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New Approach to Logistics Education with Emphasis to Engineering Competences

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Declaration:
Hereby I declare that this doctoral thesis, my original investigation and achievement, submitted for the doctoral degree at Tallinn University of Technology has not been submitted for any academic degree.

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Logistika kõrghariduse kaasajastamine rõhuasetusega insenerivaldkonna kompetentsidele

TARVO NIINE

TTÜ KIRJASTUS

CONTENTS

ABBREVIATIONS

APICS	The Association for Operations Management
APPEL	Academy of Program/Project and Engineering Leadership
APS	Advanced Planning Systems
AST&L	American Society of Transportation and Logistics
CITLS	Certified International Trade Logistics Specialist
CLEP	Council of Logistics Engineering Professionals
CLP	Certified Logistics Professional
CML	Certified Master Logistician
CMR	Customer Relationship Management
CSCMP	Council of Supply Chain Management Professionals
CTL	Certified in Transport and Logistics
DML	Demonstrated Master Logistician
DRP	Distribution Requirements Planning
EDI	Electronic Data Interchange
ELA	European Logistics Association
ERP	Enterprise Resource Planning
ICT	Information and Communications Technology
INCOSE	The International Council on Systems Engineering
ITS	Intelligent Transport Systems
LE	Logistics Engineering
LHV	Longer and Heavier Vehicles
MRP	Material Requirements Planning
RFID	Radio-Frequency Identification
SCE	Supply Chain Engineering
SCM	Supply Chain Management
SE	Systems Engineering
SMI	Supply Chain Management Institute
SOLE	International Society of Logistics
TMS	Transport Management Systems
TOS	Terminal Operating System
UAV	Unmanned Aerial Vehicles
WMS	Warehouse Management Systems

INTRODUCTION

Background and Relevance

The environment of logistics education is swiftly evolving due to technological progress and economic turbulence. A variety of technologies are advancing exponentially rather than linearly. In certain markets, capability of rapid innovation is not even a clear "*order winning*", but only qualifying factor. Often this is coupled by emphasised role of logistics in the mix of competitive advantages to ensure agile and reliable global deliveries, which is according to Mentzer *et al* [117] a powerful source of differentiation. The tools of logistics themselves are steadily advancing in almost every application from modern IT solutions used to automate cross-enterprise data sharing to automated storage and retrieval, rapid mass identification and tracking solutions in warehousing systems. This is still without mentioning the revolution of self-driving vehicles, which is approaching, according to some estimates, in the next decade.

All these technologies do not only transform individual supply chains – they also alter cargo and traffic patterns. Furthermore, rapid progress brings about side-effects, such as issues with infrastructure and the need for novel policy options. When progress comes in small steps, it mostly just improves available tools. However, the more innovation accelerates, the greater chance for a conceptual paradigm shift that would alter not only the ways of how work is carried out but also the nature of tasks to be performed in the first place, including how processes are understood and even named. In the context of logistics development, this is a practical notion. A brief explanation would stand the test of time better whereas more thorough definitions are more influenced by emphasising current realities. A concise formulation such as "the task of coordinating material and information flow" as defined by Harrison and van Hoek [75] can serve as an adequate starting point.

Technological developments in logistics over the past decades, intertwined with changes in supply chain environments, are substantial enough to suggest that the very meaning of "logistics" is much different today compared to 1980s. Klummp *et al* [96] have predicted that logistics by 2050 will again have an astounding amount of unique properties. Only some of these can be forecasted today. This suggests that conceptual refinement of "logistics" is also continuous. While the question may appear purely theoretical at first, there is crucial practical relevance to academia and educators. Universities need to do their best to prepare students for future work, the details of which are open to debate [99]. The more there are changes, the more difficult it is to predict the resulting environment. Across the areas of human specialization, the field of logistics appears to be developing with speed that is notably above average, because it combines technological and economic developments.

This means a multitude of factors for academia to continuously analyse, but most importantly, how to optimally bridge the gaps between technological capabilities, economic complexities and the principal needs of the society. In order to achieve that, as Kisperska-Moron has suggested, new organizational patterns demand that the essential competences of professional logistician of present and future would be thoroughly understood [95], along with the refined conceptual background of logistics, including relations to other disciplines and theoretical constructs, as well as the role of occupational standards in modern education and a balanced mix of inputs from various stakeholders in the context of curriculum design and development. According to Rahman *et al* [152], modern logistics education has to be interdisciplinary, as society needs broad knowledge and know-how to manage interrelated functions of logistics systems.

Can universities manage all these current and future trends and challenges in logistics? To a certain extent yes, quite probably. After all, it is difficult to find a school that wouldn't have revised their logistics curriculum in a decade. Changes are made, in some cases more proactively, in others with notable inertia and in some cases, risky changes are reverted. However, the guiding idea of this dissertation is that by striving to understand the situation on theoretical and educational level, one can gain insight into development directions that might not all be readily apparent and reveal concealed challenges. One could also say that even though universities are doing their best to stay ahead of the curve and predict future competence needs, there could be more agreement in terms of what are the optimal competence profiles expected from professionals across the jobs in modern logistics. The current field of logistics education has been described by Lancioni *et al* as clustered into fragments [100], where everyone has their own view and there is lack of multi-disciplinary approaches, as well as little effective standardisation in terms of curricula and competences.

In terms of evaluating and developing a curriculum, right next to own understanding and intuition, a major data input is stakeholder (student, alumni or industry) feedback. While the importance of feedback should not be underestimated, and it usually is not, it has certain limits. According to classic approach by Cherington and Schneider [22], "*industry's demand may not necessarily reflect its actual needs, as viewed from outside the industry*". Feedback can be at times biased, misinformed and also misinterpreted – it can easily happen that current students view differs notably from what the same class is saying a few years after graduating. Related point made by Gravier and Farris [69] is that there is a lack of current approaches to predicting the future requirements of curricula, whereas such efforts were more widespread a few decades ago. Their paper appears to reflect the opinion that in some respects, in modern times businesses influence curricula relatively more than academic understanding, which is not optimal.

All in all, local feedback has an important role in curriculum development, but the aspect falls outside the scope of this work. Still it should be pointed out here that feedback is often used for local "fine-tuning" of curricula [108] – to identify aspects in which a programme might need to have specific local characteristics. In contrast, the focus of this research is more on the "common denominators" of logistics competences regardless of local environments.

Every curriculum development initiative should be founded on asking "what is a good mix of components in a university curriculum (of logistics)". This question, admittedly, has far too many facets to form a suitable research question for dissertation so the following scope needs to be more distinctly formulated. However, the issues discussed in this research all contribute ideas for answering this question. Some of the key topics discussed in the dissertation are current and developing conceptual understanding of logistics, existing views to competence profiles in the field, a typology of current approaches to logistics programmes in undergraduate education, the relation of logistics to the discipline of supply chain management and finally, an engineering-based view to logistics as a dedicated and much needed future-oriented competence profile.

In summary, logistics is evolving and has experienced multiple paradigm shifts as described by Soni and Kodali [176] and Shinohara [168]. Due to present environment dynamics, the current period could likewise be seen as a further shift. The outcome of that process needs to be clearly understood and agreed as characteristics of conceptual strength. The main inputs involved in the emergence of new logistics paradigm as well as the resulting benefits of a strong conceptual core are illustrated on Figure 1.

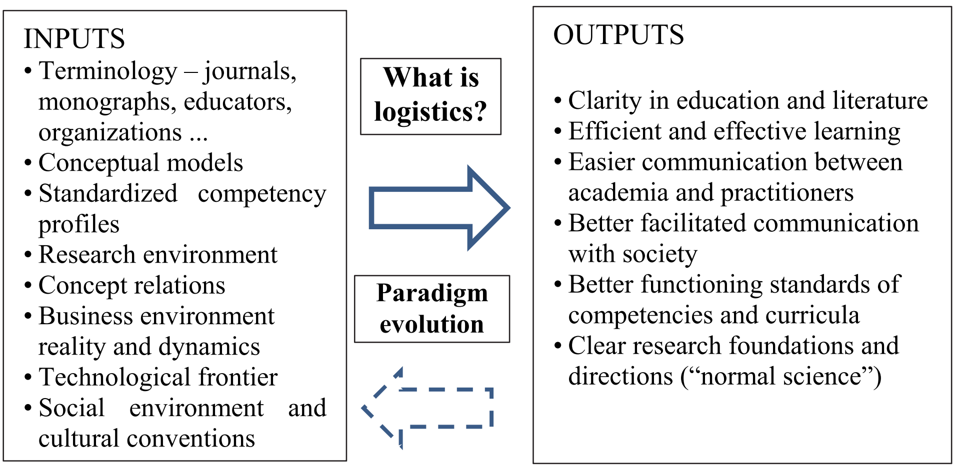

Figure 1. The inputs and outputs involved in a paradigm evolution in logistics
Source: author's compilation

It could be suggested that the current logistics paradigm is not strong enough to offer the full benefits as shown on Figure 1. For example in terms of academic research in logistics, only ca. 50% of publications in top journals are based on explicit theoretical grounds [36]. There is much confusion on how to define logistics, let alone explain the scope in details as appropriate for competency models and curricula. This requires additional explanations and this forms the heart of the problem that initiated this work.

Problem Statement and General Research Goal

Logistics curricula are often criticised with various, sometimes conflicting arguments. A programme can be of "too narrow scope" (i.e. excluding important topics of knowledge or skills) and at the same time lack specific attention to certain details, which boils down to a claim of "too general and broad scope". Another balancing problem lies between hands-on occupational competencies and more general skills of systematic and strategic thinking, which can be simplified as a "theory versus practice" contrast described by Pohlen [147]. Managing logistics curriculum is a diligent task and it is impossible to cater for every opinion. In applied fields as logistics, striking right balance of theory and skill development is critical for market relevance [108]. The range of topics in logistics is extensive but a typical undergraduate programme in Europe lasts only 3 or 4 years, followed commonly by 2 years of master's studies. Hence curricula boards are forced to make difficult choices.

The reality of logistics education is far from standardised view. This is problematic as there are an abundance of understandings of the extent and components of logistics as a discipline, the competencies required from logistics professionals and the topics to be taught in universities. A crucial issue starts with curriculum title. There is, of course, an array of clear niche viewpoints with suitably specific titles, for example "*warehouse management*" or "*intermodal terminal management*". However, among more general approaches, one could suggest that there is no clear centerfield "logistics" curriculum that the majority of academia would adhere to. Instead there are programmes of either "broad but thin" fashion, or focusing on some specialty areas without reflecting it properly in the title. One of the negative outcomes of such variety is that it can suggest false premises and fail to meet student expectations.

A notable problem in author's view that logistics education faces comes from inside the academia. Figuratively it is "getting buried under the avalanche" of a concept called "*supply chain management*" (SCM). It has been seen the same as logistics. Alternatively, the two concepts are notably distinct. This question has been debated since the birth of SCM in the 1980s [62]. This is an issue of terminological clarity, as there is debate and resulting misunderstanding still today, but also a threat to logistics (if widespread SCM paradigm implementation further marginalises the role of logistics, as has been suggested [102]) that hinders the quality and cause voids in available education offerings.

For some authors, SCM represents a modern form of integrated logistics – the logical progression of trends in logistics management [119]. For others, such as Mentzer *et al*, SCM has a much wider scope which covers logistics entirely [118]. In the extreme of both views, logistics as a separate discipline could face a threat of becoming redundant. In principle this might not be undesirable in itself, provided that the conceptual shift would take place on the level of university curricula with relative simplicity as it has happened on the level of some more general "labels" and that the resulting concepts would serve better for modern educational purposes, by covering all relevant niches. As examples of relabelling taking place, some authors of logistics have rebranded their work as SCM and the same is observed in numerous organisations as well as university programs. Additionally, "*logistics managers are now supply chain managers; a new title and business card, but the same old job description*. [74]"

This work analyses the theoretical debate in detail. The argument supported by the dissertation is that the approach of relabelling, regardless of the extent of the accompanying content revision, is problematic and objectionable. While there certainly is a need for SCM and supply chain managers and the concept of SCM caters fittingly for various competence needs, it appears not to be sufficient in covering the entire need for logistics specialists. In other words, the approach of relabelling, if progressed too far, is a case of a severe trade-off. Therefore it appears mistaken to presume that logistics is a redundant concept. This dissertation identifies various approaches to logistics present in modern education. Switching from descriptive to normative view, the work explores how logistics could be better differentiated from SCM in order to contribute to conceptual clarity and to ensuring that more of the competence needs of the society would be catered for in the future with both disciplines being taught side-by-side in various forms and in more efficient and less confusing manner. As further contribution, the work is aimed at strengthening logistics paradigm.

In summary, *the problem driving this dissertation is the relative weakness of logistics paradigm, combined with a lack of clarity of whether and what type of logistics education is needed "in the age of SCM" and the resulting variety of opinions and approaches in both terms of academic constructs as well as university programs*. Such variety entails mismatches between curricula titles, content and student expectations and can reduce education quality.

The general research goal of this work is to identify how logistics could be differentiated from SCM with more conceptual strength, and as a result suggest a novel competency approach to logistics, titled during research "logistics systems engineer" as an example of how to facilitate the differentiation. This goal foremost requires in-depth analysis of current formulations of logistics and their relations to SCM as well as existing competency models of logistics along with currently dominant approaches in higher education of logistics, which shall be now explained in detail along with methodological considerations.

Research Design

The terminology debate in logistics and supply chains reaches back more than two decades. While SCM has substantially grown and matured during those years, the essence and boundaries of logistics are, quite possibly, even less clearly understood today than a decade ago.

In order to provide evidence to support this claim, the foundational research question in this work is therefore*: how is the theoretical scope of logistics* *understood in modern academic literature?* A multitude of viewpoints on this debate are treated in chapter I. For more effective comparative overview, the author has applied a conceptual mapping model called Larson-Halldorson matrix to contrast a selection of academic views.

Chapter I includes research summary on modern technology trends in logistics, to understand state-of-the-art and projected solutions that future logisticians will be implementing and developing. The primary technology trends should in this context be viewed as unavoidable elements in modern logistics education and as rough guidelines for curriculum development.

In chapter II, the author first presents a review of prior research on higher education in logistics in order to identify current research directions, conceptual positions and knowledge gaps. This is continued by more in-depth view of competence in logistics. One way to evaluate and develop logistics curricula would be to benchmark against best practices. This can mean learning directly from other universities or competency models or striving to be a part of some certification system. However, there are numerous approaches available with noteworthy differences on some competency areas with no single internationally dominating model. This reiterates the lack of standardisation in logistics competencies. Analysing the gaps in existing models is a major research task behind this work, the results of which are presented in chapter II.

Furthermore, chapter II presents a merged meta-model of logistics knowledge areas. The author has developed the model via integrating a selection of existing models with a primary goal for the result to be utilised as an analytical tool for logistics curriculum benchmark and profiling analysis.

Accounting for relative vagueness on the concept level and a discord in competency models, it is reasonable to assume that the curricula of logistics across universities reveal a wide variety of educational profiles. The landscape definitely appears vibrant from first glance. However, this variety most likely can be described through a small number of commonly popular approaches as clusters. A cluster analysis of undergraduate level logistics curricula has been carried out by the author by first developing the method of quantitative curricula analysis so that the statistical method of clustering could be applied on the data. The methodological considerations of this approach, the findings and the resulting typology are presented in the final part chapter II.

Chapter III firstly explores how the competency profile of a logistics manager is understood in practice in a local academic environment based on a survey involving educators of the field in Estonian universities. The study aims to identify the relations between logistics and SCM in a local application context and offers insight to supplement the conceptual debate.

Although the study points out distinct differences between expected competences from logistics and supply chain managers, the author argues that such approach, namely transport management centered view, is not the only option for logistics to differentiate and that the competence expectations from the designers of future logistics systems should be viewed in a substantially broader and more interdisciplinary context.

Therefore, chapter III continues by drawing attention to the keyword "logistics engineering" (LE), which has the potential to offer this context and which much relates to the curricula typology of chapter II. As suggested in the title, the engineering aspect of logistics is a viewpoint to the discipline that can, in a refined and standardised form, have notable impact in increasing conceptual clarity and in leading logistics education more efficiently towards modern technological and economic frontiers.

Synthesising the elements treated in the dissertation, the author presents an original competency profile titled "logistics systems engineer" to strengthen one notably distinct perspective to competence in logistics. Even though it is widely acknowledged that the education in logistics needs to be interdisciplinary, then what it actually should entail is largely a matter of interpretation. The presented view lends input from the field of systems engineering (SE) and merges it with relevant logistics competency areas. Topical literature and methodological considerations along with the profile are presented in chapter III.

In summary, the dissertation is focused on the following research questions:

1. **How to formulate logistics as a distinct academic discipline in the era of supply chain management?**
2. How is logistics explained and treated in relation to supply chain management according to recent academic literature?
3. What are the main technology trends impacting future logistics?
4. What is the current scientific knowledge in logistics higher education?
5. How is logistics formulated in international competency models and standards? What is the extent of variety and potential mismatches? To what extent are the models up-to-date with technology trends?
6. Which models are suitable for comparative analysis of the profile and gaps of applicable knowledge elements in logistics curricula?
7. Can a meaningful typology of logistics curricula be created via statistical analysis? What are the common curricula types in logistics?
8. How is the competency profile of logistics manager understood in relation to supply chain manager in Estonian academic context?
9. **What characteristics are required from modern logistics engineers?**

Structurally, the answers to questions no. 2 - no. 8 all support the relevance of question no. 1 from conceptual point of view as well as suggesting a multitude of ideas as aspects influencing future outlooks of the area. The most general objective of the dissertation is therefore to answer question no. 1. The answer to question no. 7 especially supports the relevance of question no. 9.

The main solution suggested in this dissertation is both the answer to questions no. 9 and no. 1. Figure 2 illustrates the logical structure of the dissertation by relating research layers and central topics with corresponding research questions, main utilized methods, chapters of the dissertation and resulting publications.

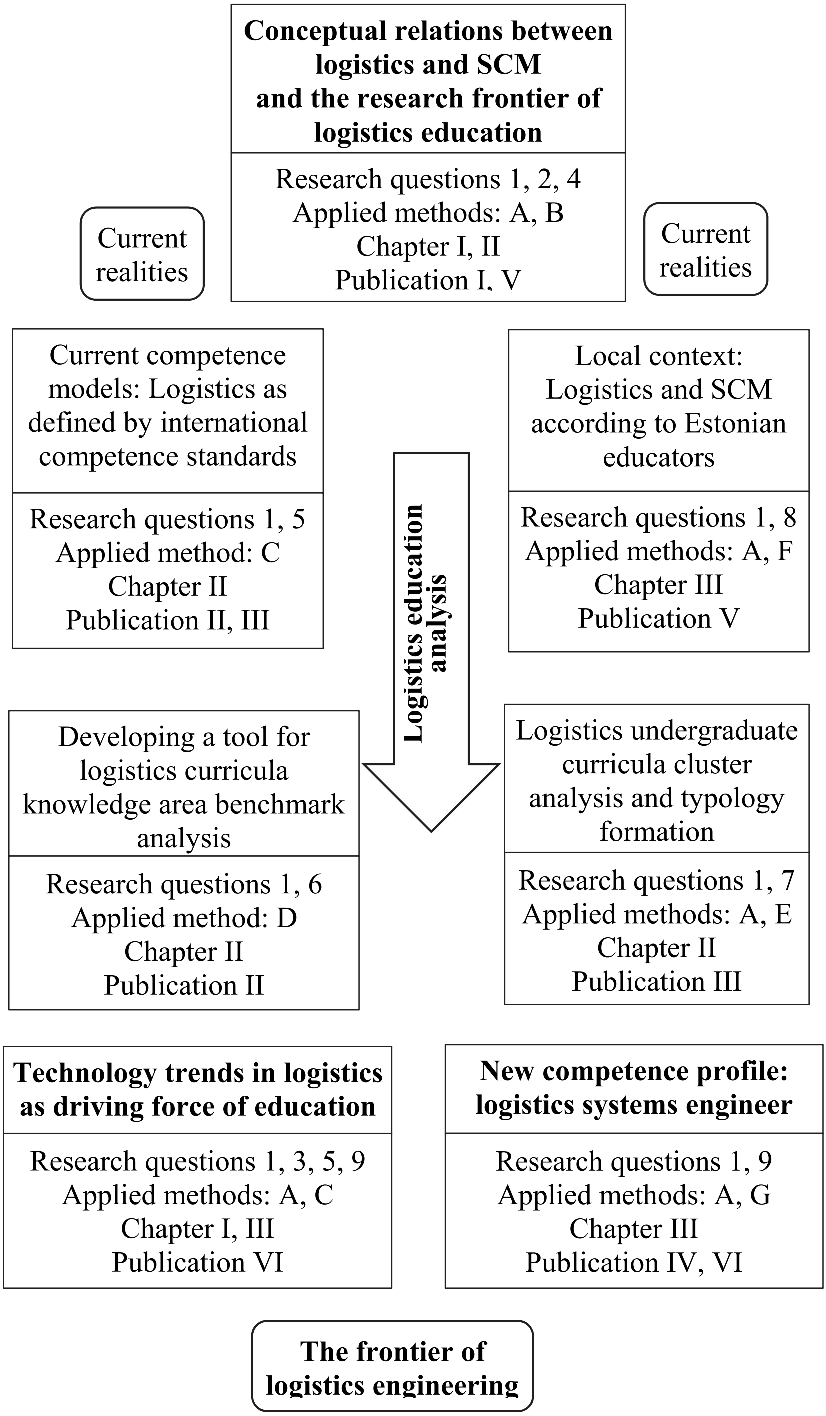

Figure 2. Structure of dissertation in relation to research questions and methods
Source: author's compilation

To clarify Figure 2 in terms of methodology, the author has applied the following approaches:

A. conventional literature review to identify areas of debate and current research gap (questions no. 1, 2, 3, 4, 5 and 7);
B. Larson-Halldorson matrix for concept mapping with input data from dedicated literature analysis (question no. 2);
C. comparative analysis of competency models (question no. 5);
D. model creation for curricula evaluation (question no. 6 and 7);
E. hierarchical cluster analysis of logistics curricula (question no. 7);
F. survey approach to provide quantitative characteristics for Larson-Halldorson method (question no. 8);
G. new competency model creation, including detailed elements of learning outcomes (question no. 9).

