approaches, with two values for each dimension, and consequently four segments. This dissertation refers to the authors of these contributions as traditionalists.

The underlying motivation for these contributions is to seek answers to the question of which the most suitable variables to include are (Nellore and Söderquist, 2000). Another issue traditionalists discuss is the values of the dimensions. Especially if the distinction between "high" and "low" is arbitrary or meaningful (Gelderman and van Weele, 2005) and how weighting should be conducted (Olsen and Ellram, 1997).

Even though traditionalist approaches have now existed more than 35 years, there is no general agreement among academics and no integrated approach to supplier segmentation (Day *et al*., 2010). Consequently, scholars are still presenting new traditionalist segmentation models, as exemplified by Rezaei *et al*. (2015). New contributions have been based on critique of existing models regarding the selection of dimensions (Nellore and Söderquist, 2000), and for the operationalisation, measurement and values of the dimensions (Gelderman and van Weele, 2005; Olsen and Ellram, 1997; Ramsay, 1996).

Table 2.3 presents a chronological overview of select traditional segmentation models in PSM. These models all have in common that the authors use two dimensions with two values each, which results in four segments. Most of the dimensions represent different aspects of factors associated with the buyer, the supplier, the market, or the product. A notable exception is the contribution by Drake *et al*. (2013), who provide a set of dimensions frequently used in the SCM literature, leanness and agility.

Table 2.3: Overview of select traditional segmentation models in PSM (Ekström *et al*., 2020a).

Author(s) (Year)	Dimensions	Values	Segments
Kraljic (1983)	Importance of purchase Complexity of supply market	Low/high Low/high	Non-critical; bottleneck; leverage; strategic
Van Stekelenborg and Kornelius (1994)	Control need of internal market Control need of external market	Low/high Low/high	Supply situation: Plain; Externally problematic; Internally problematic; Complicated
Olsen and Ellram (1997)	Difficulty of managing purchase situation Strategic importance of the purchase	Low/high Low/high	Non-critical; bottleneck; leverage; strategic
Bensaou (1999)	Buyer's specific investments Supplier's specific investments	Low/high Low/high	Market exchange; captive buyer; captive supplier; strategic partnership
Kaufman *et al*. (2000)	Technology Collaboration	Low/high Low/high	Commodity supplier; collaboration specialist; technology specialist; problem-solving supplier
Masella and Rangone (2000)	Time horizon Content of relationship	Short/long Logistic/strategic	Short term and logistic; long term and logistic; short term and strategic; long term and strategic
Wynstra and Ten Pierick (2000)	Development risk Supplier's development responsibility	Low/high Low/high	Development: routine; critical; arm's-length; strategic
Svensson (2004)	Supplier's commitment Commodity's importance	Low/high Low/high	Friendly; transactional; family; business partner
Hallikas *et al*. (2005)	Supplier dependency risk Buyer dependency risk	Low/high Low/high	Non-strategic; asymmetric (captive supplier); asymmetric (captive buyer); strategic
van Weele (2006)	Profit impact Supply risk	Low/high Low/high	Products; Suppliers: Routine; bottleneck; leverage; strategic
Drake *et al*. (2013)	Leanness Agility	Low/high Low/high	Non-strategic; agile; lean; leagile
Rezaei *et al*. (2015)	Supplier's capabilities (C) Supplier's willingness (W)	Low/high Low/high	Suppliers: low C and low W; low C and high H; high C and low W; high C and high W

With one exception, all models use low and high as the two values for each dimension. Masella and Rangone (2000) propose short or long time horizon, and logistic or strategic content of relationship, respectively. The segments proposed in the models mostly relate to different aspects of the product,

market, supplier, or relationships. However, because of their selection of dimensions and values, respectively, Drake *et al*. (2013) and Masella and Rangone (2000) propose segments which are quite different from the other contributions.

2.3.2.2. Revisionists

In addition to developing new models as an alternative to Kraljic's original model, thus extending the base of traditional models, some researchers go further in their critique. This dissertation refers to these authors as revisionists. Some of these authors criticise the design of traditional models and state that only having two dimensions make them too simplistic (Dubois and Pedersen, 2002; Hesping and Schiele, 2016; Lovell *et al*., 2005; Rezaei *et al*., 2015). The question is how to deduce relevant strategies based on only two basic dimensions (Dubois and Pedersen, 2002).

Academics also criticise traditional models for only recommending establishing supplier relationships in one segment (Dubois and Pedersen, 2002; Persson and Håkansson, 2007; Cox, 2015) and for focussing on a single relationship and not taking the issue of allocating resources between relationships into consideration (Olsen and Ellram, 1997). Other authors criticise the traditional models for not taking all interdependencies within a relationship between a buyer and a supplier into consideration, or the interdependencies between different relationships, and for their dyadic context, thus ignoring the network perspective (Dubois and Pedersen, 2002).

Furthermore, researchers criticise traditional models for being static, rather than dynamic (Persson and Håkansson, 2007; Hesping and Schiele, 2015). Empirical arguments support the idea to develop new segmentation models based on a more dynamic logic, *"while a static segmentation model address the issue of how to optimise a given purchase situation, a dynamic model offers an approach to create a more effective situation to optimise"* (Persson and Håkansson, 2007).

Traditional models also receive critique for being prescriptive, rather than serving as a starting point for discussions among stakeholders (Gelderman and van Weele, 2003; Jarzabkowski and Kaplan, 2008; Spee and Jarzabkowski, 2009). Studies have found that among practitioners, in-depth discussions on the position in the model are considered as the most important phase of the analysis (Gelderman and van Weele, 2003), and several authors have

recommended moving away from strict adherence to the recommendations of traditional models (Gelderman and van Weele, 2003).

Some authors criticise traditional models for having generic strategies and tactics for a segment, rather than unique ones for specific purchases, and question, for instance, that buyers should form cooperative partnerships for all strategic purchases (Hesping and Schiele, 2015). Others question traditional models for their strict, rather than pragmatic, application (Gelderman and van Weele, 2003; Hesping and Schiele, 2015).

2.3.2.3. Post-revisionists

Even though traditional segmentation models are frequently used in practice, many researchers have observed that there is a discrepancy between theory and practice when it comes to how segmentation models are designed by academics and consultants, as compared to how they are used by practitioners. Practitioners tend to use strategies and tactics from adjoining segments, to move from a difficult position to a more favourable one (Caniëls and Gelderman, 2005; Gelderman and van Weele, 2003; Monczka *et al*., 2011).

Some researchers have noticed that practitioners exchange the dimensions in the matrix, depending on the situation (Krause *et al*., 2009; Pagell *et al*., 2010). Cox (2015) observe that practitioners are cherry-picking, by selecting and/or adapting strategies and tactics based on their own requirements, rather than by following what is recommended by the method. This means that practitioners are either following strategies that are theoretically wrong, which should lead to sub-optimisation, or that there is something wrong with theory and method. Failure to achieve the right outcomes indicates either a failure of the tool or a failure of the user (Jarzabkowski and Kaplan, 2008). Cox (2015) argue that the fault lies with the theory, rather than with what practitioners are actually doing in the real world.

To address the perceived discrepancy between theory and practice, more complex, alternative approaches, such as the purchasing chessboard (Schuh *et al*., 2008) and the sourcing portfolio analysis (Cox, 2015), have been proposed in the literature. These authors base their contributions on a more fundamental critique of traditional segmentation models than the revisionist critique, by also questioning the underlying assumptions of the traditional models.

Some researchers even question the rigour and robustness of segmentation models, and call for a shift of paradigm in category management and strategic sourcing (Cox, 2015). This dissertation refers to these authors as post-revisionists. What the more complex models may gain in terms of analytical rigour in segmentation and robustness in recommendations, they may stand to lose in terms of simplicity and ease of use for practitioners. As an example, the purchasing portfolio matrix uses four sourcing strategies and a limited number of tactics (Kraljic, 1983), the purchasing chessboard uses four strategies and up to 64 tactics (Schuh *et al*., 2011), whereas the sourcing portfolio analysis offers 32 strategies and over 100 tactics (Cox, 2015).

2.3.3. Strategies and tactics

The concepts of strategy and tactics are central parts of PPMs, but there is no consensus in the literature regarding their application (Hesping and Schiele, 2016). Hesping and Schiele (2015) propose a hierarchical distinction, firm strategy, purchasing strategy (as one functional strategy), category strategy (for specific supply market), tactics (sourcing lever applied for specific category strategy), and supplier strategy (for specific supplier in a sourcing category).

After segmentation, traditional, static PPMs, allow optimisation of a given purchasing situation, whereas empirical arguments support the idea of developing dynamic PPMs, which could offer improved situations to optimise (Persson and Håkansson, 2007). As a result, using extant models, managers frequently believe that they have accomplished their decision-making once they have performed the initial segmentation, and are unaware of any repositioning possibilities (Cox, 2015). In contrast to traditional, static PPMs, dynamic tactical levers enables repositioning in the segmentation model in dynamic PPMs.

In line with Cox (2015), this dissertation discusses tactics in the context of static and dynamic leverage, which has overlap with tactics in the hierarchy proposed by Hesping and Schiele (2015), but which is not identical. The dissertation equates tactics with dynamic and static tactical levers, corresponding to the first and second principle of leverage (Cox, 2015), which practitioners should apply immediately after the initial segmentation. Using dynamic tactical levers, practitioners can move to a more favourable segment

in the model. Static tactical levers are tactics that practitioners can apply when all opportunities for movement to another segment are exhausted.

The basic idea with PPM strategies is that different situations require different strategies (Andersson and Servais, 2010). The strategies proposed in extant PPMs are category strategies. Several of these PPMs base their strategies on an understanding of the power balance between buyer and supplier. As an example, Kraljic (1983) propose strategies such as diversify, balance or exploit, where buyers should strive to exploit power positions. The more complex SPA, proposed by Cox (2015), also bases its proposed strategies on power positioning, but includes both static and dynamic power positioning.

That PPMs for the private sector use power positioning is hardly surprising, since the private sector use production and marketing of goods and services to achieve financial targets. However, the purpose of this dissertation is to develop a PPM for defence procurement in the public sector, where authorities use financial resources to produce public goods and services. In addition to this difference in underlying logic for the private and public sectors, extant PPMs in the PSM literature have an inbound logistics perspective. What is required in this research are strategies from an outbound logistics perspective, which enables military buyers to satisfy operational requirements. The SCM literature has many examples of such strategies. Consequently, using terminology from SCM, this dissertation discusses SCSs, which correspond to supplier strategies in the hierarchy proposed by Hesping and Schiele (2015).

2.4. Supply chain management

A supply chain consists of all activities that manufacturers and distributors must perform to create value, including purchasing, manufacturing and distribution (Chen and Paulraj, 2004). A supply chain solution is a combination of a supply method (manufacturing strategy), which reflects the production system capabilities, and a delivery method (delivery strategy), which reflects the delivery system capabilities (Hilletofth, 2009).

Researchers have proposed a variety of contingency variables, which are characteristics of the business environment, that influence the competitive priorities that supply chains should pursue for maximising profit (von Falkenhausen *et al*., 2019). In an influential contribution, Christopher and Towill (2000) and Christopher *et al*. (2009) propose five key characteristics:

duration of lifecycle, delivery lead-time, volume, product variety, and variability in demand, supply or process. Basnet and Seuring (2016) condense the fourteen most common contingencies in the literature into four variables: demand variability/uncertainty, product variety, desired customer lead-time, and supply uncertainty/risk.

When a company in a supply chain focus on the end-user, it must consider competitive priorities, such as service, quality, cost and lead-time (Naylor *et al*., 1999), or quality, flexibility, innovation, speed, time, and dependability (Chen and Paulraj, 2004). The definition of these competitive priorities is a fundamental element of SCSs (Wagner *et al*., 2012), since a SCS specifies how a company can achieve competitive advantages through competitive priorities (Chen and Paulraj, 2004).

In the past, companies could compete based on only one of the competitive priorities, but competitive pressure has forced companies to compete on more than one (Stock *et al*., 1998). However, consumers' requirements are diverse, and a company cannot simultaneously satisfy all of them effectively (Kim, 2013). In addition, Stuart (1997) contend that competitive priorities vary between industries, and between companies in an industry. Consequently, companies have to make trade-offs between contesting competitive priorities (Hallgren *et al*., 2011), and these competitive priorities support the primary purpose of the SCD (Selldin and Olhager, 2007).

Selldin and Olhager (2007) classify competitive priorities into two fundamental dimensions: efficiency and responsiveness. Efficiency refers to a supply chain's ability to compete on costs, and responsiveness refers to a supply chain's ability to compete by responding quickly to market movement, which means building on the competitive priorities delivery and flexibility (Vachon *et al*., 2009). The competitive priority quality is important for both efficiency and responsiveness (Selldin and Olhager, 2007).

Depending on their primary focus, researchers have broadly divided SCSs into efficient and responsive (Fearne and Fowler, 2006), which many researchers 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).

Supply chains perform both a physical function and a market mediation function, where the physical function involves production, storage and distribution, while the market mediation function matches supply with demand (Fisher, 1997; Aitken *et al*., 2005). For a long time, SCM was an area of cost reduction, rather than revenue generation (Ballou, 2006) and companies were cost-oriented rather than customer-oriented (Mellat-Parast and Spillan, 2014). However, successful companies have realised that the right SCS is dependent on customer-orientation, and on demand and supply variability (Lee, 2002).

A SCS is the pattern of decisions related to sourcing products, capacity planning, conversion of raw materials, demand management, communication across the supply chain, and delivery of goods and services (Narasimhan *et al*., 2008). If companies want to maximise profits, revenue generation (customer orientation) should be central in SCD (Ballou, 2006). In addition, SCSs must be context specific (Melnyk *et al*., 2014) and develop the optimum solution for a particular competitive environment (Godsell *et al*., 2006).

A differentiated SCS is one way that companies can be responsive to variable demand and maintain supply chain efficiency and researchers have proposed several models to assist companies to select a suitable SCS (Hilletofth, 2009). Most of these contributions, exemplified in Table 2.4 and Table 2.5, are in the form of two-by-two matrices, with different dimensions and values (Roscoe and Baker, 2014). Factors that determine supply chain segmentation in these models are product-related, customer-related, supply-related or geography-related (MacCarthy *et al*., 2016), with a dominant focus on products, but with an emerging interest on customer needs (Johansen *et al*., 2012). These matrices have in common that they present a discrete choice of one suitable, generic SCS, in a set of two or four. At least one of these SCSs emphasises efficiency/leanness, whereas the others are market mediation SCSs (von Falkenhausen *et al*., 2019).

In another stream of research, scholars such as Sharman (1984) and Yang *et al*. (2004) use postponement to position the CODP, which represents the primary inventory storage location in the supply chain (Kim *et al*., 2012), to construct strategy frameworks. Pagh and Cooper (1998) discuss postponement of manufacturing and logistics. Yang *et al*. (2004) extend the discussion and include postponement of design and purchasing. These frameworks have in common that they use constructs from the two-by-two matrices to propose

market mediation strategies after the CODP (von Falkenhausen *et al*., 2019), which results in spectra of possible supply chain solutions. As an example, a supply chain can be lean upstream the CODP, and agile downstream, making it leagile (Naylor *et al*., 1999). These spectra allow supply chain designers to customise the supply chain solution, dependent on a unique situation, rather than to choose from two or four generic SCSs. This dissertation distinguishes between these two waves of contributions as "discrete choice strategy typologies" and "CODP-based strategy continuums".

2.4.1. Discrete choice strategy typologies

The idea of segmentation and differentiation in SCM traces its origin to the models introduced in finance by Markowitz (1952), which have been influential for application in other disciplines (Turnbull, 1990). Fisher (1997) took segmentation and differentiation into SCM and stated, *"The root cause of the problems plaguing many supply chains is a mismatch between the type of product and the type of supply chain"*. As a remedy, Fisher introduced innovative products, requiring a responsive (customer-oriented) supply chain, and functional products, requiring an efficient (cost-oriented) supply chain, and produced a framework that has become a cornerstone of the view of SCSs (Perez-Franco *et al*., 2016).

Since Fisher's seminal contribution, authors have proposed extensions and modifications of the original model. Lee (2002) expands Fisher's model by adding supply uncertainties to demand uncertainties, and propose two additional SCSs, risk hedging and agile. Introducing the concepts of 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, into SCD. Roh *et al*. (2014) update these contributions and add innovative features as an order-winning criterion.

In a series of contributions, researchers such as Christopher (2000), Childerhouse *et al*. (2002), Christopher *et al*. (2006) and Christopher *et al*. (2009) explore the combination of leanness and agility with contingency

variables, for example duration of lifecycle, delivery lead-time, volume, product variety, and variability in demand, supply or process.

Vonderembse *et al*. (2006) expand previous contributions, such as Fisher (1997), Pagh and Cooper (1998) and Naylor (1999), by introducing the product lifecycle and discussing more than two values for each dimension. Table 2.4 and Table 2.5 summarises a selection of discrete choice strategy typologies.

Table 2.4: Select strategy typologies (Ekström *et al*., 2020b).

Author(s) (Year)	Dimensions	Values	Segments / Strategies / Competitive priorities
Fisher (1997)	Product Supply chain	Functional, Innovative Responsive, Efficient	Mismatch*, Match*, Match*, Mismatch*
Pagh and Cooper (1998)	Logistics Manufacturing	Speculation, Postponement Postponement, Speculation	Manufacturing postponement**, Full postponement**, Full speculation**, Logistics postponement**
Naylor *et al*. (1999)	Demand for variability in production Demand for variability of products	Low, High Low, High	Leanness**, {}, {}, Agility**
Mason-Jones *et al*. (2000a)	Market Supply	Qualifiers, Winners Lean, Agile	Quality/Lead-time/Service level***, Cost***, Quality/Cost/Lead-time***, Service level***
Christopher (2000)	Volume Variety/Variability	Low, High Low, High	{}, Lean**, Agile**, {}
Lee (2002)	Demand uncertainty Supply uncertainty	Low, High Low, High	Risk-hedging**, Agile**, Efficient**, Responsive**
*Segments; **Strategies; ***Competitive priorities; {}=empty set			

With the exception of Vonderembse *et al*. (2006), the contributions in Table 2.4 and Table 2.5 are all two-by-two matrices, with two dimensions, with two values each, and four segments. However, two of the models (Naylor *et al*., 1999; Christopher, 2000) are dichotomies, offering two strategies, whereas the others are quadripartites, with four strategies. Vonderembse *et al*. (2006) propose a three-by-four matrix, but merge matrix elements and provide a selection of four strategies.

Table 2.5: Select strategy typologies, continued (Ekström *et al*., 2020b).

Author(s) (Year)	Dimensions	Values	Segments / Strategies / Competitive priorities
Olhager (2003)	Production-to-delivery(P/D)-ratio Relative demand volatility	P/D < 1, P/D > 1 Low, High	MTO/(ATO)/MTS**, MTS** (make-to-stock), MTO** (make-to-order), ATO** (assemble-to-order)
Aitken *et al*. (2005)	Market requirements Supply chain focus	Market-qualifiers, Order-winners Lean supply, Agile supply	Quality/Reliability***, Price***, Quality/Reliability***, Lead-time***
Lovell *et al*. (2005)	Value-density Throughput	Low, High Low, High	Generic framework. Specific SCD depends on detailed examination of business case.
Christopher *et al*. (2006)	Demand characteristics Supply characteristics	Predictable, Unpredictable Short lead-time, Long lead-time	Lean (continuous replenishment)**, Agile (quick response)**, Lean (plan and execute)**, Leagile (postponement)**
Vonderembse *et al*. (2006)	Product type Product lifecycle	Standard, Innovative, Hybrid introduction, Growth, Maturity, Decline	Lean** for standard, Agile** for innovative (introduction, growth), Hybrid/Lean** for innovative (maturity, decline), Hybrid** (postponement) for hybrid
Roh *et al*. (2014)	Market requirements Supply chain focus	Order-qualifiers, Order-winners Lean supply, responsive supply	Quality/Lead-time/Service level***, Cost***, Quality/Lead-time /Cost/Service level***, Innovative features***
*Segments; **Strategies; ***Competitive priorities; {}=empty set			

An important aspect of a good typology is that it should be possible to test it empirically (Narasimhan *et al*., 2008). Empirical research to test these typologies has been mixed, inconclusive or negative (Perez-Franco *et al*., 2016). Supply chains are not aligning strategy with demand and evidence in support of performance improvement is limited (Basnet and Seuring, 2016). When testing Fisher's model, Selldin and Olhager (2007) found that companies with a match between products and supply chains do not necessarily outperform companies with mismatches.

2.4.2. CODP-based strategy continuums

Researchers have criticised discrete choice strategy typologies for being too simplistic (Godsell *et al*., 2006; Hilletofth, 2012), as they portray SCS selection as discrete choices (Basnet and Seuring, 2016). Since customers may

require different degrees of responsiveness (Collin *et al*., 2009), researchers should present strategies in a continuum, rather than as discrete choices (Basnet and Seuring, 2016). SCSs must be context-specific and provide an optimal solution for a particular competitive environment (Godsell *et al*., 2006). Furthermore, researchers should describe SCD as a combination of suitable strategies for sourcing, manufacturing and distribution (Hilletofth, 2009).

Even if the strategy typologies in Table 2.4 and Table 2.5 present discrete choices, several of these authors discuss the potential of continuums. Naylor *et al*. (1999) conclude that lean and agile are complementary strategies, and that companies should strive for "leagility", which means combining the lean and agile paradigms in a total SCS through an appropriate positioning of the CODP, which is the point at which a product is linked to a specific customer order (Olhager, 2003). One of the discrete choices proposed by Christopher *et al*. (2006) is leagile, which in itself is a continuum, where postponement may produce an array of possible supply chain solutions. The CODP primarily relates to the competitive priority delivery speed (Olhager, 2003) and supply chain designers should position it based on which lead-time that is acceptable to the customer (Naylor *et al*., 1999).

The decoupling point (Naylor *et al*., 1999) is an important construct in SCD, and how to position it is a crucial decision (Yang and Burns, 2003), which is of strategic interest (Olhager, 2003). Researchers refer to it as the order penetration point (OPP) (Sharman, 1984), the CODP (Hoekstra and Romme, 1992; Olhager, 2003), or the push-pull boundary (Kim *et al*., 2012). Sharman (1984) introduce OPP into logistics, and propose five generic 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 re-labelled and extended Sharman's framework by introducing more CODPs and by combining it with, for example, constructs from discrete choice strategy typologies. Olhager and Östlund (1990) relate push and pull systems to the CODP position, whereas Pagh and Cooper (1998) connect postponement to the CODP. Building on Hoekstra and Romme (1992), Naylor *et al*. (1999) describe five SCSs based on the CODP, buy-to-order (BTO), MTO, assemble-to-order (ATO), MTS and ship-to-stock (STS). Olhager

(2003) define four CODP-related SCSs, MTS, ATO, MTO and engineer-to-order (ETO).

Building on Hoekstra and Romme (1992), and Lampel and Mintzberg (1996), who propose a continuum of strategies from pure, via segmented, customised and tailored, to pure customisation, 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.

Table 2.6: Select strategy continuums (Ekström *et al*., 2020b).

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	Manufac-turing	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
Adapted from Lampel and Mintzberg, 1996; Fisher, 1997; Pagh and Cooper, 1998; Yang and Burns, 2003; Yang *et al*., 2004; Christopher *et al*., 2006.					

Yang *et al*. (2004) combine the framework proposed by Yang and Burns (2003) with three additional spectra, lean-leagile-agile, globalisation-glocalisation-localisation and centralisation-decentralisation. Table 2.6 illustrates select CODP-based strategy continuums.

The extreme points in these spectra are pure postponement (ETO) and pure speculation (MTF). ETO enables pure customisation, agility and responsiveness, but is associated with extensive lead-times, including time for development, purchasing, manufacturing, assembly, packaging and distribution. MTF enables pure standardisation, leanness and efficiency, but comes with increased costs for storage, and risk-taking regarding misjudged future demand, depreciation of the inventory and obsolescence. In between these extremes, there are five hybrid strategies, which represent postponement

of one, or more, of the activities that manufacturers and distributors must perform to develop, manufacture, assemble, package, store and distribute supplies.

The hybrid strategies, BTO, MTO, ATO, PTO and STO, are leagile, enabling varying degrees of customisation/standardisation, agility/leanness and responsiveness/efficiency. All activities that take place prior to a customer order is a form of speculation by the manufacturer, which involves risk-taking. The CODP positioning consequently separates decisions under uncertainty from decisions under certainty, speculation from postponement and push from pull. The CODP position has a significant impact on costs, lead-times and risk-taking. The advent of CODP-based strategy continuums thus raises an unavoidable question for SCD, *"at what point or combination of points in the supply chain postponement provides the greatest overall benefit"* (Boone *et al*., 2007). CODP-positioning, including postponement, is the most widely discussed configuration in the literature (Basnet and Seuring, 2016).

2.5. Open issues and gaps in extant theory

2.5.1. Military logistics

Somewhat mischievously, Yoho *et al*. (2013) suggest that the comparative paucity of published military logistics research in mainstream logistics and SCM journals constitutes an *"open goal"* for researchers. Consequently, open issues and gaps are abundant, and most academic research would contribute to the development of the body of knowledge in military logistics. However, on a more serious note, Yoho *et al*. (2013) also propose a research agenda, with six research clusters: sourcing, resiliency, interoperability, light footprint logistics, managing the logistics network, and innovation and revolution in military affairs. This dissertation contributes primarily to the first two, sourcing and resiliency, and especially to their interconnectedness.

2.5.2. Purchasing and supply management

If academics have published any research regarding PPMs in a defence context, it remains unbeknownst to the author of this dissertation. Consequently, researchers have yet to address PPMs for defence procurement. If defence authorities are going to differentiate supply chains based on

segmentation, they require a PPM. The question is which one. An existing model, with or without adaptations, or a newly developed one? Existing PPMs have been criticised on numerous levels, and this dissertation distinguishes between two types of open issues in the literature, design-related and application-related.

In line with other authors in the field (Gelderman and van Weele, 2005; Olsen and Ellram, 1997; Nellore and Söderquist, 2000; Ramsay, 1996; Rezaei *et al*., 2015), the author of this dissertation identifies three open, design-related, questions among the traditionalist contributions. Which dimensions should be in the model? Which values should the dimensions have? Which segments should the model have?

Among the revisionist contributions, this dissertation identifies another three open, design-related, questions. How many dimensions should be in the model? How many values should the dimensions have? How many segments should the model have? The dissertation also identifies five application-related, questions. Should segmentation models be prescriptive or serve as catalysts for discussions? Should the application be strict or pragmatic? Should strategies and tactics be segment-generic or purchase-specific? Should the application be static or dynamic? Should segmentation models include recommendations regarding buyer-supplier relationships?

The post-revisionist contributions provide additional open issues. This dissertation identifies one design-related and one application-related issue. How complex, in terms of number of dimensions, values, segments, strategies and tactics, can a segmentation model be, and still be useful to practitioners? How should academics formulate rules for application so that practitioners follow the proposed methodology?

If defence authorities are going to use a PPM, they must address these design-related and application-related issues, regardless if they adopt or adapt an existing model, or if they develop a new one. In addition, they must tailor the overarching framework to include domain-specific content (Luzzini *et al*., 2012).

2.5.3. Supply chain management

Melnyk *et al*. (2010) suggest that future supply chains 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 supply chains (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 SCD has not been sufficiently researched (Yoho *et al*., 2013).

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 (Melnyk *et al*., 2014). Researchers have yet to address the question regarding which implications these unique SCD issues have for the formulation of SCSs in defence.

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). Customised SCD in defence presupposes the inclusion of military end users' requirements. However, which these requirements are, and what the military perspective on commercial SCD-constructs, such as contingency variables, competitive priorities and SCSs, is, remains unaddressed in the literature.

Researchers have investigated appropriate SCSs in different industries, such as aerospace, fashion, automotive, chemicals, electronics, food, furniture, healthcare, home appliances, paper, and steel (Nag *et al*., 2014), but not in defence. 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 supply chain resiliency and management.

2.6. Key theoretical constructs

For many of the constructs defined and/or explained in this section, there are no unanimously accepted, uncontested definitions or explanations. For some of them, there are no readily available definitions or explanations. The presented definitions and explanations are the ones used in this dissertation. The author has taken some of them directly, or derived them, from the literature, which the references clearly indicate. The author is responsible for the formulation of the remaining ones and for the formulation of explanations after the references.

2.6.1. Military logistics

Activation: All activities required to combine personnel, supplies and facilities together to a military unit to increase capability or to conduct operations (Swedish Armed Forces, 2020). The Swedish Armed Forces can activate those parts of military units that consist of employed staff, but not those parts that consist of conscripts.

Availability: Ability of a military unit to participate in operations immediately (Swedish Armed Forces, 2020), without any forewarning, after activation. Synonymous with operational readiness.