The dissertation consists of the review article, summary in English and Estonian, references, appendices, and a series of six publications, referred here by Roman numbers (**I…VI**). The dissertation in total consists of 206 pages with the review article covering 81 pages and including 13 figures and 10 tables. The added original publications include 15 figures and 11 tables. The dissertation includes references to 198 sources.

Publications and Results Approval

The dissertation is founded on six publications that all share the primary author. Publications were planned, researched and written under the supervision of prof. Ott Koppel and prof. Jüri Laving from Tallinn University of Technology.

I Niine, T., Koppel, O. Logistics Management in The Era of Supply Chain Management: A Gap in Academic Literature. – *Journal of Business Management and Applied Economics,* 2014, 3, 3, 1-23.

II Niine, T., Koppel, O. Competence in Logistics – Designing a Meta-Model of Logistics Knowledge Areas. – *DAAAM International Scientific Book 2014,* 543-556.

III Niine, T., Koppel, O. Findings from Cluster Analysis of Logistics Undergraduate Curricula in Europe. 2015 IEEE Global Engineering Education Conference (EDUCON), 18-20 March 2015, Tallinn University of Technology, Tallinn, Estonia. IEEE, 231-238.

IV Niine, T., Koppel, O. Logistics Systems Engineer – Interdisciplinary Competence Model for Modern Education. – *International Journal of Engineering Pedagogy,* 2015, 5, 2, 54-63.

V Niine, T., Lend, E. Logistics Management versus Supply Chain Management – the Crystallization of Debate for Academic Clarity. – *Logistics & Sustainable Transport*, 2013, 4, 1, 39-50.

VI Niine, T., Koppel, O. The Impact of Technology Trends on Skills of Logistics Engineers – A Novel Competence Approach. 10th International DAAAM Baltic Conference INDUSTRIAL ENGINEERING, 12-13 May 2015, Tallinn, Estonia. [accepted to print]

The publications directly relate to previously postulated research questions as Figure 2 illustrates. Publication **I** explored the theoretical concept of logistics. The initial idea for publications **II** and **III** was born together as they stem from research questions no. 5, 6 and 7, which were already at the beginning of the dissertation project seen as essential areas of research to answer question no. 1. The general idea of publication **IV,** new competence model creation (research question no. 9) was born in 2012 during the research process of publication **I** and was much supported by findings in **III**. Publication **V** explores local academic perspectives to logistics and explains existing viewpoints to logistics, which forms a background of applicability of the concept introduced in **IV**. Publication **VI** explains technology trends that support the relevance of the model and better outlines the curriculum guideline element.

The partial results of this work have been presented and discussed in:

- Study and research seminar “Supply chain management: understanding and awareness”, ProLog: Estonian Purchasing and Supply Chain Management Association, 28th May, 2009 (preliminary study);
- “Comparative study of SCOR and APICS competency models” in 2nd International Conference “Education, Research and Development” organized by Bulgarian Academia of Sciences, 9-12th September, 2011, Bulgaria (research approach that was later augmented in **II**);
- Presentation: “Logistics competencies today and tomorrow” at the 14th Logistics Seminar (“Logistikaseminar”) subtitled “Face the Risk”, March 2013 in Haapsalu, organized by TTK University of Applied Sciences (included elements of **IV**);
- The 10th International Conference of Logistics and Sustainable Transport: ICLST, 12-14th June, 2013, Celje, Slovenia (**V**);
- 25th DAAAM International Symposium, Vienna, Austria, 26-29th November 2014 (**III**);
- EDUCON 2015, Global Engineering Education Conference “Engineering Education towards Excellence and Innovation”, Tallinn, 18-20th March 2015 (separate presentations concerning **III** and **IV**);
- 10th International DAAAM Baltic Conference INDUSTRIAL ENGINEERING, 12-13 May 2015, Tallinn, Estonia (**VI**);
- Various research seminars held in TUT between 2010 and 2015.

Theoretical and Practical Contribution

The prominent outcome of this work is the competency profile titled "*logistics systems engineer*". The foremost novel aspects of this model are strong focus on logistics paramount technology trends and integrating logistics with "systems engineering" area. The model substantially reinforces the concept of logistics engineering. The model is recommended to be used as a curriculum development guideline in any university that aims to offer engineering-based approach to logistics, including author's own *alma mater* (Tallinn University of Technology). Further on, this competence approach is suggested to be applied internationally in a standardised manner.

Another tangible result is author's tool for logistics curricula analysis, which allows simplified benchmarking of programs against extensive scope of logistics knowledge areas and assists in developing new logistics curricula.

Third specific result is a current look across technology trends in logistics, which explains the "frontier" of knowledge in a mind of logistics engineer.

Other outcomes of the thesis are oriented to understanding the present and outlining possible conceptual future trajectories. The survey described in chapter 3.1 demonstrates how two profiles of "logistics manager" and "supply chain manager" are contrasted in a local environment, which are distinct and suggests that merged education even in such small scale would be suboptimal.

The typology of logistics curricula describes the variety present in current educational landscape of logistics across Europe. The study reveals the extent to which some extreme approaches to logistics have "drifted apart" and points out both the need to develop more distinct sub-concepts and stronger standards.

As the core question in this work is of conceptual nature, it is difficult to classify insight into strictly theoretical and practical domains. It would be optimal if the findings in concepts and competency profiles would over time allow for logistics to be understood with greater clarity so that the discipline would move towards strengthening of the paradigm. In terms of Larson-Halldorson matrix, the intersectionist perspective to logistics is growing and it is favourable that such trend would continue. As a result, universities would be able to offer more precisely formulated curricula, which allows to better communicate the value offering of a logistics program to students as well as further improve terminological clarity. This would mean that the distinct focal points of logistics and SCM would be understood more uniformly. Paraphrasing an old academic proverb, there is nothing more practical than well understood and agreed theory. According to Gudehus and Kotzab [70], "*logistics as applied science is justified by its applicability in practice. Hence, the measure for strategic logisticians is their contribution to practical use.*"

In theoretical originality, the author emphasises that while conflicting approaches in definitions and curricula were suspected, the underlying theme is that the differences, according to the results, are substantially greater. Therefore it indicates that there is no central paradigm in logistics today, even though in practice managing logistics optimally is in spotlight as never before.

1. MODERN UNDERSTANDING OF LOGISTICS CONCEPT

This chapter reviews literature relating to research questions no. 2 and 3 – the scope and formulation of logistics concept and the technology frontier of logistics. Firstly, comments on logistics evolution are made to understand prior dynamics. Then, a Larson-Halldorsson typology theory is employed to categorise modern academic views, aimed at elucidating the central research problem on a conceptual level. The chapter then explores modern technologies in logistics to find out the main progress drivers in logistics.

1.1. Evolution of Logistics Concept

Logistics as an analytical area was broadly formulated in a classic article by Shaw in 1915 [166], as efforts directed towards bridging demand with supply. Through the century, the field has met constant changes and innovations, though not with distinct revolutionary steps but more as continuous evolution, where a broad variety of tools and frontiers require reconfigurations of logistics systems and where sometimes only flexible entities survive.

1.1.1. Early Functional View and Expansion

Regardless of Shaw's broad vision that enables the whole economy, in practice logistics meant much less for decades, being at best seen as a sum of transport and supporting physical operations with little strategic relevance up until the 1960s. Managing distribution was seen more as a necessary evil than a source of success. According to Ballou [11], "*logistics was not considered the function of strategy makers*". Logistics optimisation took place on operational level foremost in terms of routes, loads and cost savings, with little attention turned towards more complex ideas of lowering lead times, flow-based principles or using logistics as a leverage to create more value. Through the words of Drucker [43], logistics was treated as "*a low-grade nuisance*", but it was to become a critical success factor – including enough potential to be called "*economy's dark continent*".

The field of logistics as research and educational concept advanced significantly in the 1970s and 1980s, slowly replacing the previous concept "physical distribution management" (PDM). Logistics management (LM) was targeted to deal with a larger set of topics than the father-concept – according to Gattorna [60], logistics would *"cover the complete reach of product flow* *between materials and consumption*". The idea of PDM transforming into LM and then further along the way into even an even broader supply chain management (SCM) has been famously visualised by Yuva [197]. Over time, managing inbound and outbound logistics became integrated in theory as well as in practice. As PDM did not grasp new challenges and complexities, it became redundant, fading over time in academic terminology.

Snyder [172] has described four drivers of logistics starting from the 1950s:

- customer demand patterns transforming towards more dispersed nature and higher variety,
- logistics costs increasing and threatening profit,
- applications of electronic data processing allowing more systematic approach and process integration,
- benchmarking logistics management principles from military as extensive information base.

To certain extent these aspects are also pushing logistics forward today, serving as mega-trends reaching across decades. Detailed analysis of logistics development drivers have been presented by Bowersox [17], Mangan *et al* [111], New and Westbrook [133], Sheffi and Klaus [167], Soni and Kodali [176] and by Sekerin and Gribov [164]. Substantial factors of logistics dynamics have been the price of oil, globalisation, liberalisation and widespread outsourcing. Furthermore, fresh ideas of quality and process management grew into spotlight. As stated by McKinnon [113], the environment induced significant changes in the characteristics of distribution channels. The shifts in business settings and marketing priorities necessitated modifications in logistics management principles towards catering for a larger variety of more specific market niches whilst attempting to avoid overly large inventory buffers.

A definition of logistics from 1973 by Hesket *et al* [76] has stood well the test of time: "*Logistics is the management of all activities which facilitate movement and the coordination of supply and demand in the creation of time and place utility*". An over-arching theme is that over time, the significance and complexity of logistics in practice has increased on all the following fronts of cost management, market response, process quality management, customer value generation and environmental impact management.

1.1.2. Views to Logistics as a System

As the scope of logistics broadened, more topics and practical challenges were integrated over time and explaining them required a "*systems view*" to manage the interdependencies between decision areas involved. Such vantage point was supported by ideas of total system cost and cost trade-off management, which remain at the core of logistics ever since. In describing their model of logistics evolution, Rutner *et al* [158] note that key conceptual terms in 1960s were integration of functions and systems approach.

The idea of integration and holistic view in logistics can be traced back to systems theory ideas from the 1950s, with a key point, as suggested by Quayle [151], that the behaviour of a complex system cannot be understood by the segregated analysis of constituent parts. Nedelea [132] has viewed logistics in procedural and systemic perspective and noted: "*procedural approach is not enough to thoroughly define logistics, as it ignores the causal relationships established between its components / ... / that are specific to dynamic systems*".

Kahn and Mentzer [92] advocate both interdepartmental and channel integration in logistics and propose in summary that this means integrating subsystems in a larger unity of effort. In this perspective, there are three complementary viewpoints to integration: meetings and communication, teamwork and collaboration. The authors present a model which treats logistics integration through interdepartmental interactions and facilitated collaboration.

Similarly, integrated logistics has been described by Ghiani *et al* [61] as coordinated management and systemic vision of logistics activities of different companies involved in the management of materials and information flows, with the aim of maximizing the overall profitability. Integrated logistics in this view has two dimensions: efficiency and differentiation.

1. *Efficiency view* relies on the stipulation of contracts of a strictly operative nature that do not modify the company's strategies but tend to speed up exchanges with the partners and lead to a reduction of waste.
2. In *differentiation approach*, the company forges exclusive alliances with partners, thus generating unique and privileged relationships that are not replicable and generate added value.

It could be commented that the first view belongs to tactical management level, while the second is clearly strategic.

In a book "Logistics systems analysis", Daganzo [32] explicitly specifies: "*Logistics is narrowly defined here to be the science that studies how to convey items from production to consumption in cost-effective ways; some subjects of interest to logistics managers such as reliability and maintenance are not addressed*." In this treatment, systems view is not essentially contrasted with a functional view, but rather viewed as an approach to deal with logistics optimisation problems through quantitative modelling. The interrelations in the monograph are limited to coordinating transport, inventory, handling and sorting activities to improve cost-effectiveness – which is mostly tactical view.

To facilitate optimal actions, Pfohl [146] has proposed five principles of logistics thinking: thinking in values and benefits, systems thinking, total cost thinking, service orientation and efficiency. These principles breach functionally defined boundaries of logistics and indicate that the main goal of logistics should be understood on strategic management level. On a related note, a recent study [115] suggests strategy is the main driver of logistics integration.

According to Schönsleben [161], logistics is best understood as an overall management system of performance. In this treatment, logistics is defined as a planning perspective reaching across product life cycles, including design, servicing and disposals. In his view, operations management is much similar to logistics "*for it is impossible to conduct successful operations management if it is applied to only a part of the value chain*". Schönsleben further reiterates systemic view in pointing out that an enterprise is essentially a system in which people work together to reach entrepreneurial objectives.

Blanchard [15] has discussed the impact of integrated logistics support on the total cost-effectiveness of a system: "*Cost-effectiveness relates to the measure of a system in terms of mission fulfilment and total life-cycle cost. A cost-effectiveness figure-of-merit, employed for the purposes of system evaluation, may relate one to the other, i.e. system effectiveness as a function of life-cycle cost, reliability as a function of life-cycle cost, cost as a function of some measure of dependability or capability, and so on.*" The key point by Blanchard appears to be that substantial life-cycle costs are already implanted into logistics systems in early phases of design and development. He suggests that little attention has been drawn to this relationship. Instead, "*logistics has been considered after-the-fact, downstream in the system life cycle, low in the priorities ...*" and that such reactive approach to logistics has induced practical obstacles, referred as "total cost iceberg model".

If it is possible to stress one key element in achieving integration of logistics system, it is information. Gligor and Holcomb [65] note: "*Logistics information management capabilities facilitate the integration of other logistics capabilities (e.g. demand and supply-management interfaces*)". However, this entails complexity, as if other logistics capabilities are not optimal, investments into information capabilities will be of little impact. Finally, going beyond traditional systems perspective, Nilsson and Gammelgaard [141] have recently suggested that the concepts of complex adaptive systems and complexity thinking are appropriate for meeting contemporary challenges in logistics. This implies increased role in creativity and learning in logistics management.

1.1.3. The Emergence of Supply Chain Management

The field of logistics was notably influenced in the 1980s by value chain concept of Porter [149] which further expanded the system approach, though treated logistics in a functional manner. This vision directed attention towards value creation across conventional functions – such as purchasing, logistics, manufacturing and sales – and towards managing business relationships in a chain of supplies, aspect out of reach of direct control by any single business entity. In 1991, Porter [150] wrote: "*Discrete activities are part of an interdependent system in which the cost or effectiveness of one activity can be affected by the way others are performed. / ... / Such linkages can extend outside the firm to encompass the activities of suppliers, channels and buyers.*"

A few years prior to Porter, supply chain management (SCM) had emerged. The first authors to apply the term, Oliver and Webber [143], noted: "*SCM covers the flow of goods from supplier through manufacturing and distribution* *chains to end-user. / … / 1) SCM views the supply chain as a single entity; 2) It demands strategic decision making and system integration; 3) It views balancing inventories as last resort."* However, it took time for SCM to establish a strong foothold, as Burgess noted in 1998 [21]: "*without clear and agreed definition of SCM, the idea will not hold academic merit and will instead only be a short-lived buzzword for practitioners"* Lately, SCM has been accepted as a strategic concept aimed at long-term sustainability – according to Melnyk *et al* [116], "*over time, the theory and practice of SCM has experienced a transition from a tactical to a strategic focus. SCM involves more than simply making a 'better' buy; it affects the ability of the firm to maintain a sustainable competitive advantage*." SCM concept has been influenced by similar economic trends as logistics. After three decades, it is apparent that one main theoretical keyword in both concepts is cross-functional integration.

Three following quotes describe the evolving nature of SCM:

- [SCM is] *an integrative philosophy to manage the total flow of distribution channel from supplier to ultimate user* [46];
- [SCM is] *design, maintenance and operation of supply chain processes for base and extended products, for satisfaction of end-user needs* [10];
- *Supply chains are looked upon from multi-business, yet integrated perspective and such vantage point allows the development of a supply chain strategy that can be meaningful across network alliances* [109].

In the first wording, the object could easily be exchanged with systems view of logistics. In the second, production as well as logistics appear to be involved and it is indistinct, which processes can count as "supply chain processes". The third introduces the dimensions of network aligned strategies and relationship management, which are sometimes tacitly touched in broader views of logistics through integration concept, but usually not explicitly expressed in definitions.

The relationship between SCM and logistics has been unclear and debated since 1980s. As stated by Tan *et al* [181], "*SCM is synonymous with integrated logistics systems*" Notable common ground in concepts lies in outcome, which usually merges strategic aspect of sustainable business with operational aspects of capable and trustworthy delivery performance: "*Logistics involves getting, in the right way, the right product, in the right quantity and right quality, in the right place at the right time, for the right customer at the right cost*" [111]. Almost the same is the phrasing of SCM goal, for example, by Simchi-Levi *et al* [170]. This is probably the main reason for some authors to use the terms interchangeably. Some authors see the two concepts equal for all intents and purposes. A quote from Waters [190] reads: "*The choice of terms is largely a matter of semantics, and here we stick to the convention that the two terms refer to exactly the same function"*. Such understanding has been also backed by observations across practitioners by Gammelgaard and Larson [59]. In industry, the terms are usually applied without substantial theoretical considerations and as a result every case can be different in terms of tasks and responsibilities.

However, some authors perceive differences between logistics integration and supply chain integration. According to Soni and Kodali [176], SCM "*introduces the idea of external integration in addition to internal integration*." If logistics is understood purely from a viewpoint of a single business entity's process planning and control reach, then SCM is reaching further, given that it is logically less complex to manage single company compared to attempting to manage the optimal output across the entire supply chain. Such integration without controlling entity is termed virtual integration [188].

Furthermore, some modern authors, such as Desphande [37], tend to approach logistics in a more functional sense of transport-related capabilities, whereas SCM view is taken substantially further by including cross-functional aspects such as concurrent engineering and strategic partnerships. According to Giunipero and Brand [64], "*SCM is a strategic management tool used to enhance overall customer satisfaction. / ... /* [there is a] *necessity to go beyond the logistics function and focus on making business processes more effective*". There is no clear consensus, but the interpretation of Rushton *et al* [157] boils down to a formula "*supply chain = suppliers + logistics + customers*". Wisner *et al* [191] see SCM standing on three functional pillars of logistics, operations and purchasing, while Hult [81] has also added fourth – marketing. It has been also suggested that outside academia, logistics is often seen as a pure functional area. Lummus *et al* [106] note: "*industry definitions of logistics essentially discuss the physical flow of materials. / ... / Logistics could be considered as execution of supply chain management activities.*" The authors aimed to reach common industry formulation and concluded that "*SCM includes the logistical flows, the customer order management, production processes and information flows to monitor all the activities in supply chain nodes*".

Right next to approaches, which treat SCM as a furthest extension of strategic and integrated logistics, are others, which don't see logistics even properly belonging into the scope of SCM, instead differentiating between internal and external domains. According to Christopher [24], "*SCM is the management of upstream and downstream relationships with suppliers and customers in order to deliver superior customer value at less cost to the supply chain as a whole,"* whereas *"logistics is the process of strategically managing the procurement, movement and storage of materials, parts and finished inventory (and the related information flows) through the organisation and its marketing channels ..."* This somewhat contends various other definitions, and is one of the most distinct differences – although of course both fields are interlinked by a myriad of interfaces even in this treatment.