Defence acquisition: Activities required for the provision of a country's national security, which is the final output, in the form of military responses to threats to the national security, of the defence production/value chain (Markowski *et al*., 2010, pp. 12-14). Purchasing in the public defence sector. Synonymous with defence procurement.

Defence procurement: Activities required for the provision of a country's national security, which is the final output, in the form of military responses to threats to the national security, of the defence production/value chain (Markowski *et al*., 2010, pp. 12-14). Purchasing in the public defence sector. Synonymous with defence acquisition.

Military logistics: The science of planning and carrying out the movement and maintenance of forces. In its most comprehensive sense, the aspects of military operations which deal with: design and development, acquisition, storage, transport, distribution, maintenance, evacuation, and disposal of materiel; transport of personnel; acquisition or construction, maintenance, operation, and disposition of facilities; acquisition or furnishing of services; and medical and health service support (NATO, 2012, p. 20).

Mobilisation: All activities required to combine personnel, supplies and facilities together to a military unit to conduct operations after the Government's decision to mobilise (Swedish Armed Forces, 2020). The Swedish Government can mobilise all military units, including conscripts.

Mobilisation readiness: Ability of a military unit to participate in operations within a specified timeframe, after mobilisation. Synonymous with preparedness.

Operational capability: Ability to achieve a specified wartime objective, which can be to win a war or a battle, or to destroy a target set (US DoD, 2010).

Operational readiness: Ability of a military unit to participate in operations immediately (Swedish Armed Forces, 2020), without any forewarning, after activation. Synonymous with availability.

Operational requirement: Operationalisation of operational capability into requirements on the logistics system. Described in terms of requirements on availability, preparedness and sustainability.

Preparedness: Ability of a military unit to participate in operations within a specified timeframe, after mobilisation. Synonymous with mobilisation readiness.

Readiness: Consists of operational readiness, "ready for when", and mobilisation readiness, "ready for what" (Betts, 1995, p. 216), or availability and preparedness.

Supply function: The military logistics function that deals with design and development, acquisition, storage, transport, distribution, maintenance, evacuation, and disposal of supplies (derived from NATO, 2012, p. 20).

Sustainability: Ability of a defence force to maintain the necessary level of combat power for the duration required to achieve its objectives (NATO, 2018).

2.6.2. Purchasing and supply management

Dynamic tactical lever: Tactic employed to reposition to a more favourable segment in a segmentation model, immediately after segmentation (derived from Cox, 2015).

Purchasing portfolio model (PPM): Tool that combines two or more dimensions into a set of heterogeneous segments, and recommends different tactics and strategies for these segments (derived from Gelderman, 2003, p. 21). Consists of a segmentation model, tactical levers, differentiation strategies and guidance for management decisions.

Segmentation model: Tool that combines two or more dimensions into a set of heterogeneous segments (Gelderman, 2003, p. 21).

Static tactical lever: Tactic employed when all opportunities for movement to another segment are exhausted (derived from Cox, 2015).

2.6.3. Supply chain management

Agility: SCS with the ability to respond rapidly to unpredictable changes in demand or supply (Christopher and Peck, 2004).

CODP-based strategies: SCSs that involve postponement of design (engineer-to-order, ETO), purchasing (buy-to-order, BTO), manufacture (make-to-order, MTO), assembly (assemble-to-order, ATO), packaging (package-to-order, PTO) and/or shipment (ship-to-order, STO), or pure speculation (make-to-forecast, MTF, or make-to-stock, MTS) (Yang *et al*., 2004).

Competitive priorities: Manufacturers' choice of tasks or key competitive capabilities (Chen and Paulraj, 2004). Include cost, quality, delivery/lead-time, flexibility and dependability (Schnetzler *et al*., 2007).

Contingency variables: Product/market requirements (exogenous variables) in SCD (Basnet and Seuring, 2016). Include demand variability/uncertainty, product variety, desired customer lead-time and supply uncertainty/risk (Basnet and Seuring, 2016).

Customer order decoupling point (CODP): Point at which a product links to a specific customer order (Olhager, 2003). Separates forecast and order-driven activities (Mason-Jones *et al*., 2000b). Synonymous with order penetration point (OPP) (Sharman, 1984) and push-pull boundary (Kim *et al*., 2012).

Efficiency: SCS 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 *et al*., 2003).

Full postponement: SCS where both manufacturing and logistics activities are customer order initiated (Pagh and Cooper, 1998).

Full speculation: SCS based on forecasts. Involves full speculation of all manufacturing and logistics activities. (Pagh and Cooper, 1998).

Leagility: SCS with a judicious selection and integration of appropriate aspects of lean and agile (Christopher *et al*., 2006).

Leanness: SCS that involves developing a value stream to eliminate all waste, including time, and to ensure a level schedule (Naylor *et al*., 1999).

Logistics postponement: SCS with direct distribution of finished goods from centralised inventory (Pagh and Cooper, 1998).

Manufacturing postponement: SCS with final manufacturing activities performed downstream in the supply chain (Pagh and Cooper, 1998).

Responsiveness: SCS 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 *et al*., 2003).

Risk hedging: SCS aimed at pooling and sharing resources to enable risk sharing in supply disruption (Lee, 2002).

Supply chain design (SCD): Process of identifying desired strategic outcomes and developing, implementing, and managing the resources, processes, and relationships that will enable the attainment of the desired outcomes over time (derived from Melnyk *et al*., 2014).

Supply chain strategy (SCS): Specification of how a company can achieve its competitive advantage through its competitive priorities (Qi *et al*., 2011).

3. Research methodology

This chapter presents the author's position on theory building (Section 3.1) and research paradigm (Section 3.2). The chapter also explains and motivates the author's research approach (Section 3.3) and research strategy (Section 3.4), describes the research process (Section 3.5), explicates and motivates the research design (Section 3.6), and explains the Delphi rounds (Section 3.7) and model development (Section 3.8). Finally, the chapter also discusses record keeping (Section 3.9), research rigour (Section 3.10) and research ethics (Section 3.11).

3.1. Theory building

The following quote summarises the author's position on knowledge creation prior to his licentiate and doctoral studies.

> *"I keep six honest serving-men (They taught me all I knew); Their names are What and Why and When; And How and Where and Who".*
>
> *Rudyard Kipling (Kipling, 2001, p. 29)*

Kipling (2001, p. 29) relied on his serving-men for knowledge creation and as operational research practitioner and management consultant, they served the author of this dissertation equally well. The author thus subscribes to the definitions of theory suggested by Whetten (1989) and Wacker (1998). Accordingly, theory consists of elements that answer the questions of who, what, when, where, how, why, should, could and would. Wacker (1998) proposes a procedure for general theory building and empirical support of theory, as illustrated in Table 3.1.

Research is primarily oriented towards theory testing or development, based on deduction and induction, respectively (Arlbjørn and Halldórsson, 2002). The purpose of theory development is to advance research by making a contribution that is relevant to a research area (Rindova, 2011). In line with Corley and Goia (2011), the author regards a theoretical contribution as dependent on the researcher's ability to produce thinking that is original and useful (Table 3.2).

Table 3.1: A general procedure for theory building (Wacker, 1998).

	Purpose of this step	Common question	"Good" theory virtues emphasised
Definitions of variables	Defines who and what are included and what is specifically excluded in the definition.	Who? What?	Uniqueness, conservation
Limiting the domain	Observes and limits the conditions by when antecedent event and where the subsequent event are expected to occur.	When? Where?	Generalisability
Relationship (model) building	Logically assembles the reasoning for each relationship for internal consistency.	Why? How?	Parsimony, fecundity, internal consistency, abstractness
Theory predictions and empirical support	Gives specific predictions. Important for setting conditions where a theory predicts. Tests model by criteria to give empirical verification for the theory. The riskiness of the test is an important consideration.	Could the event occur? Should the event occur? Would the event occur?	Empirical tests refutability

Scholars have defined different levels of theory (Carter, 2011). A three-level classification of theories, reported in Halldórsson *et al*. (2007), consists of grand, middle range and small-scale theories. Bacharach (1989) explains the components of theory in a way that this author finds useful to understand how small-scale theories are constructed: a system of propositions that relate constructs to each other and hypotheses that relate variables to each other (Figure 3.1).

Table 3.2: Current dimensions for theoretical contribution (Corley and Goia, 2011).

		Utility	
		Practically useful	**Scientifically useful**
Origi-nality	**Revela-tory**	Revelatory insight but without adequate scientific usefulness	Original, revelatory insight and scientific usefulness
	Incre-mental	Without adequate originality and without scientific usefulness	Scientifically useful but without adequate originality

The research reported in this dissertation is about both theory testing (deduction) and theory development (induction, abduction). It tests small-scale theories, in the form of constructs and propositions, from the commercial context (PSM and SCM) in the defence context (military logistics). However,

it also develops small-scale theories in both contexts. In the words of Whetten (1989), this dissertation does not contribute with any full-fledged theories, but rather emergent products.

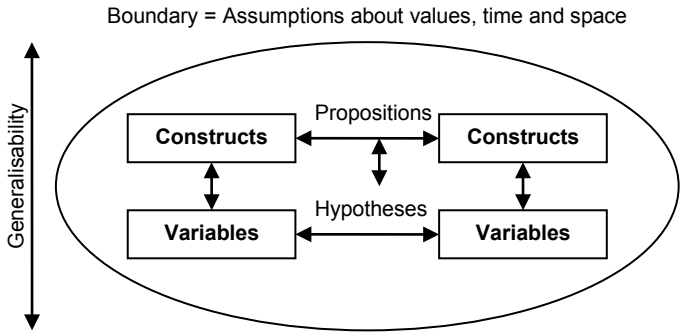


Figure 3.1: Components of a theory (Bacharach, 1989).

The author regards the reported research as both practically and scientifically useful. The practically useful part is revelatory, whereas the scientifically useful part is incremental. In the theoretical contribution typology provided by Corley and Goia (2011), this makes the theory testing part of the research scientifically useful, but without adequate originality, while the theory building part provides revelatory insights, but without adequate scientific usefulness.

3.2. Research paradigm

People commonly us the word paradigm to refer to *"world view"* or *"way of seeing things"* (Jackson, 2003, p. 36). In science, it refers to the tradition of research regarded as authoritative by a particular scientific community, *"normal science"* (Kuhn, 1996, p. 10). A paradigm consists of theoretical assumptions and laws, and methods for using them, which a particular scientific community agrees upon (Chalmers, 1999, p. 108). Gummesson (2000, p. 18) reduces a paradigm to a researcher's opinion of what interesting research problems are and which methods that can be used to address them.

In the natural sciences, paradigms generally succeed each other (Mingers, 2003). However, in the social sciences old paradigms can survive together with new ones (Arbnor and Bjerke, 1997, p. 13). Such parallel paradigms

specify assumptions regarding ontology (what is assumed to exist), epistemology (the nature of valid knowledge), ethics or axiology (what is valued or considered right), and methodology (Mingers, 2003).

In the social sciences, researchers have proposed several sets of paradigms that can exist simultaneously. Examples include Burrell and Morgan (1979, p. 23), who suggest radical humanist, radical structuralist, interpretive and functionalist, Jackson (2003, p. 38), who proposes functionalist, interpretive, emancipatory and postmodern, and Saunders *et al*. (2009, p. 119), who distinguish between positivism, realism, interpretivism and pragmatism.

Burrell and Morgan (1979, p. 1) argue, *"It is convenient to conceptualise social science in terms of four sets of assumptions related to ontology, epistemology, human nature and methodology"*. Figure 3.2 illustrates the spectra for each of these dimensions of paradigm.

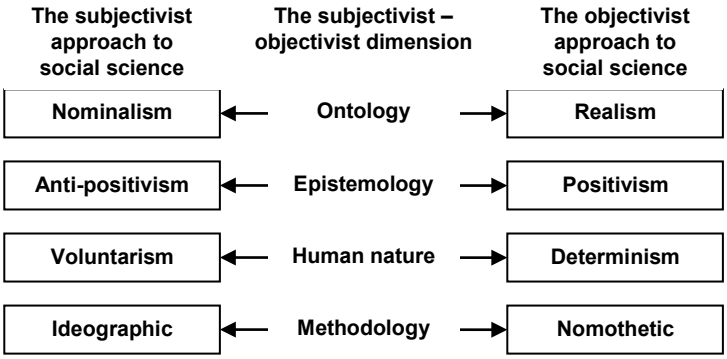


Figure 3.2: The subjective – objective dimension (Burrell and Morgan, 1979, p. 3).

In social research, Silverman (2006, p. 15) broadly categorises methodologies as either qualitative or quantitative. Qualitative methods are associated with features such as soft, flexible, subjective, political, case study, speculative and grounded, whereas the corresponding features for quantitative methods are hard, fixed, objective, value-free, survey, hypothesis testing and abstract (Silverman, 2006, p. 35).

The positivist paradigm underlies the quantitative methods, while the constructivist paradigm underlies the qualitative methods (Tashakkori and Teddlie, 1998, p. 3). According to Tashakkori and Teddlie (1998, p. 3), the last three decades of the 20th century saw several debates (wars) *"regarding*

the superiority of one or the other of the two major social science paradigms", which are the positivist-empiricist approach and the constructivist-phenomenological orientation, and the end of the paradigm wars saw the emergence of mixed methods and mixed methodology.

The emerging pragmatist paradigm, which rejects the enforced choice between positivism and constructivism in favour of embracing both points of view, underlies the mixed methods (Tashakkori and Teddlie, 1998, p. 22-23). While mixed methodology utilises qualitative and quantitative methodology, multimethodology is the combination of methodologies (Mingers, 2003), but not necessarily from both qualitative and quantitative methodology.

The concepts of ontology and epistemology are related to the individual (Arlbjørn and Halldórsson, 2002), and in line with Gummesson (2000, p. 18), it is appropriate for the author of this dissertation to summarise his educational and professional background and present his research paradigm.

The author holds a Master of Science degree in Industrial Engineering and Management, a Master of Science degree in Military Operational Research and a Licentiate in Engineering degree[1] in Engineering Logistics. Hence, the theoretical education is in engineering, primarily within the positivist paradigm from the natural sciences, and predominantly useful for quantitative problems in mechanical and natural systems. However, the author has a quarter of a century experience of working with military operational research in practice, which has for the most part involved qualitative problems in social systems, requiring an interpretivistic paradigm from the social sciences.

In line with Alvesson and Sköldberg (2000, p. 4), the author has reached the conclusion that both positivistic quantitative and interpretivistic qualitative methodologies have their merits in different situations and for different types of problems. Hence, in line with Tashakkori and Teddlie (1998, pp. 22-23), the author considers himself to be a pragmatist that utilises quantitative

[1] A licentiate degree is an intermediate degree, between a master and a doctoral degree. In Sweden, the formal requirements for a licentiate degree is 120 ECTS (two years of full-time work), whereas a doctoral degree is 240 ECTS (four years of full-time work.)

methodology from the positivistic natural sciences, qualitative methodology from the interpretivistic social sciences, mixed methodology, or multimethodology, depending on which problems that are to be addressed, resource restrictions in forms of available time and money, etc. Furthermore, this author subscribes to the hermeneutic claim, that there is a substantial dissimilarity between explaining nature and interpreting culture (Arbnor and Bjerke, 1997, p. 45).

Using the dimensions (Figure 3.2) proposed by Burrell and Morgan (1979, p. 3), the author would place himself as follows. Somewhere in the middle of the road in the ontological debate, between nominalism and realism. Far left in the epistemological debate, quite close to anti-positivism. Far left in the human nature debate, quite close to voluntarism. To the left of the middle in the methodological debate, a slight preference for the ideographic approach.

Being a professed pragmatist, the author would position himself on the scale from subjectivist-relativistic to objectivistic-rationalistic (Arbnor and Bjerke, 1997, p. 27) depending on the research problem at hand, but normally most likely closer to the subjectivist-relativistic end of the scale when investigating social systems, where human participation and interaction are significant aspects. The topics of this dissertation, purchasing (procurement), logistics systems and supply chains, are clearly examples of such social systems.

3.3. Research approach

According to Spens and Kovács (2006), there are two general research approaches, deduction and induction. Deduction is about *testing theory*, which means testing a proposition about the relationship between two or more constructs (Saunders *et al.,* 2009, p. 124). *"Deductive reasoning begins with an abstract concept and then tests that concept with empirical evidence"*, and *"support for the concept is achieved if data collected from observations are consistent with the proposed concept"* (Lambert, 2007). Deductive theory testing relates to the positivist paradigm (Åsvoll, 2014).

Induction is about *building theory* (Saunders *et al.,* 2009, p. 124). *"Inductive research creates grounded theory by beginning with data collection and then making generalisations and inferring theories based on the observations"*, and *"should begin with no preconceived ideas of what will be found"* (Lambert, 2007). Inductive theory building relates to both the positivist and

the constructivist paradigm (Åsvoll, 2014). Inductive research is normally qualitative*, "since we in this context make conclusions from specific observations to general statements"* (Arlbjørn and Halldórsson, 2002).

In addition to *deduction* and *induction*, Aristotle also identified *abduction*, which is about theory building (Kovács and Spens, 2005). Abduction (Figure 3.3) can start from either a perplexing observation or an irregularity, which established theory cannot explain, or premeditated application of an alternative theory to explain a phenomenon (Spens and Kovács, 2006). The first starting point involves "theory matching" or "systematic combining" (Dubois and Gadde, 2002). The second comprises borrowing theories from other disciplines (Stock, 1997).

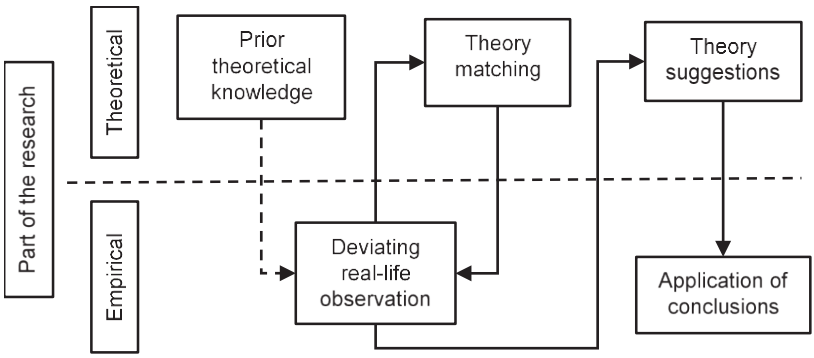


Figure 3.3: The abductive research process (Kovács and Spens, 2005).

According to Kovács and Spens (2007), in the positivistic paradigm, researchers must use the deductive research approach and in the interpretivistic paradigm, they must use the inductive research approach, whereas in the scientific realistic paradigm, researchers are free to use the deductive, the inductive or the abductive research approaches. This perspective reduces deduction, induction and abduction into three different approaches, of which the researcher must select one. There are, however, alternative perspectives. As an example, Åsvoll (2014) presents deduction, induction and abduction as elements in a research strategy, where deduction-induction-abduction is suitable for theory testing, and abduction-deduction-induction is appropriate for theory building.

This research takes as its point of departure a practical research problem in the Swedish public defence sector (Section 1.1). The research purpose is to design

and develop a PPM for defence procurement, which will be of practical use for defence authorities. The research purpose consequently entails theory building, which implies induction or abduction. In line with Åsvoll (2014), abduction-deduction-induction is an alternative way of describing a suitable approach.

The research addresses open issues and gaps in extant theory in the areas of military logistics, PSM and SCM (Section 2.5) and premeditatedly uses theories from PSM and SCM for theory building in defence procurement and military logistics, which is the starting point of an abductive approach (Kovács and Spens, 2005). In addition, the author modifies the initial PPM throughout the study, partly due to surprising empirical findings, which is in line with abductive research (Dubois and Gadde, 2002).

As a professed pragmatist (Section 3.2), the author of this dissertation is free to select any research approach that seems contextually appropriate. In line with Kovács and Spens (2005), the author of this dissertation considers the overall research approach to be abductive. However, as stated in Section 3.1, the research includes elements of both theory testing (deduction) and theory development (induction, abduction). In line with Åsvoll (2014), abduction-deduction-induction is thus an alternative way of describing the approach.

3.4. Research strategy

The author of this dissertation must select a specific qualitative, quantitative or mixed methodology (Section 3.2) for the research. According to Yin (2003, p. 1), each research strategy has advantages and disadvantages depending on three conditions: the type of RQ, the control the investigator has over actual behavioural events, and the focus on contemporary as opposed to historical phenomena. Depending on these conditions, different research strategies will be most suitable.

Sometimes all research strategies may be relevant, sometimes two strategies are equally attractive, but in some circumstances one specific strategy has a distinct advantage (Yin, 2003, p. 9). To exemplify, if the primary RQ is *"a "how" question"* which *"is being asked about a contemporary set of events, over which the investigator has little or no control"*, the case study is the research strategy that has the distinct advantage (Yin, 2009, pp. 14-15).

The system in focus in this research, a generic Swedish defence supply chain (Section 1.2), is an example of a social system, where human participation and interaction are significant aspects (Section 3.2). Moreover, this research has the ambition to involve practitioners in design, development and validation, to ensure that the PPM actually is of practical use to defence authorities (Section 1.4). Based on research paradigm (Section 3.2) and understanding of the system in focus, it is obvious to the author that a qualitative research strategy is the most appropriate, but which one to select is less self-evident.

This research deals with contemporary events, over which the author has no control, which could motivate conducting a case study (Yin, 2009, pp. 14-15). However, the Delphi technique is suitable for creating shared knowledge and agreement on topics for which expert opinions are the only source of information available (Genovese *et al.*, 2013), for research that deals with uncertainty and imperfect knowledge (Rowe and Wright, 1999) and when judgmental information is essential (Okoli and Pawlowski, 2004). Using the Delphi technique, researchers can elicit the wisdom of a group of experts, while avoiding negative effects associated with other methods, such as interpersonal biases, strong personalities, defensive attitudes and unproductive disagreements (Linstone and Turoff, 2002).

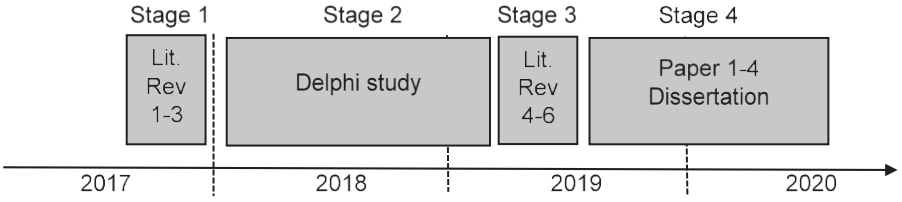
Most areas of human endeavour are candidates for application of the Delphi technique (Linstone and Turoff, 2002, p. 3). It is particularly advantageous in reducing uncertainty by using practitioners and experts in the panels, and enlightening organisations on important and current issues (Worrell *et al*., 2013). Putting together the structure of a model is one of the application areas proposed by Linstone and Turoff (2002, p. 4). Furthermore, the Delphi method is applicable for research that deals with uncertainty in an area of imperfect knowledge (Rowe and Wright, 1999).

Since its inception, the Delphi technique has won acceptance across disciplines (Czinkota and Ronkainen, 2005). Researchers have used it in areas such as information systems and health care (Fletcher and Marchildon, 2014). There are also many examples in the logistics and SCM literature where the Delphi method has been successfully implemented (Huscroft *et al.*, 2013) and it has increasingly been used to investigate factors influencing decision-making on a specific issue, topic or problem area in SCM (Kembro *et al.*, 2017).

This research deals with model design and development in military logistics, including defence procurement. An important aspect of the research is also to raise the awareness among defence practitioners of developments in related theoretical areas. Since defence procurement is an area with limited academic knowledge, and where expert opinions are the primary source of information, the author decided that the conventional Delphi technique, with modifications (Section 3.6.1), is appropriate to employ in this research.

3.5. Research process

This dissertation reports on research conducted from August 2017 to October 2020. The author had previously conducted licentiate research, between 2008 and 2011, which resulted in the licentiate thesis *"Public Private Business Models for Defence Acquisition - A Multiple Case Study of Defence Acquisition Projects in the UK"* (Ekström, 2012). However, as stated in Section 1.5, the research reported in this dissertation is a sequel to a study by FMV (2016), rather than a continuation of the licentiate research. Figure 3.4 illustrates the four stages in the reported research process.



(Lit. Rev.: Literature review)

Figure 3.4: A schematic illustration of the research process.

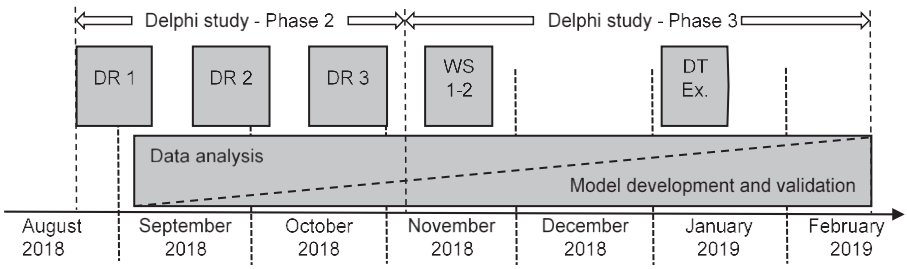
The first stage in the research commenced in the autumn of 2017 with three literature reviews. The first established the status of academic knowledge in military logistics (Section 2.1). The second searched for segmentation models and differentiation strategies in the PSM (Section 2.3) and SCM (Section 2.4) literature, to identify seeds for the Delphi study. The third established recent developments regarding the Delphi methodology (Section 3.6).

The second stage of the research process, the Delphi study, consisted of three phases. In Phase 1, research design (Section 3.6), the author designed the

modified, conventional Delphi study in the spring of 2018 and initiated the study in June, with an introduction package to the panellists.

Figure 3.5 illustrates Phase 2 and 3. In Phase 2, Delphi rounds (Section 3.7), the author collected data in three Delphi rounds, analysed the data throughout the autumn of 2018 and began the PPM model development.

As illustrated in Figure 3.5, data analysis and model development were integrated activities, were analysis of collected data dominated in the early stages of the Delphi study, and model development in the later stages. In Phase 3, data collection and analysis morphed into model development (Section 3.8). During this phase, which commenced in November 2018, the study addressed unresolved issues from the Delphi rounds, and collected additional data and validated findings in two workshops. After the workshops, the author intensified model development, to transform the results of the Delphi study into a PPM for defence procurement, and validation of the proposed PPM. As part of the validation, the author initiated two desktop exercises (Section 3.8.3) in January of 2019. The study was finalised in February 2019.



(DR: Delphi round; WS: Workshop; DT Ex.: Desktop exercises)

Figure 3.5: A schematic illustration of Phase 2 and 3 in the Delphi study.

In the third stage, the author conducted three additional literature reviews, in March 2019. The results of the Delphi study necessitated the fourth literature review, since the second did not focus on tactical levers (Section 2.3.3). Literature reviews five and six, regarding how researchers should establish rigour in Delphi studies and how researchers actually establish rigour in the logistics and SCM literature, were required to enable a reflection on research rigour (Section 3.10) and as input to Paper 4 (Section 4.5).

In the final stage of the research, the author wrote the dissertation and the four appended papers. The author submitted Paper 1, *"Towards a purchasing*

portfolio model for defence procurement – A Delphi study of Swedish defence authorities", in February 2020. It is currently, in October 2020, awaiting the editor's decision after two revisions. Paper 2, *"Differentiation strategies for defence supply chain design"*, submitted in May 2020, was accepted in October 2020 for publication in *Journal of Defense Analytics and Logistics* after one revision. Paper 3, *"Guidance for management decisions in the application of a dynamic purchasing portfolio model for defence procurement"*, was submitted in October 2020. Paper 4, *"The Delphi Technique - Limitations and possibilities"*, submitted in April 2020, was accepted without revision to the 32nd NOFOMA conference in September 2020.

3.6. Delphi study Phase 1 – Research design

3.6.1. The Delphi technique

The RAND Corporation developed the Delphi method in the military domain in the 1950s (Kauko and Palmroos, 2014), to *"obtain the most reliable consensus of opinion of a group of experts"* (Dalkey and Helmer, 1963). Rowe *et al.* (1991) identify four required characteristics of Delphi: anonymity, iteration, controlled feedback, and statistical aggregation of group response.

The Delphi technique was originally one method, intended for forecasting in the military domain (Yousuf, 2007). In 1970, Turoff (1970) introduced the complementary policy Delphi. Researchers have modified the original method to serve different purposes (Fletcher and Marchildon, 2014) in different domains (Gupta and Clarke, 1996). Authors classify the various modifications and applications differently, but the only distinction made in this dissertation is between conventional, including modifications, and policy Delphi.

According to many authors, the objective of the conventional Delphi is to reach consensus (de Loë *et al*., 2016). However, this is a tenacious misinterpretation (Mullen, 2003; Linstone and Turoff, 2011). The intended outcome of a Delphi study may include the identification of the degree of consensus or dissensus, specification of the range of different positions, and the revelation of underlying justifications (Critcher and Gladstone, 1998). The goal of a Delphi study is not to elicit a single answer, or to achieve consensus,

but to produce high-quality responses and opinions from the panel to improve decision-making (Gupta and Clarke, 1996).