Notable credit for advancing SCM should be given to Lambert *et al* [98], who suggested in 1997 that "*a clear distinction is needed between SCM and logistics to emphasise that even the strategic meaning of logistics is only a part of SCM*". In this foundational view, SCM consists of eight general management processes that are applicable for every firm in a supply chain. The article [98] states specifically, "*There is no need to replace logistics with SCM – in fact it creates more confusion in a still emerging field and detracts from the need to* *achieve the much broader level of integration of firms. / ... / It is adding confusion to the discipline of logistics to conceptualize SCM as implementing logistics across independent organizations in a supply chain. / ... / Logistics is never going to own the product development process.*”

A similar mind-set is reflected in recognised definitions of logistics and SCM by The Council of Supply Chain Management Professionals CSCMP [30].

- *Logistics management is that part of SCM that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements.*
- *SCM encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers.*

These definitions are widespread in current literature. However, the debate remains on relative size of the logistics “part” in supply chain management.

1.1.4. Research Implications

The viewpoint “logistics = SCM” is supported and strongly promoted by a wave of *relabelling* that has spread in terms of book and journal titles, university faculties, curricula and in the names of professional organisations over the last two decades. It can be suggested that this process has gone too far and has damaged parts of logistics that are no longer in appropriate focus due to the more extensive popular coverage of SCM.

Larson and Halldorsson [102] have commented: “*the unclear conceptual borders of SCM make it difficult to design educational programs in SCM without large overlap with other fields such as logistics, marketing, operations management and purchasing”*. It could be proposed that the debate affects logistics side of the equation relatively more, as it reduces to the question if separate treatment of logistics as a concept is even needed, given that SCM appears to be the dominant and uniform concept today. Stock and Boyer [179] have researched 179 definitions of SCM, synthesised their own as an all-encompassing one and then noted that the outcome is much similar to some of the internationally recognised models. On the contrary, Kukovic *et al* [97] have studied 176 definitions of logistics and found that various areas have their own specific characteristics. In their final formulation, a list of functions and operational goals are listed, but the relation to SCM is left uncertain.

The undecided relationship of the two disciplines has various implications in terms of competence profiles pursued in higher education and queries if LM a sustainable concept right next to SCM and with which specific characteristics. Provided that LM has been outgrown by more relevant and complex SCM, would it be far-fetched to assume LM meets a similar end as PDM in the past? It can be suggested that the introduction of SCM and value chain ideas have constrained the expansion of logistics. As Larson and Halldorsson [102] have worded, one side-effect of SCM is a downgrade of extensive and strategic role of logistics. Even Porter's view [149] can be interpreted as logistics being a functional area contributing to the value system, rather than the system itself.

The literature review has identified that the main source of contradictions over the nature of logistics comes from SCM as complementary but also a competing concept in terms of relevance, academic recognition and as a research area. This raises a need to evaluate logistics in relation to SCM more structurally. Chapter 1.2 introduces one possible methodology for this task and surveys a wide selection of modern academic treatments to understand the variety of logistics formulations (research question 2). Chapter 1.3 reviews literature on logistics technology trends to identify the frontier of the most relevant topics for future logisticians (research question 3). Chapter 1.4 reviews research on logistics education to identify the current state of logistics as educational concept (research question 4). In terminological perspective, a curriculum can be treated as a vastly expanded definition of a concept. Both enquiries are aimed at enlightening how logistics could be further developed and differentiated from SCM both conceptually as well as in education define a setting on which further analysis of this dissertation is founded upon.

1.2. Literature on Logistics and Supply Chain Management

This section delves into detail and analyses modern academic views based on a structured model suggested by P. Larson and A. Halldorsson in 2004 [102], which can be considered as a landmark paper in mapping the conceptual debate.

1.2.1. Literature Study Design with Larson-Halldorsson Matrix

Lambert *et al* [98] have noted: "*Practitioners and educators have addressed the idea of SCM as an extension of logistics, the same, or as an all-encompassing approach to business integration.*" Extending this idea, Larson and Halldorsson conceptualised a typology of four possible approaches, visualised on Figure 3:

- "Traditionalism" – logistics is a broad ancestral concept from which SCM has emerged as a subset of specific issues;
- "Relabelling" – through evolution, logistics has transformed into SCM, which means no separate understanding of logistics is necessary;
- "Unionism" – SCM is a wider concept and encompasses the entirety of logistics, adding challenges and decision areas not related to logistics;
- "Intersectionism" – SCM shares some common core elements with logistics, however logistics deals more specifically with some issues not directly in scope of SCM and *vice versa*. [102]

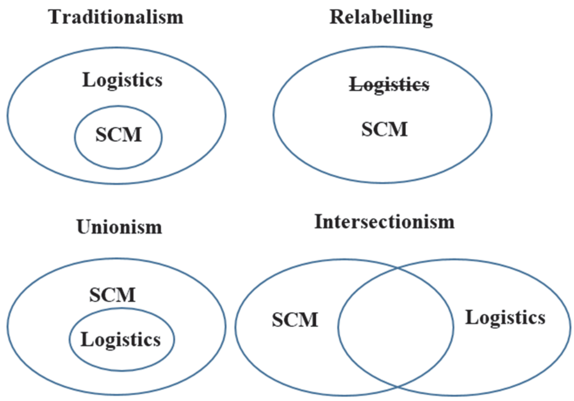

Figure 3. Existing schools of thought according to Larson and Halldorsson [102]

In traditionalist interpretation, supply chain analysts would broaden the scope of logistics analysis as a supply chain analyst would suitably belong to a logistics department and deal with conventional logistics issues by striving to understand the interrelations between the company and its suppliers. The practical meaning of traditionalism for academia, would be that SCM does not need to be treated as a separate discipline.

A relabeller would probably prefer the single discipline to be called SCM, whereas according to unionism, a supply chain manager would not be yesterday's logistics manager but a position among the upper management to oversee not only operations and performance from the integrated view, but also business relationships and benefits achieved and yet achievable through cooperation.

Finally, intersectionist would point out that unionists are partially right but that the field of SCM would become too complex to manage for a single person and as a single competence profile – someone would still need to manage logistics with a different focus from SCM. A supply chain specialist would be focused on strategic view whereas logistician would be focused on arranging the flows optimally. This would imply a supply chain curriculum positioned somewhere between logistics and general business administration.

Larson and Halldorsson surveyed the opinion of educators in the field with a novel mathematical approach to categorize respondents across the four understandings. It was based on measuring opinion indirectly to avoid cognitive bias – the respondents were asked to evaluate the relevance of 88 elements to both logistics and SCM. The authors defined two indices, *abs* and *raw*. The first index, *abs* (1), is the sum of absolute value of differences between importance for SCM and for logistics, across all survey items.

$$abs = \text{sum } |\text{SCM}_i - \text{logistics}_i| \quad (1)$$

The second index, *raw* (2), is the sum of raw differences between importance for SCM and importance for logistics, across all survey items.

$raw = \text{sum} (SCM_i - logistics_i)$ (2)

In both indices, i denotes the number of valid respective respondents.

High *raw* scores identify unionists, as they perceive large differences favouring SCM. The group with lower *raw* scores but relatively high *abs* index are intersectionists – the differences between concepts are notable but there are also topics more relevant to logistics manager than to supply chain manager, resulting in low *raw* index. Relabellers are identified by low *abs* score (and by definition also low *raw* index). Finally, traditionalists are identified by medium-to-high *abs* index and negative *raw* index of respondents.

The result [102] demonstrated that all four schools of thought existed among the educators, but the dominant approach was relabelling (50 out of 95 respondents), followed by 22 unionists.

In implications to education, a strong relabelling view would not see a need for separate disciplines as it would create more confusion. Intersectionist would strongly disagree and insist on differentiation (though it can be intersectionists would argue among themselves over the common ground). Unionist would see SCM as a proper discipline and logistics would be a niche approach at best, redundant at worst, whereas traditionalist would think *vice versa*. All in all, relabelling view appears to be the most conflicting, but on the other hand also a pragmatic approach.

The following study[1] started in 2012 with a primary goal to identify the changes occurred in logistics and SCM treatments in international monographs in the last decade. It was hypothesised that SCM has developed and matured, while the relationship with logistics would still appear unclear. The study aimed to categorize modern book authors' views with Larson-Halldorsson typology.

A relevant observation on the situation had recently been made by M. Goetschalckx [61]: *"while logistics management requires an integrated, holistic approach, its treatment in courses and textbooks tends to be either integrated and qualitative or mathematical and very specific. This book bridges the gap between those two approaches by providing a comprehensive and modelling-based treatment of the logistics processes"*

One reason for focusing on books rather than journal publications was that the debate has recently fallen somewhat out of fashion and the nature of modern logistics is not being overly discussed, whereas logistics is still being taught in universities and textbooks are still written. It was also assumed that the treatments in the books would have direct impact on how the concepts are taught to students and therefore how the upcoming professionals would treat the topic in the near future. *The study aimed to identify, if the scope of logistics is defined clearly among modern textbook authors and similarly in relation to SCM.* [136]

[1] The study by author described here utilised Larson-Halldorsson matrix without the mathematical components. However, the formulas are shown here because they are utilised in a related study carried out by author, which is described in chapter 3.1.

The monographs to analyse were chosen by two criteria:

1. the monographs had to be less than 10 years of age, in assuming that such books can still have significant impact as they are used in studies
2. the monographs apply general perspective to either SCM or LM, which wouldn't be functionally constrained.

The author analysed a randomly collected sample and charted 20 books with distinct focus to SCM and 15 books on logistics (with or without SCM element in the title). This proportion appears to reflect the current education landscape adequately – there appear to be more books about SCM than focusing on LM, though sometimes the terms are merged. The categorization was done either by definition evaluation or by interpreting the context of terminology use.

1.2.2. Findings from Supply Chain Management Authors

In this section, the summary of findings from SCM textbooks are presented, followed by attention towards books on logistics. Table 1 presents a concise overview about the included literature and their respective categories.

It was noted that some authors avoided explaining the distinct nature of logistics, which introduced difficulties on determining a specific opinion on the conceptual debate. For this reason, the columns "logistics" and "SCM" note the level of detail offered in formulating the terms, where the coding means:

- "-" – the source does not provide specific explanation for the concept;
- "+" – the source explains the nature of the concept partially or the relative positioning is deduced from context without a proper definition;
- "++" – the source presents specific explanation on the meaning and boundaries of the concept.

Detailed analysis of these treatments were published by author in [136]. The analysed authors' perspectives to logistics appear mostly superficial or even dismissive as an inferior concept. Most of the authors focusing on SCM oppose the idea of treating logistics with a comparable augmented meaning or indeed see logistics from company-based or even purely transport-based functional focus. Only seldom is the idea that the disciplines have historically been equal, suggested. While a few perspectives treat logistics as a worthy discipline in its own right ("*intersectionism*"), the dominating viewpoint is *unionism* with perhaps Emmett and Crocker [47] summarising what is expressed by the majority in this section: "*logistics, which originally encompassed the whole supply chain, is now being understood by many companies as a new name for transport or for warehousing/stores or for distribution. Logistics can therefore be a confusing word. Additionally, some people use the term logistics to describe their own internal company process, and use the supply chain term, when they are dealing with external suppliers/customers*".

Table 1. 20 books of SCM and their conceptual perspective

Book	Logistics	SCM	Perspective
Supply Chain Management. Sources for competitive advantages [7]	+	++	unionism
Total Supply Chain Management [12]	+	++	unionism
Supply Chain Management. Best Practices [16]	+	++	unionism
Introductions to Operations and Supply Chain Management [18]	+	++	unionism
Supply Chain Management [23	+	+	unionism
Strategic Supply Chain Management [28]	+	+	unionism
Relationship-driven Supply Chain. Creating a Culture of Collaboration [47]	+	++	unionism
Essentials of Supply Chain Management [80]	++	++	unionism
Purchasing and Supply Chain Management [125]	+	++	unionism
Project Technology and Supply Chain Management [127]	+	++	unionism
Purchasing and Supply Chain Management [151]	+	++	unionism
Guide to Supply Chain Management [162]	-	+	unionism
Enterprise Supply Chain Management [163]	-	+	unionism
Principles of Supply Chain Management [191]	+	++	unionism
Competitive Supply Chains. A Value-Based Management Perspective [196]	+	+	unionism
Retail Supply Chain Management [10]	+	++	unionism / intersectionism
Service Management. An Integrated Approach to SCM [73]	++	++	unionism / intersectionism
Adaptive Supply Chain Management [88]	++	++	unionism / intersectionism
Supply Chain Management and Advanced Planning [177]	+	++	unionism / intersectionism
Supply Chain Management on Demand [1]	-	-	n/a

Source: author's compilation

In contrast, the perspective leaning towards intersectionism is eloquently summarised by Ivanov and Sokolov [88]: "*logistics deals mostly with local functions for implementing the physical transition of material flows and SCM deals with the value-adding chain as a whole and concentrates on the managerial links between the local functions for implementing the physical transition of inbound and outbound material flows*".

It needs to be pointed out that the dominating perspective of unionism from SCM authors' vantage point rejects relabelling on concept level, but it can still be sympathetic towards relabelling in education. It is quite clear, however, that when the title is SCM, the specific formulation of logistics is not a priority question for most authors.

In summary, the results suggest the relative maturation of SCM is broadly observed. However, it seems that as the agreed definition of SCM (such as one suggested by CSCMP) is extensive, it is challenging to include all topic areas in one book and to treat every aspect with appropriate level of detail, especially as a typical SCM textbook is not too cumbersome, with a typical example ranging between 300-400 pages.

1.2.3. Findings from Modern Logistics Authors

The books on logistics turn on average much greater attention towards the conceptual debate. This is coherent with the understanding that SCM has mostly established itself in recent decades and the burden of differentiation now lies on logistics, whereas it used to be the opposite still 10-20 years ago. Table 2 reflects the variety of different perspectives present in monographs of logistics, which leaves the scope of logistics rather vague.

Table 2. 15 books of logistics and their conceptual perspective

Book	Logistics	SCM	Perspective
Global Supply Chain Management and International Logistics [19]	++	+	relabelling
The Logic of Logistics. Theory, Algorithms, Applications [169]	++	+	relabelling
Supply Chain Risk Management. Vulnerability and Resilience in Logistics [190]	++	++	relabelling
Comprehensive Logistics [70]	++	-	relabelling / intersectionism
Logistics and Supply Chain Management [24]	+	++	intersectionism
Integral Logistics Management [161]	++	++	intersectionism
Value-Added Logistics in Supply Chain Management [41]	++	++	unionism / intersectionism
International Logistics: The Management of International Trade Operations [34]	++	++	unionism / intersectionism
Logistics Management and Strategy [75]	++	++	unionism / intersectionism
Logistics Systems Design and Implementation [101]	++	-	unionism / intersectionism
Handbook of Logistics and Distribution Management [157]	++	++	unionism / intersectionism
Logistics Operations and Management. Concepts and Models [53]	+	-	intersectionism
Logistics & Retail Management [54]	+	-	intersectionism
Introduction to Logistics Systems Management [61]	++	-	intersectionism
Shipping and Logistics Management [107]	+	-	intersectionism

Source: author's compilation

As Table 2 indicates, few authors are sympathetic to relabelling approach while others see a clear need to differentiate. Harrison and van Hoek [75] point out that even though *"SCM is wider than logistics"*, *"logistics and SCM are sufficiently different for separate definitions to be needed"* Such perspective appears to be popular and from this aspect it is difficult to decide between unionism and intersectionism. It could be suggested that in practical interpretations, intersectionism can be assumed when the title is logistics.

However, what is more valuable in these findings is that most authors reject relabelling either explicitly or implicitly. The authors that were found supporting relabelling have specific reasons. In case of Simchi-Levi *et al* [169] and Waters [190], this could be due to more specific viewpoints to the topic matter, risk management and quantitative optimisation, which would not absolutely demand distinct differentiation between LM and SCM. In case of Branch [19], this is related to more practical handbook approach that does not attempt to theoretically cover everything the terms used might imply. Probably both arguments apply for Gudehus and Kotzab [70] and this is a case of explicitly stated relabelling, whereas by content, the book appears substantially more detailed and in stark contrast to an average generic SCM textbook.

There is an alternative interpretation to Larson-Halldorsson typology. Given that the side of SCM theory is established as a wider concept, then the options for logistics authors are to either: 1) write about logistics from a specific niche perspective; 2) integrate a variety of niche views and stand as intersectionist against generic SCM, which can fail to draw attention to specifics of various tactical and operational management issues; 3) give up writing about logistics and write on SCM as a true relabeller; or 4) write on both terms regardless of conceptual views. From author's observations, all four have been met.

The second option, however, is noteworthy and encouraging in terms of conceptual sustainability – a few books of that type exceed 900 pages with a level of detail which is comparatively rare in SCM domain. It could be proposed that the practical indicator of intersectionism is the depth with which logistics topics are approached. When details are concerned, many authors still prefer to discuss them as "logistics" rather than SCM. It could be paraphrased that in formulating logistics, just "bigger is better" is no longer a success factor as it can't compete with the scope of SCM.

To summarise, on the level of concise definitions, unionist viewpoint is dominant and difficult to argue with. However, when unfolding the topic across hundreds of pages, logistics has substantial room to differentiate and this allows to evaluate the entire landscape of observed logistics treatments as intersectionistic. However, as Figure 4 illustrates, it is not as simple as Larson and Halldorsson described, but with more variety of partly contrasting opinions of how to specifically formulate the differentiation. This means that logistics treatments do bring additional knowledge to the table, but the scope should be more clearly formulated and agreed upon for future development next to SCM.

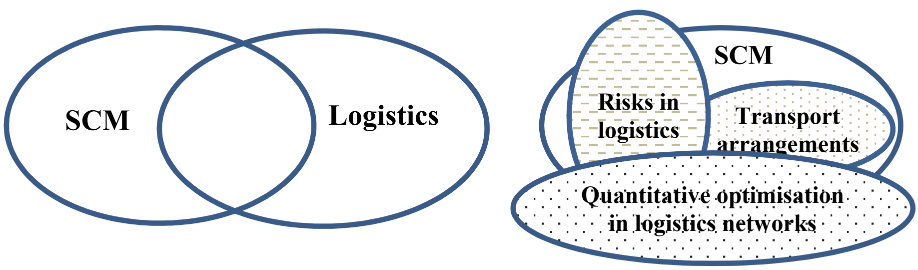

Figure 4. Theoretical intersectionism and some observed intersectionistic perspectives
Source: author's compilation

In conclusion, the survival of logistics concept is not a lost cause, but could use refinement. Positioning logistics uniformly away from SCM would benefit both fields. This would entail some "downgrading" when the broadest relabeller ideas are concerned, but it definitely would not have to force logistics back onto the level of purely operational planning of transport and inventory – as the study demonstrated, there is substantial room between the two extremes.

1.3. Technology trends impacting logistics

The goal of this chapter is to explore technology trends entailing the potential of highest influence to future logistics systems and to logistics education.

Notable driving force of logistics technologies are "green" sustainability oriented solutions, pushing the area towards lower environmental impact, improved services, lower costs and greater efficiency. According to Supply Chain Management Institute SMI [171], supply chains of the future will evolve "*spurred not only by regulation, but also by changes in consumer behaviour*". A 2014 report by APICS (The Association for Operations Management) [3] discussed sustainability effects on reputation, cost reduction, supply chain reliability, service innovation and increased revenue. The technology trends are sometimes strongly related to regulatory and economic background. McKinnon *et al* [114] have observed: "*In environmental terms, the rate of technological improvement has been faster in road freight transport than across the rail and waterborne sectors. This is partly because regulatory pressures to cut emissions have been stronger, but also because it has a higher energy intensity and is thus more sensitive to rising oil prices.*"

Golinska and Kawa [68] have suggested: "*Innovative instruments provide opportunities for making manufacturing and logistics operations cleaner and more resource-efficient.*" The authors list *vehicle emissions*, *energy efficiency* and *technologies for smart cities* as key areas of near-future trends. The smart city concept refers to an array of interrelated technologies in urban environment. Directly logistics related are vehicle sensors and intelligent transport systems (ITS) for safer and controlled traffic, but also integrated information solutions for businesses and consumers to facilitate transformation towards online supply chains via growth in online marketplaces and electronic retail [20].

A study by SMI [171] asked how supply chains evolve in energy-constrained world in the next 20 years. Based on a Delphi survey of 48 experts, it was concluded that *cutting carbon emissions* will be one of the greatest challenges for future logistics. In terms of sustainability, the issue was seen as a priority, followed by maintaining an adequate fuel supply in the future of oil scarcity. According to International Energy Agency [86], logistics accounts for roughly 22% of carbon dioxide emissions from fossil fuel consumption by the society. However, McKinnon *et al* [114] are optimistic that "*over a 20-30-year horizon, the development and diffusion of clean vehicle technology is likely to reduce substantially the externalities of all the main modes of freight transport*".