3.6.2. Design of the modified, conventional Delphi study

The first Delphi study established many key features of the method, such as panel selection, anonymity and at least two rounds of questionnaires (Fletcher and Marchildon, 2014). Worrell *et al.* (2013) state that all implementations and variations of the conventional Delphi share four core characteristics: a panel of knowledgeable experts, anonymity among the panellists, group communication to manage feedback and consensus seeking, and controlled feedback and iteration.

The expert panel is a central component of Delphi, which involves issues such as size, selection, composition and completion rate (de Loë *et al.*, 2016). Okoli and Pawlowski (2004) consider the selection of qualified experts to be one of the most critical elements of the method. A Delphi panel should include experts who are knowledgeable in the research topic, and who represent different perspectives (Okoli and Pawlowski, 2004; Ogden *et al.*, 2005; Melnyk *et al.*, 2009). The sample of experts in a Delphi study is not statistically representative, but deliberately selected to reflect on an issue (Worrell *et al.*, 2013).

Most extant guidelines (Akkermans *et al.*, 2003; Ogden *et al.*, 2005; Huscroft *et al.*, 2013) recommend a panel size between twenty and thirty experts, even if some recommendations state that ten experts should be sufficient (Rowe and Wright, 2001). A modification to the conventional Delphi is to use multiple expert panels, to account for multiple perspectives in complex, multidimensional problems (Worrell *et al.*, 2013). Following Rowe and Wright (2001), in a modified design, two panels require twenty experts (Kauko and Palmroos, 2014).

There are two principally different ways to initiate the first round of questions. The conventional way is to use exploration and evaluation phases, where the first round explores the topic through broad or open-ended questions, and subsequent rounds evaluate the findings of the previous ones (Fletcher and Marchildon, 2014). The modified way is to use theory, a literature review, or another source, to produce seeds as a starting point (Worrell *et al.*, 2013). In both cases, the panellists provide answers to questions as numeric estimates,

ratings on a scale, yes/no, and/or written comments to the raised issues (Kauko and Palmroos, 2014).

In subsequent rounds, the panellists receive controlled feedback, including examples of answers from other panellists and measures on consensus (Worrell *et al.*, 2013). This feedback provides the panellists with the opportunity to revise their answers based on the answers of other experts (Fletcher and Marchildon, 2014), which some researchers perceive as the most important aspect of Delphi (Parenté *et al.*, 2005). Thus, group communication, enabling panellists to study the answers of other experts, complemented with statistics to illustrate the level of consensus (Worrell *et al.*, 2013), is a fundamental aspect of Delphi (Kauko and Palmroos, 2014).

Through iteration over multiple rounds, controlled feedback can lead to consensus, or near-consensus (Fletcher and Marchildon, 2014). The number of rounds can be predetermined or based on convergence criteria (Mullen, 2003). In the latter case, researchers repeat rounds until they reach consensus, or until it becomes evident that further convergence is not possible (Anderson *et al.*, 1994). Researchers should base the number of rounds on when the study attains stability in the responses, not when consensus is achieved (Linstone and Turoff, 2011), but panellists should provide answers to at least two rounds of questions (Fletcher and Marchildon, 2014). Predetermination of the number of rounds is a common modification of the conventional Delphi.

The final answer of the panel is the mean, or median, of the panellists' individual answers (Kauko and Palmroos, 2014). Researchers can measure increased consensus as a decrease of the standard deviation (Worrell *et al.*, 2013). Previous research indicates that three rounds is sufficient for stability (Rowe and Wright, 1999) and accuracy (Parenté *et al.*, 2005). However, other recommendations include two to four rounds, and published studies vary between two and five rounds (Mullen, 2003). In the original Delphi, researchers should keep iterating until the process reaches stability. Dajani *et al.* (1979) define five forms of stability: consensus, majority, bipolarity, plurality and disagreement.

The research reported in this dissertation uses a modified, conventional Delphi study in line with Worrell´s *et al*. (2013) recommendations and provides an audit trail of the most important theoretical and methodological decisions to demonstrate trustworthiness (Skulmoski *et al*., 2007). The study uses four modifications to the conventional Delphi: two Delphi panels, a predetermined

number of rounds, a seeded list, based on open issues in the literature, as questions in the first round and, in line with Melnyk *et al.* (2009), two concluding workshops to review and extend findings.

3.6.3. Delphi panel selection

The study invited forty-five experienced practitioners and researchers from the Swedish defence authorities: thirty-three from the Swedish Armed Forces, eight from FMV and two each from FOI and the Swedish Defence University (SEDU). When the author had prior knowledge of the expertise of individuals, the study sent invitations directly to these experts. In most cases, the study sent invitations to managers of relevant organisational units within the Swedish defence authorities, and asked them to allocate experts to the study. The author gave managers and prospective panellists an estimate of the time that each panellist would have to allocate to the study, from its initiation through to its finalisation.

The invited practitioners from the Swedish Armed Forces include the strategic, operational and tactical perspectives on military logistics, whereas the practitioners from FMV represent the military, technical, commercial and legal perspectives on defence procurement. The invited researchers from FOI have long experience of doing research on logistics and procurement in close cooperation with the defence authorities. The invited researchers from SEDU are officers, who combine extensive practical experience with a research perspective. Most of the invited experts have experience in excess of twenty years, some of whom closer to forty years. None of them have less than one decade of relevant experience.

The invitation letter included a description of the objective of the proposed study, a brief explanation of the Delphi Technique, and an outline of the intended research process, scope and timeline of the study. In total, twenty-five experts accepted the invitation, but three of them left the study before the first round of questions and two of them did not provide the first set of answers. The final panel consisted of twenty experts, whereof twelve from the Swedish Armed Forces, four from FMV, two from FOI, and two from SEDU. The study guaranteed anonymity, confidentiality and that the panellists could leave the study at any point. The experts had no knowledge of the total number of participating experts, their identity or of the two panels.

3.6.4. Two Delphi panels

With twenty-two experts, later reduced to twenty, the study had the opportunity to use a modified design, with two panels. For three reasons the author decided to use two panels. First, this was an opportunity to enhance rigour. If the two panels independently came to the same results, this would reinforce rigour. Second, given the results of the literature review on PPMs, with divergent opinions, it was difficult to formulate questions that the panellists could answer on a Likert-scale. The author considered using the extremes from the literature as extremes on Likert-scales, but with two panels, the study could formulate questions from different perspectives to the two panels, which made questionnaire design and subsequent analysis less ambiguous. If the two panels arrived at the same conclusions despite the different questions, this would reinforce rigour. Third, academics have accused conventional Delphi of forcing consensus (Fletcher and Marchildon, 2014). Two panels would mitigate this risk, especially considering that the study formulated questions from different perspectives.

The author allocated the experts to the two panels randomly, with the restraint that the representation should be similar. The author referred to the two panels as Panel A and Panel 1. After the reduction to twenty panellists, the panels each had ten experts, whereof six from the Swedish Armed Forces, two from FMV, one from FOI, and one from SEDU. The author coded the panellists in Panel A as A1-A10 and the panellists in Panel 1 as 1A-1J. In Panel A, the response rates in the three rounds were 100 %, 80 % and 70 %. In Panel 1, the corresponding rates were 100 %, 90 % and 80 %.

3.6.5. Introduction package

Researchers have found that written information is effective to prepare the participants in a Delphi study (Whitman, 1990). The study distributed an introduction package to each panellist for self-study before the first Delphi round of questions. The package contained a thorough description of the background to the study and its objective, a summary of the Delphi technique, and a detailed description of the study at hand. The package also included an overview of the academic literature on segmentation models and differentiation strategies. The introduction package summarised the academic debate on such models and strategies, including explicit critique regarding

design issues and application issues regarding PPMs. The introduction package invited the panellists to contact the author with any questions they might have regarding its contents. In addition, before the first Delphi round, the author contacted the panellists to ensure that they had all read and understood the introduction package.

3.7. Delphi study Phase 2 – Delphi rounds

The study predetermined to use three Delphi rounds, which is a modification of the original conventional Delphi technique. The study provided the panellists with different sets of questions for the three rounds (Appendix A and Appendix B); three sets for the first round, and two each for the second and third rounds. The author sent reminders to the panellists towards the end of each round.

Responses from each round provide researchers with input to formulate the questions for the subsequent round. After each round, the panellists receive a compilation of the answers from the entire panel, and have the possibility to change their answers based on this information, without the risk of embarrassment (Lummus *et al*., 2005).

3.7.1. Delphi round 1

In the first round, the first set of questions consisted of queries concerning the background of the experts, such as education, experience, specialities, and responsibilities. Based on the literature review on segmentation and differentiation, the second and third sets consisted of questions regarding PPM design and application (Appendix A) and defence SCD (Appendix A), respectively. In line with the academic discussion (Section 2.5.2), the author formulated some of the questions, primarily regarding PPM application, from different perspectives to the two panels.

For all questions except one, the panellists provided answers on a five-level Likert-scale, ranging from “strongly disagree” to “strongly agree”. In the remaining question, the panellists expressed their preferences regarding a selection of existing segmentation models. For each question, the panellists could also justify their answers in free text format. If a panellist had abstained from answering a particular question, he or she could also motivate this choice

in free text format. The questionnaire also enabled the panellists to provide comments regarding issues that they thought was missing in the questionnaire.

The author compiled the answers in a database (Section 3.9.1) and used the Likert-scale answers to calculate means and standard deviations. The study distributed means to the panellists in the next round, whereas standard deviations contributed to assessing the degree of consensus. The author analysed the free text answers to determine whether to alter or delete any of the existing questions, and whether or not to include any new questions in the questionnaire for the next round based on new insights. The free text answers were also analysed to identify emerging ideas for model development. There were no insights in the first round that motivated any additional questions or changes to the existing ones.

The author used the background information to analyse if there were any differences in the responses attributable to different backgrounds, but could not identify any such differences.

3.7.2. Delphi round 2

In the second round, the study repeated the second and third sets of questions, regarding PPM design and application, and defence SCD, from the first round (Appendix A). For each question, the study provided the panellists with the most frequent answers from the first round, as well as with the mean. Studying other experts' answers is an essential part of the method (Kauko and Palmroos, 2014). The study therefore exemplified the justifications and motivations provided by the panellists, thus providing the panellists the opportunity to revise their answers based on the replies from the other experts. As in the first round, the panellists provided answers on a five-level Likert-scale. They could also justify answers, motivate abstainment and comment on missing topics in free text format.

The author compiled answers and conducted analyses as in the first round. In the second round, the tendency to change their answers from the first round was limited among the panellists. The relatively few revisions reinforced the most frequent answers from the first round, and reduced the spread around the mean. The author saw this as an indication that a third round on the same format would not provide any further insights, and therefore changed the

format for the final round. There were no differences in the responses depending on background of the panellists.

3.7.3. Delphi round 3

The purpose of the research is to design and develop a PPM for defence procurement, which will be of practical use for defence authorities. This entails establishing answers to the open issues in Section 2.5.2, such as "how many dimensions" and "which dimensions", to establish design rules, and if the model should be prescriptive, or not, to establish application rules. The study used the third round to elicit answers to these questions (Appendix B).

Instead of asking the panellists to position themselves on a Likert-scale, the study asked them to answer "yes", "no" or "I don't know" on most of the questions, without the option of free text comments. The questions regarding PPM design and application were a subset of the questions from the first two rounds. The author did not repeat questions were the study had reached consensus in the previous rounds. In addition, the study asked the panellists to address three new questions regarding PPM design.

The new questions were combinations of several questions, as well as free text answers, from the two previous rounds, which the author analysed and used to generate mutually exclusive alternatives (Appendix B). The study asked the panellists to state their preference for one of the presented alternatives for the three new questions. The panellists could also provide comments in free text. The combination of questions enabled a reduction of the number of questions regarding PPM design.

The questions regarding defence SCD were the same as in the first two rounds. However, the panellists could only answer "yes", "no" or "I don't know", without the option of free text comments.

The author compiled answers and conducted analyses as in the preceding rounds. For most questions, round three led to consensus among the panellists. However, for some questions, there were only slight majorities or bipolarity, which required further analysis, discussion and interpretation. In addition, for some issues further discussions on the implications of the results were required. As an example, the result of round three was that the PPM should have three dimensions, whereof one should be a precursor to a two-dimensional model. However, the study had yet to decide which the three

dimensions should be and which values they should have. The study put all unresolved issues on the agenda for the concluding workshops, to try to reach consensus or confirm different points of view, such as bipolarity (Section 3.6.2).

3.8. Delphi study Phase 3 – Model development

3.8.1. Workshops

The purpose of the workshops was to clarify and interpret results, to establish PPM design and application rules, and to establish acceptability, applicability and sufficiency of commercial SCD-constructs, as input to the continued model development. Before the workshops, the study distributed the results of the final Delphi round. However, for the selection of dimensions and values in the segmentation model, the Delphi rounds had not reached the required level of detail. Based on the literature, the Swedish Defence Policy (Swedish MoD, 2015) and the results of the Delphi rounds, the author therefore proposed dimensions and values as input to the workshops.

The discussions during the first workshop primarily focused on the implications of the three questions regarding PPM design that the study had introduced in the final round (Annex B). The participants agreed on PPM design and application rules, and helped the author to interpret surprising results. The study used the output of the first workshop as input to the second, which allowed the participants in the second workshop to start discussions on a higher level of understanding and to confirm the results of the first.

In addition to the agenda for the first workshop, the participants in the second workshop also addressed an emergent theme in the study. The application rule "dynamic application", involves analysis of repositioning opportunities in the segmentation model. There are two directions in which to move to a more favourable position in the two-dimensional model, down and left, which corresponds to reducing operational dependency and increasing market capability. However, the application rules established by the study thus far did not include guidance regarding how to move in the model.

Using operational and commercial analysis, the workshop participants identified suitable dynamic tactical levers, which are different ways of moving

in the model. The participants also identified appropriate static tactical levers, which are the remaining options when moving in the model is not possible.

3.8.2. Model development

After the workshops, the author continued development of the PPM, based on extant theory, the design and application rules, the acceptability, applicability and sufficiency of commercial SCD-constructs, and the tactical levers.

The author derived the proposed model directly from the design rules in Table 4.2 and Table 4.3. In accordance with these rules, the segmentation model is a two-stage model based on three dimensions, a precursor and a two-dimensional model, with predefined dimensions and values. The precursor represents the operational requirements of the Swedish Armed Forces, and the two-dimensional model represents the market's ability to deliver supplies and limitations in the Swedish Armed Forces' operational capability if the market does not deliver supplies on time.

With the exception of the merger of segments, the design rules made segmentation model design straightforward. The final design rule entails the merger of sixteen matrix elements into four segments. Merging these elements into four, square segments would render the design rule "four values for each dimension" meaningless. In addition, the major concerns of the military panellists are the situations when the market's ability to deliver supplies on time is low or non-existent, and/or when the limitations in the Swedish Armed Forces' operational capability if the market does not deliver supplies on time is severe or disastrous. Consequently, after exploring several possible solutions, and discussing these with fellow researchers, the author proposed a merger of segments where the most problematic combinations of these situations occupies a larger area. The author also proposed the names of the resulting four segments.

The final step in the model development was to combine the two-stage segmentation model (Section 4.2.3) and the application rules (Table 4.4) with the differentiation strategies (Section 4.3.3) and the identified dynamic and static tactical levers (Section 4.4.1), to propose guidance for management decisions in the application of a dynamic PPM for defence procurement (Section 4.4.2). The first application rule, *both* prescriptive *and* serve as a catalyst for discussions, was a surprising result of the study, with implications

for the guidance, which was resolved during the workshops (Section 4.2.2). The final application rule, which involves immediate repositioning to a more favourable segment, was an emergent theme (Section 3.9.2) of the study. Since the author had not anticipated the implications of a dynamic PPM, the study had to introduce tactical levers as a topic for discussion during the workshops and conduct an additional literature review.

3.8.3. Desktop exercises

To validate the guidance for management decisions, the study conducted two open-discussion, desktop exercises with experienced representatives of the defence authorities, two from the Swedish Armed Forces and four from FMV. The prepared scenario involved the procurement of a particular, advanced type of ammunition. The study selected this ammunition since it represents current, complex defence procurement, with few suppliers and long lead-times, which means that the market's ability to satisfy all operational requirements is low or non-existent. In addition, the limitations in the Armed Forces' operational capability if the market does not deliver on time is likely to be disastrous or severe. Consequently, potential users of the PPM for defence procurement are likely to segment this advanced ammunition as strategic supplies, which is the segment that provides most challenges in procurement and most opportunities for repositioning in the two-dimensional segmentation model. During and after the desktop exercises, the participants evaluated the methodology in plenary, which resulted in minor revisions after the first exercise. No further revisions were required after the second desktop exercise.

3.8.4. Referral round

To validate the PPM and the author's interpretation of the results of the Delphi study, including design and application rules, the author distributed the PPM, including segmentation model, tactical levers, differentiation strategies and guidance for management decisions, among the panellists. There was consensus that the author had interpreted the results correctly, and the panellists approved the proposed model.

3.9. Record keeping

3.9.1. Database

The author kept a database, in a spreadsheet, with all information relevant to the study. To ensure anonymity, the author coded all panellists (Section 3.6.4) in the database. The author used the database to document all questions and answers after each Delphi round and to calculate means and standard deviations. The database also included information regarding the study's administration, such as dates for sending out invitations, information, questionnaires and reminders, and for receiving responses. The database also included response rates for each round and thus kept track of attrition.

3.9.2. Journal

The author kept a journal to document all ideas and insights associated with the study, but not suitable for documentation in the database. This primarily included ideas for analysis and model development. The journal was particularly useful during the workshops and the desktop exercises, but also during the months of analysis and model development, when ideas could surface when the author least expected it, and did not have access to the database.

The journal was mostly useful for the more creative aspects of analysis and model development. As an example, the first draft of the two-stage model presented in this dissertation came from this journal, where the author sketched it when it emerged during a discussion with a fellow researcher regarding how to interpret the results of the final Delphi round (Section 3.7.3). Similarly, the author drew different versions of the merger of the elements in the two-dimensional model in the journal. Another epiphany documented in the journal was the insight that an important outcome of the study was that the model should be dynamic, which had implications for how important tactical levers were to the model development. This was an emergent theme that the author had not anticipated in the design of the study and consequently not included specifically in the literature review on segmentation and differentiation.

3.10. Research rigour

Traditionally, researchers have evaluated research rigour based on quantitative, positivistic quality criteria concepts such as validity and reliability (Halldórsson and Aastrup, 2003). Statements such as, *"Whether quantitative or qualitative, good research design requires external validity, reliability, construct validity, and internal validity"* (Ellram, 1996), have guided researchers in this regard. However, the validity in qualitative studies is *"often seen as a serious problem"* (Gammelgaard, 2004). Halldórsson and Aastrup (2003) argue that the quality criteria should consider the emerging qualitative, naturalistic approaches and complement the quality criteria of correspondence (internal validity, reliability, external validity and objectivity) for quantitative research with quality criteria of trustworthiness (credibility, dependability, transferability, confirmability) for qualitative research.

Establishing rigour is the cornerstone of good research, but this issue is elusive in Delphi studies, largely due to the ongoing epistemological debate and recurrent modifications of the original method (Hasson and Keeny, 2011). The academic debate regarding if the Delphi technique belongs to the positivist or interpretivistic paradigm, has led to a corresponding, unresolved debate regarding which quality criteria to apply (Hasson and Keeny, 2011).

Day and Bobeva (2005) suggest that trustworthiness is more appropriate, or that researchers should combine criteria from both paradigms. Mullen (2003) conclude that researchers should use quantitative and qualitative methodologies as appropriate, and use quality criteria accordingly. Hasson and Keeny (2011) recommend that researchers should use quality criteria from both paradigms.

In a review of 463 Delphi-studies, Gupta and Clarke (1996) found that researchers are inclined to modifying Delphi, thus undermining rigour. Researchers must understand what rigour means in Delphi studies (Rowe and Wright, 2011), but few researchers even attempt to address this issue, leaving Delphi studies and the method *"open to criticism and dismissal"* (Hasson and Keeny, 2011). To ensure rigour, researchers must thoughtfully consider design issues, and justify design decisions in the methodology section (Worrell *et al.*, 2013). Skulmoski *et al.* (2007) argue that researchers can use an audit trail of the most important theoretical and methodological decisions to demonstrate trustworthiness in a Delphi study.

Based on the academic discussions on rigour in Delphi studies, as summarised above, it is clear that researchers should address the issue of research rigour in published research. Either by explicitly discussing the quality criteria of correspondence and/or trustworthiness, or by providing an audit trail, explicating the most important theoretical and methodological decisions. In the latter case, researchers should provide answers to how they have addressed the issues in Table 4.9 and issues such as justification of the method, type of Delphi study, response rates for each round (attrition/retention), and how they have established consensus (Hasson *et al.*, 2000).

Based on a review of the literature on rigour in Delphi studies, the author defines explicit and implicit indicators of research rigour in Delphi studies (Ekström, 2020). Explicit indicators are discussions on quality criteria of correspondence (external validity, reliability, objectivity, and internal validity) and/or trustworthiness (credibility, dependability, transferability, and confirmability). Implicit indicators are the provision of comprehensive, methodological audit trails, including justification of the method, type of Delphi, expert selection and attrition/retention, panel size, questionnaire design, content of feedback, number of rounds and consensus measurement.

As a professed pragmatist (Section 3.2), the author of this dissertation is free to select any research approach that seems contextually appropriate (Section 3.3). The author also feels free to select appropriate quality criteria. In line with Day and Bobeva (2005), the author is of the opinion that the quality criteria of trustworthiness is appropriate for qualitative research. Sections 3.10.1-3.10.4 discuss the explicit indicators of research rigour in this research, whereas Chapter 3 demonstrate the implicit indicators throughout the chapter.

3.10.1. Credibility

Credibility is comparable to internal validity (Halldórsson and Aastrup, 2003; Hasson and Keeney, 2011) and is the most important aspect of demonstrating trustworthiness in qualitative studies (Tashakkori and Teddlie, 1998, p. 90). Credibility establishes how believable the research findings are, if they represent reasonable conclusions based on the data and if they are representative of the participants' original views (Korstjens and Moser, 2018).

Strategies to ensure credibility include prolonged engagement, persistent observation, triangulation and member check (Korstjens and Moser, 2018).

To enhance internal validity in qualitative research, Merriam (1998, p. 205) propose two complementary strategies, participatory research and declaration of the researchers' biases.

Member checks are the most important credibility checks (Tashakkori and Teddlie, 1998, p. 92). The author used member checks to allow the participants in the Delphi study to validate findings, interpretations and conclusions, both during and after the study (Merriam, 1998, p. 204). Member checks were conducted both in the form of written communications during and after the study, and joint sessions towards the finalisation of the study.

The written communications included queries from the author regarding interpretation of design and application rules, the emergence of the proposed PPM and the final reports. The joint sessions were the workshops and desktop exercises, during which the participants discussed interpretations, findings and conclusions in plenary. With one exception, these member checks confirmed correct interpretation, and validated findings and conclusions, including the proposed PPM. The exception consisted of minor adjustments to the guidance for management decisions after the first desktop exercise.

As an operational researcher and researcher in military logistics, the author has worked in and around the system in focus for twenty-six years, which establishes prolonged engagement and persistent observation (Tashakkori and Teddlie, 1998, p. 90). The study was participatory and involved the participants in all phases. The study used investigator triangulation and the author discussed decisions regarding research design, data analysis and interpretation with fellow researchers. Finally, the author has declared his background and research paradigm in Section 3.2, thus clarifying his assumptions, worldview and theoretical orientation (Merriam, 1998, p. 205).

In addition to the recognised strategies for establishing credibility, the author claims that the research design, with two parallel Delphi panels, enhances the credibility of the findings. The author also asserts that the inclusion of quotes from the Delphi panellists (Section 4.2 and Section 4.3), contributes to enhancing credibility.

3.10.2. Transferability

Transferability corresponds to external validity (Halldórsson and Aastrup, 2003; Hasson and Keeney, 2011). Transferability establishes to what extent the findings are transferable to other contexts (Korstjens and Moser, 2018).

The strategy for transferability is a thick description (Tashakkori and Teddlie, 1998, p. 91). Within the limitations of space, the author of this dissertation has endeavoured to provide enough context in the papers and in the dissertation to make the findings meaningful to those who are external to the system in focus. The author hopes that the thickness of description is such that practitioners from other contexts will be able to recognise differences and similarities between the system in focus and their own, and thus be able to draw informed conclusions regarding transferability of the findings to their own contexts.

3.10.3. Dependability

Dependability relates to reliability (Halldórsson and Aastrup, 2003; Hasson and Keeney, 2011). Dependability is the stability of findings over time, including participants' evaluation of findings, interpretations and recommendations, and reassurance that data supports the findings, interpretations and recommendations (Korstjens and Moser, 2018).

The strategy recommended for dependability is the provision of an audit trail (Korstjens and Moser, 2018). A dependability audit concerns the research process, including decisions regarding research design and methodology (Tashakkori and Teddlie, 1998, p. 92). In line with Skulmoski *et al.* (2007), the author of this dissertation has provided an audit trail of the most important theoretical and methodological decisions to demonstrate trustworthiness, in the papers as well as in this dissertation. In the latter, the author has documented these decisions throughout Chapter 3. The dissertation also explicates the participants' evaluation of findings and interpretations in Section 3.8.4.

3.10.4. Confirmability

Conformability is a parallel to objectivity (Halldórsson and Aastrup, 2003; Hasson and Keeney, 2011). Conformability is the extent to which other

researchers could confirm the findings, and involves establishing that findings emanate directly from the data (Korstjens and Moser, 2018).

The strategy recommended for dependability is the provision of an audit trail (Korstjens and Moser, 2018). A confirmability audit concerns the research findings, including establishing that data supports findings and interpretations (Tashakkori and Teddlie, 1998, p. 93). In line with Skulmoski *et al*. (2007), the author of this dissertation has provided an audit trail of the most important theoretical and methodological decisions to demonstrate trustworthiness throughout Chapter 3.

In addition, the author asserts that the research design, with two panels that reached very similar results, contributes to the establishment of confirmability. The author also asserts that the inclusion of quotes from the Delphi panellists (Section 4.2 and Section 4.3), contributes to enhancing confirmability.

3.11. Research ethics

The Swedish Research Council (2017, p. 10) summarises its recommendations on good research practice in eight rules. The author hereby declares to have adhered to these rules. The author has told the truth about the research, consciously reviewed and reported the basic premises of the study, and openly accounted for the methods and results. The author has no commercial interests or other associations to account for. The author has not made unauthorised use of the research results of others. The author used a database and a journal to keep the research organised, strived to conduct the research without doing harm to people, and to be fair in the judgement of others' research.

The research context for this dissertation is the Swedish public defence sector. Such research potentially involves particular research ethical considerations, since it may address issues that concern national defence and security. The author addressed this potential problem in the early stages of the study. First, the author discussed this aspect of the research with fellow researchers at SEDU. Second, the author decided to avoid any classified information in the research and to focus the research on the development of a generic model, while evading any scenarios, examples or applications that would involve using classified data or information. If defence authorities use the proposed PPM for defence procurement, they must probably classify some of the results

and solutions it produces, and the defence SCD that may follow. However, the author is satisfied that the presented research does not include classified information or have any implications for national defence and security. The participation of experts from the Swedish defence authorities in data collection, model development and validation reinforces this position.

Regarding specific ethical considerations in qualitative research, researchers commonly discuss these issues using ethical principles such as autonomy (informed consent), beneficence (do not harm) and justice (reciprocity) (Orb *et al.*, 2001). In the following sections, the author discusses the reported research from the points of view of autonomy, beneficence and justice.

3.11.1. Autonomy

Guidelines and principles containing recommendations for ethical considerations in research trace their roots to the Nuremberg Code of 1947, which stipulates that voluntary consent is indispensable (Fouka and Mantorou, 2011). The author informed the panellists of the objective of the study, research method and process, and stressed that participation was voluntary. Respecting the principle of non-coercion, the author informed the panellists that while the study would distribute reminders in case of late answers, they could withdraw from the study at any point without any questions asked or any repercussions. All panellists participated voluntarily and gave informed consent before the first Delphi round. Some panellists exercised their right to leave the study. The author did not pressure them to continue.

3.11.2. Beneficence

Confidentiality and anonymity are central aspects of the principle of beneficence (Orb *et al.*, 2001), which refers to the Hippocratic *"be of benefit, do not harm"* (Fouka and Mantorou, 2011). Confidentiality and anonymity are also important aspects of Delphi studies, which guarantee the participants anonymity (Rowe *et al.*, 1991).