As an underlying market trend, the SMI study [171] foresees that the customers of the future "*continue to demand greater control over the logistics process, and will more actively intervene in the delivery process of the goods they do order. This will increase the complexity of logistics processes, making necessary a highly sophisticated technical infrastructure.*" To support control, advances in both information as well as physical delivery capabilities are required, which can be seen as main pillars of progress in logistics.

The impact of modern vehicle technologies to sustainability across transport modes has been approached through three pillars [114]: *carrying capacity, energy efficiency* and *externalities*, including both direct external effects to current population as well as impacts to future generations, such as climate change. The authors present numerous examples how small innovations in transport finally effect one or more of these pillars in all transport modes.

Modern technological advances in logistics can introduce various benefits on different layers in parallel – to companies, customers, society and future outlooks. For example, alternative fuels and *clean vehicle technologies* reduce emissions and reliance on oil and can improve energy efficiency. According to Intergovernmental Panel on Climate Change [87], advanced vehicle technologies have a primary role in decarbonisation of transport, which is seen as even more relevant than contributions from structural and behavioural change. The World Economic Forum [192] has rated clean vehicle technologies as a priority with biggest impact for decarbonizing global supply chains across 13 proposed action areas. This statement has been recently echoed in Nordic context and in 2030 horizon by Liimatainen *et al* [103].

Substantial positive impact to environment stems from the growth in *electrical vehicles* and *e-mobility*. According to Frost & Sullivan [57], the fields of smart cities, e-mobility and zero emission technologies are three areas in the top ten of global economic mega-trends. In the same report, wide-scale implementation of *automatic technologies* in cargo handling, packaging and *robotic transport* in industry applications is forecasted for the upcoming decade.

On other trends in transport, the SMI study [171] proposes considerable growth in *autonomous systems* and increases in capacities across modes, ultra-large container vessels, aircraft and LHVs (longer and heavier vehicles). Furthermore, d*riverless transportation systems* entail the potential to equip future transport modes with the ability to safely navigate in different environments and significantly alter cost patterns. The experts held much favourable views towards transport automation and noted that computer-driven systems may become the "state-of-the-art" for many forms of transport by 2030.

Currently, the area of UAVs (unmanned aerial vehicles or also drones) is in first phases of testing commercial applications across courier express parcel sector. According to DHL Research Trends [40]: "*Rather than being an alternative for standard delivery, UAVs can be used, for example, for urgent deliveries into areas that are geographically difficult to access. Unmanned aerial delivery is a reasonable option in places with major environmental issues and where e-commerce is growing faster than infrastructure*".

Drones is only one venue of autonomous logistics. Vehicles across transport modes, as projected by DHL Research Trends [40], will develop cognitivity and become "*self-steering and capable of acting proactively. Autonomous vehicles with radar, satellite navigation and ultrasonic sensors can not only steer themselves but also enable dynamic real-time routing depending on traffic*".

Advanced cognitivity and sensors are also advancing in warehouses where processes be facilitated by real-time warehouse control systems. Automatically guided vehicles can use magnetic or optical guidance [13]. Regattieri *et al* [154] noted: "*Automated control allows the probability of errors in storage and retrieval to be minimised, along with the probability of product damage during movements*". The solutions are driven by advances in physical sensors as well as software, creating a platform called as swarm intelligence.

In 2012, Deutshe Post AG [38] initiated a scenario study to identify five possible realities of logistics and world economy in 2050. All five visions depend on combinations of technological progress, economic growth, trade patterns and sustainability. The two more optimistic scenarios on future outlooks are "mega-efficiency in megacities" and "customized lifestyles". In keywords, the first embraces green paradigm shift, smart urban logistics to deal with congestion and emissions, *high efficiency traffic concepts*, *robotics-based logistics*, global grid of *large-scale transport* including underground networks, *information logistics*, open trade and global governance. The authors summarize it as "transition to the *automation age* turning the world upside down".

The second scenario [38] differs on total cargo volume in logistics systems and assumes strong emergence of *3D printing* and *localized production*. In this future, only raw materials and data still flow globally and managing "last mile" transport becomes a critical success factor, while global cargo flows are in relative decline. The extensive production of personalized products in this scenario would notably increase energy and raw materials consumption.

Some of the key determinants in other scenarios [38] are increasing protectionism and failure to manage externalities. However, as important common denominator across scenarios, many current tasks in logistics will not be human-operated in 2050 and are instead replaced by computer-controlled systems. Regardless of scenario, the Delphi study identified 14 key future factors, of which three relate the most to technological frontier – *information and communications technology (ICT) and robotics*, *material technologies* and *urban development* solutions.

In terms of short-term advances in logistics, improving the aerodynamics of trucks, is suggested to bring up to 20 % better fuel efficiency [39]. Recent EU regulations on truck weight and length limits allow for greater aerodynamics which is, according to European Commission [51], estimated to effect total CO_2 emissions by affected trucks between 7-10%. Another area effecting vehicle efficiency is weight reduction with lightweight materials, which reduces fuel consumption, increases capacity and as a result requires less road space. It has been suggested [49] that replacing steel with aluminium could, *ceteris paribus*, increase carrying capacity of conventional trucks by more than 10%.

A range of benefits come from progress in ITS solutions. Novel *safety features* in vehicles can reduce direct costs of accidents and externalities. The continuing spreading of *vehicle tracking applications* have reduced travel distances, transport costs and delivery times, alleviated traffic in congested areas and increased fleet utilisation efficiency by facilitating better control and precise planning [31]. Taniguchi [182] has recently commented on promising areas and trending solutions in ITS: *collision avoiding systems*, *lane keeping systems*, *radio-frequency identification (RFID) tracking*, *driving monitoring systems* and *real time travel data analysis*. Yet another beneficial area is using real-time tracking data in *optimization of vehicle routing and scheduling*.

The potential of RFID-based tracking is also strong in retail sector, promising to improve the efficiency of the processes and help to save costs and increase revenues. According to Rogers *et al* [156], the current industry is in a second phase of "RFID hype", where the focus is not on the tagging of pallets and cartons with RFID transponders for improved tracking but instead tagging at the individual product level in selected commodity groups. As the investment costs for the technology is decreasing, the potential benefits increase and broaden. Fu *et al* [58] have identified four key areas of RFID implementations: meeting the demand, sharing real-time information, creating value in delivery and reducing errors. Additional outcomes are higher inventory accuracy, increased transparency, improved product availability and reduction in manual labour will in near future reach notably bigger audiences. Synergies are created as modern tracking and tracing solutions combine automatic identification, such as RFID, with supply chain collaboration initiatives [121].

Logistics has been named by Hompel *et al* [78] the most innovative application industry for information technologies. The authors go as far as promoting the *cloud computing* environment as a means offering a fundamental redesign of logistics systems, and noting that the potential of "cloud" is by far not yet exploited today. The terms *comprehensive wireless connectivity* and *real-time location systems* have been viewed in similar context [85]. The real-time aspect of logistics information is expected to grow. The future constraint is not obtaining the data but rather distributing data along supply chain, which requires inter-company integration and efforts in analysing the data. Global Supply Chain Institute [66] has surveyed ten game-changing trends in supply chain management, of which two are directly infused with advances in facilitating technologies – *information visibility* and *virtual integration*.

In a vision for next decade supply chain advances in India, the experts of A.T. Kearney & CSCMP [9] present six pillars, in which technology aspect is represented in *improved supply chain infrastructure* and *affordable technologies and big data*. The key elements of infrastructure relate to faster deliveries on road and rail, containerization and unitization technologies, continuing modal shift to intermodal solutions and semi-automatic handling. The data aspect suggests "information explosion is a certainty" with widespread internet and mobile coverage and huge increases in data generation and storage.

The report foresees data volumes increasing exponentially as internal data from *enterprise resource planning* (ERP) systems is complemented with external such as geospatial data and point-of-sale terminals. As data storage costs are seen to drop significantly, partly due to cloud computing, more data becomes available and fuels growth in flexible, reliable and affordable *data analytics architectures* [9].

Kim and Lee [94] have explored the challenges of logistics operations in container terminals. Alongside the evolution of various physical loading equipment, such as quay cranes, yard trucks etc., the crucial management element is the *terminal operating system* (TOS), which is a software program used to implement the decision-making processes in terminals. Information technologies are similarly infused in other operational logistics areas in warehousing, handling and tracking. Intermec [85] has listed *voice recognition*, modern forms of *bar codes*, *RFID, digital imaging* and resulting *remote management* among their top ten supply chain technology trends.

Three broad approaches to logistics technology trends are summarized in Table 3 below, which mostly reflect and augment the topics already discussed in this chapter. Zelewski *et al* [198] have recently carried out a Delphi study to identify logistics industry trends in Germany in the next five years. The authors find it remarkable that no particular trend stands out, rather than the top five, which suggests the fields synergize in order to realize the concept of continuous shipment tracking including corresponding added value services. DHL Trend Research [40] has emphasized eleven technology trends.

Table 3. Significant technology trends in logistics in recent studies

Logistics Trends 2020 Zelewski *et al,* 2014 [198]	**Logistics Trend radar** DHL Trend Research, 2014 [40]	**Material handling and logistics: US roadmap** Gue *et al*, 2014 [71]
application of telematics	big open data	the growth of e-commerce
deeper penetration of logistics systems with ICT	cloud logistics	mass personalisation
implementation of GPS systems	autonomous logistics	mobile, wearable computing
traffic information and real time routing	3D printing	robotics, automation and driverless vehicles
electronic marketplaces for logistics services	robotics and automation	sensors and the internet of things
networking and integration through IT-systems	internet of things	big data and predictive analysis
real time capability of transport information systems	localization and local intelligence	new methods of distribution
application of mobile computing	wearable technology	tracking integration
traffic information systems to reduce emissions	augmented reality	cloud-based visibility
implementation of logistics simulation models	low-cost sensor technology	sensor data standards
	crypto-currencies and crypto-payment	process optimisation tools

Source: author's compilation across three main studies, first published in [138]

While "Logistics Trend Radar" [40] points out that autonomous logistics and 3D printing are topics further away than 5 year horizon, all other areas are noted to have considerable impact in near term. Even the *internet of things* is seen to approach steadily as more objects become "smarter": *The Internet of Things empowers smart objects to be active participants in self-steering, event-driven logistics processes. Logistics is one of the major industries which will benefit from the intelligent conjunction of information and material flows* [40].

This relies heavily upon low-cost sensors which create smart infrastructures for monitoring, inspecting, and controlling logistical processes. According to Rifkin [155], "*professionals are looking to the distributed, collaborative, laterally scaled internet communication system, with its open-systems architecture as a model for radically transforming global logistics.*"

The area is also called "physical internet". Montreuil [126] has described it as "*exploiting the internet, which has revolutionized the digital world, as a metaphor for steering innovation in the physical sphere*". McKinnon *et al* (2014) have pointed out that various technologies can be categorised under this concept, such as parcel drones, driverless cars, robotic material handling and online smart-home concepts. Most are still at an early stage, but are expected to mature and serve as building blocks to make physical internet a reality.

In summary, the author has consolidated a list of ten major technology areas, which should be mandatory for logistics specialists and included in education [138]:

1. Electric vehicles, alternative fuels and clean technologies;
2. Telematics, real-time tracking and intelligent transport systems;
3. Auto-pilot and autonomous vehicles: UAV, self-driving cars, ships etc.;
4. Vehicle design, materials and systems of safety, costs and performance;
5. Robotics, sensors and ID-solutions in cargo handling and security;
6. Mobile and cloud computing applications and wireless communication;
7. Logistics process and network simulation and optimisation software;
8. Electronic marketplaces, e-commerce and smart networking;
9. Big data, augmented reality, automatic data analysis and integration;
10. Additive manufacturing (3D printing) applications.

As these areas are developing rapidly, it is crucial to keep education in these topics up to date. The author returns to these issues, continuing the analysis of the technological aspect in logistics education in chapter 3.

1.4. Conclusions of Chapter 1

The author presents the following conclusions that directly relate to research questions no. 2 (points 1-4) and question no. 3 (point 5).

1. It appears that the conceptual landscape is heterogeneous but still clearer compared to original findings in 2004. Firstly, traditionalism is gone, which

could be seen as a milestone of SCM maturation. From SCM authors' perspective, unionism is a dominant view. It seems that SCM is recognised as a strong concept for research and business administration practice. In the turn of the century, SCM authors were still making efforts to establish the paradigm and demonstrate the "bigger picture" argument in contrast to logistics. Today, such active struggle is no longer necessary. It is defined by international authorities and mostly agreed that SCM is wider than logistics. In specific formulations, some remaining variety is normal and progressive. Numerous SCM authors are treating logistics as a historical phase of own development. This is, by theory, unionism and by practical implications partially also justifying relabelling. These authors appear notably more homogeneous compared to the "other group", logistics authors.

2. The dominance of SCM forces logistics authors to either merge with the paradigm or search for differentiation to keep logistics concept alive and evolving. The historical background of "strategic and integrated logistics" allows some authors to accept and be shaped by the SCM paradigm, which has, after all, huge practical relevance by dealing with strategic frontiers of modern business. On the other hand, authors aiming to keep logistics conceptually sustainable adapt by turning more attention to selected niches of more specific issues, better functionally constrained topics and methods. In some cases, the authors integrate a wider array of such "specialty topics" in a monograph and as such aim for a stronger version of intersectionism.
3. The main support for intersectionism from logistics point of view is both an argument of relevance and feasibility – specifically that typical SCM approaches tend to offer a relatively thin layer of knowledge across the entirety of the huge scope involved by definition. It could be suggested that because of such scope, the average treatment of SCM in monographs is extensive rather than detailed. This allows logistics treatments to "fill the blanks", which results in focusing on catering for a profile of specialist-type manager as compared to a typical generalist pilgrim of SCM. Therefore intersectionism is a more pragmatic outcome as it focuses on defining relevant niches rather than competing with SCM for the same spotlight.
4. The growth and strengthening of intersectionist approach(es) could be beneficial for clarity for both concepts and would also allow for better formulated and communicated competency profiles in higher education. This would further distinguish between the roles of supply chain manager and professional logistician and this has merit – currently both roles are still rather conflictingly understood in practice. The economy requires people to analyse supply chains, manage supplier and customer relationships and search for ways of value chain cooperation (supply chain managers) as well as specialists who create and manage physical and information flows, understand modern tools and technologies and can design new solutions for facilitating logistics processes (i.e. logisticians, with various specializations across the functional areas). Therefore, from society as well as academia point of view, pure relabelling of logistics programs to SCM would

disservice both areas as the current approaches to SCM in academia are not specific enough to cover more detailed niches.

5. The author reviewed technology trends in logistics and summarised top ten competence areas required in training future logistics specialists. It appears that the keyword "trends in logistics" tends to often reveal substantially more technologies than business or organisational concepts, whereas for "trends in SCM", the emphasis is the opposite. This reflects a notable extent of one possible and relevant dimension in intersectionism.

The literature indicated that further support for intersectionism can be beneficial and teaching logistics is relevant next to SCM, provided that both are formulated adequately. The author is turning attention to logistics education more descriptively in chapter 2 and normatively in chapter 3. The dissertation now aims to observe the field of competency models and curricula in logistics to find ways how this field could be directed towards more optimal outcomes.

2. COMPETENCY, STANDARDS AND A TYPOLOGY OF CURRICULA IN LOGISTICS EDUCATION

This chapter treats the issue of formulating logistics first on the level of education and existing competency standards (concerning research questions no. 4 and 5) and then in terms of university curricula. As contrasts between various approaches to logistics competencies appear substantial, it is appropriate and relevant to synthesize a merged structural model of logistics knowledge areas covering the existing constructs, which could be used for more efficient curricula analysis, benchmarking and positioning (research question no. 6). Such extended model is described and usability demonstrated in chapter 2.3.

To map the variety present in logistics programme content in undergraduate education, a quantitative cluster analysis of a selection of logistics curricula is then constructed (research question no. 7), resulting in a four-way typology. The outcome, its relation to competency models as well as to conceptual understanding expanded in chapter 1, allows for more specific understanding of current challenges in logistics education.

2.1. Previous Research on Logistics Education

This section summarises research on logistics education focusing on curricula and competencies. As logistics dynamics combines technology with turbulent markets, it hints that it is by nature challenging for logistics education to stay ahead of the curve. Such notion is a common theme in various publications, for instance by van Hoek [186], Razzaque *et al* [153] and Daud *et al* [33].

Gammelgaard [59] has found that significant effort is needed in logistics education to meet changing demands. A critical viewpoint was presented by Myers *et al* [130] in a study focused on mid-entry level employees of logistics positions. The study found that direct job-related skills such as decision-making and time management are primary contributors to success whereas experience and education background was only secondary. In authors' view, this called for a switch in logistics education towards more problem-solving skills.

Another recurring theme is a push for more interdisciplinary approaches. Rahman and Yang [152] have commented that logistics managers need integrated cross-functional abilities, supply chain mind-set, team orientation and a variety of people and technological skills. Lancioni *et al* [100] have proposed that logistics faculties need to develop partnerships with other academic departments to facilitate creation of multi-disciplinary courses. Murhpy and Poist [129] have researched senior positions in logistics and suggested that the field has turned more business management focused as many executive search firms suggest supply chain orientation as a primary skill of logistics managers. Such view can offer interdisciplinary benefits. However, relations to technological capabilities and natural sciences can weaken as a side-effect.

The research into the development of logistics programs at college level is limited [99]. A comprehensive meta-analysis of logistics education research by Gravier and Farris [69] in 2008 included articles across five decades and identified three areas of logistics education research: curriculum, skills and competencies, teaching methods. Authors found that curriculum issues were the most prevalent in the 1970s, whereas starting from the 1990s, research on teaching methods has started to grow, recent examples being van Hoek *et al* [187], Wu and Huang [194]. The dominant approaches were noted to be case studies of curriculum and competence development, followed by surveys. These articles on curricula focus mostly on either feedback or observations of shortcomings, such as Gibson *et al* [63] and Rutner *et al* [159], or on promoting success stories, such as Mangan *et al* [110] and Okongwu [142].

One of the few broader studies aimed at describing a variety of courses in logistics was carried out by Wu *et al* [193] in 2007. It was found that three biggest categories of courses were "logistics", "transportation" and "information technology", accounting for 48% of total credit hours. As an side-note on US-based curricula, it was found that 33% of logistics departments belong under marketing or business administration faculties. The paper also pointed out the broad range of variations in content by observing the magnitude of operations management topics in curricula. The study effectively reiterated the interdisciplinary nature of logistics, as many departments studied were found also to research areas such as statistics, finance and law.

Jian *et al* [90] have analysed logistics education in China across 271 colleges and found that 90% were teaching to logistics management, whereas rest taught logistics engineering (LE). The authors concluded that there is a lack of engineering students and too much emphasis put on teaching management.

In 2013, Lutz and Birou [108] analysed the topics and methods applied in logistics classes on undergraduate and graduate levels, mostly based on US data. The authors identified 95 topics covered in different courses in logistics on undergraduate level, 81 on graduate levels and noted high variance in both topics covered as well as in their perceived importance. As an interesting nuance, the data suggested that international courses, were, on average, more reliant on transport topics compared to a typical approach to course in USA.

In summary, it appears that the landscape of higher education in logistics is notably diverse, which reflects the terminology debate. Extending this issue to curricula, the area has not been dedicatedly analysed. The keywords stressed in logistics education research are market relevance, technologies and interdisciplinary approaches. While there have been exploratory studies on course content carried out, there is a research gap in contrasting various curricula quantitatively in order to identify the focal points of various curricula along with shortcomings. This has many reasons, such as quantitative content evaluation difficulties and data availability. As one result, curricula are often updated for practical considerations rather than for conceptual views.

2.2. Approaches to Competency in Logistics

As chapter I demonstrated, the scope of logistics is much debatable, which as one result confuses universities aiming to teach logistics in a broad and central manner. It does not automatically mean that there couldn't be more harmony when logistics is unfolded across expected competencies from a professional. However, it stands to reason that if the definition is unsettled, one is expected to meet even more disagreements in approaches to logistics competencies, nor would universities have clear standards to rely on.

There is notably less uncertainty in traditional function-specific niches of logistics. Areas such as warehouse operations, forwarding and terminal management have better defined scope and often have respective occupational standards and certification options, which allows universities, if it is desired, to build curricula with more specific focus. In contrast, the broader and more interdisciplinary the perspective to logistics aims to get, the more difficulties for scope and content management it presents. For example, logistics support for manufacturing environments would require merging conventional operations planning and scheduling issues with inventory and material flow management, but the treatment needs also to be intertwined with areas of purchasing, quality management, material handling, automation and information system topics and respective competencies. As Gudehus [70] has suggested, the more logistics is expanding and specializing, theory and practice diverge. The further the reach of logistics is augmented, the more interdisciplinary relations it entails, merging the viewpoints of social and natural sciences from business administration to engineering and from human resource related issues to technology design [134]. As remarked by Popper [148], the challenges for theorists are to understand a complex system, to find out its rules and to make the system controllable.