In line with the Declaration of Helsinki (Swedish Research Council, 2017, p. 10), the author took every precaution to *"protect the privacy of the research subjects and the confidentiality of their personal information and to minimise the impact of the study on their physical, mental and social integrity"*. The author assured each panellist anonymity, vis-à-vis other panellists and all

other parties, throughout and after the study. The author also guaranteed confidentiality of shared information, once the author had received it, and that the panellists would not be identifiable in communications, presentations, reports, or published manuscripts. To improve anonymity and confidentiality, the author suggested that the panellists could send their responses by traditional mail, or by private email, since their employers have legal access to emails. All panellists opted to use digital responses, but two used private email accounts.

Another aspect of avoidance of harm, or non-maleficence (Saunders *et al*., 2009), in this research was that the author's research proposal was peer reviewed, and that the author discussed research design, selection of panellists, data collection, data analysis and model development with fellow researchers. These collaborations with other researchers are in line with proactive steps suggested in the literature to avoid harmful effects (Keller and Lee, 2003).

3.11.3. Justice

The principle of justice involves equal share and fairness (Orb *et al.*, 2001), or fair distribution of costs and benefits (Vanclay *et al*., 2013). There were no monetary costs to the panellists, but their participation required their investment in time, which the taxpayers finance, through the participants' employers. In the initial contacts with managers and prospective panellists, and again in the invitation letter, the author therefore included an estimate of the time that the study would expect each panellist to allocate to the study, from its initiation through to its finalisation (Section 3.6.3).

The author also explicated the potential benefits to the panellists and their employers. First, the panellists had a learning experience, through which they gained knowledge regarding theories from PSM and SCM, and the Delphi technique. Second, the panellists, their employers and the taxpayers stand to gain from the result of the research, a PPM for defence procurement.

The author of this dissertation invested considerable amounts of time, but the Swedish Armed Forces and FMV financed the research, through SEDU. The benefit that the author stands to gain predominantly consists of a successful defence of this dissertation. In the eventuality of a successful defence, this may in turn result in future promotions and academic recognition.

4. Findings from appended papers

This chapter presents a short overview of the four appended papers, including their connections to the dissertation's research purpose and research questions (Section 4.1). It proceeds by summarising the papers, including the research purposes and questions of the individual papers, and their findings (Sections 4.2-4.5). Finally, the chapter summarises the contributions of the papers to the dissertation's research questions and purpose.

The RQs in the papers are denoted "x.i", where "x" signifies the number of the paper and "i" represents the number of the RQ in that paper.

4.1. Overview of the appended papers

The purpose of this research is to design and develop a PPM for defence procurement, which will be of practical use for defence authorities. The research purpose thus consists of a principal and a subordinate clause, model development and practical relevance. As described in Section 1.4, this dissertation operationalises the research purpose into the following three RQs:

> RQ1: Which segmentation model design satisfies the practical relevance requirement of defence authorities?
>
> RQ2: Which supply chain strategies satisfy the operational requirements of armed forces?
>
> RQ3: How can guidance for management decisions be formulated to ensure practical relevance of a PPM for defence procurement?

The primary focus of the three RQs is the principal clause of the research purpose, which is to design and develop a PPM for defence procurement. By the definition employed in this dissertation, a PPM consists of a segmentation model, tactical levers, differentiation strategies and guidance for management decisions. The contributions of the first three papers are to these different elements of the PPM (Table 4.1).

The secondary focus of the three RQs is to ensure research relevance, which is the subordinate clause of the research purpose. This means to ensure that

the PPM which will be of practical use for defence authorities. The selected research strategy (Section 3.4) and design (Section 3.6) contributes to addressing the subordinate clause, by involving practitioners in model development and validation (Section 3.8).

In addition to the constituent parts of the PPM and research relevance, research rigour is an essential part of the research. In the words of Mentzer (2008), *"How can research be useful if our methods are not rigorous enough to allow us to be confident in our results?"* The primary focus of Paper 4 is establishment of how researchers should address rigour in Delphi studies, and investigation of how the design of this research contributes to rigour.

Table 4.1: Connections between papers, research questions and rigour.

Papers	RQ1	RQ2	RQ3	Research rigour
Paper 1	Primary contribution	No contribution	Secondary contribution	Secondary contribution
Paper 2	Secondary contribution	Primary contribution	Secondary contribution	Secondary contribution
Paper 3	No contribution	No contribution	Primary contribution	Secondary contribution
Paper 4	Secondary contribution	Secondary contribution	Secondary contribution	Primary contribution

The first paper establishes design rules (RQ1) and application rules (RQ3) for a PPM that satisfy the defence authorities' requirements. It also proposes a two-stage segmentation model that will be of practical use to defence authorities (RQ1). Paper 2 determines the operational requirements that must be satisfied in defence SCD (RQ1, RQ2) and investigates how acceptable, applicable and sufficient commercial SCD-constructs are in the defence context (RQ2). It also proposes eight SCSs, which are acceptable, applicable and sufficient in defence SCD (RQ2, RQ3). Paper 3 establishes tactical levers for the segmentation model and formulates guidance for management decisions that will be of practical use for defence authorities (RQ3). Paper 4 contributes with a reflection on how the research design contributed to research rigour and hence research relevance.

4.2. Paper 1: Towards a purchasing portfolio model for defence procurement

The purpose of Paper 1 is to explain the constructs of a PPM that defence authorities can use in practice for SCD, and to design a segmentation model. The paper operationalises the purpose through three research questions:

> RQ 1.1: Which segmentation model designs satisfy defence authorities' requirements on practical relevance?
>
> RQ 1.2: Which design rules satisfy the defence authorities' requirements?
>
> RQ 1.3: Which application rules satisfy the defence authorities' requirements?

The study asked the Delphi panellists to state preferences regarding the PPMs in Table 2.3 and a model proposed by FMV (2016). The latter builds on Kraljic's, but with the dimensions supply risk and operational risk. Forty percent preferred Kraljic (1983), five percent van Stekelenborg and Kornelius (1994), five percent Olsen and Ellram (1997), and fifteen percent abstained from answering. Thirty-five percent, all of whom officers, preferred FMV's model. The author interpreted this result as an indication that any traditional model must be adapted to include the military operational perspective to win acceptance. A comment from one panellist reinforces this interpretation: *"For the Swedish Armed Forces this is probably the most decisive aspect of a model that is supposed to enable the implementation of logistics"*. However, the panel agreed that a suitable PPM requires three dimensions in the segmentation model, which had to be developed.

The study also asked the panellists if the study should base a PPM on commercial or operational goals. In the first Delphi round, there was consensus regarding using operational goals. One panellist stressed the significance: *"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 the model on factors that are important to us if it is going to be useful to us"*.

Most panellists provided similar comments. They must aim at cost efficiency, but cannot allow cost reductions to supersede operational goals. One civilian panellist summarised the current situation: *"Cost-efficiency is important in*

peace. However, we must proactively also prepare the supply chains for war. Thus far we have worked actively with cost-efficiency in peace, but we must develop how we work with preparations for war". Another panellist concisely stated, *"Operational requirements and goals must be allowed to be more important"*. Hence, the new segmentation model should use operational goals. However, as succinctly formulated by one panellist, there is an inherent dilemma in defence SCD, *"Operational goals and requirements has precedence over cost from an operational perspective. However, in peace, production costs are important. There is a contradiction here."* The defence supply chain must be lean and efficient in peace, but agile and responsive in war.

4.2.1. Design rules

Most design issues were resolved in the final stages of the study. Table 4.2 and Table 4.3 summarise the design rules established by the study and exemplifies the panellists' comments from the first two Delphi rounds. In round three, the panellists agreed that the segmentation model should have three, predefined dimensions and predefined values. Arguments against a two-dimensional model included *"two-by-twos are an oversimplification of a complex decision situation"*.

The workshop attendants decided to use the first dimension as a precursor to a two-dimensional model, and agreed that it should describe operational requirements derived from the Swedish Defence Policy, which means requirements on availability, preparedness and sustainability. They also agreed that the dimensions in the two-dimensional model should describe "the market's ability to deliver supplies on time" and "limitations in the Swedish Armed Forces' operational capability if the market does not deliver supplies on time".

During the workshops, the panellists established that the Swedish Defence Policy should provide the values in the precursor, and that the two-dimensional model should have an even number of values. In the words of one panellist, *"This is required to force users to position themselves and avoid the risk of ending up in the middle"*. The panellists settled for four values for each dimension, "guaranteed", "high", "low" and "non-existent" for "the market's ability to deliver supplies on time", and "disastrous", "severe", "minor" and

"non-existent" for "limitations in the Swedish Armed Forces' operational capability if the market does not deliver supplies on time".

Table 4.2: Design rules established by the study (Ekström *et al*., 2020a).

Design rules established by the study	Examples of panellists' comments in Delphi rounds 1 and 2
Predefined dimensions Predefined values	"In order for the model to have impact, it must be simple to apply, and proven. To change dimensions and values over time will create uncertainty regarding previous segmentations." "To achieve internal and external transparency, we require predefined dimensions and values."
Three dimensions: precursor plus two-dimensional model	"Two dimensions are an oversimplification of a complex decision situation." "Two dimensions put unwanted restraints on flexibility." "More dimensions than three will lead to models that are too complex to operate and understand." "Simplicity is required since there is a large number of people involved in procurement." "If the model becomes too complex, it will not be used…" "At a previous employer I have used the Purchasing Chessboard, which was pretty messy, so I am not an advocate of too complex models…" "If we settle for a model with three dimensions, I think that it would be appropriate to use one dimension as a precursor. Then we would avoid the unwanted complexity of a three-dimensional model. The two-dimensional model should be simple enough to be used, and to be used correctly."
Dimensions in precursor: "operational requirements of the Swedish Armed Forces" dependent on three variables (availability, preparedness and sustainability). Dimensions in two-dimensional model: "the market's ability to deliver supplies on time" and "limitations in the Swedish Armed Forces' operational capability if the market does not deliver supplies on time"	"It is important that dimensions reflect the operational requirements of the Swedish Armed Forces." "As a first step, we should base dimensions and values in the precursor on the Swedish Defence Policy. If required once the HQ has formulated operational requirements on logistics, we can easily change them, without having to change the two-dimensional model."
Three values each for availability and preparedness in precursor, which provides six values for the starting point of sustainability Values of dimensions in precursor. Availability: immediately, within three months, or within six months. Preparedness: mobilisation within hours, days, or within one week. Sustainability: must commence within days, a week, three months, or within six months.	"As a first step, we should base dimensions and values in the precursor on the Swedish Defence Policy. If required once the HQ has formulated operational requirements on logistics, we can easily change them, without having to change the two-dimensional model."

Table 4.3: Design rules established by the study, continued (Ekström *et al.*, 2020a).

Design rules established by the study	Examples of panellists' comments in Delphi rounds 1 and 2
Four values for each dimension in two-dimensional model:	"An even number of values is required to force users to position themselves and avoid the risk of ending up in the middle." "Only two values can sometimes oversimplify a complex decision situation too much." "Two values is not enough to describe the complexity." "Four values is better, since with only two values there is a risk that you want to 'qualify' to be among the 'important ones'." "There should be four values, which makes it impossible to select 'the middle ground'. Four values 'enforces' positioning in the model."
Values of dimensions in two-dimensional model. The market's ability to deliver supplies on time: "guaranteed", "high", "low" and "non-existent". Limitations in the Swedish Armed Forces' operational capability if the market does not deliver supplies on time: "disastrous", "severe", "minor" and "non-existent".	"Should be dependent on the selection of dimensions. High and low works well if the dimensions are the same as in Kraljic's model." "Depends on the dimensions. The values should be specific for the selected dimensions, not generic."
Four merged segments.	"Nine segments, or more, would be too complex." "If there are more than eight segments, the model will become too difficult to use." "More than four segments would make the model too complex for use in practice."

4.2.2. Application rules

The panel made most decisions regarding application rules at the end of the study. Table 4.4 presents the application rules established by the study and exemplifies the panellists' comments. During the workshops, the panellists decided that a PPM could be *both* prescriptive *and* serve as a catalyst for in-depth discussions. The PPM should be prescriptive for supplies where the market's ability to deliver supply on time is guaranteed or high, while absence of such supplies would have minor or non-existent limitations in the Swedish Armed Forces' operational capability. For all other decision-situations, the model should serve as a catalyst for in-depth discussions among stakeholders.

Table 4.4: Application rules established by the study (Ekström *et al*., 2020a).

Application rules established by the study	**Examples of panellists' comments in Delphi rounds 1 and 2**
Prescriptive *and* catalyst for discussions – Prescriptive for routine supplies and catalyst for discussions for all other segments.	"Reality is more complex than theory, which is why a prescriptive model would be too rigid. In a decision, a multitude of aspects and perspectives need to be considered and combined." "The decision maker should not be eliminated from the decision making process." "The flexibility of the model cannot be lost because of prescriptiveness." "For certain segments, prescriptiveness would be appropriate."
Pragmatic – Allow the use of strategies from other segments.	"For me it is self-evident that application of a model can never be strict because it is a model, or in other words a simplification of reality, where part of the complexity of the real world has been eliminated". "Rules for application cannot be too strict, because of the ever-changing dynamics of the surrounding world." "A certain flexibility is required." "The model must allow users to draw on their experience, which means that application must be pragmatic." "Rather than using strategies from other segments, it should be considered if it is possible to move that particular supply to another segment." "Pragmatic application requires very skilled personnel, and enough time."
Segment-generic – Strategies should be generic in different segments, but application should be pragmatic	"Segmentation should lead to distinctive segments, which should be treated differently". "The whole point of having PPMs is to treat segments differently, which requires exclusive strategies in the different segments!" "They should be developed exclusively for different segments, but application should be pragmatic."
Dynamic – Require new segmentation when circumstances in the environment change. Include recommendations for when new segmentation is required	"The environment is variable, and so is the technology that we must acquire. Static application of the model would make procurement more difficult". "Not adapting to a changing world is stupid! Application must be dynamic." "A changing environment requires a dynamic model." "A dynamic model requires explicit recommendations for when a new segmentation is required, even if it is notoriously difficult to predict changes that would require a new segmentation..." "From the point of view of laws and regulations, the model should include explicit recommendations to minimise inevitable appeals in public procurement…" "It is important with clarity in the form of guidelines, written routines and similar documentation." "There must be a flexibility and adherence to external changes."
Interactive – Allow immediate actions to reposition to a more favourable segment. Include recommendations regarding which actions that are possible.	"Flexibility is preferable." "If success is the objective, we should strive for a favourable position." "This will make the model useful in practice." "This would help us to achieve better results." "This is essential if we are going to be successful." "It would be strange to accept a position, without trying to improve it." "There must be clear and concise guidelines for when a repositioning could be done, and for how this should be done." "Without specific guidelines, from a public procurement perspective, the risk of appeals would increase." "Including recommendations is a prerequisite to achieve success."

The panellists preferred segment-generic strategies, but would like application to be pragmatic, and allow using strategies from other segments if appropriate. They determined that the PPM should be dynamic regarding environmental changes. If circumstances change, application rules should require a new analysis, potentially leading to repositioning of supplies. The PPM should also include recommendations concerning which changes in the environment that would require a renewed segmentation. The panellists also established that the PPM should be interactive (dynamic, Section 1.6), which means that immediately after segmentation, the possibility to move to a more favourable segment should be analysed. The PPM should also include recommendations regarding potential actions.

4.2.3. The two-stage segmentation model

The two-stage segmentation model consists of a precursor and a two-dimensional model, as illustrated in Figure 4.1. The study derives the solution directly from the panellists. As succinctly formulated by one panellist, *"If we settle for a model with three dimensions, I think that it would be appropriate to use one dimension as a precursor. Then we would avoid the unwanted complexity of a three-dimensional model. The two-dimensional model should be simple enough to be used, and to be used correctly."*

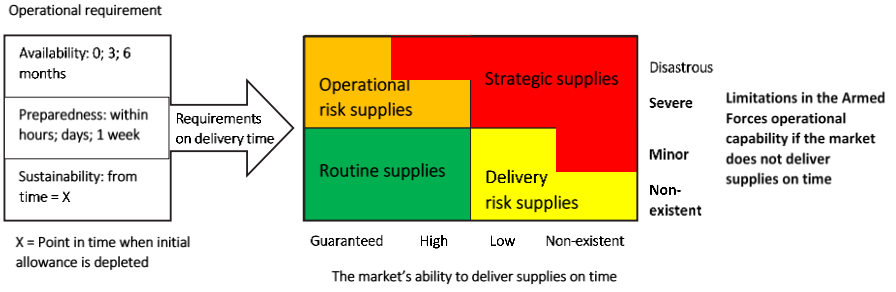


Figure 4.1: The two-stage segmentation model (Ekström *et al.*, 2020a).

The precursor represents the operational requirements, and the two-dimensional model represents the market's ability to deliver supplies and limitations in the Swedish Armed Forces' operational capability if the market does not deliver supplies on time.

4.2.3.1. The precursor

The innovative precursor facilitates the alignments of the Swedish Armed Forces' and FMV's strategies and objectives. It highlights the Swedish Armed Forces' requirements, and ensures that defence procurement prioritises the end-users operational perspective, as well as the traditional economic perspective. It incorporates operational requirements on availability, preparedness and sustainability.

Availability and preparedness has three values each, which theoretically provides six values for the starting point of sustainability. Availability has the values immediately, within three months, or within six months. Preparedness involves mobilisation within hours, days, or within one week. Since some requirements on availability and preparedness coincide in time, in practice sustainability must commence within days, a week, three months, or within six months.

The outputs of the precursor are requirements on when the supply chain must deliver supplies to satisfy the requirements on availability and preparedness and from when the supply chain must deliver supplies to satisfy the requirement on sustainability. Before users take action, supplies must be analysed for all operational requirements, for all military units, since segmentation may place supplies in any segment, depending on the input. After the analysis, a particular supply item may occur in several segments, and may require different treatments.

4.2.3.2. The two-dimensional model

The two-dimensional model has four values for each dimension. The market's ability to deliver supplies on time has the values "guaranteed", "high", "low" and "non-existent". Limitations in the Swedish Armed Forces' operational capability if the market does not deliver supplies on time has the values "disastrous", "severe", "minor" and "non-existent".

The panellists agreed that the study should merge the sixteen matrix elements in the two-dimensional model into four segments. Several panellists shared the sentiment that *"More than four segments would make the model too complex for use in practice."* In the proposed model, the author merges the sixteen elements into four homogenous segments, which users should treat differently: "routine", "operational risk", "delivery risk", and "strategic" supplies.

For routine supplies, there is a high probability that the market can deliver on time and the negative impact on the operational capability if it does not is negligible. Operational risk supplies are supplies where there is a high probability that the market can deliver on time, but where failure to do so would lead to a high operational risk, which may be unacceptable. For delivery risk supplies, the probability that the market will be able to deliver on time is low, but the negative impact on the operational capability if it does not is also low, and may constitute acceptable risk-taking. Strategic supplies are crucial to the operational capability and the Swedish Armed Forces can therefore not leave delivery to chance.

4.3. Paper 2: Differentiation strategies for defence supply chain design

The purpose of Paper 2 is to explain the constructs of SCSs that satisfy military operational requirements, and to propose SCSs that are appropriate in defence. The paper operationalises the purpose through three research questions:

RQ 2.1: How acceptable, applicable and sufficient are commercial SCD-constructs in defence?

RQ 2.2: Which SCSs satisfy defence authorities' operational requirements?

4.3.1. Operational requirements

During the workshops, the panellists agreed that the study should operationalise the Swedish Armed Forces' unique SCD issues through operational requirements on logistics, derived from Sweden's Defence Policy (Swedish MoD, 2015). It specifies the operational outcome that the supply chains must contribute to in terms of availability, preparedness and sustainability.

The Swedish Armed Forces' main task in peace is to maintain availability and preparedness (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.

4.3.2. Acceptability, applicability and sufficiency of commercial SCD-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 Swedish Armed Forces, 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 supply chains, and that the study should use the CODP to propose defence SCSs. This means that the panellists require a strategy continuum, rather than a typology.

For each SCD-construct in Section 2.6.3, the study asked the panellists to answer if they are acceptable and applicable for defence SCD. Table 4.5 and Table 4.6 exemplify comments from the two first Delphi rounds. The comments demonstrate diverging opinions in the study's early stages. However, for most questions, by round three 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 supply chains"*. 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 Swedish Armed Forces".*

Table 4.5: Acceptability and applicability of commercial SCD-constructs (Ekström *et al*., 2020b).

Commercial SCD-constructs	**Comments from Delphi rounds 1 and 2**
CODP	"New, unnecessary, civilian, complicated concept, but, it is clearly useful".
ETO, BTO, MTO, ATO, PTO, STO, MTS	"It could be advantageous to postpone certain manufacturing activities for some supplies". "Military supply chains must be dynamic, flexible and adaptable. A combination of different strategies is appropriate".
Postponement, Speculation	"I guess the strategy as such is OK, but I am a bit sceptic regarding the term 'speculation'".
Manufacturing postponement, Full postponement, Full speculation, Logistics postponement	"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 Swedish Armed Forces understand".
Push, Pull	"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 supply chain".
Functional, Innovative products	"Provides a rationale for which choices that can, and must, be made". "Not in a military supply chain". "Difficult to sort out which supply that belongs to which category, since this may change in different phases".
Efficiency, Responsiveness	"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 supply chains 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 supply chains". "Efficiency may be prevailing for routine supplies, but responsiveness should apply for our more important supplies".
Risk-hedging, Agile, Efficient, Responsive	"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".
Predictability, Lead-time	"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 supply chain". "The significance of these words in themselves points towards the conclusion that these are obvious dimensions to take into consideration".

Table 4.6: Acceptability and applicability of commercial SCD-constructs, continued (Ekström *et al*., 2020b).

Commercial SCD-constructs	Comments from Delphi rounds 1 and 2
Lean, Agile	"Yes, but not puritanically implement one strategy for the entire supply chain. 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 supply chain". "Modern terminology in a traditional context, but, yes".
Competitive priorities (Quality, Lead-time, Service-level, Cost)	"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 Swedish Armed Forces' 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".

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

4.3.3. Acceptable, applicable and sufficient defence supply chain strategies

The panellists concluded that the SCSs in Table 2.6 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 satisfaction of all operational requirements. This study defines this alternative as pre-storage, or procure-to-stock (PTS), and thus 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, since buyers can contract suppliers to differentiate SCSs to satisfy their requirements.

ETO is applicable for capability development (CAPDEV), which involves 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.

Table 4.7: Operational requirements versus proposed supply chain strategies (Ekström *et al*., 2020b).

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

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 4.7 matches CAPDEV and the Swedish Armed Forces' 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. When the Swedish Armed Forces require replacement supplies depends on consumption patterns, which depend on time, activity, chance, or a combination. Consequently, Table 4.7 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 4.7 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.

4.4. Paper 3: Guidance for management decisions in the application of a purchasing portfolio model for defence procurement

The purpose of Paper 3 is to develop guidance for management decisions, including tactical levers, for the application of a PPM for defence procurement, based on the military customers' unique SCD issues and tailored to the specific requirements of defence procurement. The paper operationalises the purpose through two research questions:

> RQ 3.1: Which tactical levers are suitable for repositioning in a PPM for defence procurement?
>
> RQ 3.2: How should we formulate guidance for management decisions to ensure practical relevance of a PPM for defence procurement?

4.4.1. Tactical levers

During the workshop, the operational analysis identified tactics 1a-e (Table 4.8) as potential dynamic tactical levers for reducing operational dependency. The commercial analysis identified tactics 2a-e (Table 4.8) as potential dynamic tactical levers for increasing market capabilities. Once topics for potential dynamic tactical levers were exhausted, the workshop participants identified tactics 3a-b as suitable static tactical levers. Table 4.8 presents these tactics in the order in which the workshop participants discussed them.

Table 4.8: Tactics for dynamic and static leverage after initial segmentation (Ekström *et al*., 2020c).

Tactical levers	**Tactics for dynamic and static leverage**				
Dynamic	**a**	**b**	**c**	**d**	**e**
1. Reduce operational dependency	1a Identify substitute supplies	1b Identify overlapping capabilities	1c Identify redundancy in capabilities	1d Modify operational planning	1e Standardisation of supplies[1, 4]
2. Increase market capabilities	2a Supply base extension[1, 2, 3]	2b Inventory buffer stock[3, 4] and position[4]	2c Decentralise production[4]	2d Localise sourcing[4], storage[3, 4] and/or distribution[4]	2e Increase production capacities [3, 4] and/or distribution capacities[4]
Static	**a**	**b**	**c**	**d**	**e**
3. Risk analysis[1]	3a Operational risk-taking[5]	3b Prestorage (PTS)[5]			
[1] Hesping and Schiele (2016); [2] Cox (2015); [3] Basnet and Seuring (2016); [4] MacCarthy *et al*. (2016); [5] Ekström *et al*. (2020b)					

In cases when there are substitute supplies on the market, such as lower-grade commercial fuels, tactic 1a is a possibility. Tactic 1b is an option if there are two similar capabilities. If the actual capability is greater than the required, tactic 1c is an alternative. In some cases, it may be possible to modify the operational planning, to enable tactic 1d. When possible, armed forces strive for standardisation of, as an example, spare parts for different vehicles, which allows tactic 1e.

Occasionally, it is possible to find alternative suppliers, which permits tactic 2a. To contract suppliers to use buffer stocks of raw materials, sub-components, etc. and to position these stocks as close to the user as possible is an avenue that defence authorities can explore in tactic 2b. Tactic 2c

involves contracting suppliers to decentralise production to reduce lead-times. Similarly, tactic 2d entails contracting suppliers to localise sourcing, storage and/or distribution. In tactic 2e, defence authorities can contract suppliers to increase production and/or distribution capacities.

When defence authorities have exhausted all opportunities to reduce operational dependency and/or increase market capabilities, it only remains to decide if the remaining risk is acceptable, or not. In some cases, operational risk-taking, tactic 3a, may be motivated. When it is not, the only alternative left is tactic 3b, prestorage (procure-to-stock, PTS).

The ensuing literature review did not identify any corresponding tactics to tactics 1b-d, which is not surprising, since they have a distinctly military perspective. However, several authors discuss substitution and standardisation of supplies, tactics 1a and 1e. As demonstrated in Table 4.8, the literature review also corroborated tactics 2a-e. In line with Hesping and Schiele (2016), Table 4.8 refers to these static tactical levers as risk analysis.

Hesping and Schiele (2016) provide a comprehensive list of tactics that the literature on PPMs recommend. However, with the exception of the tactics already suggested by the workshop participants, the literature review did not identify any further tactics that are suitable as dynamic tactical levers.

4.4.2. Guidance for management decisions

4.4.2.1. Step 1: Selection of operational requirement to satisfy

Step 1 uses the precursor (Figure 4.1), which involves selection of which operational requirement that is to be satisfied. There are three types of requirements, availability, preparedness and sustainability. The Swedish government differentiates requirements on availability and preparedness between military units. They have three values each, immediately, within three months and within six months, and mobilisation within hours, days, or within one week, respectively.

Requirements on sustainability follows once the Armed Forces has depleted supplies stored for availability and preparedness, and involves a flow of replacement supplies for the duration of, for example, an operation. Sustainability requires a flow of supplies from external suppliers. The point in time from which this is required depends on consumption patterns, which

differs between supply classes. The point in time when this flow can start varies between different supplies, and depends on lead-times for production and distribution. To address the potential gap in time between depletion of supplies stored for availability and preparedness, and delivery of replacement supplies from external suppliers, defence supply chains must store sufficient replacement supplies.

For each supply item, the output of Step 1 are answers to the questions “how much” and “when” for availability and preparedness, and to the questions “how much”, “when” and “for how long” for sustainability.

4.4.2.2. Step 2: Market and impact analysis

Based on the input from the precursor and an estimated consumption pattern, the market analysis addresses the market’s ability to deliver supplies on time. Staff in the Swedish Armed Forces and/or FMV with adequate market knowledge for a particular supply item perform the analysis, which results in one of four values, guaranteed, high, low or non-existent.

The impact analysis clarifies the limitations in the Swedish Armed Forces’ operational capability if the market does not deliver supplies on time. Staff in the Swedish Armed Forces with requisite insights regarding the interrelatedness of logistics and operational capabilities perform the analysis, which results in one of four values, non-existent, minor, severe and disastrous.

Market and impact analysis are independent activities, which the Swedish Armed Forces and/or FMV can perform as separate activities. However, they must combine the results as input to Step 3.

4.4.2.3. Step 3: Segmentation of supplies

Given the market and impact analyses, the Swedish Armed Forces and/or FMV positions the supply item in the two-dimensional segmentation model (Figure 4.1), which places the supply item in one of the four segments routine, delivery risk, operational risk or strategic supplies. It is advantageous if the staff who performed market and impact analysis execute the positioning in the model jointly.

4.4.2.4. Step 4 a: Selection of supply chain strategies for routine supplies

For routine supplies, the PPM is prescriptive. No further cooperation between the staff responsible for segmentation, market and impact analysis is required. No in-depth discussions among other stakeholders is required. The responsible authority, FMV for advanced systems and the Swedish Armed Forces for all other supplies, procures supply items in accordance with the matching, or potentially matching SCSs (Table 4.7).

PTS is a match and ETO is a mismatch for all operational requirements. The potential matches for requirements on availability and preparedness depend on lead-times for different supplies. The potential matches for requirements on sustainability depend on lead-times and consumption patterns for different supplies, and on duration and stage of an operation.

4.4.2.5. Step 4 b: Selection of supply chain strategies for delivery risk supplies

For delivery risk supplies, the PPM is a catalyst for in-depth discussions among all stakeholders prior to any decisions. In addition to staff responsible for segmentation, market and impact analysis, other stakeholders from the Swedish Armed Forces and FMV are required to join a cross-functional team, or an integrated project team (IPT), to resolve legal, commercial, technical and operational issues regarding the interrelatedness of logistics and operational capabilities, including operational, commercial and risk analysis. From the Swedish Armed Forces this includes staff from the operational level, the Training and Procurement Staff (TPS) and the Joint Forces Command (JFC). From FMV, this includes the Logistics Division, the Commercial Affairs Division and the Legal Affairs and Security Office.

Immediately after segmentation, the IPT analyses opportunities to reposition the supply item to routine supplies by increasing the probability of delivery on time (Tactical levers 2a-e, Table 4.8). If possible, the IPT repositions the supply item to routine supplies (R1 or R2, Figure 4.2), and procurement follows in accordance with Step 4a. If repositioning is impossible, the IPT analyses if operational risk-taking is an option (Tactical lever 3a, Table 4.8). As part of this analysis, the IPT analyses if they can reduce the level of operational risk-taking by increasing the probability of delivery on time (Tactical levers 2a-e, Table 4.8) or by reducing the impact of failure to deliver

on time (Tactical levers 1a-d, Table 4.8). If possible, the IPT repositions the supply item within the segment (R3 or R4, Figure 4.2).

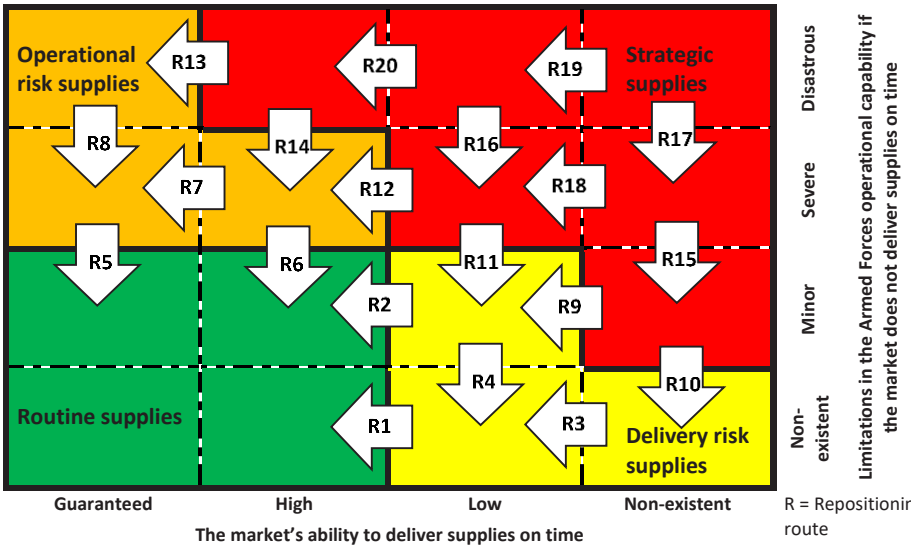


Figure 4.2: Repositioning routes in the two-dimensional segmentation model (Ekström *et al*., 2020c).

If the remaining level of operational risk-taking is acceptable, the responsible authority procures supply items in accordance with the matching, or potentially matching SCSs (Table 4.7). PTS is a match and ETO is a mismatch for all operational requirements. The potential matches for requirements on availability and preparedness depend on lead-times for different supplies. The potential matches for requirements on sustainability depend on lead-times and consumption patterns for different supplies, and on duration and stage of an operation.

For each of the potential supply chain solutions, BTO, MTO, ATO, PTO, STO and MTF, the risk that the market fails to deliver on time is high. However, the limitations in operational capability if it fails are minor, or non-existent, which could justify operational risk-taking.

If increasing market capabilities and reducing operational dependency is unfeasible or unaffordable and operational risk-taking is at an unacceptable level, defence authorities must utilise PTS (Tactical lever 3b, Table 4.8). However, PTS is associated with extra costs and commercial risk-taking, and defence authorities must use it restrictively.

4.4.2.6. Step 4 c: Selection of supply chain strategies for operational risk supplies

For operational risk supplies, the PPM is a catalyst for in-depth discussions among all stakeholders prior to any decisions. In addition to staff responsible for segmentation, market and impact analysis, other stakeholders from the Swedish Armed Forces and FMV are required to join an IPT, to resolve legal, commercial, technical and operational issues regarding the interrelatedness of logistics and operational capabilities, including operational, commercial and risk analysis. From the Swedish Armed Forces this includes staff from the operational level, TPS and JFC. From FMV, this includes the Logistics Division, the Commercial Affairs Division and the Legal Affairs and Security Office.

Immediately after segmentation, the IPT analyses opportunities to reposition the supply item to routine supplies, by reducing the impact of failure to deliver on time (Tactical levers 1a-d, Table 4.8). If possible, the IPT repositions the supply item to routine supplies (R5 or R6, Figure 4.2), and procurement follows in accordance with Step 4a. If repositioning is impossible, the IPT analyses if operational risk-taking is an option (Tactical lever 3a, Table 4.8). As part of this analysis, the IPT analyses if they can reduce the level of operational risk-taking by increasing the probability of delivery on time (Tactical levers 2a-e, Table 4.8) or by reducing the impact of failure to deliver on time (Tactical levers 1a-d, Table 4.8). If possible, the IPT repositions the supply item within the segment (R7 or R8, Figure 4.2).

If the remaining level of operational risk-taking is acceptable, the responsible authority procures supply items in accordance with the matching, or potentially matching SCSs (Table 4.7). PTS is a match and ETO is a mismatch for all operational requirements. The potential matches for requirements on availability and preparedness depend on lead-times for different supplies. The potential matches for requirements on sustainability depend on lead-times and consumption patterns for different supplies, and on duration and stage of an operation.

For each of the potential supply chain solutions, BTO, MTO, ATO, PTO, STO and MTF, the risk that the market fails to deliver on time is low. However, the limitations in operational capability if it fails are disastrous, or severe. Nevertheless, the IPT may find that operational risk-taking is acceptable and/or necessary, given the costs and commercial risks associated with PTS.

The IPT may also find it judicious to use a combination of PTS and operational risk-taking, where a certain percentage of the required supplies are pre-stored to reduce the operational risk.

If increasing market capabilities and reducing operational dependency is unfeasible or unaffordable and operational risk-taking is at an unacceptable level, defence authorities must utilise PTS (Tactical lever 3b, Table 4.8). However, PTS is associated with extra costs and commercial risk-taking, and defence authorities must use it restrictively.

4.4.2.7. Step 4 d: Selection of supply chain strategies for strategic supplies

For strategic supplies, the PPM is a catalyst for in-depth discussions among all stakeholders prior to any decisions. In addition to staff responsible for segmentation, market and impact analysis, other stakeholders from the Swedish Armed Forces and FMV are required to join an IPT, to resolve legal, commercial, technical and operational issues regarding the interrelatedness of logistics and operational capabilities, including operational, commercial and risk analysis. From the Swedish Armed Forces this includes staff from the operational and military strategic levels, TPS, JFC and Defence Staff. From FMV, this includes the Logistics Division, the Commercial Affairs Division, the Legal Affairs and Security Office and the Governance, Policies and Plans Office.

Immediately after segmentation, the IPT analyses opportunities to reposition the supply item to delivery risk or operational risk supplies, by reducing the impact of failure to deliver on time (Tactical levers 1a-d, Table 4.8) or by increasing the probability of delivery on time (Tactical levers 2a-e, Table 4.8). If possible, the IPT repositions the supply item to delivery risk supplies (R9, R10 or R11, Figure 4.2) or operational risk supplies (R12, R13 or R14, Figure 4.2), and procurement follows in accordance with Step 4b or 4c.

If repositioning is impossible, the IPT analyses if operational risk-taking is an option (Tactical lever 3a, Table 4.8). As part of this analysis, the IPT analyses if they can reduce the level of operational risk-taking by increasing the probability of delivery on time (Tactical levers 2a-e, Table 4.8) or by reducing the impact of failure to deliver on time (Tactical levers 1a-d, Table 4.8). If possible, the IPT repositions the supply item within the segment (R15, R16, R17, R18, R19 or R20, Figure 4.2).

If the remaining level of operational risk-taking is acceptable, the responsible authority procures supply items in accordance with the matching, or potentially matching SCSs (Table 4.7). PTS is a match and ETO is a mismatch for all operational requirements. The potential matches for requirements on availability and preparedness depend on lead-times for different supplies. The potential matches for requirements on sustainability depend on lead-times and consumption patterns for different supplies, and on duration and stage of an operation.

For each of the potential supply chain solutions, BTO, MTO, ATO, PTO, STO and MTF, the risk that the market fails to deliver on time ranges from relatively low to high. The limitations in operational capability if it fails ranges from minor to disastrous.

For strategic supplies operational risk-taking is less likely to be acceptable than for other supply segments. If it is at an unacceptable level, defence authorities must utilise PTS (Tactical lever 3b, Table 4.8). Even if PTS is associated with extra costs and commercial risk-taking, and defence authorities must use it restrictively, for strategic supplies, it may be the only feasible solution.

4.4.2.8. Step 5: Repositioning due to changes in the external environment

The staff within the Swedish Armed Forces and FMV who are responsible for the application of the PPM are also responsible for monitoring the development of factors in the external environment, corresponding to the three dimensions in the segmentation model (Figure 4.1). This responsibility entails conducting operational and commercial analysis, respectively, which may require repositioning in the model.

The Swedish Armed Forces and FMV should use existing frameworks from the commercial and military sector to structure the analyses and ensure that all aspects of development are included in the analyses. This means using frameworks such as STEEPLE (social/demographic, technological, economic, environmental, political, legal, ethical), PESTLIED (political, economic, social, technological, legal, international, environmental, demographic), PMESII (political, military, economic, social, infrastructure, information systems), and/or DIME (diplomatic, informational, military, economic), or other of their several derivatives, to assist the analyses. The

analysis should include trend analysis, scenario development and sensitivity analysis.

If the operational requirements change, the responsible staff within the Swedish Armed Forces and FMV must repeat the segmentation from Step 1. The operational requirements may change due to new directives from the political level. Capability development or capability termination may also have effects on the operational requirements.

If the market's ability to deliver supplies on time changes, the responsible staff within the Swedish Armed Forces and FMV must repeat the segmentation from Step 2. Developments, which may change the market's ability to deliver supplies on time, include new entries into the marketplace, as well as mergers, acquisitions and closures. Changes in production and distribution capacities and localisation, may also have an impact on the lead-time, and consequently affect the market's ability to deliver supplies on time. Some of these changes may increase the lead-time, whereas others may reduce it.

If the limitations in the Swedish Armed Forces' operational capability if the market does not deliver supplies on time changes, the responsible staff within the Swedish Armed Forces and FMV must repeat the segmentation from Step 2. Changes in operational planning, capability development or capability termination are examples of developments, which may affect the limitations in the operational capability.

If the repetition of the segmentation results in repositioning of a supply item in the model, a new SCS may be the most suitable one. This means that volatility in operational requirements, market capabilities and operational consequences has implications for the length and content of contracts with suppliers.

The importance of step 5 must not be underestimated. As an example, a minor change in the marketplace, such as the termination of a localised storage facility, may turn operational risk supplies into strategic supplies, which could have major operational implications. In addition, simultaneous changes in the dimensions in the two-dimensional model (Figure 4.1) may transform routine supplies into strategic supplies. The Swedish Armed Forces and FMV must accordingly conduct continuous monitoring and regularly communicate the results of the operational and commercial analyses, so that all stakeholders fully understand the implications of any changes.

4.5. Paper 4: The Delphi Technique – Opportunities and challenges

The dual purpose of Paper 4 is to analyse the implications on research rigour of using two panels in a Delphi study, and to take a first step towards investigating how researchers in logistics and SCM establish rigour in Delphi studies. The paper operationalises the research purpose through the following research questions.

RQ 4.1: How does a modified Delphi design, with two panels, effect research rigour?

RQ 4.2: How do researchers in logistics and SCM establish rigour in Delphi studies?

4.5.1. Recommendations in select guidelines

"There are many different views on what are the 'proper', 'appropriate', 'best', and/or 'useful' procedures for accomplishing the various specific aspects of Delphi" (Linstone and Turoff, 2002, p. 3). Several authors have defined the one, true Delphi, while often contradicting each other and dismissing studies that do not fit their definitions (Mullen, 2003). Worrell *et al.* (2013) observe that the design choices made before the first questionnaire "directly impact the rigour and relevance of the results".

Design decisions and the explicit declaration thereof, is an important aspect of Delphi studies. However, in published research it is not always clear which decisions that have been made, or why. As an example, occasionally, authors omit to declare the number of rounds in the study, "which is problematic given the centrality of multiple rounds to the method" (de Loë *et al.*, 2016). Such examples of questionable application has prompted authors to provide guidelines regarding how to make design decisions in Delphi studies. Table 4.9 presents recommendations from select guidelines on Delphi study design.

As is evident in Table 4.9, guidelines are not exhaustive and occasionally contradictory. Hasson *et al.* (2000) and Okoli and Pawlowski (2004) do not include recommendations on the number of questions. Hasson *et al.* (2000) recommend keeping iterating until the study reaches consensus or attrition,

whereas Okoli and Pawlowski (2004) recommend iteration until the study reaches consensus or a plateau, with a maximum of six rounds.

Table 4.9: Recommendations in select guidelines on Delphi study design (Ekström, 2020).

Feature	**Hasson *et al*. (2000)**	**Okoli and Pawlowski (2004)**	**Worrell *et al*. (2013)**
Expert selection	Purposive or criterion sampling	KRNW	Convenience sample, or KRNW
Panel size	Not explicit	10-18	4 (under ideal circumstances), or 10-30 (under typical circumstances)
First round	Brainstorming, or Seeded list (literature review)	Brainstorming	Brainstorming, or Seeded list (literature review)
Number of questions	Not included	"30 minutes to complete"	20-25
Number of rounds (questionnaires)	Until consensus or attrition (decreased number of returns)	Until consensus or plateau, or a maximum of 6 rounds	Until consensus or plateau, or 3 rounds (predetermined)
Statistics to panellists	Central tendencies* and levels of dispersion**	Mean rank and Kendall's W	Standard deviation reduction, or Kendall's W
*KRNW = Knowledge resource nomination worksheet; *means, medians and mode; **standard deviation and the inter-quartile range; W = Coefficient of concordance*			

4.5.2. Rigour in select Delphi-studies in logistics and SCM

All thirteen articles evaluated in this paper use a modified Delphi, which academics have identified as an important source of problems with rigour (Gupta and Clarke, 1996). Delphi studies must demonstrate rigour (Rowe and Wright, 2011), either explicitly (Day and Bobeva, 2005; Hasson and Keeny, 2011) or implicitly, through the provision of an audit trail (Skulmoski *et al.*, 2007; Worrell *et al.*, 2013). This paper defines discussions of correspondence and/or trustworthiness as indicators of authors' explicit reflections on rigour.

Of the evaluated articles, four address aspects of both reliability and validity, whereas five mention one of them. However, none of these articles provides a thorough discussion on all aspects of correspondence. The remaining articles do not refer to either reliability or validity. Even if the sample is illustrative rather than representative, it is an interesting observation that none of the authors mentions the issue of trustworthiness. In the literature on the Delphi technique, academics have discussed the issues of positioning in the

epistemological debate and scientific rigour at length, for almost half a century. However, similar discussions would seem to be absent in the logistics and SCM literature.

In the absence of explicit reflections on rigour, Delphi studies may provide an audit trail to demonstrate rigour. In the literature, academics have suggested that the issues in Table 4.9 are especially important. A critical element of Delphi is the selection of experts (Okoli and Pawlowski, 2004) and all articles in the sample provide satisfactory information on this topic. Another essential aspect of Delphi is group communication and the possibility for the panellists to revise their answers anonymously (Parenté *et al*., 2005). Again, all articles in the sample describe this process appropriately. For the most part, the articles in the sample also provide details regarding the other issues in Table 4.9 and issues such as justification of the method. There are, however, also omissions.

All articles state the panel size, but a majority of them do not provide any information regarding attrition/retention, which is problematic. The potential for attrition is a major factor behind the recommendation to use a predetermined number of rounds rather than termination criteria. Consequently, authors should elucidate attrition/retention. In addition, four of the articles do not provide any information regarding measures of consensus. The degree of consent, or dissent, and the measurement thereof, is an important aspect of Delphi, and authors should provide explicit information regarding how it is established.

Only two articles in the sample (von der Gracht and Darkow, 2010; 2016) explicitly state which type of Delphi they use. Alongside Seuring and Müller (2008) and Giunipero *et al.* (2012), they belong to a group of authors who have published more than one Delphi study in logistics and SCM research, and von der Gracht (2012) has published articles on Delphi methodology. These authors demonstrate proficiency, also regarding establishing rigour. Seuring and Müller (2008) and von der Gracht and Darkow (2010; 2016) are three of the four articles which discuss both reliability and validity explicitly. With minor exceptions, they also provide complete audit trails.

The articles in the sample demonstrate a wide range of experience of publishing research based on Delphi. There are also indications that some authors in logistics and SCM belong to the category of researchers who, erroneously, believe that the objective of Delphi studies is always to reach consensus. If inexperienced users of the method decide not to discuss rigour

explicitly, they should provide a complete audit trail instead. The evaluation of this sample demonstrates that this is not always the case in logistics and SCM research.

4.5.3. Will two panels enhance rigour in Delphi-studies?

Hasson *et al.* (2000) state, *"There is no evidence of the reliability of the Delphi method"* and ask the rhetorical question *"if the same information were given to two or more panels, would the same results be obtained?"* Hasson and Keeny (2011) observe, *"Further research is required to test the accuracy of the method"*.

This paper reports on an analysis of a Delphi study by Ekström *et al.* (2020a), which the authors designed specifically to explore how researchers may enhance rigour in Delphi studies. The study used two Delphi panels, with a similar distribution of experts in them, and gave them the same information. The expectation was that the two panels would arrive at the same conclusions, thereby enhancing rigour.

The panellists answered five questions regarding PPM application. Based on open issues in the academic discussion on PPM application, the researchers formulated the questions as statements from different perspectives, so that agreement with a statement in one panel would correspond to disagreement in the other. Following slightly different paths, the two panels arrived at similar results for four of the questions. However, for the first question, they arrived at diametrically opposed results, where one panel decided that the PPM should be prescriptive, whereas the other concluded that the PPM should serve as a catalyst for discussions among stakeholders.

This result was unexpected, and had the research design not included concluding workshops, the end-result of the study would have been bipolarity. However, during the concluding workshops, the participants discussed the contradictory results at length, until arriving at the consensus conclusion that a PPM can be *both* prescriptive *and* a catalyst for discussions. The result of the study is that the PPM should be prescriptive for routine segments and serve as a catalyst for discussions for all other segments. The question is why the study produced this result. Is it a consequence of the two panels, the different formulations of the statements, the workshops, or a combination? Another

question is if a conventional study, with one Delphi panel and no workshops, could have reached a similar result.

Ekström *et al.* (2020a) addressed the rhetorical question regarding two panels, which Hasson and Keeny (2011) put forth, and the provisional answer is "yes and no". The study obtained the same results for four of the five questions, thus reinforcing the validity of these results, but for the remaining question, the two panels came to very different results. In policy Delphi, the objective is to generate opposing viewpoints (Turoff, 1970) and bipolar results may be very significant (Linstone and Turoff, 2011). However, contrary to a widespread misconception, that consensus is always the objective in a Delphi study (Mullen, 2003; Linstone and Turoff, 2011); bipolarity is also a possible result of a conventional Delphi study (Dajani *et al.*, 1979). It is accordingly possible that the study could have reached bipolarity after three rounds, also if it had used one panel, and used the extremes from the literature review as extremes on Likert-scales in the questionnaire. Consequently, it is not possible to state that the two panels provided any other results than what a conventional study might have done.

Poor questionnaire design has been a source of critique of Delphi studies (Gupta and Clarke, 1996; de Loë *et al.*, 2016). In the questionnaires in the study be Ekström *et al.* (2020a), the seeds came from the academic debate on PPM application, where academics stand against each other regarding a number of issues. The study provided the panellists with the same background information, including both sides of the academic debates, but formulated the questions to the two panels from different perspectives. The study used piloting to ensure that the questions were unambiguous. Nevertheless, it could be argued that the formulation of the questions forced the two panels to consensus (Fletcher and Marchildon, 2014), but in different directions.

Melnyk *et al.* (2009) suggest that researchers can use workshops in Delphi studies to review and extend findings. Ekström *et al.* (2020a) included workshops at the end of the study in their design for this purpose. During these workshops, the participants discussed the seemingly contradictory result of the Delphi rounds, and were able to reach consensus. Without these workshops, it seems unlikely that the study would have produced the novel PPM, which is *both* prescriptive *and* a catalyst for discussions among stakeholders.

Ekström *et al.* (2020a) produced a novel PPM, which the practitioners who participated in the study perceive as an innovation that will be of practical use in defence acquisition. The researchers found it unlikely that the novel design would have been possible without the participation of experts in two different panels. As discussed above, it is possible that a conventional Delphi study could have reached a similar result after three rounds. However, that a conventional design, without the concluding workshops, could have produced the novel PPM seems unlikely. A prerequisite of this would have been if the researchers had presented the panellists with the option of developing a model that was *both* prescriptive *and* could serve as a catalyst for in-depth discussions. However, the literature on PPMs did not provide this a possible seed for the questionnaires.

4.6. Contributions of the appended papers

The three research questions are an operationalisation of the principal clause of the research purpose (Section 4.1). Table 4.10 summarises how the papers contribute to the research questions and ultimately to the research purpose.

The three main contributions in the first three papers are the segmentation model, the differentiation strategies and the guidance for management decisions, which are the constituent parts of the PPM for defence procurement. However, the three papers also produce intermediate contributions, which are required for the main ones.

The design rules (Paper 1) and the operational requirements (Paper 2) are necessary to design the segmentation model (Paper 1). The operational requirements (Paper 2) are also essential to formulate the differentiation strategies (Paper 2). Finally, the application rules (Paper 1), the segmentation model (Paper 1), the differentiation strategies (Paper 2) and the tactical levers (Paper 3) are prerequisites of the guidance for management decisions (Paper 3).

Table 4.10: Contributions of appended papers to research questions and research purpose.

Papers	RQ1	RQ2	RQ3	Research purpose
Paper 1	Design rules Segmentation model	No contribution	Application rules Segmentation model	Segmentation model
Paper 2	Operational requirements	Operational requirements Differentiation strategies	Differentiation strategies	Differentiation strategies
Paper 3	No contribution	No contribution	Tactical levers Guidance for management decisions	Guidance for management decisions
Paper 4	Research rigour	Research rigour	Research rigour	Research relevance (by rigour)

The subordinate clause of the research purpose is to ensure research relevance. The participation of the panellists in the study is one part of accomplishing research relevance. Another part is the validation of the results of the study. The final part of research relevance is research rigour. Without rigour, the results cannot be relevant (Mentzer, 2008). Paper 4 contributes to research relevance by investigating how researchers should establish rigour in Delphi studies and the effects that the modified design of this study had on rigour.

5. Discussion on findings

This chapter discusses the main findings presented in Chapter 4 and relates them to the managerial problem and theoretical gaps stated in Sections 1.1 and 1.2, respectively, as well as to the frame of reference presented in Chapter 2. The purpose of this research is to design and develop a PPM for defence procurement, which will be of practical use for defence authorities. This dissertation defines a PPM as a tool that combines two or more dimensions into a set of heterogeneous segments, and recommends different tactics and strategies for these segments. Accordingly, a PPM consists of a segmentation model, tactical levers, differentiation strategies and guidance for management decisions. This chapter follows this structure and discusses the complete PPM and its constituent parts as follows; the complete PPM in Section 5.1, the segmentation model in Section 5.2, tactical levers in Section 5.3, defence SCSs in Section 5.4, and guidance for management decisions in Section 5.5. The chapter ends with a reflection regarding the employed research design in Section 5.6.

5.1. A dynamic purchasing portfolio for defence procurement

This dissertation develops a dynamic PPM for defence procurement. In several respects, the dissertation thus ventures into underdeveloped areas of academic knowledge. The author makes this claim based on several observations. In previous research, authors have developed PPMs for the private sector, where companies seek financial outcomes. This dissertation develops a PPM for the public sector, where authorities seek operational outcomes.

Extant PPMs have an inbound logistics perspective and use strategies that seek to enable buyers to exploit power-positions vis-à-vis suppliers. Furthermore, with the exception of Drake *et al*. (2013), researchers have previously investigated segmentation and differentiation in independent silos, the PSM and SCM literature. This dissertation develops a PPM with both an inbound

and an outbound logistics perspective, based on both the PSM and SCM literature, and uses strategies that seek to satisfy operational requirements.

With few exceptions, extant PPMs are static models (Cox, 2015). This dissertation develops a dynamic model, in which users should explore opportunities to reposition to a more favourable segment immediately after initial segmentation. Moreover, this dissertation introduces several novelties regarding PPMs, such as a two-stage segmentation model, based on three dimensions. Finally, this dissertation contributes to the areas of military logistics and defence procurement, which are areas with limited contributions in the academic literature (Yoho *et al.*, 2013).

In combination, the unique characteristics of the research presented in this dissertation, makes it difficult to compare the complete PPM to previous research. The ensuing sections discuss the constituent parts of the proposed PPM in relation to previous literature.

5.2. The segmentation model

Since the introduction of PPMs (Kraljic, 1983), there has been considerable academic debate in the PSM literature on design and application issues. Most contributions in previous research are what this dissertation defines as traditionalists (Section 2.3.2.1). They are modifications of Kraljic's original two-by-two segmentation model (Rezaei *et al*., 2015). These contributions have been criticised for being too simplistic (Lovell *et al*., 2005; Hesping and Schiele, 2016) by what this dissertation defines as revisionists (Section 2.3.2.2). To address perceived discrepancy between theory and practice, authors such as Cox (2015), who this dissertation defines as post-revisionists (Section 2.3.2.3), have proposed increased model complexity. What these models may gain in theoretical rigour, they may lose in practical relevance.

Among these traditionalist, revisionist and post-revisionist contributions, this dissertation identifies several open design and application issues (Section 2.5.2). This dissertation addresses these issues, and asks which segmentation model designs that satisfy defence authorities' requirements on practical relevance. The findings reinforce the revisionist critique of traditionalist models. Practitioners in defence authorities share the misgiving that they are an oversimplification of a complex decision situation. However, in contrast to

the suggestions by post-revisionists, practitioners advocate a model that is not too complex for practical use.

The practitioners in this study observe that extant models do not include the operational requirements that are of interest to them. Furthermore, supporting Luzzini *et al*. (2012), the findings indicate that if practitioners in the defence authorities are to accept and use a PPM, researchers must develop it to suit their specific requirements. This dissertation focusses on PPMs in defence procurement, which is a unique context for two reasons. In contrast to the private sector, the goal in the public sector is operational outcomes. Moreover, armed forces' operational requirements are different in peace and war.

By addressing open design and application issues, identifying and integrating unique design issues in the defence context, and involving practitioners in the development, this research has produced a unique solution to a current managerial problem in the defence context. The dissertation proposes an innovative segmentation model. It is a two-stage model, based on three dimensions, with one dimension as a precursor to reduce application complexity. The ensuing two-dimensional model merges the sixteen elements into four homogenous segments. However, three segments in the two-dimensional model are not squares, which is a novelty.

The proposed model is quite different from segmentation models previously suggested in the literature. Using three dimensions, it has a higher design complexity than the models proposed by traditionalists in the PSM literature. However, by using one dimension as a precursor, it avoids the unwanted complexity of a three-dimensional model. In addition, the two-dimensional segmentation model has a unique design, which diverges from the ones proposed in previous literature. By leaving traditional two-by-two designs, this research proposes a model that allows the most problematic combination of values for the dimensions to occupy a larger area in the model.

5.3. Tactical levers

Using a workshop with experts in military logistics and defence procurement, this research establishes ten dynamic and two static tactical levers. The dynamic tactical levers constitute an operationalisation of the application rule "dynamic application" (Table 4.4).