Gudehus and Kotzab [70] have pointed out three aspects to logistics tasks.

- *Practitioners* regard logistics as the activities necessary to set up and operate transport, storage, traffic and handling systems and networks.
- *Planners* understand logistics as the design, dimensioning and optimization of logistic networks, processes and systems.
- *Theorists* see logistics as investigation of practices, principles, examination of options, and development of strategies, algorithms and rules for planning, set up and operation of systems and networks.

In terms of occupational standards in logistics, the coverage across all three levels might not always be guaranteed, although it should be expected from competency profiles aimed towards professionals and managers. This also applies for university education in logistics – while focusing on theorist and planner aspects, relevant practitioner viewpoints should not be disregarded.

The term "logistics potentials" has been proposed to describe critical logistics-related competencies. Sennheiser *et al* [165] have defined it as specific resources and capabilities, suggesting that the most common bottleneck in practical environments does not lie in resources *per se* but in the capabilities to adaptively acquire and exploit them. According to Mentzer *et al*[118], there are three types of main logistics capabilities – supply, demand and information management. Esper *et al* [48] have expanded the model into five aspects: customer focus, supply management, integration, measurement and information exchange capabilities. Matwiejczuk [112] has explained how competencies are a synergized sum of resources and capabilities. In this view, there are ten key competency areas of logistics that emphasize the integration of processes and stakeholders, with *order management* and *customer integration* forming the top of service-based advantages, and *IT technologies*, *process management* and *flow leanness and transparency* as primary cost-based advantages.

Wu *et al* [195] have identified 50 skills in nine categories that logistics experts and educators in Taiwan regard as essential competencies. Next to more conventional topics, noteworthy elements included were crisis management, social responsibility, production integration and independent decision-making. The paper also promoted technological competencies combined with international perspective: "*An effective logistician should combine global business expertise with functional and technical skills, rather than being primarily a functional/technical or a logistics specialist*."

Most textbooks of logistics present a model of component areas, tasks and responsibilities in logistics. Perhaps one of the best structured approaches to logistics decision areas has been put forward by Langevin and Riopel [101] with a system of 48 decision areas across strategic planning, physical facility network and operations. While such constructs all offer inspiration, the problem is that they are usually not detailed enough to use as direct input in curriculum development. Therefore the next section directs attention to logistics competency standards of wider recognition – one gap in current logistics education research – to first identify the level of congruence between them.

2.3. Comparative Study of Logistics Competency Models

The criteria for selecting logistician competency models were the following.

1. The model needs to focus on "logistics" with a relatively broad scope. A title such as "distribution and logistics management" would be included as distribution is an integral part of logistics, whereas purely "warehouse management", such as offered by International Warehouse Logistics Association [89], was excluded as logistics is in numerous dimensions broader than warehouse operations. Another model left out was Certified Logistics Technician (CLT) programme [128], as it focuses on technical competencies involved in front-line material handling and distribution.

2. Models of SCM without mentioning logistics were excluded, adhering to the possibility that some of these authors would not see their model suitable for detailing logistics. In this respect, contrasting present variety among supply chain manager competency models is worthy of separate study and attempting to add this dimension to the current analysis would obfuscate focus. It must be noted that the topic is controversial, as one can find examples of logistics organisations certifying supply chain managers, such as Certification of Supply Chain Professionals SCM-PRO [25].
3. The model is required to detail logistician knowledge areas on a professional level suitable for comparison against university and college curricula. This criterion is only partly objective. While a few certification programs strictly require college diploma or degree, others are flexible and suggest a combination of practicing experience supplemented by additional modular training. The models of European origin tend to reference European Qualifications Framework [50], developed by the Joint Quality Initiative as part of the Bologna process, in which level 6 corresponds to first full level of higher education. Approaches on lower levels did not suit study scope. Yet some approaches don't reference the related education level at all. Models that were deemed to be focusing on positions not specifically requiring higher education were left aside.
4. The models ought to have notably international reach. Standards of seemingly local recognition only were excluded.
5. The model must have well-defined structure of competencies, including various detailed applicable skills and knowledge areas. For that reason, Certified Logistics Professional (CLP) certification by the Logistics and Supply Chain Management Society [105] was not included, as in their case the certification process is built around a scoring calculator of various career-related achievements, but not on specific competencies. In their understanding, the scope of logistics is represented only on a definition level, which leaves the system flexible, but extremely subjective.

After the selection process, six models passed the criteria as well as had detailed information readily available on the internet.

- Distribution and logistics managers' competency model by the Association for Operations Management APICS [4];
- Certified in transport and logistics (CTL) by American Society of Transportation and Logistics AST&L [8];
- Demonstrated master logistician (DML) [175] and Certified master logistician (CML) [173] by the International Society of Logistics SOLE;
- International Diploma in Logistics and Transport by Chartered Institute of Logistics and Transport CILT [26];
- Logistics professional by European Logistics Association ELA [45];
- Certified International Trade Logistics Specialist (CITLS) by International Trade Certification IIEI [82].

The models and their usability for curricula analysis is more thoroughly commented in author’s original publications in [134] and [135]. Relevant characteristics of models are comparatively summarised below in Table 4. Categories and elements describe quantitative structure of the components. An important difference lies in whether the model is designed around inputs or outputs. The latter means that the model is explicitly defining learning outcomes, required skills and competencies, whereas input-centric model is built around topics and views as content that is to be included in study process, without explicit formulation of the resulting competence (at least not more than a general statement of “has read or heard about X”).

Table 4. Comparison of logistics competency models involved in the study

Viewpoint	**Logistics competency models**					
	ELA	***CILT***	***SOLE***	***AST&L***	***APICS***	***CITLS***
Categories	13	6	6	10	6	3
Elements	195	92	148	56	276	30
Inputs or outcomes	outputs	both	inputs	outputs	outputs	both
Recently updated	yes	no	no	yes	yes	yes
Scope	broad	average	broad	average	broad	average
Usability	good	good	average	good	good	average

Source: authors’ compilation first published in [135]

All models appear essentially usable as curriculum development guidelines. The “average” scope should be understood in relation not only to more extensive ones but to other models that were left out from this study due to being too narrow in scope. Nevertheless, it can be said that all models are interdisciplinary to a notable degree. The models include varying ways of certification, with some being much more strict and selective than others.

A direct comparison of any chosen pair of models from table 4 is made difficult by the input/output question as well as various structural designs and also varying level of detail applied both from model to model and from section to section inside. Still, with some margin for error, general contrasts between models can be observed. The titles are not always reflecting the different emphasis present in models, whereas the background of the respective international bodies can sometimes be more explanatory. While SOLE model is centred on engineering approach, AST&L has notable transport-specific history and APICS has operations management background.

Table 5 presents a comparison of CITLS model against four other competence models. In many cases, the match was partial, indicated by “+/-”, but the study also pointed out areas of sizeable gaps across models. It should not be viewed as direct criticism to CITLS or any other model. Instead it is one frame that illustrates a common theme across models and demonstrates that even CITLS as the most concise model, has viewpoints to add to the others, with some close to ten times more detailed.

Table 5. The presence of CITLS elements in four other models

CITLS elements	Presence in analysed models			
	ELA	*CILT*	*AST&L*	*APICS*
Air freight shipments	-	+	-	-
Ocean freight practices	-	+	-	-
Intermodal shipments	-	+	-	-
Trade regulations	+	+/-	-	+
International distribution	+	+	+	+
Insurance issues in trade	-	+	-	-
Incoterms	-	+	-	-
Packaging requirements	-	+	-	+
Customs warehouses and free trade zones	+/-	-	-	+
Logistics monitoring & control	+	+/-	+	+
International trade terminology	-	+	-	+
International trade documentation	-	+	-	-
Expansion to international markets	+/-	+	+/-	+/-
Import/export potential analysis	+/-	-	-	-
International market research	+	+	+	+/-
Establishing pricing for international markets	+/-	-	-	-
International finance tools	-	+	+/-	+
International business resources	+/-	+	+	+
Warehousing overview	+	+	+	+
Traditional warehousing	+	+	-	+
Principles of warehousing	+	+	-	+
Third-party warehousing	-	-	-	-
Warehousing as an operational element	+	+	+	+
Warehousing as a supportive integrated system	-	+/-	-	-
Physical operations in warehousing	+	-	-	-
Warehouse processes and practices	+	+	+	+
Warehouse layout and design	+	+	-	+
Automation and computerization technologies	+	+	-	-
Warehouse utilization and workforce design	+	-	-	-
Integrated warehouse modeling	-	+	+/-	+

Source: authors' compilation first published in [135]

Notably, SOLE is missing from Table 5. It appeared that even though SOLE promotes a balance between business administration and engineering and industrial processes, the formulation of some elements were substantially vague to render the comparison unfeasible.

Figure 5 depicts the structures of ELA and APICS models. The analysis involved comparing a complex array of relationships due to ELA consisting of 9 "pillars" but APICS including 24 rather differently categorized sections. Suggesting the quantified amount of intersections and mismatches would be subjective and imprecise, so Figure 5 resorts to mapping relations of APICS sections against ELA. Bold lines represent almost full match, whereas dotted lines suggest that the approach of one model is either broader or formulated in more substantial detail than the other. Links to the question mark point out that either a small proportion (dotted line) or a significant amount (bold line) of elements are not represented by ELA. As a result, it appears that approx. 1/3 of

APICS elements are not included in the ELA model, although the author reiterates that it is not specific criticism, but an observation across all models.

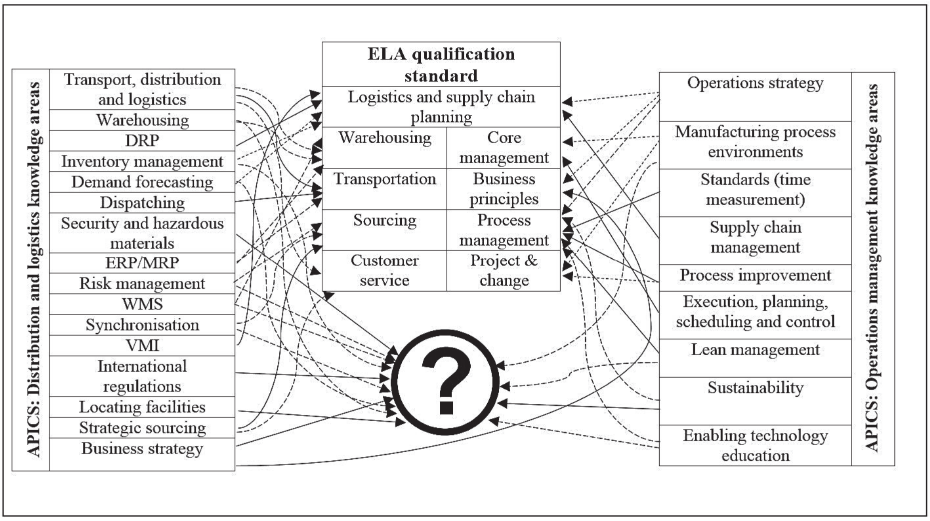

Figure 5. Relations between ELA and APICS models of logistics competencies
Source: author's compilation, first published in [134]

In short, the analysis demonstrated there is no model extensive and still detailed enough to cover the rest. This means that a logistician being perfectly competent to be certified by any one of these models would not automatically have the competencies needed by others. The mismatches appear substantial and it can be said there is little overall standardization in terms of logistics competencies, even though some of these models serve as practically relevant and recognised standardisation systems. It was also observed that some models include inner overlap in subsections, which shows the difficulty in approaching logistics with any distinctly formulated categorization of competencies.

It should be asked if a central standardized approach to logistics competency is even needed. The current models do manage to cover some of the relevant angles to logistics, even though their titles do not suggest the specified nature of some models as much as the content differences indicate. This also means that curricula boards can use any model for benchmarking purposes, but in terms of attempting to cover logistics centrally and holistically, there is a lack of a model that could be used as analytical basis with relative ease. The next chapter presents such approach, synthesised from already analysed models.

2.4. A Meta-model of Logistics Knowledge Areas

In order to facilitate simplified logistics curriculum benchmarking, it was decided to build a new model from the building blocks of selected existing models instead of choosing the most suitable and filling in the gaps. The general process of this research is described on Figure 6.

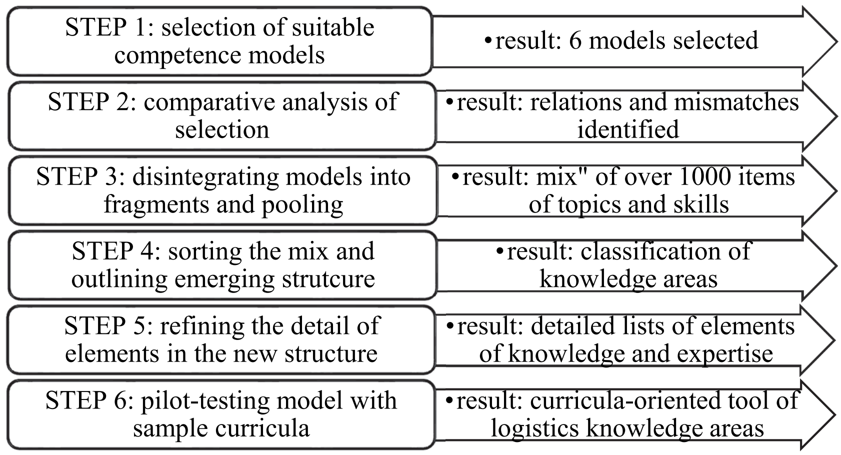

Figure 6. Model creation process and outcomes
Source: author's compilation, first published in [134]

One consideration in the process was to orient the model towards the characteristics of curricula. Some of the existing structures were lacking in terms of classifying knowledge areas directly from teaching viewpoint, instead focusing on workplace performance. This is not a criticism towards said competency models, but a notion that today despite efforts only some of the curricula are explicitly formulated through learning outcomes.

The models were disintegrated into small fragments, merged into fragment pool and sorted to remove duplicates. Many elements were rephrased towards broader knowledge areas. For example, a process-oriented model might include elements such as "*establishes an onsite customer inventory management program*" and "*determines objectives for VMI initiative*". In simplification, the preferred way was to merge such aspects under the topic "*vendor managed inventory*", because such is the level of detail one would meet in observing an average curriculum and it would make sense to treat various aspects of VMI process together. The suitable level of simplification appeared to be to reduce the initial pool of over one thousand fragments into between 200-300 elements that would still allow to measure curriculum content thoroughly and would keep the analysis more manageable to carry out in practice.

The classification of the fragments into optimal knowledge area segments was relatively more challenging. Finally, all topics were categorized to twenty segments of knowledge areas forming five broad layers:

1. General business administration and management topics
2. Central logistics management, planning and control topics
3. Transport topics across technologies, operations and management
4. Supporting technology, logistics process and systems engineering topics
5. Cross-functional supporting viewpoints

Considerations on how such classification emerged were commented by author in [134]. It relates to the views of Gudehus and Kotzab [70], with the second layer more focused on the theorist and planner perspectives and the third and fourth layer more oriented towards function-specific planner and practitioner views. The first layer represents business administration as micro environment of logistics. Finally, fifth layer adds interdisciplinary context with an intent to stress three areas of expertise that are interlaced with logistics on various levels and are appropriate to stress as distinct knowledge areas – namely legal environment of logistics; sustainability and risk analysis. Including these viewpoints meant that the model was no longer functionally categorised as all three relate to aspects already included in the layers above. This overlap – such as the item "international transport conventions" belonging into both "legal environment" and "operational transport" segment – was intentional. As an upside, this gave the model better functionality in identifying the strengths and weaknesses of given curriculum from more viewpoints. The downside – not being able to evaluate the entire topic coverage of the curriculum as precisely – appeared practically minimal. The model is presented in appendix 1.

The main application of the integrated model is to serve as a original tool for "short-cut" coverage and profiling analysis for any logistics curriculum. Findings from such analysis and benchmarking against competitors can then be used to delve into details of improvement actions and comparative analysis with more specific models, which can lead to course redesign initiatives. It is important to stress that the expected outcome of the analysis in practice is not trivial – it is erroneous to assume that most of the well-designed programs would cover easily the entirety of the knowledge areas. This comes down to the facts that the total amount of studying time is limited in any curriculum and the range of topics to cover is extensive. The results of the initial analysis would identify the shortcomings as well as chart the focal points, strengths and weaknesses of the programme in question. From first-hand experience, it can happen that the measured profile turns out different than initially assumed curriculum profile.

In pilot testing of the model, five sample curricula of undergraduate logistics in Europe were analysed. The resulting coverage rates of the programmes turned out to be between roughly 50% and 60%, which appears concerning. One soothing argument could be that there is more taught in classroom than shown in curriculum documentation, but this would more likely boost the coverage in some already prominently performing segment, rather than "help out" in weak spots. Another argument can be made of intended curricula differentiation. However, it is still strange, for example, when a curriculum in question is stronger on engineering side in general and yet falls unexpectedly short in some technology areas that would logically belong to such profile.

All in all, the goal of such gap-analysis is not to increase the coverage rates easily to 100% (although in integrated development of full 5-year bachelor-master programmes it could be achieved). Instead it is to point out smaller, easily applied improvements. Should any university decide to offer more differentiated niche program, the model offers the primary content dimensions to consider and a way to evaluate the profile of competing "best practices". The meta-model of logistics knowledge areas [134], as presented in the appendix 1, is meant to illustrate the extent of topics that logistics has grown to involve. The result attempts to show "how big is the big picture" in modern logistics.

Given the variety of logistics formulation in theory and in competency profiles, it can be assumed that the field of curricula would also have widely varying content, while still maintaining some common denominators. The next section aims to explain it in more detail with the help of cluster analysis.

2.5. A Cluster Analysis of Logistics Curricula

This section summarises the study which applied quantitative cluster analysis to a sample of logistics curricula to identify existing typology and category differences in order to explore the landscape of logistics education. In comparison to competency models, curricula can be even broader in scope, by adding various supporting topics of other disciplines. Neither are academic research skills usually mentioned in practice-oriented competency models.

2.5.1. Considerations on Study Design

It could be said that every program is distinctive – some relate to various local or international standards; some need to cater for specific regional needs; some are influenced by expertise of key professors; some strive for wider coverage while others dedicate attention to selected details or omit topics areas entirely. Furthermore, in "how to teach" every specimen is unique indeed.

However, on "what to teach", three viewpoints can be imagined. Point A would look at objects from distance and in zoomed-out fashion all curricula would look similar. In terms of logistics, point A would need to be a great distance away to lose grasp on even the most notable differences, but it can still be imagined – perhaps concluding something like "all deal with transport and material flows. Viewpoint C would "zoom in" closest to finally identify distinct uniqueness in every specimen. Viewpoint B is located between A and C and as such can identify a small number of categories how some curricula flock together but stand apart from other sets. Analysing views in various spots between A and C to reach meaningful interpretation of landscape patterns is metaphorically the essence of hierarchical cluster analysis.

According to Hair *et al* [72], the objective of cluster analysis is to classify a sample of entities into a small number of exclusive groups based on the similarities among the entities. In hierarchical method, the number of groups is not determined before. Instead, the most appropriate segmentation is decided after statistical analysis. As Everitt *et al* [52] have commented, hierarchical classifications may be presented in a dendrogram, which illustrates the identified separation levels. Antonenko *et al* [2] note that cluster analysis is complementary to factor analysis – the latter groups variables cross cases whereas the former groups cases based on the variables of interest.

Applying cluster analysis is a recognised tool in education research. Egan [44] has suggested: "[in education research] *important issues are not technical but interpretative. / ... / When the 'grossness' of cluster analysis is understood and accepted, the technique can nonetheless serve an important heuristic function*". According to Huberty *et al* [79], there are three reasons for cluster analysis: 1) data exploration to identify meaningful clusters; 2) generating and testing hypotheses regarding cluster structure; 3) questioning already formed clusters. In current case, first motivation applies. They add: "*sample size needed to conduct a cluster analysis is a judgement call of the researcher*". This relates to understanding commented by Kaufman [93] that cluster analysis is an art of finding groups in data.

It is not trivial to carry out clustering with relatively complex objects as curricula, where data availability and measuring precision are relevant obstacles. However, it has been applied before in education. Two decades ago, Overby and Kemp [144] analysed business curricula in USA with clustering, and the approach of this study is similar translated to the context of logistics.

For successful quantitative analysis of curricula content, one would require:

- A structured model and method to categorize topics, which presence can be expected in logistics curriculum and which would provide quantitative evaluation data;
- Statistical approach to analyse the data and offer interpretation;
- A sample of suitable curricula to be analysed.

For an objective point of reference, most of the competency models could be, in principle, usable. However, as shown, the problem often lies in limited scope, so options were to either use multiple models or a new consolidated one. This study is therefore founded on the structure suggested in chapter 2.4.

The structure needed additional tweaks to use for reaching input vectors for cluster analysis – some sections of similar profiling were consolidated and others split to separate most suitable set of distinct dimensions.

Ideally, the "first best" goal was to evaluate the level of curriculum coverage in each of the defined sections by measuring the stated presence of a long list of model items in the curriculum. While such data analysis is perfectly feasible with some curricula, as pointed out in 2.4, it is not with many others. As data collection indicated, only some publicly available curricula include the level of course content details required for such analysis, whereas many curricula just list courses with possibly rather brief content overview.

Instead, the author had to resort to "second best" option. The measurement was carried out on the level of course titles by identifying the percentage share of the curriculum dedicated to dimensions defined by the underlying model. This meant that the measuring model would only need to contain sections that would reasonably avoid too much of overlap. The adjusted model ended up with being composed of 15 sections as shown on Figure 7. The process of evaluating each curriculum now meant relating every course to a respective section or in rare cases two.

Level I: General business administration		
Section #1: Business strategy, marketing and environment	Section #2: Accounting and financial management	Section #3: Organization, people and process management
Level II: Broad logistics core		
Section #4: Supply chain management concepts	Section #5: Logistics management and trade	Section #6: Purchasing and inventory management
Level III: Viewpoints on transport		
Section #7: Transport operations	Section #8: Transport - society and systems view	Section #9: Transport technology and engineering
Level IV: Supporting functional areas		
Section #10: Warehousing processes and technologies	Section #11: Information and communication technologies	Section #12: Manufacturing processes and technologies
Level V: Foundational topics		
Section #13: Laws and legal environment	Section #14: Basics of natural sciences	Section #15: Basics of social sciences

Figure 7. Synthesised approach to logistics knowledge areas for curricula evaluation
Source: author's compilation, first published in [135]

The most notable difference between describing a sum of competencies in logistics and topical knowledge areas is that Figure 7 has omitted some aspects of foundational competencies, such as attitudes, personality traits and capabilities, which are sometimes called graduate abilities, including for example team working, leadership, interpersonal skills, cultural awareness, creativity etc. It has rightfully been suggested by Cranmer [29] that managing such capabilities explicitly in a curriculum has the greatest impact on total learning outcomes. However, such traits are in practice only rarely taught explicitly and their implicit presence in a curriculum is difficult to identify, let alone evaluate with a percentual share of total learning activities.

The idea of Figure 7 is that each of these sections can form a potential area of expertise and a potential focal point in a curriculum. The amount of focus which curriculum dedicates to each section, can be interpreted as the attention profile of the program. A notable limitation is that the model analyses content areas in curriculum not specifically the precise amount of attention turned to topics or the actual quality of input, nor least the quality of study output.

The sample of curricula was formed with following criteria:

1. The title applies appropriately broad focus to logistics.
2. The curriculum belongs to first level of higher education with at least three year nominal full-time study duration. In most cases this means a bachelor degree, but in some countries and cases, vocational diploma is awarded. Master level was not included as approaches there tend to be more specialised and narrow, which would blur the comparison.

3. The curriculum is international, i.e. in English. This constrained the sample notably and intentionally. With local programs, more specific regional focus can be expected, whereas international programs could be assumed to be more universal to a certain degree.
4. The sample only focused on European curricula. Valid continental differences have already been suggested in other studies. The aim here is to concentrate to identify variety inside a region.

The initial list of suitable curricula was identified through databases available at http://www.university-directory.eu/ and www.bachelorsportal.eu/. This netted altogether 71 curricula: 18 from United Kingdom, ten from Germany, nine from Netherlands, six from Poland and various others. The next step was considering specific data availability. This was partially a further reason why the research was limited to Europe – in some areas, publicly available information tends to be on average less specific. The data was deemed suitably specific in 42 cases and these were then evaluated against the model.

The measuring of each curriculum results in a 15-dimensional vector, which then can be treated as a specimen for hierarchical cluster analysis. The matrix with 42 vectors was analysed with cluster analysis tools in Statistica 10 software package. Ward's clustering was used, where according to Hair *et al* [72], similarity of specimen is calculated as the sum of squares between the two clusters and which tends to result in clusters of roughly equal size. As all the data elements were percentual, there was no need for data normalization.

2.5.2. Four General Types of Logistics Curricula

After the curricula had been manually analysed and descriptive 15-dimensional vectors obtained, the software outputted the dendrogram on Figure 8. The first separating segment is located in the far right with six specimen.

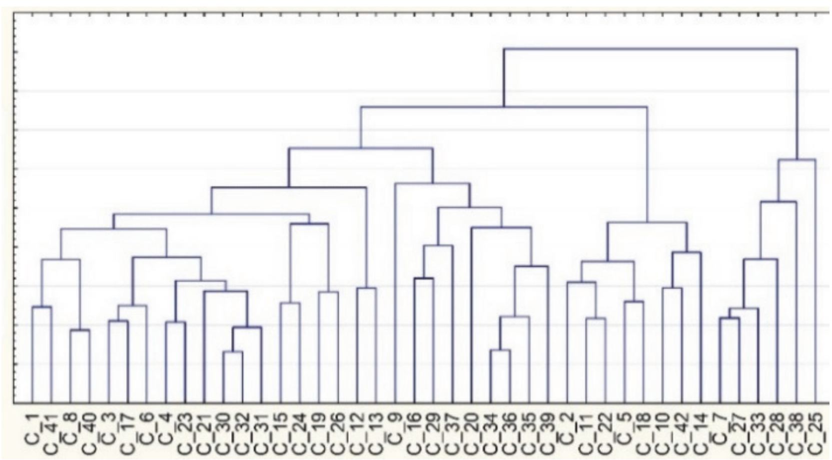

Figure 8. Dendrogram of relations between 42 curricula in a sample
Source: Statistica 10 cluster model output of authors' data, first published in [135]

Closer inspection reveals that these stand out by emphasizing various engineering topics: transport, handling and IT technology. The curricula also underline the role of basic natural sciences: mathematics, physics etc. All six carry different names, not all of them titled engineering. However, due to their actual content, it is appropriate to call this cluster "*logistics engineering*".

The next branch included eight curricula. This segment was starkly different and relative focal points both types of curricula are visualized on Figure 9.

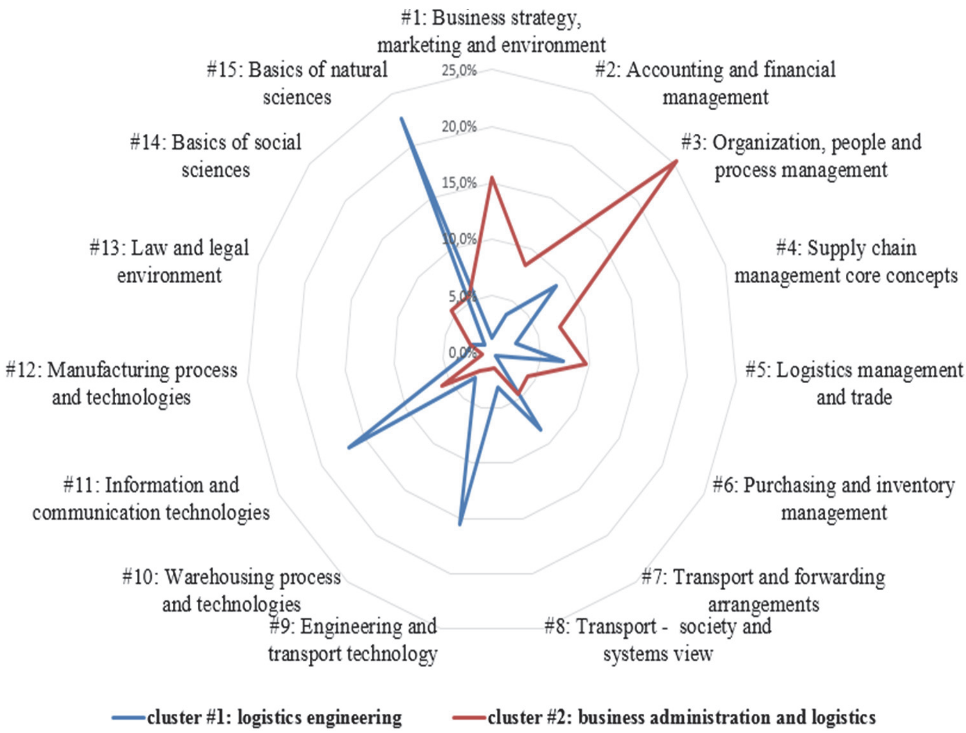

Figure 9. The contrasted curricula profiles of two extreme clusters in logistics undergraduate education: *logistics engineering* and *business administration* perspective
Source: author's compilation, first published in [135]

The specimen of the second cluster emphasise heavily general business topics: marketing, business environment, operations, human resources management etc. Therefore it seems most fitting to label this cluster "*business administration and logistics*". The element of logistics here comes mostly in a form of general introductory courses to logistics operations and management. While some representatives in this cluster have indeed formulated their curriculum as traditional business administration with a major in logistics, others are "business logistics" or "logistics and supply chain management", even though this cluster does not stand apart from the rest by including more courses on SCM.

This leaves 2/3 of curricula that could be further categorized. The leftmost 17 on Figure 8 are by average profile quite similar to previous cluster, with two clear differences. Firstly, the focus on general management has been replaced by more topical courses of logistics and distribution management. Secondly, this cluster dedicates roughly twice the attention towards the foundations of natural sciences – but still not nearly as much as done in engineering cluster. The third cluster is called "*interdisciplinary logistics management*" – the management aspect here is focusing towards logistics processes and networks.

The leftover middle section of Figure 8 has one key difference from the third cluster – they dedicate substantial focus on transport topics. The average profiles of curricula in third and fourth cluster are depicted on Figure 10.

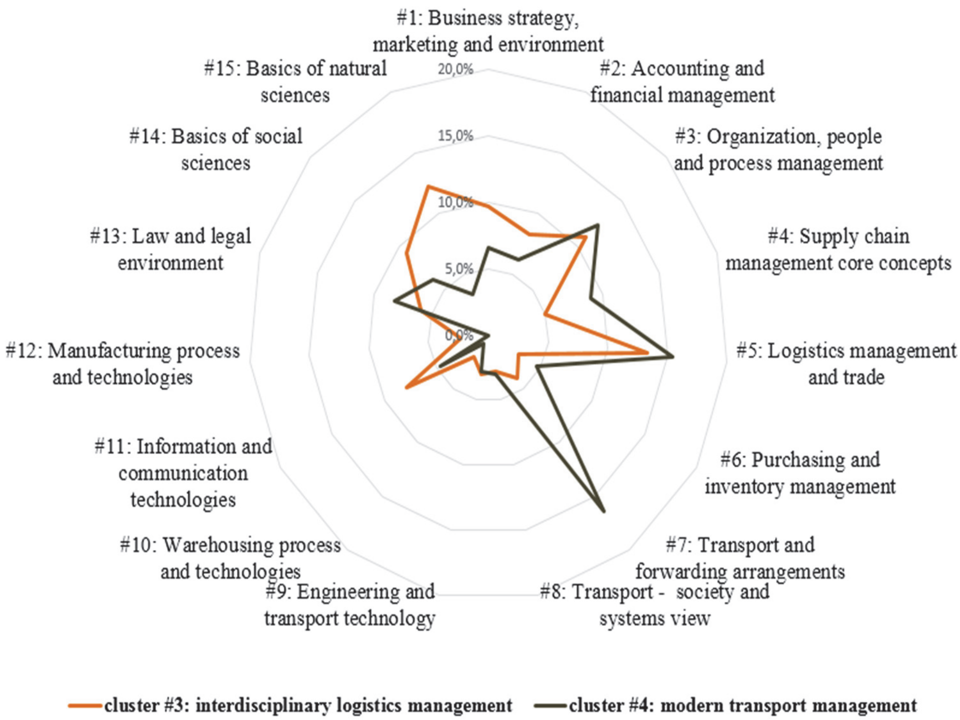

Figure 10. The contrasted curricula profiles of clusters *interdisciplinary logistics management* and *modern transport management*
Source: author's compilation, first published in [135]

In practical terms, the fourth cluster includes dedicated courses on transport modes and cargo forwarding operations, hence the name for the cluster: "*modern transport management*". To achieve greater focus on these topics, lesser focus is dedicated to foundational knowledge and business background.

Across the four clusters, there are also similarities. In most cases, logistics curriculum includes one course for warehouse operations and management and one for inventory management. The study also identified aspects which vary more but not substantially – such as legal issues and manufacturing viewpoints. The percentual shares of curriculum attention turned to all 15 dimensions across the four categories are better visualised in Table 6.

Table 6. Average curricula profiles of four main categories in logistics education

Content areas	**Logistics engineering**	**Business management**	**Logistics management**	**Transport management**
Business strategy, marketing, environment	1,3%	15,5%	9,7%	6,6%
Accounting and financial management	3,7%	8,4%	8,3%	6,2%
Organization, people and process management	8,8%	25,2%	11,0%	12,3%
Supply chain management concepts	2,6%	7,3%	5,0%	8,9%
Logistics management and trade	7,3%	9,7%	13,3%	15,4%
Purchasing and inventory management	0,5%	4,3%	2,9%	4,7%
Transport and forwarding arrangements	8,5%	4,5%	4,0%	16,4%
Transport - society and systems view	3,1%	1,4%	2,8%	3,0%
Engineering and transport technology	15,5%	1,6%	3,1%	2,8%
Warehousing process and technologies	2,8%	2,0%	2,0%	0,8%
Information technologies	16,8%	5,9%	7,8%	4,7%
Manufacturing process and technologies	2,7%	0,9%	2,3%	0,0%
Law and legal environment	2,1%	2,3%	5,9%	8,2%
Basics of social sciences	1,0%	5,5%	9,2%	6,2%
Basics of natural sciences	22,7%	5,6%	12,2%	3,3%

Source: authors' data from cluster analysis

The outcome does not mean that the range of logistics is only limited with the described four perspectives, but that these are the most dominant. The general level of variety suggests that there are substantially more ways to build different programs and still "get away" with calling it just "logistics".

In summary, this study identified four categories of logistics curricula on undergraduate level in Europe, reflecting the current variety on the field of modern logistics curricula. The curricula do have certain common core, but actual profiling differences between curricula are substantial. In some respects it is problematic, but on the other hand it is also a good thing – provided that the basics (the scope of which is unfortunately unclear) are covered sufficiently, it is welcome if universities focus on niches not typically covered elsewhere.

2.6. Conclusions and discussion of Chapter 2

The author would like to point out the following conclusions and afterthoughts relating to research questions no. 4-7.

1. A vital theme in logistics education is interdisciplinary competence profile design. This does not necessarily conflict with intersectionist theory. Instead it reiterates that regardless of programme scope, certain cross-disciplinary variety is advantageous. This is also supported by academic concepts of systemic logistics. Although logistics is just a subset of SCM, it does not mean that it is a trivial occupational area not worthy of separate paradigm in academia.

2. There is notable variety, mismatches, conflicting priorities and debate between approaches to logistics on the level of certification programmes, competency models and university curricula. As standards are contradicting and overall standardisation in logistics education is weak, universities are getting mixed messages on what to teach. The variety of curricula is notably influenced by the lack of harmonised input from both competency model layer as well as from theoretical treatments. This results in logistics curricula boards needing to rely mostly on other sources of development input – either directing more attention towards the characteristics of local labour market or perhaps instead focusing on own strengths and existing resources, which further diversifies the landscape. The author argues that a higher degree of standardisation would benefit logistics education so that input from "universal theoretical views" and "local practice" would be more proportionately balanced.
3. The existing competence models in logistics can all be used partially in curriculum development, but it has to be acknowledged that the models are different and none of them are universal. Chapter 2.4 created a merged model of logistics knowledge areas across existing competency models. The outcome is by main intent in principle usable in efficient curriculum evaluation, although in practice it might be partially seen more as a theoretical curiosity, given that centerfield, all-bases-covered logistics education does not seem to be a popular priority. It appears that a carefully balanced "something for everyone" curriculum is really challenging to reach nor is it actively sought after.
4. The cluster analysis of logistics undergraduate curricula in Europe pointed out that the field is not in complete disorder, but with a distinct four-way typology. While some universities approach logistics as a functional specialisation in conventional business studies, others dedicate more attention either to planning of logistics flows, processes and network or put more focus to transport-specific issues. **Notably separate cluster was "logistics engineering" with dedicated attention towards technologies, design and the foundations of natural sciences.**
5. The four categories are foremost descriptive and the author proposes care in attempting to make normative conclusions. Every program can be optimal given its own local context. The four approaches cater for somewhat different needs in the economy and graduates of all competency profiles can be applicable on the labour market to find work that would suit their profile. There might of course be a question of a proper balance between those approaches, but the current data is much too limited here to even grasp the supply side quantitatively, let alone the demand side.
6. It should not be suggested that some universities would severely lag behind in keeping their programme up-to-date and in adjusting to modern trends. It can be argued that curricula boards are actually less restricted by the lack of strong standardization than anything else, given the overall dynamics in the business and technological environments. However, as

internationalisation in education is steadily growing and logistics is by nature a global industry, making sure that also universal and standardised elements are used in development input would support student mobility as well as would make curricula development more efficient.

7. Nevertheless, the conceptual problem appears to deepen over time. Even though four clusters emerged, the content of curricula might not match their title. An informed specialist has little trouble glancing the course content and making appropriate conclusions. However, it is likely that in some cases, a high school graduate or potential exchange student is ending up confused. When it happens that the actual content does not meet initial expectations, it is only partially student's fault but also the responsibility of academia to communicate the educational offering more clearly.
8. The push towards better clarity has to come from academia on both conceptual and competency standard levels. Current standards in logistics appear to be more focused on competition and differentiating from the rest rather than moving towards harmonisation. Therefore, if logistics can be extensively flavoured in many ways, it can finally reach the point which raises the question if it is still in principle even the same main course.

All in all, the findings suggest that competency standards in logistics need both harmonisation as well as development of modern profiles. As it is often noted, the required education profile needs to be T-shaped combining strong foundations with clear specialties. Therefore it would be beneficial to have well-formulated concepts for all four types of logistician's profiles and possibly more. Currently, some are better off than others and still everything is called "logistics". There is a clear need to specify that perspective. Wu [193] has noted that there is a dominance of business focus over technology design and engineering focus in logistics and the authors observations are in accord.

It appears that from the four perspectives, logistics engineering is the category which needs strengthening the most in terms of clear competency profile, as the existing approach by SOLE is vague and not often updated. This forms the core of chapter 3.

3. SYNTHESIS – CONTRASTING LOGISTICS AND SUPPLY CHAIN MANAGEMENT

This chapter focuses on treating logistics distinctly from SCM. Previous chapters led way to explain why this is needed – clarity and concept sustainability – and the level this formulation should take place on to achieve critical mass for wider acceptance – on both conceptual and competence layers.

Chapter 3.1 summarises a survey, which applied Halldorsson-Larson method across local Estonian educators in logistics and contrasted perceived competency profile of "logistics manager" to "supply chain manager" to identify, if separate treatment appears relevant in a local education landscape.

Chapter 3.2 contributes to filling one gap in the layer of standardised competency profiles in logistics, which is logistics engineering – one, that is in rough approximations existing in university practice but in non-standardised ways. The profile integrates major future technology areas in logistics and views from systems engineering – hence the suggested title "logistics systems engineer". The chapter includes an overview of literature on both "logistics engineering" and "systems engineering" concepts.

The approach to logistician profile in chapter 3.1 is based on practice and demonstrates that logistics is already seen as a separate profile from SCM (research question no. 8). The second approach emerges normatively based on theoretical considerations and ideas echoed in this dissertation, which exhibits an alternative view to logistics (question no. 9) – a profile that fills a different niche and is comprehensive and more modern than many current practices.

3.1. Logistics and Supply Chain Managers: a Local Survey

The survey summarised here took place in the winter of 2013 in Estonia. The central idea was to carry out a study much similar to the one done by Larson and Haldorsson in 2004 [102], as described in chapter 1.2.1, to identify, how the fields of logistics and SCM are seen in the minds of local educators in the area.

The motivating aim of the study was to empirically test if the four-way typology reflected in the original survey still remains as a source of confusion or has the understanding developed towards any better clarity. In 2009, the author of this work [140] had carried out expert interviews with a selection of academia representatives and found that there was still notable debate on the concept relations, which hindered academic cooperation as well as implied difficulties in communicating with industry specialists.

3.1.1. Methodological Considerations

The mathematical model in the original study appeared methodologically sound so it was applied without alterations. The central question was redirected – while the original study asked if the following topics were relevant for "logistics management" and "supply chain management" courses, then the new study asked to "*determine the importance of the following items in a „ought to be" competence profile of a supply chain manager and logistics manager*".