To some extent, the findings are in line with previous research, such as Cox (2015), Basnet and Seuring (2016), Hesping and Schiele (2016) and MacCarthy *et al.* (2016). However, with the exception of Cox (2015), most contributions in the literature do not discuss tactical levers intended for repositioning in a dynamic PPM. Nevertheless, the study finds agreement for the five dynamic tactical levers intended for increasing market capabilities (Table 4.8).

Regarding dynamic tactical levers for reducing operational dependency (Table 4.8), the study finds conformity for two out of five. Since previous research has focused more on the commercial goals of an organisation than the operational goals (Cox, 2015), this lack of confirmation is to be expected.

The static tactical lever (Table 4.8) is labelled risk analysis in this dissertation, which is in line with Hesping and Schiele (2016). In combination, the proposed dynamic and static tactical levers proposed in this paper demonstrate similarities with elements in the supply chain risk management (SCRM) process, as summarised by Fan and Stevenson (2017). The ten tactics in the dynamic tactical levers correspond to risk mitigation, whereas the two tactics in the static tactical lever correspond to risk acceptance and risk avoidance, respectively.

5.4. Defence supply chain strategies

Since Fisher's (1997) influential contribution, there has been substantial academic discussion on SCSs in the SCM literature. Authors, such as Lee (2002) and Christopher *et al*. (2009), have extended and modified Fisher's model, and proposed similar models, which this dissertation defines as discrete choice strategy typologies (Section 2.4.1). Other authors, such as Yang *et al*. (2004), have proposed different approaches, which this dissertation defines as CODP-based strategy continuums (Section 2.4.2). These typologies and continuums have in common that researchers advocate matching supply chains with unique SCD issues (Christopher *et al*., 2006; Melnyk *et al*., 2014).

This dissertation investigates the acceptability, applicability and sufficiency of commercial SCD-constructs, such as contingency variables, competitive priorities and SCSs, in defence. The research concludes that all investigated constructs are acceptable and applicable, but not sufficient. 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.

The research investigates the unique defence SCD issues, and operationalises them through operational requirements on availability, preparedness and sustainability. Basnet and Seuring (2016) submit that companies must make trade-offs between contesting competitive priorities. The findings of this research indicate that in defence, operational requirements have different implications for competitive priorities in peace, mobilisation and war. In line with Kovács and Tatham (2009), the findings suggest that there is a dilemma in defence SCD. In peace, efficiency is important, but in war, effectiveness has precedence over cost.

Even if the investigated SCD-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 product lifecycle. The findings of this research 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 cost is the likely order-winner, which means that supply chains 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 supply chain should be agile (Aitken *et al*., 2005; Kovács and Tatham, 2009).

This dissertation 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, since supply chains may not always be able to satisfy operational requirements, in which case defence authorities must pre-store supplies (PTS). The answer to which SCS to select, or at what point in the defence supply chain 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 supply chains, for a particular military 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.

Basnet and Seuring (2016) conclude that four variables: demand variability/uncertainty, product variety, desired customer lead-time, and supply uncertainty/risk, represent the essential contingencies in SCD. The findings of this research indicate that in defence, the values of these variables 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 this dynamic 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 (Kovács and Tatham, 2009).

For every SCS proposed in this dissertation, variants are possible. A 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 supply chain, thus postponing different process-related decisions, but there are other issues to consider. These include customisation or standardisation of products, centralisation or decentralisation of production, globalisation or localisation of sourcing, storage and distribution, strategic inventories other than at the CODP, strategic capacity positioning, transportation modes, and supply chain 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) (Ekström, 2013) to contract suppliers to deliver availability of supplies, rather than using traditional, transaction-based contracts.

5.5. Guidance for management decisions

Researchers have observed a discrepancy between theory and practice regarding PPMs (Monczka *et al*., 2011; Cox, 2015). Practitioners even change the design, depending on the situation (Krause *et al*., 2009). This raises the question how researchers should formulate guidance for management decisions to enhance practical relevance.

The purpose of segmentation is to identify homogenous segments that practitioners should treat differently. In previous research, academics have debated different aspects of this treatment, including prescriptiveness versus serving as a starting point for discussions among stakeholders (Gelderman and van Weele, 2003; Jarzabkowski and Kaplan, 2008). A surprising finding in this study is that PPMs can be *both* prescriptive *and* serve as a catalyst for in-depth discussions. The PPM that this dissertation proposes is prescriptive for routine purchasing situations, and serves as a catalyst for in-depth discussions for more complex ones. Other academic discussions regarding treatment have included strict versus pragmatic application, segment-generic versus purchase-specific strategies, and static versus dynamic application. In this research, practitioners expressed preference for pragmatic and dynamic application, and segment-generic strategies.

In general, previous research has contributed with inbound-focused, static PPMs. The guidance developed in this dissertation answers calls for more comprehensive PPMs (Rezaei and Ortt, 2012) and dynamic PPMs (Cox, 2015). In contrast to previously proposed methodologies, such as the ones proposed by Kraljic (1983), Olsen and Ellram (1997), and Svensson (2004), a significant aspect of this guidance is the repositioning. Similar to the sourcing portfolio analysis (SPA), as described by Cox (2015), this guidance allows users to find a more advantageous position in which to optimise decisions. However, where defence procurement practitioners consider the SPA to be too

complex for use in practise, this guidance is based on a PPM that occupies the middle ground between the simplistic two-by-twos and the more complex SPA.

Another important difference between the guidance developed in this dissertation and existing methodologies is that the ultimate objective is quite different. Extant models, such as Kraljic (1983) and Cox (2015), strive to exploit power positions between the buyer and the supplier, whereas the PPM for defence procurement aims to satisfy the operational requirements of armed forces. This difference is in line with the underlying difference between the private and the public sector. Where the private sector uses production and marketing of goods and services to achieve financial targets, the public sector uses its financial resources to produce public goods and services.

5.6. A reflection on research design

The research presented in this dissertation builds on a modified, conventional Delphi study (Section 3.6.2). The author used four modifications; two Delphi panels, a predetermined number of rounds, a seeded list and two concluding workshops, which each had different implications for the research. In combination, they contributed to the results.

The study used a seeded list, based on open issues in the literature. A seeded list to construct questions for the first round is a common modification of the design (Worrell *et al*., 2013). That the seeded list influenced the direction of the study and its results is a certainty. However, to discuss to what extent a traditional design, with an exploration phase (Fletcher and Marchildon, 2014), would have produced similar results would be pure conjecture. The intention of the selected design was to address the open issues regarding PPM design and application in the defence procurement context. From this perspective, the design was successful.

The study used two panels. This modification is not as common as the other three, but researchers, such as Kauko and Palmroos (2014), have used it previously. The author explicates the rationale for the modification in Section 3.6.4. The idea with the modification was to enhance rigour and Section 4.5.3 summarises the findings of Paper 4, which analysed the implications on research rigour of using two panels in a Delphi study. The analysis does not show that the design produced different results than what would have been

possible to achieve with one panel. However, for most questions, the two panels reached identical results, which enhances both credibility (Section 3.10.1) and confirmability (Section 3.10.4), and thus research rigour.

The study used three, predetermined Delphi rounds, which is a common modification of the design (Mullen, 2003). Had the study used traditional convergence criteria, the author would probably not have administered round three, since round two demonstrated stability in the results. With the third round, the author changed the format of the questionnaires and the study reached consensus for most questions, which would not have been the case with only two rounds. The design consequently contributed to producing more useful results, such as design and application rules, than a traditional design would have done.

The study used two concluding workshops to review and extend findings (Melnyk *et al.*, 2009). These workshops were essential to clarify results and to establish design and application rules regarding PPM, as well as acceptability, applicability and sufficiency of commercial SCD-constructs, as input to the model development. Without the workshops, the result of the study would have been the outcome of the Delphi rounds, including bipolarity regarding the issue of prescriptive or catalyst for in-depth discussions. Because of this modification of the design, the study came to the surprising result that PPMs can be *both* prescriptive *and* serve as catalysts. It also contributed to the novel design of the segmentation model.

6. Conclusion

This dissertation contributes to both theory and methodology. This final chapter presents these theoretical and methodological contributions in Section 6.1 and Section 6.2, respectively. The chapter then presents implications, limitations and suggestions for further research under both these headings. Section 6.1.1 establishes implications for practitioners and Section 6.1.2 explicates limitations and suggests further research on the dynamic PPM for defence procurement. Section 6.2.1 presents implications for researchers and Section 6.2.2 describes limitations and proposes further research on the Delphi technique.

6.1. Theoretical contributions

The purpose of this research is to design and develop a PPM for defence procurement, which will be of practical use for defence authorities. The dissertation establishes that a PPM consists of a segmentation model, tactical levers, differentiation strategies and guidance for management decisions. In previous research, academics primarily discuss PPMs in the PSM literature. However, researchers discuss segmentation and differentiation in both the PSM and SCM literature. This dissertation makes theoretical contributions to both these areas, but also to military logistics, including defence procurement.

Previous research has developed predominantly static PPMs for companies seeking financial outcomes. Such PPMs have an inbound logistics perspective and proposes strategies that enable buyers to exploit power-positions. This dissertation summarises the academic debate on extant PPMs and establishes open design and application issues. The dissertation contributes to theoretical knowledge in PSM by eliciting the practitioners' perspective on these issues in a defence setting, establishing design and application rules, and developing a PPM for defence procurement.

The research highlights the practitioners' perspective and demonstrates that extant PPMs do not satisfy the Swedish defence authorities' requirements on practical relevance. In line with authors such as Lovell *et al*. (2005), and

Hesping and Schiele (2016), these practitioners perceive Kraljic´s original two-by-two model (Kraljic, 1983), as well as similar derivatives of it, as too simplistic. However, they regard more complex models, such as Cox's SPA (Cox, 2015), as too complex. In addition, they observe that extant models do not include operational requirements, which the military practitioners consider the most important aspect of defence SCD.

A few authors, such as Cox (2015), have previously discussed and proposed dynamic PPMs, which enables practitioners to optimise an improved situation (Persson and Håkansson, 2007), but not in the public procurement context. This dissertation extends previous knowledge in the PSM literature by proposing a dynamic PPM for defence authorities, seeking operational outcomes. Rather than suggesting strategies for buyers to exploit power-positions, as traditional PPMs such as Kraljic (1983) and Cox (2015), this dissertation proposes differentiation strategies to satisfy the military end users' operational requirements on their supply chains.

With Drake *et al*. (2013) as a notable exception, few researchers have previously combined constructs from PSM and SCM in PPM development. This dissertation integrates the inbound logistics perspective from PSM with the outbound logistics perspective from SCM, to construct a PPM that is suitable for defence procurement, and thus extends the contribution by Drake *et al*. (2013). The proposed PPM thus extends previous research in both the PSM and the SCM literature.

The proposed PPM consists of a novel, two-stage segmentation model, twelve tactical levers, eight differentiation strategies and guidance for application of the model. In each of these different parts of the PPM, the dissertation extends previous knowledge. For the first three, it also contributes with innovations.

In previous research, traditional two-by-two segmentation models dominate (Rezaei *et al*., 2015). This dissertation proposes a segmentation model based on three dimensions. To reduce application complexity, the author implements the segmentation model as a two-stage model, with a precursor and a two-dimensional model. The novel two-dimensional segmentation model has four values for each dimension and is accordingly a four-by-four model. However, to reduce application complexity, the author merges the sixteen elements into four segments. Of these segments, only one is a square and the most problematic segment occupies a larger area than the others do. The proposed segmentation model consequently offers a unique design in comparison to

previous contributions. This dissertation thus provides a new perspective on how researchers in both PSM and SCM can design segmentation models.

This dissertation develops a dynamic PPM, which requires dynamic tactical levers for repositioning in the two-dimensional segmentation model. Since most extant PPMs are static, previous research has focused on static tactical levers. Cox (2015) is an exception, but contributes with a model for companies that seek financial outcomes. This research contributes with tactical levers for defence authorities that seek operational outcomes. In particular, the dynamic tactical levers for reducing operational dependency are inventive and contributes to previous knowledge.

The research reported in this dissertation investigates the acceptability, applicability and sufficiency of commercial SCD-constructs in a military setting. It demonstrates that while these constructs are acceptable and applicable, they are not sufficient. The findings indicate that defence authorities prefer strategy continuums to typologies, since continuums are better suited to meet their requirements. Building on the contribution by Yang *et al*. (2004), this research proposes eight differentiation strategies, which build on CODP-positioning, for defence SCD. Seven of these are in line with previous contributions in the SCM literature, but the eighth is a complement to make the set sufficient for the requirements of the military end users. The eighth strategy, procure-to-stock (PTS), is required when suppliers cannot guarantee to satisfy the operational requirements. The research adds to previous knowledge in SCM by developing SCSs from the end users' perspective and by proposing a new SCS, PTS.

The findings of this research indicate that academics must make an acceptable trade-off between theoretical rigour and practical relevance in model design if practitioners are going to use such models as intended, and that practitioners' perspectives should be included in this trade-off. In line with Luzzini *et al*. (2012), the author concludes that researchers should develop PPMs specifically for unique requirements. The research indicates that models designed specifically for unique requirements in different contexts, in close cooperation with practitioners, are likely to have increased practical relevance. Moreover, the dissertation demonstrates that if researchers adapt the complexity of treatment for different segments to the decision situation's complexity, this is likely to increase practical relevance, and that involvement

of practitioners is essential to design innovative PPMs with increased practical relevance.

This research contributes to the body of knowledge in the underdeveloped area of military logistics in several ways. In response to Melnyk *et al*. (2014), who specifically call for more research to identify the unique SCD features, this dissertation describes how these features can be operationalised through the operational requirements on availability, preparedness and sustainability. As a reaction to Yoho *et al*. (2013), who call for more research in military supply network resiliency and management, this dissertation takes constructs from PSM and SCM and develops a PPM for defence procurement, which contributes to the design and management of resilient defence supply chains.

This dissertation highlights end-customers' requirements in defence supply chains and demonstrates that defence authorities have unique requirements. The findings suggest that the importance of competitive priorities shift in peace, mobilisation and war. While cost may be the order-winner in peace, lead-time is more likely to be the order-winner in war. In line with Christopher *et al*. (2006), this dissertation suggests that both researchers and companies should match these specific requirements in SCD.

6.1.1. Implications for practitioners

This research develops a PPM for defence procurement in close cooperation with practitioners from Swedish defence authorities. The result is a model that occupies the middle ground between the simplistic, traditional two-by-twos and the more complex models in the literature, such as the SPA. However, the unique design reduces the complexity of the model to accommodate requirements on practical relevance. The novel application rules enhances the practical relevance even further. The model is potentially useful to practitioners, both in the public and private defence sectors. It may also be useful to procurement practitioners in the wider public sector, as well as to non-governmental organisations dealing with preparedness and crisis management.

With three dimensions, including operational requirements, the model satisfies the requirements of the Swedish defence authorities and will enable them to combine the expertise within the Swedish Armed Forces and FMV into a holistic perspective on defence procurement and defence SCD. The

model will provide the defence authorities with an instrument that integrates operational requirements with market capabilities and operational consequences. In addition, the model matches operational requirements with the market's abilities to satisfy them, which will facilitate future defence SCD.

The innovative precursor simplifies alignment of the Swedish Armed Forces' and FMV's strategies and objectives. It highlights the Swedish Armed Forces' requirements, and ensures that defence procurement prioritises the end users' operational perspective, as well as the traditional legal and commercial perspective. It incorporates operational requirements on availability, preparedness and sustainability. The model is an instrument that will enable defence authorities to position the CODP at such points, which will allow the SCD to satisfy these operational requirements.

The guidance for management decisions provides a systematic methodology, which enables practitioners to reach procurement and SCD decisions in a structured way. One particular aspect of the structured and systematic methodology is that it enables informed decision-making regarding defence SCD and operational risk-taking. Using the model, defence authorities will be able to determine when it is necessary to store supplies, rather than to rely on the supplier's abilities. The model will also enable them to identify the optimal mix of SCSs, which satisfies operational requirements at minimum cost and technical risk, without unwarranted operational risk-taking. If they decide to take an operational risk, which may be necessary for reasons of affordability, rather than to select a SCD that satisfies operational requirements, the model will ensure that the defence authorities make such decisions with transparency and traceability regarding operational risk-taking.

Earlier research in the private sector has suggested that the application of PPMs requires critical thinking and sophistication of the purchasing function. Application of the PPM for defence procurement is likely to require the same in the defence context. However, the author bases the design and the guidance on the requirements of the users, through the established design and application rules, which ought to make future implementation straightforward. In addition, prospective users of the model have validated all steps of the development and the final model.

Previous studies have found that practitioners regard in-depth discussions on the position in the model as the most important phase of the analysis. Contrary to extant, prescriptive PPMs, this dissertation proposes a model that requires

such in-depth discussions. The PPM for defence procurement is *both* prescriptive *and* serves as a catalyst for in-depth discussions. The model thus visibly adapts the complexity of treatment of different segments to the decision situation's complexity, which will allow practitioners to focus their efforts on complex procurement situations. Moreover, the fact that potential future users of the model participated in model development and validation has resulted in a model that users should apply pragmatically. That the author has developed the model in accordance with design and application rules validated by practitioners should narrow the gap between development and application.

An important aspect of this research is to raise the awareness among defence practitioners of developments in related theoretical areas. The study has achieved this objective directly with the Delphi panellists and the workshop participants. It is the hope of the author that the research reaches a wider audience through the reports to the defence authorities, the published papers and this dissertation, and that these publications further contribute to raising the awareness. Practitioners in military logistics and defence procurement have much to gain by understanding such theoretical developments, since the military parts of the supply chains in many cases are relatively small parts of global supply chains, with multinational defence industry companies.

The results presented in this dissertation will enable such defence industry companies to enhance their abilities to understand the operational requirements of the defence authorities. The dissertation emphasises that defence authorities' operational requirements are different in peace, mobilisation and war, and that companies should develop SCSs accordingly. Even if the objective of the defence industry is to make profit, this dissertation clarifies that there are more prospects than to focus on efficiency. Efficiency may lead to business opportunities regarding operational requirements in peace. However, to satisfy military customer's requirements in mobilisation and war, companies should probably focus more on responsiveness.

Outside the defence sector, and after some adaptation of the proposed model, public and non-governmental organisations dealing with preparedness and crisis management, including humanitarian logistics and disaster relief aid, may have use of a PPM that includes their operational requirements. In addition, in the public sector, decision-makers still regard procurement as a supporting function, whereas it has evolved into a strategic function in the

private sector. The proposed PPM for defence procurement may be a step towards a shift, at least in defence procurement.

6.1.2. Limitations and further research on the dynamic PPM for defence procurement

The major limitation with the theoretical findings presented in this dissertation is that the results build on a Delphi study conducted in the Swedish defence context, with a military, operational perspective. In addition, Sweden is a small, non-aligned country, with a long tradition of domestic defence industry. The author has validated the results of the research in the Swedish context, but to determine generalisability and transferability of the findings, additional studies are required. The author suggests that researchers conduct studies with other methods and stakeholders, in other contexts, including different national perspectives and different industries. As an example, it would be interesting to conduct a multiple case study, including defence authorities and defence industry companies, to investigate the application of the proposed model.

Another limitation with the research is that it does not include buyer-supplier relationships. Any implementation of the proposed PPM for defence procurement must address such relationships. Therefore, the author suggests that future research addresses such relationships in the context of PPMs. In particular, it would be of interest to investigate the integration of recommendations regarding buyer-supplier relationships with the guidance for management decisions in the PPM. In this context, such research should include different forms of public private business models, including public private partnerships. A related issue that would be interesting to investigate is how PBL relates to the PPM for defence procurement. In future research, researchers should investigate if they can expand the framework to integrate performance-based contracts.

The issues of logistics values and utilities (Mentzer *et al*., 1997; Rutner and Langley, 2000), value creation (Prahalad and Ramaswamy, 2004) and value co-creation (Vargo *et al*., 2008) relate to the results presented in this dissertation. It would be interesting to explore these topics further in the public defence context, especially related to the proposed SCSs. How can, for example, a military buyer define the value of a safety stock at a supplier, and consequently motivate the expense, and how can the buyer and the supplier co-create such values?

In the SCM-literature, 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. In particular, the findings from this research indicate that in the public defence sector, 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 preferred customer, customer attractiveness and preferential treatment of military customers in peace. This dissertation 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.

Industry 4.0 and emerging technologies, such as additive manufacturing, or three-dimensional printing, will inevitably have consequences for defence SCD. Industry 4.0 marks the fourth industrial revolution, enabled by the introduction of the Internet-of-things into manufacturing (Tjahjono *et al*., 2017). Additive manufacturing enables manufacturing all around the world (den Boer *et al*., 2020) and positioning manufacturing closer to the end-user will potentially reduce lead-times and logistics costs (Durão *et al*., 2017). It would be interesting to investigate the applicability and consequences for defence supply chains, especially for the SCSs proposed in this dissertation. How can, for instance, lead-times in defence supply chains be reduced by the introduction of Internet-of-things and three-dimensional printing? A pertinent question is also; to what extent implementation is possible, given the classified nature of information in the military sphere?

Finally, the dynamic and static tactical levers identified in this dissertation share characteristics with the SCRM process. In future research, it would be interesting to use SCRM theory to develop a framework of dynamic and static tactical levers and investigate it empirically in the context of dynamic PPMs.

6.2. Methodological contributions

This dissertation contributes to the general discussion on rigour in Delphi studies and addresses the absent discussion on such rigour in the logistics and SCM literature.

The Delphi study reported in this dissertation used four modifications to the conventional design: two Delphi panels, a predetermined number of rounds, a seeded list, based on open issues in the literature, as questions in the first round and two concluding workshops to review and extend findings. The author used two panels to enhance research rigour and to mitigate the risk of forcing consensus, but they were also instrumental to produce surprising results. The results are an indication that two Delphi panels may enhance rigour and mitigate the risk of forcing consensus, but also more easily reveal bipolarity. Furthermore, concluding workshops proved instrumental in the study. It produced a novel PPM, which the participating practitioners perceive as an innovation that will be of practical use in defence procurement. It is not likely that a conventional Delphi design would have provided a similar result. The conclusion is that, at least in some cases, the design of a Delphi study will have an impact on which results the study produces.

Having conducted a literature review regarding rigour in Delphi studies in the logistics and SCM literature, the author finds no indication of a general discussion regarding rigour in Delphi studies in this literature. The question if researchers should use positivistic or interpretivistic quality criteria, or both, to discuss rigour explicitly, remains unaddressed. The same is true for the question regarding which methodological aspects that must be included to provide an audit trail to demonstrate rigour implicitly. In other research areas, such as healthcare, there are examples of lively discussions on this topic. Since researchers increasingly use the Delphi technique in published logistics and SCM research, such discussions would seem to be overdue. This dissertation contributes to methodology in the logistics and SCM literature by initiating such a discussion.

Furthermore, based on a pilot study of thirteen papers, the author submits that a standardised way to demonstrate rigour in Delphi studies is missing in the logistics and SCM literature. The results indicate that there is a wide range of experience among researchers who use the Delphi technique, from apparent first time users to expert users, and that they address the issue of rigour quite

differently. Where a few expert users discuss some aspects of validity and reliability explicitly, most non-experts do not. However, none of them discusses all aspects of correspondence. As an alternative to positivistic quality criteria, researchers who use the Delphi technique may apply the elements of trustworthiness from interpretivism, but none of the authors in the sample chooses to do so. The provision of an audit trail is another option that researchers have to demonstrate rigour in Delphi studies. For the most part, the articles in the sample provide an adequate audit trail, including theoretical and methodological decisions. However, two aspects of a satisfactory audit trail is missing in several articles. A majority of the articles do not mention attrition/retention and four do not discuss the issue of how consensus is measured. These findings support the claim that a general discussion regarding rigour in Delphi studies in logistics and SCM is required.

6.2.1. Implications for researchers

Regarding research rigour, Delphi studies are no different from other qualitative studies. The requirement to establish research rigour is as important for Delphi studies as it is for all other studies. However, it is claimed that few researchers even attempt to address this issue, which leaves Delphi studies and the method "open to criticism and dismissal" (Hasson and Keeny, 2011). The pilot study conducted by the author of this dissertation indicates that also authors in the logistics and SCM community can improve regarding the establishment of research rigour in articles based on the Delphi technique.

As far as this author has been able to determine, there are no specific criteria for the establishment of Delphi study rigour in the logistics and SCM literature, or even a lively discussion on the subject. In the absence of such domain-specific criteria, the author suggests that researchers in the logistics and SCM research community follow the criteria in other literatures. As an example, Hasson and Keeny (2011), Skulmoski *et al.*, (2007) and Worrell *et al.* (2013) contribute with general discussions on research rigour in Delphi studies. In addition, Hasson *et al.* (2000), Okoli and Pawlowski (2004) and Worrell *et al.* (2013) offer recommendations on design issues.

The author of this dissertation suggests that logistics and SCM researchers demonstrate rigour either explicitly, by discussing criteria of correspondence and/or trustworthiness, or implicitly, by providing an audit trail of the most important theoretical and methodological decisions. The latter should include

justification of the method, type of Delphi, expert selection and attrition/retention, panel size, questionnaire design, content of feedback, number of rounds and consensus measurement.

6.2.2. Limitations and further research on the Delphi technique

The author bases the PPM proposed in this dissertation on findings from a Delphi study in which the author made four modifications to the conventional design. The results indicate that two Delphi panels may enhance rigour and reveal bipolarity more easily than traditional designs. More research is required to investigate the limitations of traditional designs and the possibilities with modified designs. In particular, it would be interesting to investigate to what extent two panels enhance rigour, mitigate the risk of forcing consensus and contribute to establishing bipolarity. Comparative studies, in which researchers simultaneously investigate alternative designs in the same study, would help to enhance our understanding regarding the impact that the design of a Delphi study has on the results it produces.

Based on a literature review regarding rigour in Delphi studies in the logistics and SCM literature, the author draws the conclusion that, as of yet, there is no discussion on rigour in Delphi studies in the logistics and SCM literature. In health research, as an example, there is a longstanding and wide-ranging discussion on rigour in Delphi studies. It would be interesting to see a similar discussion established also in the logistics and SCM research community. In particular, it would seem to be essential for researchers to discuss and establish what is required to demonstrate rigour in Delphi studies in the logistics and SCM literature.

The pilot literature review on research rigour in Delphi studies in the logistics and SCM literature reported in this dissertation uses a convenience sample of thirteen papers. The dissertation thus provides a starting point for further investigation. In further research, it would be interesting to use a representative sample to test the generalisability of the preliminary results. Given the relatively limited number of Delphi studies in the logistics and SCM literature, an alternative is to conduct a systematic literature review on this topic.

References

Ackoff, R. (1974). *Redesigning the Future: A Systems Approach to Societal Problems*. John Wiley & Sons, Hoboken, New Jersey, USA.

Aitken, J., Childerhouse, P., Christopher, M. and Towill, D.R. (2005). "Designing and managing multiple pipelines", *Journal of Business Logistics*, Vol. 26, No. 2, pp. 73-96.

Akkermans, H.A., Bogerd, P., Yücesan, E. and van Wassenhove, L.N. (2003). "The impact of ERP on supply chain management: Exploratory findings from a European Delphi study", *European Journal of Operational Research*, Vol. 146, No. 2, pp. 284-301.

Alvesson, M. and Sköldberg, K. (2000). *Reflexive Methodology – New Vistas for Qualitative Research*. Sage Publications Inc., Thousand Oaks, California, USA.

Anderson, J.C., Rungtusanatham, M. and Schroeder, R.G. (1994). "A Theory of Quality Management Underlying the Deming Management Method", *The Academy of Management Review*, Vol. 19, No. 3, pp. 472-509.

Andersson, S., Servais, P. (2010). "Combining industrial buyer and seller strategies for international supply and marketing management", *European Business Review*, Vol. 22, No. 1, pp. 64-81.

Arbnor, I. and Bjerke, B. (1997). *Methodology for Creating Business Knowledge, Second Edition*. Sage Publications Inc., Thousand Oaks, California, USA.

Arlbjørn, J. S. and Halldórsson, A. (2002). "Logistics knowledge creation: reflections on content, context and processes", *International Journal of Physical Distribution & Logistics Management*, Vol. 32, No.1, pp. 22-40.

Bacharach, S. B. (1989). "Organisational Theories: Some Criteria for Evaluation", *The Academy of Management Review*, Vol. 14, No. 4, pp. 496-515.

Ballou, R. H. (2006). "Revenue Estimation for Logistics Customer Service Offerings", *International Journal of Logistics Management*, Vol. 17, No. 1, pp. 21-37.

Basnet, C. and Seuring, S. (2016). "Demand-oriented Supply Chain Strategies – a Review of the Literature", *Operations and Supply Chain Management: An International Journal*, Vol. 9, No. 2, pp. 73-89.

Bensaou, M. (1999). “Portfolios of buyer-supplier relationships”, *Sloan Management Review*, Vol. 40, No. 4, pp. 35-44.

Betts, R. (1995). *Military readiness: Concepts, Choices, Consequences*, Brookings Institution, Washington, D.C., USA.