The question was turned towards workplace competencies for three reasons.

1. Understanding the view to tasks and responsibilities in industry practice was relevant in itself as well as in identifying if separate study programs are needed from universities.
2. Academic course approach was not deemed sufficiently practical, as studies are becoming more modular and in this context one course is not nearly enough to even list the requirements in an integrated way.
3. In a small local environment as Estonia, it can be suggested that even though respondents would see supply chain and logistics manager as somewhat separate profiles, they could still be effectively merged in "one-size-fits-all" programme to get economy of scale in teaching. As such approach had been prevalent in the past, the workplace viewpoint was needed to ensure that the respondent would express their ideas in ideological sense – the „course" approach would have left some educators in conflict between their normative view and their actual teaching job.

The list of elements enquired in the survey were modernised and specified. While the initial 88 items were not structurally divided by authors, the update lent input from profession-focused elements from APICS respective competency models [4 - 5]. As a result, ten key areas of competence were filled with 100 keywords, including various knowledge areas, skills, participation and management of processes aiming to maintain a balance between strategic, tactical and operational issues. The survey also asked the respondents to state view in the terminological debate directly. This presented the opportunity to test whether, for example, someone claiming to be "unionist" is actually a unionist according to their measured answers or perhaps some extent of "paradigm blindness" could be identified. The survey form is presented in appendix 2.

The survey was sent out to 80 educators at Estonian universities. The respondents included teachers also from general management topics to better understand not only the educated specialist view but also that of people who might not know the theories and details of modern SCM and logistics but are still affecting the students by explaining their views in broader context.

The anonymous web-based survey gathered 29 full responses. Some of the invited participants declined by stating that they lack the expertise to know the "theoretically" correct view. Still, exploratory conclusions and statistically valid general statements (with Student t-test) can be shown on the limited sample.

3.1.2. Findings – a Case against Relabelling

The respondents initially identified themselves as: 14 intersectionists, 8 unionists, 4 traditionalists and 3 relabellers. Their answers to the main question, however, produced slightly different picture as shown on Figure 11. The stated personal opinion on Figure 11 is shown with various markers, whereas the categories of viewpoints based on detailed survey data is marked as segments.

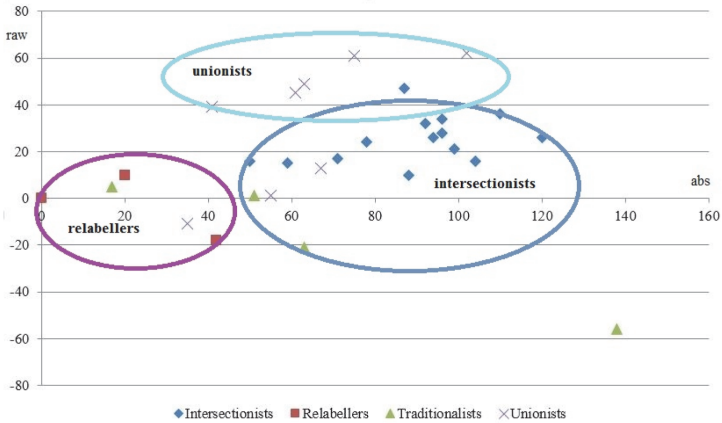

Figure 11. Respondent’s views categorized into predefined schools of thought[2]
Source: author’s compilation, first published in [139]

The initial study of 2004 [102] applied cluster analysis to demonstrate four existing clusters. In the current study, the same hierarchical clustering failed to give results that could be similarly interpreted. Instead, it appeared that the majority of viewpoints had closed in to form the central opinion of intersectionism while the boundaries to unionism and relabellers were still unclear. Traditionalism is almost completely absent and relabelling has marginalised. Of four respondents identifying as traditionalists, one is clearly a relabeller, one an intersectionist and one difficult to identify. This is in stark contrast to the original study and demonstrates that majority of representatives of local academia treat logistics manager separately from supply chain manager.

The remaining confusion can be further interpreted in environment-specific context – as local economy is small with a substantial share of micro and small enterprises, then in a smaller company, it is much more probable that the person managing logistics is also responsible for supply chain issues therefore the terms would practically serve as substitutes. In this regard, the dominance of intersectionism in the eyes of local specialists was positively surprising.

This suggests logistics management has relevance – intersectionism has withstood the attacks from relabellers and on other front from unionists, who would claim that a logistics manager is just “incomplete supply chain manager”. Unionism prevails, although it is connected to SCM being „ fashionable topic“. The remark about relative simplicity of local landscape applies here as well.

[2] The mathematical model and indices on x- and y-axis are explained in chapter 1.2.1.

A closer view exposes substantial differences between the profiles. Table 7 demonstrates intersectionism with eleven highest and lowest rated topics in both profiles. In the top, only one element is shared: information flow analysis.

Table 7. Eleven most important and least important competences expected from a supply chain manager in comparison to a logistics manager

Topic or competence field	**SCM score**	**Topic or competence field**	**LOG score**
Supply chain cost optimisation	4,86	Transport cost optimisation	4,62
Analysis of competitive advantages	4,76	Transport market overview	4,59
Information flow analysis	4,66	Choice of mode	4,52
Supply costs analysis	4,62	Transport cost analysis	4,52
Negotiations	4,62	Track & trace	4,48
Defining general company strategy	4,59	Warehousing and picking systems	4,45
Change management	4,59	Incoterms	4,41
Cash-to-cash cycle time	4,55	Information flow analysis	4,41
Supplier performance analysis	4,55	International transport regulation	4,41
Supply chain synchronisation	4,55	Warehousing cost analysis	4,38
Distribution system planning	4,52	Defining and implementing strategy	4,34
...	...	...	...
ISO9000/14000 standards	3,55	TQM	3,28
E-business	3,52	Production planning	3,21
Packaging solutions	3,41	Supplier performance analysis	3,17
Vehicle usage analysis	3,21	SCOR-model	3,17
Inventory control methods	3,14	Calculating economic value added	3,10
Cargo consolidation for transport	3,10	B2B marketing	3,10
Road tolls	2,97	Product lifecycle analysis	3,10
Cargo space utilization	2,83	Supplier choice criteria	3,07
Drivers work time regulations	2,83	Collaborative forecasting	3,03
Vehicle capabilities	2,79	E-business	2,86
Load securing	2,38	Currency risks analysis	2,76

Source: authors' survey results, first published in [139]

The Student t-test, with 95% confidence level, revealed that with 68 of 100 items the null hypothesis was rejected: altogether 50 items were significantly more relevant for SCM than logistics, for 18 items the other way around and the remaining 32 items represent "the common ground". The first group of 50 items can be seen as supporting unionist view, but it can also be that the study design was still a bit biased towards more SCM topics than hands-on logistics topics, as a couple of respondents pointed out. Therefore, it could be argued that the differences between two profiles are more substantial than the survey could demonstrate. Only 1/3 of elements were shown to be equally relevant for both logistics and SCM and 1/6 formed special competence of logistics manager.

Table 8 summarises elements with highest perceived differences from both ends of the spectrum (tested to be significantly different): selected ones from the SCM extreme and all 18 from the logistics focal point, with respective t-values. It appears that transport aspects are seen less relevant to SCM whereas mostly purchasing and supply issues are seen of lesser relevance to logistics. The polar differences are substantial and therefore suggest that separating the profiles in studies is a more practical approach, though some courses can easily be shared.

Table 8. Most sizeable gaps between the two competence profiles

Topic or competence field	**SCM score**	**LOG score**	**SCM - LOG**	**t-value**[3]
Supplier performance analysis	4,55	3,17	1,38	4,429
Supplier choice criteria	4,41	3,07	1,34	5,124
Supply costs analysis	4,62	3,45	1,17	4,250
Supplier relationship management	4,48	3,34	1,14	3,927
Collaborative forecasting	4,07	3,03	1,03	2,937
Cooperation in supply chain	4,45	3,48	0,97	4,632
Currency risks analysis	3,72	2,76	0,97	2,605
Purchasing cost optimisation	4,28	3,31	0,97	2,251
Calculating economic value added	4,03	3,10	0,93	2,511
Cash-to-cash cycle time	4,55	3,72	0,83	4,800
Supply chain cost optimisation	4,86	4,03	0,83	5,870
SCOR-model	3,97	3,17	0,79	4,737
Inventory mapping in supply chain	4,14	3,38	0,76	4,297
...	...	...	...	...
Transport market overview	4,21	4,59	-0,38	3,638
Packaging solutions	3,41	3,83	-0,41	2,052
Customs regulations	3,76	4,21	-0,45	2,776
Warehousing and picking systems	3,93	4,45	-0,52	2,726
Track and trace	3,93	4,48	-0,55	3,417
International transport regulations	3,86	4,41	-0,55	3,016
Transport cost optimisation	4,03	4,62	-0,59	2,674
Route optimisation	3,69	4,31	-0,62	3,415
Inventory control methods	3,14	3,79	-0,66	3,272
Transport cost analysis	3,86	4,52	-0,66	3,088
Choice of mode	3,72	4,52	-0,79	4,214
Road tolls	2,97	4,07	-1,10	5,055
Driver work time regulations	2,83	3,97	-1,14	5,299
Cargo consolidation for transport	3,10	4,27	-1,17	5,147
Vehicle usage analysis	3,21	4,38	-1,17	5,893
Cargo space utilization	2,83	4,21	-1,38	5,870
Vehicle capabilities	2,79	4,21	-1,41	5,874
Load securing	2,38	3,83	-1,45	5,769

Source: authors' survey results, first published in [139]

[3] Given the sample size, the reference t-value with 95% probability level was 2,048. The analysis was conventional paired Student t-test. Higher than reference t-values indicate significant difference between two profiles in respective elements. The table has truncated SCM-oriented and shared items, but includes all topics with specific relation to logistics in the bottom part of the table.

T-values is table 6 were calculated by MS Excel with formula (3):

$$T = \frac{\bar{d}}{SE\ (d)} = \frac{\bar{d}}{\frac{sd}{\sqrt{n}}} \quad (3)$$

where $\bar{d}$ stands for average difference between data sets across all respondents in respective element, $SE\ (d)$ is a standard error of mean difference, s_d is standard deviation of the differences and n represents sample size.

Examples from the "shared core" included various topics and management levels: barcodes, performance indicators, just-in-time, dead stock analysis, cargo clauses etc. – such items form the roots of relabelling view.

The aggregated sums across ten competence categories are presented in Table 9. The differences between two profiles were statistically distinct in all ten categories. In the section distribution and transport, 11 out of 14 items were significantly more relevant for logistics managers and the other three belonged to the middle ground, specifically *distribution system planning, cargo clauses* and *reverse logistics*. For some categories, the elements were roughly split. Warehousing, for example, included nine topics of which three were seen as closer to logistics – *picking systems, packaging,* and *inventory control methods* – while six had shared relevance – *warehouse management systems, RFID-tags, automated warehousing* etc. One comment to make is that physical operations were seen more closely related to logistics. If it is a detail of transport, it is not SCM, but if it relates on information flow, it is both logistics and SCM.

In terms of purchasing, general management and process management topics, SCM dominance over logistics was the most notable. It was even slightly surprising and it could be interpreted as logistics being treated clearly on a lower level of management compared to SCM. In comparison to some theoretical views, the treatment of logistics manager responsibilities among the respondents was notably narrow. Even in inventory management, four items out of ten were seen as less related to logistics than SCM, namely: *VMI, forecasting techniques, forecast accuracy* and even *reorder point calculations.*

Table 9. Perceived competence mix of a supply chain and a logistics manager

Competence category	SCM average	LOG average
Distribution and transport	3,44	4,24
Warehousing	3,74	4,01
Information flow and information systems	4,08	3,79
Finance specifics	4,24	3,78
International environment	3,85	3,65
Purchasing and supplier relations	4,43	3,58
Sales and customer relations	4,23	3,90
Inventory management	4,13	3,82
Process management and supply chain optimisation	4,13	3,71
General management and strategy	4,26	3,88

Source: authors' survey results, first published in [139]

In conclusion, the findings indicate that logistics manager is a distinct competence profile in the eyes of local educators, though a rather narrow perspective compared to some understandings in academia. It proposes that logistics as education area is still relevant next to SCM – one more strategic, the other focusing on details. Most individual views in the survey object relabelling or reject it fully, while the specific composition of differences is up for debate.

3.2. Logistics Systems Engineer Competency Profile

Although *logistics engineering* has backing from a non-profit international organisation (SOLE) and has at first glance an extensive respective certification programme (CML) [174], it is not without shortcomings. First, the programme does not define competency elements, but nebulously postulates two pillars of education areas: *systems management* and *distribution and customer support*, which are expanded into different lists of 39 elements in two occasions in the same Study Guide [173]. Secondly, the elements are not formulated as learning outputs, which is expected from modern competence models and which would define better specific roles of workplace performance. Lastly, the programme manual was last updated in 2005. Another topical organisation is Council of Logistics Engineering Professionals CLEP. However, they appear to be present only in the USA, they are not running specific certification system and judging by their web-page [27], their focus is directly aimed at military logistics.

In order to construct a broad systems approach, remarks have to be made first on current academic views to *logistics engineering*. The author is moving on to introduce modern treatments of *systems engineering* competencies as a non-domain-specific approach to engineering, which is then integrated with elements of various levels of logistics competencies and most important future technology areas so that the outcome would follow systemic ideas as presented in chapter 1.1.2, technology trends of 1.3, would be suitably interdisciplinary and still would have distinct differences from an average SCM approach.

3.2.1. Logistics and Supply Chain Engineering

A visionary paper promoting logistics engineering education from systemic perspective was published in 2000 by Naim *et al* [131]. The authors argue that logistics as a discipline is still in "infancy" stage and suggest the idea of "*logistics systems engineering*" as a modernised systems and process perspective to logistics education. Naim *et al* claim that logistics is essentially by definition process-centric by being based on planning of material and information flows. The paper, however, only touches briefly the aspect of constructing a single course, not a full curriculum. This course would be founded on four interlaced areas of finance, organisation, technology and people, as first modelled by Towill [185]. Naim *et al* [131] expand this approach and suggest 33 elements as topical components in a systemic logistics course categorised across the four pillars.

All in all, while the ideology of the paper is much supported and reflected in this dissertation, their practical contribution was notably superficial and it appears the paper has gone largely unnoticed, only being referenced a handful of times by other authors, mostly on more distant topics. Still, the authors [131] clearly communicate the message that "*a logistician has to be able to bridge the gap between the "soft" system issues and the "hard" engineering requirements that characterize any logistical problem*."

In terms of more recent publications, notably little has been written on *logistics engineering* in general as most academic references date back to previous century. This does not mean that technologies, design and implementations in logistics are not analysed, but that the field appears conceptually out of fashion. What is lacking is a systematic and integrated approach to LE topics. Furthermore, though there are few books on LE, it is unfortunate that one prominent specimen [183], combining chapters from over 40 authors, does not properly define the area. The preface promises to "*provide a comprehensive reference tool that could be effectively used as an engineering textbook*", but the book itself is a loosely linked collection of papers with no explanation of a systematic view to structure. One chapter suggest an "logistics engineering toolbox", but is really an introduction to a handful of mathematical research concepts and algorithms – relevant but selective view at best and not relating to a variety of topics discussed further by Teodocovic *et al* [184].

In contrast, Sutherland [180] has pointed out: "*there are few, if any, significant differences between the two* [logistics management and logistics engineering] *except that logistics engineers are often charged with handling more "scientific" applications / ... / such as optimising vehicle routing problem*". Such treatment is probably the type of case referenced by Ghiani *et al* [61], according to which some views to LE are too narrow and quantitative.

Recently, the term LE has been in a much broader sense applied in military context, which can be interpreted also in business setting. Sanford [160] has listed five key areas of LE-related core competences: material management, distribution, air transport, fuels and contingency operations. According to Jones *et al* [91], LE forms a foundation to ensure availability, life-cycle management and cost optimization: "*Logistics engineering brings science to the art of logistics and optimizes difficult programmatic decisions in a recourse-constrained environment. /.../ Logistics engineering is a technical discipline that applies analytics and tools to facilitate knowledge-based decision-making through-out a system's life-cycle. Logistics engineering addresses all facets of systems acquisition."* Not only is such life-cycle planning view numerous levels broader than mathematical optimisation, but most notably, the report also includes the dimension of process engineering, even incorporating approaches such as *lean six sigma* and *theory of constraints*.

Some authors apply similarly broad focus in business context under the rather new term "*supply chain engineering*" (SCE). M. Goetschalckx [67] has recently written a book on his view of the concept, where he also stresses the relevance of managing supply chains through systems engineering concepts: "*A* *supply chain system can be loosely described as a system that – through procurement, production, and distribution – delivers goods to satisfy the demands. / ... / A systematic approach to the design and planning of any supply chain can be based on the principles and methods of system engineering."*

The book promotes various process modelling tools and algorithms ranging across engineering design, demand and supply forecasting, transport planning, inventory optimization and supply chain systems. Dolgui and Proth [42] are promoting a similar, if not even wider view by also including elements of outsourcing and pricing and stating that "*supply chain engineering is based on analysis of essential principles of production and distribution systems*". Furthermore, according to Miebach [120], supply chain engineering covers the design of both technical and economical characteristics of supply chains.

In summary, it seems the treatments of LE and its extension SCE, range from specific fragmented optimisation tasks to designing, optimising and reconfiguring characteristics of complex supply chain systems on strategic and global levels. The former appears evidently too narrow for a widely applicable competence profile. The most augmented approach however runs into risk of being close to equivalent with supply chain management and this would mostly ruin the purpose of striving for more clarity in the area. Hence suitable balance must be found between twin goals of specifying an interdisciplinary logistics engineering profile and defining the difference from SCM.

The philosophy applied in this dissertation is the one of intersectionism, which leads to a practical question: which elements of SCM should not belong into engineering treatments. Using the model of eight subsystems of SCM as defined by Lambert, the engineering view is most distant to the aspects of customer and supplier relationship management, whereas all the other pillars deal more directly with processes, that require development and life-cycle management of technological solutions as well as process monitoring and reconfigurations according to strategic goals. In other words, SCM would be more focused on understanding the strategic environment, setting strategic goals, principles and service standards that should be met as well as developing partnerships and optimising relationship networks. In comparison, engineering perspective would be focused on understanding the realities on which solutions and process configurations are feasible and what are the systematic impacts of various alternatives across functions and viewpoints. An engineer would be responsible for monitoring process performance across core logistics areas and would also need to be competent in terms of concurrent engineering and project management. This would still leave many supply chain aspects as shared responsibilities between the two viewpoints, but the idea is that one provides strategic input and the other realizes the solutions.

It should be emphasised that in such view, similar to Naim *et al* [131], the key element is systems engineering. Whether to call it supply chain or logistics engineering is practically a secondary consideration – in content, the terms would be equally suitable, as "engineering" is the defining and contrasting part from SCM. The supply chain view would keep LE up-to-date with forefront of technology and business realities. Literature indicates that supply chain engineering is a fresh concept starting to gain momentum. This work argues, however, that it would be more beneficial to retain the name logistics, as it would separate two terms more clearly (SCM and LE) and would slightly alleviate the issue of logistician being understood in two extremes: as "a person who calls for a truck" and "a person who essentially manages the organisation".

3.2.2. Systems Engineering as a Competence Area

Systems engineering is a more established interdisciplinary field compared to logistics engineering. The International Council on Systems Engineering INCOSE [84] has described SE as the discipline developed to realize successful systems by focusing on defining customer needs and required functionality early in the development cycle and integrating a structured development process that proceeds from concept to operation. In another formulation, According to Locatelli *et al* [104], SE is an emerging paradigm in complex project environments to transform the governance from "project based" to "system based". Even though the field is dynamic and evolving, it is mostly agreed that a key element of systems engineering deals with managing complex engineering systems over their entire life cycle.

The lifecycle view has been described my MITRE [124] in a V-shaped model, which presents seven components of SE: concept development, requirements engineering, system architecture, systems design and development, integration, testing and evaluation and finally transition operation and maintenance. As commented upon by Locatelli *et al* [104] and Ferris [56], SE covers both technical aspects and managerial concern. According to BKCASE platform [14], a systems engineer "*serves to translate customer needs into specifications that can be realized by system development. The systems engineer must analyse, specify, design, and verify the system to ensure that functional, interface, performance, and other quality characteristics, and cost are balanced to meet the needs of the system stakeholders*"

There are various models of competencies in the field, comparatively analysed by Ferris [55]. Competence in this context is understood in a broad sense reaching across skills, knowledge, abilities, behaviours and other characteristics performed in work roles that are observable and measurable. The models with wider recognition that were reviewed for this work by author are:

1. "INCOSE Systems Engineer Competency Model" by International Council of Systems Engineering [83];
2. "Systems Engineering Competency Model" by MITRE Corporation [123];
3. "Systems Engineering competencies" by Academy of Program/Project and Engineering Leadership APPEL [6].