Boone, C., Craighead, C. and Hanna, J. (2007). “Postponement: an evolving supply chain concept”, *International Journal of Physical Distribution & Logistics Management*, Vol. 37, No. 8, pp. 594-611.

Burrell, G. and Morgan, G. (1979). *Sociological Paradigms and Organisational Analysis, First Edition.* Routledge, London, UK.

Caniëls, M.C.J. and Gelderman, C.J. (2005). “Purchasing strategies in the Kraljic matrix – A power and dependence perspective”, *Journal of Purchasing & Supply Management*, Vol. 11, No. 2-3, pp. 141-155.

Cardinali, R. (2001). “Does the future of military logistics lie in outsourcing and privatization? Accountants – the new gatekeepers of wartime operations”, *Work study*, Vol. 50, No. 3, pp. 105-110.

Carter, C. R. (2011). “A Call for Theory: The Maturation of the Supply Chain Management Discipline”, *Journal of Supply Chain Management*, Vol. 47, No. 2, pp. 3-7.

Chalmers, A. F. (1999). *What is this thing called Science? Third Edition*. Open University Press, Maidenhead, Berkshire, UK.

Chen, I. and Paulraj, A. (2004). “Towards a theory of supply chain management: the constructs and measurements”, *Journal of Operations Management*, Vol. 22, No. 2, pp. 119-150.

Chen, I., Paulraj, A. and Lado, A. (2004). “Strategic purchasing, supply management, and firm performance”, *Journal of Operations Management*, Vol. 22, No. 5, pp. 505-523.

Childerhouse, P., Aitken, J. and Towill, D.R. (2002). “Analysis and design of focused demand chains”, *Journal of Operations Management*, Vol. 20, No. 6, pp. 675-689.

Christopher, M. (2000). “The agile supply chain: competing in volatile markets”, *Industrial Marketing Management*, Vol. 29, No. 1, pp. 37-44.

Christopher, M. and Peck, H. (2004). "Building the Resilient Supply Chain", *International Journal of Logistics Management*, Vol. 15, No. 2, pp. 1-14.

Christopher, M., Peck, H. and Towill, D.R. (2006). “A taxonomy for selecting global supply chain strategies”, *International Journal of Logistics Management*, Vol. 17, No. 2, pp. 277-287.

Christopher, M., Towill, D., Aitken, J. and Childerhouse, P. (2009). "Value stream classification", *Journal of Manufacturing Technology Management*, Vol. 20, No. 4, pp. 460-474.

Collin, J., Eloranta, E. and Holmström, J. (2009). "How to design the right supply chains for your customers", Supply Chain Management: An International Journal, Vol. 14, No. 6, pp. 411-417.

Corley, K. and Goia, D. (2011). "Building Theory about Theory Building: What Constitutes a Theoretical Contribution?", *Academy of Management Review*, Vol. 36, No. 1, 12-32.

Cox, A. (2015). "Sourcing portfolio analysis and power positioning: towards a "paradigm shift" in category management and strategic sourcing", *Supply Chain Management: An International Journal*, Vol. 20, No. 6, pp. 717-736.

Critcher, C. and Gladstone, B. (1998). "Utilizing The Delphi Technique In Policy Discussion: A Case Study Of A Privatized Utility In Britain", *Public Administration*, Vol. 76, No. 3, pp. 431-449.

Cusick, J.J. and Pipp, D.C. (1997). "In Search of Focused Logistics", *Joint Force Quarterly*, Spring 1997, pp. 125-127.

Czinkota, M.R. and Ronkainen, I.A. (2005). "A forecast of globalization, international business and trade: report from a Delphi study", *Journal of World Business*, Vol. 40, No. 2, pp. 111-123.

Dajani, J.S., Sincoff, M.Z. and Talley, W.K. (1979). "Stability and agreement criteria for the termination of Delphi studies", *Technological Forecasting & Social Change*, Vol. 13, No. 1, pp. 83-90.

Dalkey, N. and Helmer, O. (1963). "An Experimental Application of the DELPHI Method to the Use of Experts", *Management Science*, Vol. 9, No. 3, pp. 458-467.

Davids, C., Beeres, R. and van Fenema, P. (2013). "Operational defense sourcing: organizing military logistics in Afghanistan", *International Journal of Physical Distribution & Logistics Management*, Vol. 43, No. 2, pp. 116-133.

Day, J. and Bobeva, M. (2005). "A Generic Toolkit for the Successful Management of Delphi Studies", *The Electronic Journal of Business Research Methodology*, Vol. 3, No. 2, pp. 103-116.

Day, M., Magnan, G. and Munkgaard Moeller, M. (2010). "Evaluating the bases of supplier segmentation: A review and taxonomy", *Industrial Marketing Management*, Vol. 39, No 4, pp. 625–639.

de Loë, R.C., Melnychuk, N., Murray, D. and Plummer, R. (2016). "Advancing the State of Policy Delphi Practice: A Systematic Review Evaluating Methodological Evolution, Innovation, and Opportunities", *Technological Forecasting & Social Change*, Vol. 104, pp. 78-88.

den Boer, J., Lambrechts, W., & Krikke, H. (2020). "Additive Manufacturing in Military and Humanitarian Missions: Advantages and Challenges in the Spare Parts Supply Chain", *Journal of Cleaner Production*, Vol. 257. Pp. 1-11.

Dickens Johnson, M.M. (2008). "Current trends of outsourcing practice in government and business: causes, case studies and logic", *Journal of Public Procurement*, Vol. 8, No. 2, pp. 248-268.

Drake, P.R., Lee, D.M., Hussain, M., (2013). "The lean and agile purchasing portfolio model", *Supply Chain Management: An International Journal*, Vol. 18, No. 1, pp. 3-20.

Dubois, A. and Gadde, L.-E. (2002). "Systematic combining: an abductive approach to case research", *Journal of Business Research*, Vol. 55, pp. 553-60.

Dubois, A. and Pedersen A.-C. (2002). Why relationships do not fit into purchasing portfolio models – a comparison between the portfolio and industrial network approaches, *European Journal of Purchasing & Supply Management*, Vol. 8, No. 1, pp. 35-43.

Donne, J. (1959). *Devotions Upon Emergent Occasions – Together with Death's Duel*. Ann Arbor Paperbacks, The University of Michigan Press, Ann Arbour, Mi, USA.

Durão, L. F. C. S., Christ, A., Zancul, E., Anderl, R., and Schützer, K. (2017). "Additive Manufacturing Scenarios for Distributed Production of Spare Parts", *The International Journal of Advanced Manufacturing Technology*, Vol. 93, pp. 869-880.

Dyer, J.H., Cho, D.S. and Chu, W. (1998). "Strategic Supplier Segmentation: The Next "Best Practice" in Supply Chain Management", *California Management Review*, Vol. 40, No. 2, pp. 57-77.

Eccles, H.E., (1959). *Logistics in the national defense*. The Stackpole Co, Harrisburg, Pa, USA.

Ekström, T. (2012). *Public Private Business Models for Defence Acquisition - A Multiple Case Study of Defence Acquisition Projects in the UK*. Licentiate Thesis, Lund University (Media-Tryck), Lund, Sweden.

Ekström, T. (2013). *Performance Based Logistics – A Paradigm shift from Transaction Based Defence Equipment Procurement to Performance Based Defence Acquisition (In Swedish)*. FOI, Stockholm, Sweden.

Ekström, T. (2020). "The Delphi Technique - Limitations and Possibilities", Paper presented at the 32nd Annual NOFOMA Conference, 17 – 18 September 2020 on Internet.

Ekström, T., Hilletofth, P. and Skoglund, P. (2020a). "Towards a Purchasing Portfolio Model for Defence Procurement – A Delphi study of Swedish defence authorities", *Working Manuscript (Submitted, under review)*.

Ekström, T., Hilletofth, P. and Skoglund, P. (2020b). "Differentiation strategies for defence supply chain design", *Accepted for publication in Journal of Defense Analytics and Logistics*.

Ekström, T., Hilletofth, P. and Skoglund, P. (2020c). "Guidance for management decisions in the application of a dynamic purchasing portfolio model", *Working Manuscript (Submitted, under review)*.

Ellram, L. (1996). "The use of the Case Study Method in Logistics Research", *Journal of Business Logistics*, Vol. 17, No. 2, pp. 93-138.

Erbel, M. and Kinsey, C. (2018). "Think again – supplying war: reappraising military logistics and its centrality to strategy and war", *Journal of Strategic Studies*, Vol. 41, No. 4, pp. 519-544.

Fan, Y., and Stevenson, M. (2018). "A Review of Supply Chain Risk Management: Definition, Theory, and Research Agenda", *International Journal of Physical Distribution & Logistics Management*, Vol. 48, No. 3, pp. 205-230.

Fearne, A. and Fowler, N. (2006). "Efficiency versus effectiveness in construction supply chains: the dangers of "lean" thinking in isolation", *Supply Chain Management: An International Journal*, Vol. 11, No. 4, pp. 283-287.

Fisher, M.L. (1997). "What is the right supply chain for your product?", *Harvard Business Review*, Vol. 75, No. 2, pp. 105-116.

Fletcher, A.J. and Marchildon, G.P. (2014). "Using the Delphi Method for Qualitative, Participatory Action Research in Health Leadership", *International Journal of Qualitative Methods*, Vol. 13, No. 1, pp. 1-18.

FMV (2016). *Optimerad distribution, lager- och förrådshållning - Delrapport 3 till Försvarslogistikchefen. (Optimised distribution and warehousing – Interim report 3 to the Chief of Defence Logistics)*. FMV, Stockholm, Sweden.

Fouka, G. and Mantorou, M. (2011). "What are the Major Ethical Issues in Conducting Research? Is there a Conflict between the Research Ethics and the Nature of Nursing?", *Health Science Journal*, Vol. 5, No. 1, pp. 3-14.

Foxton, P. D. (1994). *Powering War – Modern Land Force Logistics*. Brassey's, London, UK.

Gammelgaard, B. (2004). "Schools in logistics research? A methodological framework for analysis of the discipline", *International Journal of Physical Distribution & Logistics Management*, Vol. 34, No. 6, pp. 479-491.

Gelderman, C.J. (2003). *A Portfolio Approach to the Development of Differentiated Purchasing Strategies*. Doctoral Dissertation, Eindhoven University of Technology, Eindhoven, The Netherlands.

Gelderman, C.J. and Van Weele, A.J. (2003). "Handling Measurement Issues and Strategic Directions in Kraljic's Purchasing Portfolio Model", *Journal of Purchasing and Supply Management*, Vol. 9, No. 5-6, pp. 207-216.

Gelderman, C.J. and Van Weele, A.J. (2005). "Purchasing Portfolio Models: A Critique and Update", *Journal of Supply Chain Management*, Vol. 41, No. 3, pp. 19-28.

Genovese, A., Koh, S.C.L. and Acquaye, A. (2013). "Energy efficiency retrofitting services supply chains: Evidence about stakeholders and configurations from the Yorkshire and Humber region case", *International Journal of Production Economics*, Vol. 144, No. 1, pp. 20-43.

Giunipero, L.C., Hooker, R.E. and Denslow, D. (2012). "Purchasing and supply management sustainability: Drivers and barriers", *Journal of Purchasing & Supply Management*, Vol. 18, No. 4, pp. 258-269.

Glas, A. (2017). "Preferential treatment from the defense industry for the military", *Journal of Defense Analytics and Logistics*, Vol. 1, No. 2, pp. 96-119.

Glas, A., Hofmann, E. and Eßig, M. (2013). "Performance-based logistics: a portfolio for contracting military supply", *International Journal of Physical Distribution & Logistics Management*, Vol. 43, No. 2, pp. 97-115.

Godsell, J., Harrison, A., Emberson, C. and Storey, J. (2006). "Customer responsive supply chain strategy: an unnatural act?", *International Journal of Logistics Research and Applications*, Vol. 9, No. 1, pp. 47-56.

Grimsey, D. and Lewis, M. K. (2004). *Public Private Partnerships – The Worldwide Revolution in Infrastructure Provision and Project Finance*. Edward Elgar Publishing Limited, Cheltenham, UK.

Gummesson, E. (2000). *Qualitative Methods in Management Research, Second Edition*. Sage Publications Inc., Thousand Oaks, California, USA.

Gunasekaran, A., Lai, K. and Cheng, E. (2008). "Responsive supply chain: a competitive strategy in a networked economy", *Omega*, Vol. 36, No. 4, pp. 549-564.

Gupta, U.G. and Clarke, R.E. (1996). "Theory and Applications of the Delphi Technique: A Bibliography (1975-1994)", *Technological Forecasting & Social Change*, Vol. 53, No. 2, pp. 185-211.

Halldórsson, Á. and Aastrup, J. (2003). "Quality criteria for qualitative inquiries in logistics", *European Journal of Operational Research*, Vol. 144, No. 2, pp. 321-332.

Halldórsson, Á., Kotzab, H., Mikkola, J.H. and Skjøtt-Larsen, T. (2007). "Complementary theories to supply chain management", *Supply Chain Management: An International Journal*, Vol. 12, No. 4, pp. 284-296.

Hallgren, M., Olhager, J. and Schroeder, R.G. (2011). "A hybrid model of competitive capabilities", *International Journal of Operations & Production Management*, Vol. 31, No. 5, pp. 511-526.

Hallikas. J., Puumalainen, K., Vesterinen, T. and Virolainen, V.-M. (2005). "Risk-based classification of supplier relationships", *Journal of Purchasing and Supply Management*, Vol. 11, No. 2-3, pp. 72-82.

Hasson, F. and Keeney, S. (2011). "Enhancing rigour in the Delphi technique research", *Technological Forecasting and Social Change*, Vol. 78, No. 9, pp. 1695-1704.

Hasson, F., Keeney, S. and McKenna, H. (2000). "Research guidelines for the Delphi survey technique", *Journal of Advanced Nursing*, Vol. 32, No. 4, pp. 1008-1015.

Hauk, J. (1964). "Logistics and Physical Distribution Management in the Military", *Transportation Journal*, Vol. 4, No. 2, pp. 12-19.

Hesping, F.H. and Schiele, H. (2015). "Purchasing strategy development: A multi-level review", *Journal of Purchasing and Supply Management*, Vol. 21, No. 2, pp. 138-150.

Hesping, F.H. and Schiele, H. (2016). "Matching tactical sourcing levers with the Kraljič matrix: Empirical evidence on purchasing portfolios". *International Journal of Production Economics*, Vol. 177, pp. 101-117.

Hilletofth, P. (2009). “How to develop a differentiated supply chain strategy”, *Industrial Management & Data Systems*, Vol. 109, No. 1, pp. 16-33.

Hilletofth, P. (2012). “Differentiation focused supply chain design”, *Industrial Management & Data Systems*, Vol. 112, No. 9, pp. 1274-1291.

Hoekstra, S. and Romme, J. (Ed.). (1992). *Integral logistic structures: developing customer-oriented goods flow*. McGraw-Hill, London, UK.

Hood, C. (1995). “The “New Public Management” in the 1980s: Variations on a theme. Accounting”, *Organizations and Society*, Vol. 20, No. 2/3, pp. 93-109.

Humphries, A. and Wilding, R. (2001). “Partnerships in UK Defence Procurement”, *International Journal of Logistics Management*, Vol. 12, No. 1, pp. 83-96.

Huscroft, J.R., Hazen, B.T., Hall, D.J., Skipper, J.B. and Hanna, J.B. (2013). “Reverse logistics: past research, current management issues, and future directions”, *International Journal of Logistics Management*, Vol. 24, No. 3, pp. 304–327.

Jackson, M. C. (2003). *Systems Thinking – Creative Holism for Managers*. John Wiley & Sons, Chichester, UK.

Jarzabkowski, P. and Kaplan, S. (2008). “Using strategy tools in practice: an exploration of "technologies of rationality" in use”, Academy of Management Proceedings, Academy of Management, Vol. 1, pp. 1-6.

Johansen, A.J., Madsen, E.S. and Arlbjørn, J.S. (2012). “Supply Chain Segmentation Models: A Question of Muddling Through?”, Proceedings of the 24th Annual NOFOMA Conference, , pp. 380-394, Turku, Finland.

Jüttner, U., Peck, H. and Christopher, M. (2003). “Supply chain risk management: outlining an agenda for future research”, *International Journal of Logistics Research and Applications*, Vol. 6, No. 4, pp. 197-210.

Kaufman, A., Wood, C.H. and Theyel, G. (2000). “Collaboration and technology linkages: a strategic supplier typology”, *Strategic Management Journal*, Vol. 21, No. 6, pp. 649-663.

Kauko, K. and Palmroos, P. (2014). “The Delphi method in forecasting financial markets – An experimental study”, International Journal of Forecasting, Vol. 30, No. 2, pp. 313-327.

Keller, H.E. and Lee, S. (2003). “Ethical Issues Surrounding Human Participants Research Using the Internet”, *Ethics & Behavior*, Vol. 13, No. 3, pp. 211-219.

Kembro, J., Näslund, D. and Olhager, J. (2017). "Information sharing across multiple supply chain tiers: A Delphi study on antecedents", *International Journal of Production Economics*, Vol. 193, pp. 77-86.

Kim, B. (2013). "Competitive priorities and supply chain strategy in the fashion industry", *Qualitative Market Research: An International Journal*, Vol. 16, No. 2, 2013, pp. 214-242.

Kim, S.-H., Fowler, J.W., Shunk, D.L. and Pfund, M.E. (2012). "Improving the push–pull strategy in a serial supply chain by a hybrid push–pull control with multiple pulling points", *International Journal of Production Research*, Vol. 50, No. 19, pp. 5651-5668.

Kipling, R. (2001). *The Elephant's Child*, in Kipling, R. (2001). *Just So Stories*. Dover Publications, New York, USA.

Korstjens, I. and Moser, A. (2018). "Series: Practical guidance to qualitative research. Part 4: Trustworthiness and publishing", *European Journal of General Practice*, Vol. 24, No. 1, pp. 120-124.

Kovács, G. and Spens, K. M. (2005). "Abductive reasoning in logistics research", *International Journal of Physical Distribution & Logistics Management*, Vol. 35, No. 2, pp.132-144.

Kovács, G. and Spens, K. M. (2007). "Logistics Theory Building". *The Icfai Journal of Supply Chain Management*, Vol. 4, No. 4, pp.7-27.

Kovács, G. and Tatham, P. (2009). "Responding to disruptions in the supply network – from dormant to action", *Journal of Business Logistics*, Vol. 30, No. 2, pp. 215-229.

Kraljic, P. (1983). "Purchasing must become supply management", *Harvard Business Review*, Vol. 61, No. 5, pp. 109-117.

Krause, D.R., Vachon S. and Klassen, R.D. (2009). "Special topic forum on sustainable supply chain management: Introduction and reflections on the role of purchasing management". *Journal of Supply Chain Management*, Vol. 45, No. 4, pp. 18-25.

Kress, Moshe (2002). *Operational Logistics. The Art and Science of Sustaining Military Operations*. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Kuhn, T. S. (1996). *The Structure of Scientific Revolutions, Third Edition*. The University of Chicago Press, Chicago, USA.

Lambert, S. (2007). "A Business Model Research Schema". Proceedings of the 19th Bled eConference: eValues, Bled, Slovenia.

Lampel, J. and Mintzberg, H. (1996). "Customizing customization", *MIT Sloan Management Review*, Vol. 38, No. 1, pp. 21-30.

Lawrence, A. (2009). *Acquisition Management*, in Bucur-Marcu, H., Fluri, P. and Tagarev, T., Editors (2009). *Defence Management: An Introduction*. Geneva Centre for the Democratic Control of Armed Forces, (DCAF), Geneva, Switzerland.

Lee, H.L. (2002). "Aligning supply chain strategies with product uncertainties", *California Management Review*, Vol. 44, No. 3, pp. 105-119.

Lilliecreutz, J. and Ydreskog, L. (1999), 'Supplier Classification as an Enabler for a Differentiated Purchasing Strategy', *Global Purchasing & Supply Chain Management*, November, pp. 66-74.

Linstone, H. and Turoff, M. (2002). *The Delphi Method, Techniques and Applications*. https://web.njit.edu/~turoff/pubs/delphibook/delphibook.pdf (accessed 11 June 2020).

Linstone, H. and Turoff, M. (2011). "Delphi: A brief look backward and forward", *Technological Forecasting & Social Change*, Vol. 78, No. 9, pp. 1712-1719.

Louth, J. (2015). "Logistics as Force Enabler", *The RUSI Journal*, Vol. 160, No. 3, pp. 58-63.

Lovell, A., Saw, R. and Stimson, J. (2005). "Product value-density: managing diversity through supply chain segmentation", *International Journal of Logistics Management*, Vol. 16, No. 1, pp. 142-158.

Lummus, R.R., Vokurka, R.J. and Duclos, L.K. (2005). "Delphi study on supply chain flexibility", *International Journal of Production Research*, Vol. 43, No. 13, pp. 2687-2708.

Luzzini, D., Caniato, F., Ronchi, S. and Spina, G. (2012). "A transaction costs approach to purchasing portfolio management", *International Journal of Operations & Production Management*, Vol. 32, No. 9, pp. 1015-1042.

MacCarthy, B., Blome, C., Olhager, J., Srai, J. and Zhao, X. (2016). "Supply chain evolution – theory, concepts and science", *International Journal of Operations & Production Management*, Vol. 36, No. 12, pp. 1696-1718.

Markowitz. H. (1952). "Portfolio Selection", *The Journal of Finance*, Vol. 7, No. 1, pp. 77-91.

Markowski, S., Hall, P. and Wylie, R. (2010). *Procurement and the chain of supply – A general framework*, in Markowski, S., Hall, P. and Wylie, R.,

Editors (2010). *Defence Procurement and Industrial Policy – A small country perspective*. Routledge, Abingdon, UK.

Martel, A., Benmoussa, A., Chouinard, M., Klibi, W. and Kettani, O. (2013). "Designing global supply networks for conflict or disaster support: the case of the Canadian Armed Forces", *Journal of the Operational Research Society*, Vol. 64, No. 4, pp. 577-596.

Masella, C. and Rangone, A. (2000). "A contingent approach to the design of vendor selection systems for different types of co-operative customer/supplier relationships", *International Journal of Operations & Production Management*, Vol. 20, No. 1, pp. 70-84.

Mason-Jones, R., Naylor, B. and Towill, D. (2000a). "Lean, agile or leagile? Matching your supply chain to the marketplace", *International Journal of Production Research*, Vol. 38, No. 17, pp. 4061-4070.

Mason-Jones, R., Naylor, B. and Towill, D. (2000b). "Engineering the leagile supply chain", *International Journal of Agile Management Systems*, Vol. 2, No. 1, pp. 54-61.

McDuff, D. (1994). *Karin Boye: Complete Poems*. Bloodaxe Books Ltd, Hexam, UK.

McGinnis, M. (1992). "Military Logistics: insights for Business Logistics", *International Journal of Physical Distribution & Logistics Management*, Vol. 22, No. 2, pp. 22-32.

Mellat-Parast, M. and Spillan, J.E. (2014). "Logistics and supply chain process integration as a source of competitive advantage - An empirical analysis", *The International Journal of Logistics Management*, Vol. 25, No. 2, pp. 289-314.

Melnyk, S.A., Davis, E.W., Spekman, R.E. and Sandor, J. (2010). "Outcome-driven supply chains", *MIT Sloan Management Review*, Vol. 51, No. 2, pp. 33-38.

Melnyk, S., Lummus, R., Vokurka, R., Burns, L. and Sandor, J. (2009). "Mapping the future of supply chain management: a Delphi study", *International Journal of Production Research*, Vol. 47, No. 16, pp. 4629-4653.

Melnyk, S., Narasimhan, R. and DeCampos, H. (2014). "Supply chain design: issues, challenges, frameworks and solutions", *International Journal of Production Research*, Vol. 52 No. 7, pp. 1887-1896.

Mentzer, J. T. (2008). "Rigour versus relevance: Why would be choose only one?" *Journal of Supply Chain Management*, Vol. 44, No. 2, pp.72-77.

Mentzer, J.T., Rutner, S.M. and Matsuno, K. (1997) "Application of the means-end value hierarchy model to understanding logistics service value", *International Journal of Physical Distribution & Logistics Management*, Vol. 27, No 9/10, pp. 630-643.

Merriam, S.B. (1998). *Qualitative Research and Case Study Applications in Education*. Jossey-Bass, San Francisco, California, USA.

Mingers, J. (2003). "A classification of the philosophical assumptions of management science methods", *Journal of the Operational Research Society*, Vol. 54, No. 6, pp. 559-570.

Monczka, R.M., Petersen, K.J., Handfield, R.B. and Ragatz, G.L. (1998). "Success factors in strategic supplier alliances: the buying company perspective", *Decision Sciences*, Vol. 29, No. 3, pp. 553-577.

Moore, D. M. (2000). "Purchasing services – an essential feature for UK armed forces or a risk too far?", Proceedings of the 10th International Annual IPSERA Conference, Jönköping, Sweden.

Moore, S., Stockfisch, J., Goldberg, M., Holroyd, S. and Hildebrandt, G. (1991). *Measuring military readiness and sustainability*. Rand, Santa Monica, CA, USA.

Mullen, P.M. (2003). "Delphi: myths and reality", *Journal of Health Organization and Management*, Vol. 17, No. 1, pp. 37-52.

Nag, B., Han, C. and Yao, D. (2014). "Mapping supply chain strategy: an industry analysis", *Journal of Manufacturing Technology Management*, Vol. 25, No. 3, pp. 351-370.

Narasimhan, R., Kim, S.W. and Tan, K.C. (2008). "An empirical investigation of supply chain strategy typologies and relationships to performance", *International Journal of Production Research*, Vol. 46, No. 18, pp. 5231-5259.

NATO (2012). *NATO Logistics Handbook*. NATO HQ, Brussels, Belgium. https://www.nato.int/docu/logi-en/logistics_hndbk_2012-en.pdf, (accessed 11 June 2020).

NATO (2018). *NATO Glossary of Terms and Definitions*. NATO HQ, Brussels, Belgium.

Naylor, J.B., Naim, M.M. and Berry, D. (1999). "Leagility: integrating the lean and agile manufacturing paradigms in the total supply chain", *International Journal of Production Economics*, Vol. 62, No. 1, pp. 107-118.

Nellore, R. and Söderquist, K. (2000). "Portfolio approaches to procurement - analysing the missing link to specifications". *Long Range Planning*, Vol. 33, No. 2, pp. 245-267.

Norrman, A. and Henkow, O, (2014). "Logistics principles vs. legal principles: frictions and challenges", *International Journal of Physical Distribution & Logistics Management*, Vol. 44, No. 10, pp. 744-767.

Ogden, J.A., Petersen, K.J., Carter, J.R. and Monczka, R.M. (2005). "Supply Management Strategies for the Future: A Delphi Study", The Journal of Supply Chain Management, Vol. 41, No. 3, pp. 29-48.

Okoli, C. and Pawlowski, S. (2004). "The Delphi method as a research tool: an example, design considerations and applications", *Information & Management*, Vol. 42, No. 1, pp. 15-29.

Olhager, J. (2003). "Strategic positioning of the order penetration point", *International Journal of Production Economics*, Vol. 85, No. 3, pp. 319-329.

Olhager, J. and Östlund, B. (1990). "An integrated push–pull manufacturing strategy", *European Journal of Operational Research*, Vol. 45, No. 2, pp. 135-142.

Olsen, R.F. and Ellram, L.M. (1997). "A portfolio approach to supplier relationships", *Industrial Marketing Management*, Vol. 26, No. 2, pp. 101-113.

Orb, A., Eisenhauer, L. and Wynaden, D. (2001). "Ethics in Qualitative Research", *Journal of Nursing Scholarship*, Vol. 33, No. 1, pp. 93-96.

Pagell, M., Wu, Z. and Wasserman, M.E. (2010). "Thinking differently about Purchasing Portfolios: An Assessment of Sustainable Sourcing", *Journal of Supply Chain Management*, Vol. 46, No. 1, pp. 57-73.

Pagh, J.D. and Cooper, M.C. (1998). "Supply chain postponement and speculation strategies: how to choose the right strategy", *Journal of Business Logistics*, Vol. 19, No. 2, pp. 13-33.

Parenté, R.J, Hiöb, T.N., Silver, R.A., Jenkins, C., Poe, M.P. and Mullins, R.J. (2005). "The Delphi method, impeachment and terrorism: Accuracies of short-range forecasts for volatile world events", *Technological Forecasting & Social Change*, Vol. 72, No. 4, pp. 401-411.

Parker, D. and Hartley, K. (2003). "Transaction costs, relational contracting and public private partnerships: a case study of UK defence". *Journal of Purchasing & Supply Management*, Vol. 9, pp. 97-108.

Peppers Jr., J.G. (1988). *History of United States military logistics*. Logistics Education Foundation Publishing, Huntsville, Al, USA.

Perez-Franco, R., Phadnis, S., Caplice, C. and Sheffi, Y. (2016). "Rethinking supply chain strategy as a conceptual system", *International Journal of Production Economics*, Vol. 182, pp. 384-396.

Persson, G. and Håkansson, H. (2007). Supplier Segmentation - "When Supplier Relationships Matter". *The Industrial Marketing and Purchasing (IMP) Journal*, Vol. 1, No. 3, pp. 26-41.

Prahalad, C.K. and Ramaswamy, V. (2004). "Co-creation Experiences: The Next Practice in Value Creation", *Journal of Interactive Marketing*, Vol. 18, No. 3, pp. 5-14.

Prebilič, V. (2006). "Theoretical Aspects of Military Logistics". *Defence & Security Analysis*, Vol. 22, No. 2, pp.159-177.

Purvis, L., Spall, S., Naim, M. and Spiegler, V. (2016). "Developing a resilient supply chain strategy during 'boom' and 'bust'", *Production Planning & Control*, Vol. 27, No. 7-8, pp. 579-590.

Qi, Y., Huo, B., Wang, Z. and Yeung, H.Y.J. (2017). "The impact of operations and supply chain strategies on integration and performance", *International Journal of Production Economics*, Vol. 185, pp. 162-174.

Qi, Y., Zhao, X. and Sheu, C. (2011). "The impact of competitive strategy and supply chain strategy on business performance: the role of environmental uncertainty", *Decision Sciences*, Vol. 42, No. 2, pp. 371-389.

Ramsay, J., 1996. "The case against purchasing partnerships", *International Journal of Purchasing and Materials Management*, Vol. 32, No. 3, pp. 13-19.

Randall, T.R., Morgan, R.M. and Morton, A.R. (2003). "Efficient versus responsive supply chain choice: an empirical examination of influential factors", *Journal of Product Innovation Management*, Vol. 20, No. 6, pp. 430-443.

Reinfeldt, F. (2013). "Försvaret är ett särintresse (Defence is an area of special interest)", Dagens Nyheter, Stockholm, Sweden. https://www.dn.se/nyheter/politik/reinfeldt-forsvaret-ar-ett-sarintresse/ (accessed 11 June 2020).

Rezaei, J. and Ortt, R. (2013). "Supplier segmentation using fuzzy logic", *Industrial Marketing Management*, Vol. 42, pp. 507-517.

Rezaei, J., Wang. J., and Tavasszy, L. (2015). "Linking supplier development to supplier segmentation using Best Worst Method", *Expert Systems With Applications*, Vol. 42, No. 23, pp. 9152-9164.

Rindova, V. (2011). "Moving from Ideas to a Theoretical Contribution: Comments on the Process of Developing Theory in Organizational Research", *Journal of Supply Chain Management*, Vol. 47, No. 2, pp. 19-21.

Roh, J., Hong, P. and Min, H. (2014). "Implementation of a responsive supply chain strategy in global complexity: the case of manufacturing firms", *International Journal of Production Economics*, Vol. 147, pp. 198-210.

Roscoe, S. and Baker, P. (2014). "Supply chain segmentation in the sporting goods industry", *International Journal of Logistics Research and Applications*, Vol. 17, No. 2, pp. 136-155.

Rosenhead, J., Editor. (1989). *Rational Analysis for a Problematic World – Problem Structuring Methods for Complexity, Uncertainty and Conflict*. John Wiley & Sons, Chichester, UK.

Rowe, G. and Wright, G. (1999). "The Delphi technique as a forecasting tool: issues and analysis", *International Journal of Forecasting*, Vol. 15, No. 4, pp. 353-375.

Rowe, G. and Wright, G. (2001). *Expert opinions in forecasting: The role of the Delphi Technique*, in Armstrong, J. (Ed.). *Principles of Forecasting*, Kluwer Academic, Boston, MA, USA, pp. 125-144.

Rowe, G. and Wright, G. (2011). "The Delphi technique: Past, present, and future prospects – Introduction to the special issue", *Technological Forecasting & Social Change*, Vol. 78, No. 9, pp. 1487-1490.

Rowe, G., Wright, G. and Bolger, F. (1991). "Delphi: A Re-evaluation of Research and Theory", *Technological Forecasting & Social Change*, Vol. 39, No. 3, pp. 235-251.

Rutner, S. M. and Langley, C. J. (2000). "Logistics Value: Definition, Process and Measurement", *The International Journal of Logistics Management*, Vol. 11, No. 2, pp. 73-82.

Rutner, S. M., Aviles, M. and Cox, S. (2012). "Logistics evolution: a comparison of military and commercial logistics thought", *The International Journal of Logistics Management*, Vol. 23, No. 1, pp. 96-118.

Saunders, M., Lewis, P. and Thornhill, A. (2009): *Research Methods for Business Students, 5th Edition*. Prentice-Hall, Harlow, UK.

Schnetzler, M., Sennheiser, A. and Schönsleben, P. (2007). "A decomposition-based approach for the development of a supply chain strategy", *International Journal of Production Economics*, Vol. 105, No. 1, pp. 21-42.

Schuh, C., Kromoser, R., Strohmer, M.F., Pérez, R.R., and Triplat, A. (2008). *The Purchasing Chessboard: 64 Methods to Reduce Cost and Increase Value with Suppliers*. Springer, New York, NY, USA.

Selldin, E. and Olhager, J. (2007). "Linking products with supply chains: testing Fisher's model", *Supply Chain Management: An International Journal*, Vol. 12, No. 1, pp. 42-51.

Seuring, S. and Müller, M. (2008). "Core Issues in Sustainable Supply Chain Management – a Delphi Study", *Business Strategy and the Environment*, Vol. 17, No. 8, pp. 455-466.

Shapiro, D. L., Kirkman, B. L., and Courtney, H. G. (2007). "Perceived causes and solutions of the translation problem in management research", *Academy of Management Review*, Vol. 50, No. 2, pp. 249-266.

Sharma, P. and Kulkarni, M. (2016). "Bayesian belief network for assessing impact of factors on army's lean–agile replenishment system", *Journal of Military Studies*, Vol. 7, No. 1, pp. 11-23.

Sharman, G. (1984). "The rediscovery of logistics", *Harvard Business Review*, Vol. 62, No. 5, pp. 71-79.

Silverman, D. (2006). *Interpreting Qualitative Data – Methods for Analysing Talk, Text and Interaction, Third Edition*. Sage Publications Inc., Thousand Oaks, California, USA.

SIPRI (2019). SIPRI Yearbook 2019, Stockholm International Peace Research Institute, Sweden. https://www.sipri.org/yearbook/2019/04 (accessed 11 June 2020).

Skoglund, P. (2012). *Sourcing decisions for military logistics in Peace Support Operations – A case study of the Swedish armed forces*. Doctoral Dissertation, Jönköping University, Jönköping, Sweden.

Skulmoski, G., T. Hartman, F. and Krahn, J. (2007). "The Delphi Method for Graduate Research", *Journal of Information Technology Education: Research*, Vol. 6, pp. 1-21.

Spee, A.P. and Jarzabkowski, P. (2009). "Strategy tools as boundary objects", *Strategic Organization*, Vol. 7, No. 2, pp. 223-232.

Spens, K.M. and Kovács, G. (2006). "A content analysis of research approaches in logistics research", *International Journal of Physical Distribution & Logistics Management*, Vol. 36, No. 5, pp. 374-390.

Stock, G.N., Greis, N.P. and Kasarda, J.D. (1998). "Logistics, strategy and structure - A conceptual framework International", *Journal of Operations & Production Management*, Vol. 18, No. 1, pp. 37-52.

Stock, J. R. (1997). "Applying theories from other disciplines to logistics". *International Journal of Physical Distribution and Logistics Management*, Vol. 27, No. 9/19, pp. 515-539.

Stock, J. R., Boyer, S. L. and Harmon, T. (2010). "Research opportunities in supply chain management", *Journal of the Academy of Marketing Science*, Vol. 38, pp. 32-41.

Stuart, F.I. (1997). "Supply-Chain Strategy: Organizational Influence Through Supplier Alliances", *British Journal of Management*, Vol. 8, pp. 223-236.

Svensson, G. (2004). "Supplier segmentation in the automotive industry: A dyadic approach of a managerial model", *International Journal of Physical Distribution & Logistics Management*, Vol. 34, No. 1, pp. 12-38.

Swartz, S. and Johnson, A. (2004). "A multimethod approach to the combat air forces mix and deployment problem", *Mathematical and Computer Modelling*, Vol. 39, No. 6-8, pp. 773-797.

Swedish Armed Forces (2020). *Försvarsplan 2020 – Nomenklatur Operationer (Defence Plan 2020 – Operational Nomenclature)*. Swedish Armed Forces HQ, Stockholm, Sweden.

Swedish Government (2020). *FOI ska analysera nationell försörjningsberedskap (FOI to analyse national supply preparedness)*. https://www.regeringen.se/pressmeddelanden/2020/07/foi-ska-analysera-nationell-forsorjningsberedskap/ (accessed 11 June 2020).

Swedish MoD (2015). *Sweden's Defence Policy 2016 to 2020*. https://www.government.se/globalassets/government/dokument/forsvarsdepartementet/sweden_defence_policy_2016_to_2020 (accessed 11 June 2020).

Swedish MoD (2019). *Näringslivets roll inom totalförsvaret. (The Role of Trade and Industry in the Total Defence)*. https://www.regeringen.se/4ad9c6/globalassets/regeringen/dokument/forsvarsdepartementet/sou/sou-2019-51-naringslivets-roll-inom-totalforsvaret.pdf (accessed 11 June 2020).

Swedish Research Council (2017). *Good Research Practice*. Swedish Research Council, Stockholm, Sweden. https://www.vr.se/english/mandates/ethics/ethics-in-research.html (accessed 06 November 2020).

Tashakkori, A. and Teddlie, C. (1998). *Mixed Methodology – Combining Qualitative and Quantitative Approaches*. Sage Publications Inc., Thousand Oaks, California, USA.

Terpend R., Krause, D.R. and Dooley, K.J. (2011). "Managing buyer–supplier relationships: empirical patterns of strategy formulation in industrial purchasing", *Journal of Supply Chain Management*, Vol. 47, No. 1, pp. 73-94.

Tjahjono, B., Esplugues, C., Ares, E., and Pelaez, G. (2017). "What does Industry 4.0 mean to Supply Chain", *Procedia Manufacturing*, Vol. 13, pp. 1175-1182.

Turnbull, P. (1990). "A Review of Portfolio Planning Models for Industrial Marketing and Purchasing Management", *European Journal of Marketing*, Vol. 24, No. 3, pp. 7-22.

Turoff, M. (1970). "The Design of a Policy Delphi", *Technological Forecasting & Social Change*, Vol. 2, No. 2, pp. 149-171.

US DoD (2010). *Dictionary of Military and Associated Terms*. Washington, DC, USA. https://fas.org/irp/doddir/dod/jp1_02-april2010.pdf (accessed 11 June 2020).

Uttley, M. and Kinsey, C. (2012). *The Role of Logistics in War*, in Lindley-French, J. and Boyer, Y. (Eds.). *The Oxford Handbook of War*. Oxford University Press, Oxford, UK, pp. 401-416.

Vachon, S., Halley, A. and Beaulieu, M. (2009). "Aligning competitive priorities in the supply chain: the role of interactions with suppliers", *International Journal of Operations & Production Management*, Vol. 29, No. 4, pp. 322-340.

Vanclay, F., Baines, J.T. and Taylor, C.N. (2013). "Principles for ethical research involving humans: ethical professional practice in impact assessment Part I", *Impact Assessment and Project Appraisal*, Vol. 31, No. 4, pp. 243-253.

Van Creveld, M. (1977). *Supplying War – Logistics from Wallenstein to Patton*. Cambridge University Press, Cambridge, UK.

Van Stekelenborg, R.H.A. and Kornelius, L. (1994). *A diversified approach towards purchasing and supply: evaluation of production management*

methods. In Proceedings of the Evaluation of production management methods: IFIP WG 5.7 working conference, Gramado, Brazil, 21-24 March 1994 (pp. 307-317). Elsevier, Amsterdam, the Netherlands.

van Weele, A.J. (2006). *Purchasing Management: Analysis, Planning and Practice, Fourth Edition*. Thompson Learning, London, UK.

Vargo, S. L., Maglio, P. P. and Akaka, M. A. (2008). "On Value and Value Co-Creation: A Service Systems and Service Logic Perspective", *European Management Journal*, Vol. 26, No. 3, pp. 145-152.

Vonderembse, M., Uppal, M., Huang, S. and Dismukes, J. (2006). "Designing supply chains: towards theory development", *International Journal of Production Economics*, Vol. 100, No. 2, pp. 223-238.

von der Gracht, H.A. and Darkow, I.-L. (2010). "Scenarios for the logistics services industry: A Delphi-based analysis for 2025", *International Journal of Production Economics*, Vol. 127, No. 1, pp. 46-59.

von der Gracht, H.A. and Darkow, I.-L. (2016). "Energy-constrained and low-carbon scenarios for the transportation and logistics industry", *The International Journal of Logistics Management*, Vol. 27, No. 1, pp. 142-166.

von Falkenhausen, C., Fleischmann, M. and Bode, C. (2019). "How to Find the Right Supply Chain Strategy? An Analysis of Contingency Variables", *Decision Sciences*, Vol. 50, No. 4, pp. 726-755.

Wacker, J.G. (1998). "A definition of theory: research guidelines for different theory-building research methods in operations management", *Journal of Operations Management*, Vol. 16, No. 4, pp. 361-385.

Wagner, S.M., Grosse-Ruyken, P.T. and Erhun, F. (2012). "The link between supply chain fit and financial performance of the firm", *Journal of Operations Management*, Vol. 30, pp. 340-353.

Whetten, D.A. (1989). "What constitutes a theoretical contribution?", *The Academy of Management Review*, Vol. 14, No. 4, pp. 490-495.

Whitman, N. I. (1990). "The Committee Meeting Alternative: Using the Delphi Technique", *The Journal of Nursing Administration*, Vol. 20, No. 7-8, pp. 30-36.

Wilhite, A., Burns, L., Patnayakuni, R. and Tseng, F. (2013). "Military supply chains and closed-loop systems: resource allocation and incentives in supply sourcing and supply chain design", *International Journal of Production Research*, Vol. 52, No. 7, pp. 1926-1939.

Worrell, J., Di Gangi, P. and Bush, A. (2013). "Exploring the use of the Delphi method in accounting information systems research", *International Journal of Accounting Information Systems*, Vol. 14, No. 3, pp. 193-208.

Wynstra, J.Y.F. and ten Pierick, E. (2000). "Managing supplier involvement in new product development: a portfolio approach", *European Journal of Purchasing & Supply Management*, Vol. 6, No. 1, pp. 49-57.

Yang, B. and Burns, N.D. (2003). "Implications of postponement for the supply chain", *International Journal of Production Research*, Vol. 41, No. 9, pp. 2075-2090.

Yang, B., Burns, N.D. and Backhouse, C.J. (2004). "Postponement: a review and an integrated framework", *International Journal of Operations & Production Management*, Vol. 24, No. 5, pp. 468-487.

Yin, R. K. (2003). *Case Study Research – Design and Methods, Third Edition*. Sage Publications Inc., Thousand Oaks, California, USA.

Yin, R. K. (2009). *Case Study Research – Design and Methods, Fourth Edition*. Sage Publications Inc., Thousand Oaks, California, USA.

Yoho, K., Rietjens, S. and Tatham, P. (2013). "Defence logistics: an important research field in need of researchers", *International Journal of Physical Distribution & Logistics Management*, Vol. 43, No. 2, pp. 80-96.

Yousuf, M.I. (2007). "Using Experts' Opinions Through Delphi Technique", *Practical Assessment, Research, and Evaluation*, Vol. 12, No. 4, pp. 1-8.

Åsvoll, H. (2014). "Abduction, deduction and induction: can these concepts be used for an understanding of methodological processes in interpretative case studies?", *International Journal of Qualitative Studies in Education*, Vol. 27, No. 3, pp. 289-307.

Appendix A: Questionnaires for Delphi rounds 1 and 2

This appendix presents an abridged and translated version of the questions in the first and second Delphi rounds (Section 3.7.1 and Section 3.7.2). The author formulated the main questions as statements, to enable answers on Likert-scales, whereas the follow-up questions used free-text answers.

"Panel A and 1" signifies that the panellists in Panel A and Panel 1 (Section 3.6.4) answered the same question. "Panel A" and "Panel 1" indicate that the two panels addressed the same issues, but that the author formulated the statements from different perspectives.

The panellists answered questions denoted (*) on a Likert-scale and questions denoted (**) in free text. For question 4, (***) denotes that the panellists could choose from the models in Table 2.3, plus a model proposed by FMV (2016) (Section 4.2).

Questions regarding PPM design

1. Should we base a PPM on commercial or operational goals?
   Panel A: We should base PPM development on commercial goals (*)
   Panel 1: We should base PPM development on operational goals (*)

2. Should a PPM have predefined dimensions and values?
   Panel A and 1: A PPM should have predefined dimensions (*)
   Panel A and 1: A PPM should have predefined values (*)

3. Are two dimensions sufficient to describe a complex decision situation?
   Panel A and 1: Two dimensions are sufficient to describe a complex decision situation (*)

4. Which dimensions should be included in a two-dimensional PPM?
   Panel A and 1: With two dimensions, which (if any) of the following dimensions are suitable? (***)
   Panel A and 1: If these dimensions are unsuitable, can you suggest suitable dimensions? (**)

5. If two dimensions are insufficient, how many dimensions should be included in the PPM?
   Panel A and 1: If two dimensions are insufficient, how many dimensions are required? (**)
   Panel A and 1: If you prefer three (or more) dimensions, can you suggest suitable dimensions? (**)

6. Are two values per dimension sufficient to describe a complex decision situation?
   Panel A and 1: Two values per dimension is sufficient to describe a complex decision situation (*)
   Panel A and 1: With two values per dimension, these values should be "high" and "low" (*)
   Panel A and 1: If these values are unsuitable, can you suggest suitable values? (**)

7. If two values per dimension is insufficient, how many values are required?
   Panel A and 1: If two values per dimension are insufficient, how many values are required? (**)
   Panel A and 1: Can you suggest values for the number of values you suggested? (**)

Questions regarding PPM application

8. Should PPMs be prescriptive or serve as catalysts for discussions?
   Panel A: A PPM should be prescriptive (*)
   Panel 1: A PPM should serve as a catalyst for in-depth discussions among stakeholders (*)

9. Should application be strict or pragmatic?
   Panel A: Application should be strict (*)
   Panel 1: Application should be pragmatic (*)

10. Should strategies and tactics be segment-generic or purchase-specific?
    Panel A: Strategies and tactics should be purchase-specific (*)
    Panel 1: Strategies and tactics should be segment-generic (*)

11. Should application be static or dynamic regarding external changes?
    Panel A: Application should be static regarding external changes (*)
    Panel 1: Application should be dynamic regarding external changes (*)

12. Should a dynamic PPM include recommendations regarding when to repeat segmentation?
    Panel A and 1: A dynamic PPM should include recommendations regarding when to repeat segmentation (*)
13. Should the application be static or dynamic regarding immediate repositioning?
    Panel A: Application should be static (no immediate repositioning) (*)
    Panel 1: Application should be dynamic (allow immediate repositioning) (*)
14. Should a dynamic PPM include recommendations regarding how to reposition?
    Panel A and 1: A dynamic PPM should include recommendations regarding how to reposition (*)

Questions regarding defence SCD

15. Should we base defence SCD on commercial or operational goals?
    Panel A: We should base defence SCD on commercial goals (*)
    Panel 1: We should base defence SCD on operational goals (*)
16. Is the CODP an acceptable and applicable concept in defence SCD?
    Panel A and 1: The CODP is an acceptable and applicable concept in defence SCD (*)
    Panel A and 1: The CODP-based strategies ETO, BTO, MTO, ATO, PTO, STO and MTS are acceptable and applicable in defence SCD (*)
17. Are the SCSs manufacturing postponement, full postponement, full speculation, logistics postponement acceptable and applicable?
    Panel A and 1: The SCSs postponement and speculation are acceptable and applicable in defence SCD (*)
    Panel A and 1: The SCSs manufacturing postponement, full postponement, full speculation, logistics postponement are acceptable and applicable in defence SCD (*)
18. Are the SCSs “push” and “pull” acceptable and applicable?
    Panel A and 1: The SCSs “push” and “pull” are acceptable and applicable in defence SCD (*)

19. Is the distinction between products as functional or innovative acceptable and applicable?
    Panel A and 1: The distinction between products as functional or innovative is acceptable and applicable in defence SCD (*)

20. Are the SCSs risk hedging, agile, efficient and responsive acceptable and applicable?
    Panel A and 1: The SCSs efficient and responsive are acceptable and applicable in defence SCD (*)
    Panel A and 1: The SCSs risk hedging, agile, efficient and responsive are acceptable and applicable in defence SCD (*)

21. Are the SCSs lean and agile acceptable and applicable?
    Panel A and 1: The SCSs lean and agile are acceptable and applicable in defence SCD (*)

22. Are competitive priorities, such as cost, quality, lead-time and service-level acceptable and applicable?
    Panel A and 1: Competitive priorities, such as cost, quality, lead-time and service-level acceptable and applicable in defence SCD (*)

Appendix B: Questionnaire for Delphi round 3

This appendix presents an abridged and translated version of the questions for the third Delphi round (Section 3.7.3). Most questions required the panellists to answer "yes", "no" or "I don't know", which is denoted by (*). Three questions were combinations of several questions, as well as free text answers, from the two previous rounds, which the author used to generate mutually exclusive alternatives. These questions are denoted (**). The study asked the panellists to state their preference for one of the presented alternatives.

"Panel A and 1" signifies that the panellists in Panel A and Panel 1 answered the same question. "Panel A" and "Panel 1" indicate that the two panels addressed the same issues, but that the author formulated the statements from different perspectives.

Questions regarding PPM design

1. Should we base a PPM on commercial or operational goals?
   Panel A: We should base PPM development on commercial goals (*)
   Panel 1: We should base PPM development on operational goals (*)

2. Should a PPM have predefined dimensions and values?
   Panel A and 1: A PPM should have predefined dimensions (*)
   Panel A and 1: A PPM should have predefined values (*)

3. How many dimensions should be in the PPM and which ones? (**)
   Two: Importance of purchase for buyer and complexity of supplier market
   Two: Delivery risk and operational risk
   Two: Functional products and innovative products
   Two: Predictability and lead-times
   Two: Importance of cost and importance of service level
   Two: Availability and operational capability
   Two: Unspecified
   Three: Importance of purchase for buyer, complexity of supplier market and operational risk

Three: Importance of purchase for buyer, complexity of supplier market and time horizon
Three: Security of supply, operational security and delivery speed
Three: Unspecified
Four: Importance of purchase for buyer, complexity of supplier market, strategic partner and security of supply
Four: Unspecified
Five: Unspecified

4. How many values per dimension? Which ones? (**)
   Two: Adapted after selected dimensions, for example "high-low", "more-less" or "short-long"
   Three: Adapted after selected dimensions, for example "insufficient-acceptable-high", or "low-normal (medium)-high"
   Four: Adapted after selected dimensions, for example "low-medium-high-forced", "decisive-serious/significant-limited-negligible"
   More than four: Adapted after selected dimensions
   Unspecified number and values: Number and values should be adapted after the complexity of the decision situation

5. There should be a precursor in the PPM (**)
   Yes. There should be a precursor that explicates the difference between capability creation and capability utilisation
   Yes. There should be a precursor that explicates the difference between production and operation
   Yes. There should be a precursor that explicates the difference between peace, crises and war
   Yes. There should be a precursor that explicates the difference between dormant and active
   Yes. There should be a precursor that explicates the difference between availability, preparedness and sustainability
   Yes. There should be a precursor, but it remains to specified
   No. There should be no precursor

Questions regarding PPM application

6. Should PPMs be prescriptive or serve as catalysts for discussions?
   Panel A: A PPM should be prescriptive (*)
   Panel 1: A PPM should serve as a catalyst for in-depth discussions among stakeholders (*)

7. Should application be strict or pragmatic?
   Panel A: Application should be strict (*)
   Panel 1: Application should be pragmatic (*)

8. Should strategies and tactics be segment-generic or purchase-specific?
   Panel A: Strategies and tactics should be purchase-specific (*)
   Panel 1: Strategies and tactics should be segment-generic (*)

9. Should application be static or dynamic regarding external changes?
   Panel A: Application should be static regarding external changes (*)
   Panel 1: Application should be dynamic regarding external changes (*)

10. Should a dynamic PPM include recommendations regarding when to repeat segmentation?
    Panel A and 1: A dynamic PPM should include recommendations regarding when to repeat segmentation (*)

11. Should the application be static or dynamic regarding immediate repositioning?
    Panel A: Application should be static (no immediate repositioning) (*)
    Panel 1: Application should be dynamic (allow immediate repositioning) (*)

12. Should a dynamic PPM include recommendations regarding how to reposition?
    Panel A and 1: A dynamic PPM should include recommendations regarding how to reposition (*)

Questions regarding defence SCD

13. Is the CODP an acceptable and applicable concept in defence SCD?
    Panel A and 1: The CODP is an acceptable and applicable concept in defence SCD (*)
    Panel A and 1: The CODP-based strategies ETO, BTO, MTO, ATO, PTO, STO and MTS are acceptable and applicable in defence SCD (*)

14. Are the SCSs manufacturing postponement, full postponement, full speculation, logistics postponement acceptable and applicable?
    Panel A and 1: The SCSs postponement and speculation are acceptable and applicable in defence SCD (*)
    Panel A and 1: The SCSs manufacturing postponement, full postponement, full speculation, logistics postponement are acceptable and applicable in defence SCD (*)

15. Are the SCSs "push" and "pull" acceptable and applicable?
    Panel A and 1: The SCSs "push" and "pull" are acceptable and applicable in defence SCD (*)

16. Are the SCSs risk hedging, agile, efficient and responsive acceptable and applicable?
    Panel A and 1: The SCSs efficient and responsive are acceptable and applicable in defence SCD (*)
    Panel A and 1: The SCSs risk hedging, agile, efficient and responsive are acceptable and applicable in defence SCD (*)

17. Are the SCSs lean and agile acceptable and applicable?
    Panel A and 1: The SCSs lean and agile are acceptable and applicable in defence SCD (*)

18. Are competitive priorities, such as cost, quality, lead-time and service-level acceptable and applicable?
    Panel A and 1: Competitive priorities, such as cost, quality, lead-time and service-level acceptable and applicable in defence SCD (*)

Segmentation and Differentiation in Defence Supply Chain Design

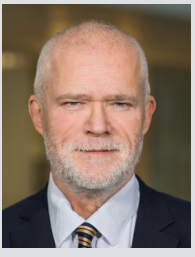
– A Dynamic Purchasing Portfolio Model for Defence Procurement

An important priority in the current Swedish Defence Bill is to increase the operational warfighting capability of the Swedish Armed Forces, which has implications for the defence supply chain. A recent study suggested that the Swedish Armed Forces should use segmentation of supplies and differentiation of supply chains to enable an affordable supply chain design. This raises questions regarding which segmentation model and which supply chain strategies the Swedish Armed Forces should use.

The purpose of this research is to design and develop a purchasing portfolio model for defence procurement, which will be of practical use for defence authorities. The author defines a purchasing portfolio model as consisting of a segmentation model, tactical levers, differentiation strategies and guidance for management decisions. The research builds on a Delphi study with twenty experts from Swedish defence authorities. It addresses the operational requirements on readiness and sustainability that must be satisfied, as well as research gaps and open issues in the literature regarding purchasing portfolio model design and application.

The findings include several novelties. The author proposes a dynamic purchasing portfolio model, including an innovative two-stage segmentation model, with a precursor and a two-dimensional model. The latter merges sixteen elements into one square and three other segments. Another originality is that the purchasing portfolio model is both prescriptive and serves as a catalyst for in-depth discussions. The author also develops guidance for management decisions, including twelve tactical levers, and eight supply chains strategies to differentiate treatment of the supply segments.

The research contributes to theory by combining constructs from the purchasing and supply management literature and supply chain management literature, and applying them in the context of military logistics, including defence procurement. It contributes to practice by developing a purchasing portfolio model that is relevant to practitioners in defence procurement and satisfies the operational requirements of the Swedish Armed Forces. It also contributes to methodology by investigating how researchers can use two panels in Delphi studies to enhance research validity.



THOMAS EKSTRÖM is a teacher and researcher at the Department of Military Studies, Swedish Defence University. He holds a Master of Science degree in Industrial Engineering and Management from the Faculty of Science and Engineering, Linköping University, a Master of Science degree in Military Operational Research from the Royal Military College of Science, Cranfield University, and a Licentiate of Engineering degree in Engineering Logistics from the School of Engineering, Lund University. Thomas' research interests include defence supply chain design and operation, and business models for defence acquisition, including performance-based logistics.

ISBN 978-91-87289-62-0