The INCOSE framework [77] is divided into three areas of systems thinking, holistic life cycle view and systems management. It has been noted that "*the*

INCOSE framework is simple and easy to understand and focuses on specific aspects of competency". The MITRE model [123] consists of 36 competencies in five sections: enterprise perspectives, SE life cycle, SE management, engineering technical specialties and collaboration and individual characteristics. The APPEL model [6]consists of ten competency areas. In contrast, the model explicitly includes project management, human capital and knowledge management areas, further being composed of 114 elements.

The current field of engineering education has been criticised by a few authors. Patil and Codner [145] note: "*There is increasing evidence of a mismatch between graduate student's skills developed and those needed by graduate engineers in the workplace*". Davidz and Nightingale [35] have indicated "*the adequacy of certification programs remains controversial, primarily due to their newness for widespread certification*". Recently, integrating SE into the profile of any engineer regardless of domain has been advocated by Wasson [189], who proposes a course guideline with a set of 43 elements of SE fundamentals: *"... understand the difference in SE as a professional career discipline versus domain engineers that apply SE methods, processes and tools to solve domain specific problems. Both contextual roles are crucial to meeting team needs to develop complex systems*"

In conclusion it appears that systems engineering has characteristics which could also be useful in logistics education – it strives for a "big-picture" life cycle view, it involves a mix of technical and economic principles in the framework of project and system management and as such it is notably "more interdisciplinary" than some current constructs.

The author has previously shown [137] that selected logistician competency profiles described earlier in chapter 2.2 are not sufficiently including SE elements. It is noteworthy the even a model built originally with engineering focus, SOLE, does not appear to explicitly include many detailed aspects of SE, at least not according to comparison with elements as they are formulated in the reviewed SE competency models. The author argues that this is not intended by design in principle, but rather an oversight to be fixed.

3.2.3. Creating a New Competency Model

This chapter introduces the competence profile of *logistics systems engineer* that is a result of integration of SE competency perspectives, modern most relevant technology areas in logistics and selected relevant elements of existing models of logistician competency. The methodological considerations were more thoroughly commented on by author in a recent article [137]. The process of new model creation and the primary inputs are visualised on Figure 12.

In model creation, two difficult decisions were needed. Firstly on the extent of SE elements to include and secondly on the scope of logistics decision areas. The result includes basics of processes, technologies, models and optimisation tools, whilst still ensuring that functional skills are developed along with strategic and management issues. Therefore INCOSE, MITRE and APPEL models were analysed and consolidated, accounting for suggestions by Wasson [189]. While the topic reach shouldn't be precisely measured, it was envisioned that SE material would cover about 15% in the resulting curriculum guideline. What is more important, is to include SE-specific approaches to course design and teaching methods so that not only the curriculum would be of interdisciplinary variety but that the philosophy behind it would reach the level of courses, learning methods and study assignments.

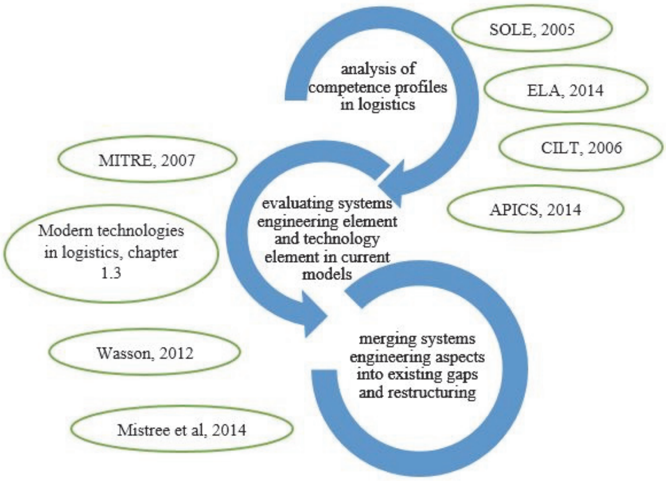

Figure 12. Applied methodology and main inputs in new model design
Source: author's compilation, first published in [137]

In exploring the technological frontier in logistics engineering, the author analysed which technology elements, as were summarised in chapter 1.3, are already present in the current models of logistics competences (described in chapter 2.2). The result demonstrated notable absence across board.

1. APICS model [4] states "*demonstrates an understanding of the factors that are considered important to the branch of knowledge or technology*" and "*implements new technology*" with no specific reference to *ad hoc* list of relevant technologies. However in various sections, the following technology elements are mentioned: materials and distribution requirements planning (MRP, DRP), ERP, advanced planning systems (APS), renewable materials, energy reduction, warehouse management systems (WMS) and electronic data interchange (EDI).
2. CILT [26] mentions the word "technology" many times but only in ICT context and also without touching specific technology areas, only referencing EDI, e-commerce, internet tools and business software.
3. AST&L model [8] approaches transport through the viewpoint of exploitation and economics rather than design: "*how the operating and service characteristics of each mode affect cost, performance, and the products moved*". The only time "technology innovation" is mentioned in the model is under "creative component".

4. SOLE [173] lists some educational areas connected to technologies and related design and implementation life-cycle: conceptual system design, civil engineering, safety and reliability engineering and user tests. However, none of the technologies listed in chapter 1.3 are mentioned.
5. ELA model [45] states: "*Due to the constant progress in ICT, specific technologies are not defined in the modules. It is a prerequisite, though, that current technologies must be applied in all relevant fields. ICT competences are implicit in every module*." The model mentions vendor managed inventory (VMI), e-procurement, APS, WMS, transport management systems (TMS) and customer relationship management (CRM) systems and software testing. No reference is made to other technologies, except: "*Understands the impact of technological innovation on supply chain design*"
6. IIEI model, CITLS [82] briefly references "*automation and computerization technologies*" without further explanations.

In summary, the models are partially relevant in terms of modern IT and almost completely disregard the relevance of technological development in terms of physical handling and warehouse operations, sensors, tracking and automation solutions nor various types of vehicle development across transport modes.

The author acknowledges that technological component is "lightweight" in management approaches compared to engineering. In that respect it is commended that various IT-concepts have been reflected in some models. However, the amount of physical technologies mentioned in the models is notably lacking. It should be kept in mind that it is challenging to keep models up to date with changing environments, however broad technology areas of expertise would have to be at least mentioned in a competence profile of a professional logistician. The proposed model in this dissertation includes references to ten key trending technology areas as summarised in chapter 1.3.

An additional component in the model is required individual foundational competencies. There is an abundance of personal traits and attitudes that are foundational for a field covering such a variety of jobs as logistics, but recently, Mistree *et al* [122] published their approach to foundational aspects expected from any engineer. To complement traits already present in various models, the author utilised their approach as a double check for outcome quality.

The structure of the proposed model is shown on Figure 13. It consists of six layers, starting from foundational engineering competences. In this view, systems engineering treatments form the conceptual basis to the model that needs to be adequately reflected in treating all the layers. This is followed by a layer for specific technologies that need to be engineered and maintained in logistics, and a core layer of more conventional logistics topic areas. The technology layer covers physical operations of transport, handling, storage and related support. IT-systems are intentionally not included on this layer – rather they form a separate segment of specialty on the layer above, as they relate to integrating all data aspects of logistics and are important to emphasize.

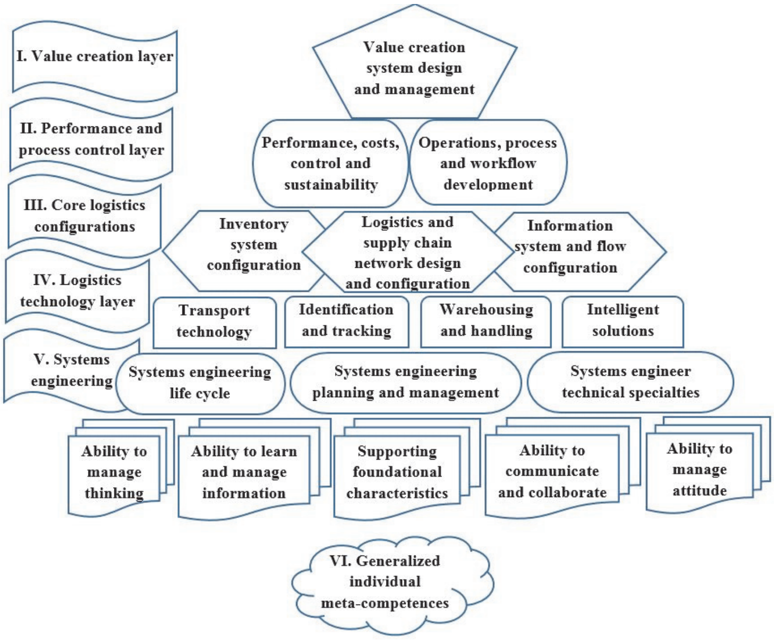

Figure 13. The building blocks of logistics systems engineer's profile
Source: author's compilation, first published in [137]

The core is designed to include broad operational and tactical elements of logistics and supply chain decisions, which are categorised into three parts: *network design and configurations*, *inventory system* and *information system and flow configuration*. The central part foremost includes the areas of supply chain design, supplier selection and evaluation, physical material flow characteristics configuration, transport and material handling arrangements and optimisation. In this view, inventory and information are treated as main variables in logistics networks - alternation in configurations require careful management and understanding of the trade-offs across entire logistics system. This relates to metaphor of information as "glue", which keeps all the systems running and also facilitates planning and control across multiple dimensions.

The idea of presenting these aspects side-by-side refers to the core reaching across the initial requirements for logistics system (understanding demand) to arranging the optimal supply network (suppliers, cost and time implications of deliveries, inventory costs and risks) and keeping the system effective, efficient and flexible by optimal management of information and inventories.

The next layer adds the view of operations and process management and stresses that improvements to logistics system do not only come from technologies, network configuration and better information management but also from optimised workflow and processes – as proper optimisation of processes is what facilitates the more hands-on improvements in logistics quality and stakeholder satisfaction. This layer also includes views to performance measurement in both financial and non-financial aspects in order to provide direct input to all other areas and drive continuous improvement.

The crown of the model, "*value creation system design*" is the strategic capstone of entire logistics system that must explain the driving force – the value generated to customers, but also other outputs that the system is generating that can be valued by other stakeholders. This aspect is on top not only because of importance but also that it is mostly the primary aspect what is perceived of the system from the outside perspective.

Understanding the value creation system gives meaning to all activities in logistics. Changes on this level need to trickle down across the layers to accommodate accordingly: to streamline processes, create new and reconfigure existing supply networks, identify current and future priorities, define investments and bring about innovation. To facilitate it, the roots, i.e. the foundational competences, serve as enablers. Also, systems can develop from bottom to top and the more dynamic the environment, the more crucial is to take advantage of such emerging windows of opportunity.

The learning outputs of the created model are presented in appendix 3. Due to extensive reach of such profile, it is probably not feasible to achieve such training during typical three-year undergraduate programme. The author is therefore leaning towards five year study programs for logistics systems engineers, similar to some other fields of engineering. In authors view, the profile suitably relates to master level formulation and requirements both according to Estonian Standard of Higher Education [178] and European Qualifications Framework [50]. In case of partial implementation of the model is considered by university, some relevant comments are presented in Table 10.

Table 10. Brief application guideline for "logistics systems engineer" curriculum

Layer	**Comment**
Value creation layer	Mandatory elements would need to place the entire organisation into strategic and environment-sensitive context to explain, analyse, feedback and develop the overall output of the system. Value system and value generation analysis is also recommended as course project.
Performance and process layer	Many topics can be treated as electives, but ensuring that elements from both component segments are covered.
Core logistics configurations	Mandatory. In ICT topics, modern areas can be electives, while everyone is taught to design solutions that are already common in everyday business practice.
Logistics technologies	Can be constructed as elective "expertise" pillars, such as: vehicles, automated handling, intelligent transport, simulation, e-commerce, big data solutions etc. Basics in each pillar should be mandatory. Cooperation with leading-edge companies is required to keep content up-to-date.
Systems engineering	As a separate block of courses or alternatively partially integrated into the courses of core subjects. Should not cover more than 10-15 % of *ad hoc* curriculum space.

Source: author's compilation

It must be acknowledged that the model, as any competence profile, is never final but open to local adaptations and to timely alterations in parallel to continuing changes on educational landscape. Still, the result appears usable for curriculum development in the case of authors' own *alma mater* in Tallinn University of Technology. Going further, the model is suggested to be implemented as local occupational standard and, assuming public and industry recognition, also a certification system. This profile would complement and augment current understanding of competence in logistics and with emphasized engineering and technology focus, would best serve for environments that operate on the very frontier of progress in logistics.

3.2.4. Further Research

Further research directly stemming from the topics discussed in this thesis are.

1. More detailed analysis of conceptual and ontological developments in logistics and niche approaches forming as branches of logistics and supply chain management in competences and education.
2. The analysis of SCM educational landscape similarly as carried out for logistics in this work, which would indicate the trends of SCM education.
3. Analyses to quantitatively view the performance of various curricula types in logistics and relate them to labour market realities and demand trends.
4. Studies of logistician and logistics manager profiles in various contexts to refine the role of vocational studies and academic degree studies. For example, in more simple local logistics environments, a world-class logistics systems engineer might be overqualified.
5. Success factors, feedback and other "best practice" analysis in logistics curricula, competency models and certifications. It can happen, that sometimes exceptional individual specimen are even more potent as benchmarking targets than wider theoretic constructs.
6. Enquiries into how systems engineering has been integrated with other domains and what has been learned. This would further refine the "guideline" aspect that the currently suggested profile aims to initiate.

In summary, all trends on logistics education landscape are related to findings in this work. A detailed area of author's future interest is how to integrate SE with logistics not only as topics of study but also as influence factor of applied learning methods – interdisciplinary education assumes multifaceted learning also on the level of activities, tasks and assignments.

3.3. Conclusions and Discussion

Chapter 3 approached logistics as educational profile from two aspects: most typical currently perceived workplace profile (research question no. 8) and formulating and modelling an original concept-based view of "logistics systems engineer" as professional competence profile and a field of study (research question no. 9). The author would like to present the following findings and remarks.

1. In 2004, Larson and Halldorsson demonstrated the presence of four schools of thought in the terminology debate. The author's survey carried out among Estonian educators pointed out that *traditionalist* view has practically disappeared and *relabelling* view has lost popular support. For logistics, in terms of conceptual survival, this is generally favourable – phasing out relabelling would benefit both logistics and SCM.
2. In the survey, logistics manager is seen to be a distinct competence profile from supply chain manager even through the eyes of educators in a small local environment. Globally and in more complex environments, the author suggests that the separation of concepts is even more relevant.
3. In line with recent SCM theoretical treatments, the supply chain manager competence profile is observed to be more uniformly understood compared both to past and to logistics manager, even though both heavily depend on practical context. However, the author suggests there is a potential downside in "pigeonholing" logistics too narrowly into transport management and logistics service providing area. Such perspective of course benefits the sector of logistics services, but there is definitely room also for highly educated logisticians right next to supply chain managers in production, wholesale and retail sectors. For many of these cases, the profile "logistics systems engineer" can be successfully applied.
4. Having studied the current understanding of *logistics engineering* and *systems engineering*, it concludes that integrating them in education is reasonable and advantageous. As has been previously suggested, the characteristics of logistics as a system is a fitting example of a complex area, for which the field of systems engineering could serve as a supporter of interdisciplinary approaches and analytical views to processes, projects and to material and information flows.
5. The synthesised competence profile of "logistics system engineering" is presented in appendix 3, covering over 200 competence elements. The profile is intended to suit for integrated bachelor and master studies but can be also partially applied in either as curriculum development guideline. It forms a basis which could evolve into an occupational standard and, over time, certification programme.
6. The author found that many crucial areas of logistics future technologies, reviewed in chapter 1.3, are not present in current logistician competence models. The author's proposed model includes these as core elements. The author is determined that combining these technology areas with studies using systems engineering approach is the primary characteristic that demonstrates both novelty and relevance of the created model.
7. Even though the synthesised profile is rather broad, as compared to some understandings of logistics, it is still notably different from a SCM

approach and in some respects is not nearly as broad. As chapter 1 suggested, the dominating SCM concept does not dedicate enough systematic attention towards engineering aspects (although a smaller set of authors and universities do). In support, as chapter 2 showed, distantly similar engineering-focused profiles are already functioning in education and this evolution is supported by the model presented here, resulting in contributing clarity to both fields of supply chains and logistics.

8. One obstacle in wider implementation of such profile in universities is cost. Logistics engineering covers an abundance of technologies, which require universities to invest into an array of simulation, testing and other lab equipment. Another requirement is tight cooperation with industry to ensure the problems research by students are as realistic as possible and that quality internships would be facilitated. This is a complex issue for universities, especially ones with lesser resources and this is, in authors' view, also one of the reasons why business-focused logistics programs are so abundant – they are substantially cheaper and easier to manage.
9. As chapters 2 and 3 demonstrated, there is more than one way to differentiate logistics education from SCM – engineering-centric view, transport management view, logistics service provider view etc. Furthermore yet different approaches can be envisioned for more narrow niches. The author argues that the area of logistics education needs more standardisation but not in terms of forced central harmonisation but in a sense of forming and applying multiple well-defined concepts. Provided that generic SCM does not feasibly cover all niches (this paper argues that it does not and even could not due to sheer conceptual size) and that there is a lack of other well-defined intermediary concepts (instead everyone has their own idea of differentiation), retaining and refining logistician profiles from multiple viewpoints would allow for diversity of specialists needed by the society.

Finally, it needs to be reiterated that logistics need to be defined more clearly. But that clarity should not be so much sought for in terms of definitions, but in terms of educational profiles. This is the reason why the author has presented his understanding of logistics engineering in a competence profile – such wide scope would be impossible to cover and still formulate clearly within the limits of a single sentence. Logistics reality is complex and so the models explaining it can't be too simple. Instead, there is much more relevant need to understand and agree on various education profiles, which would allow universities to optimally combine competition with cooperation and finally combining standardisation with making pioneering steps on the development frontier.

SUMMARY

The research area of this dissertation was higher education in logistics and related competence models. **A practical problem behind this research was lack of clarity of whether and what type of logistics education is needed "in the age of SCM"** and the resulting variety of opinions and approaches in university programs, which can entail notably different emphasis. This is partially due to little effective standardisation and mismatch in competency models in logistics. This results in discrepancies between curricula titles, content and student expectations. **The theoretical problem relates to the debate on the nature and extent of logistics and confusion in the conceptual relation of logistics to the field of supply chain management, which results in a weak logistics paradigm.**

The goal of the work was to identify how logistics could be specifically formulated in contrast to supply chain management, to chart the current status in concepts, competency treatments, curricula and the views of academicians and finally to synthesise a modern competence profile for logistics engineers that would be updated with prominent developments in logistics technologies.

The structure of the thesis was based on the following research questions:

1. **How to formulate logistics as a distinct academic discipline in the era of supply chain management?**
2. How is logistics explained and treated in relation to supply chain management according to recent academic literature?
3. What are the main technology trends impacting future logistics?
4. What is the current scientific knowledge in logistics higher education?
5. How is logistics formulated in international competency models and standards? What is the extent of variety and potential mismatches? To what extent are the models up-to-date with technology trends?
6. Which models are suitable for comparative analysis of the profile and gaps of applicable knowledge elements in logistics curricula?
7. Can a meaningful typology of logistics curricula be created via statistical analysis? What are the common curricula types in logistics?
8. How is the competency profile of logistics manager understood in relation to supply chain manager in Estonian academic context?
9. **What characteristics are required from modern logistics engineers?**

The answers to questions no. 2 - no. 8 are all supporting the relevance and explaining background of question no. 1. The most general aim of the dissertation was to answer question no. 1. The main practical outcome proposed in this dissertation was both the answer to questions no. 9 and no. 1.

The author has applied the following methodological approaches in the thesis:

A. conventional literature review to identify areas of debate and current research gap (questions no. 1, 2, 3, 4, 5 and 7);
B. Larson-Halldorson matrix for concept mapping with input data from dedicated literature analysis (question no. 2);
C. comparative analysis of competency models (question no. 5);
D. model creation for curricula evaluation (question no. 6 and 7);
E. hierarchical cluster analysis of logistics curricula (question no. 7);
F. survey approach to provide quantitative characteristics for Larson-Halldorson method (question no. 8);
G. new competency model creation, including detailed elements of learning outcomes (question no. 9).

Chapter 1 contrasted academic perspectives on the conceptual level by applying Larson-Halldorsson matrix in mapping modern authors' views. As central theoretical contribution, the author would like to emphasize the following.

1. Some authors of logistics have attempted to strive the field knowingly towards the "relabelling" perspective (logistics = SCM). This is supported by notably popular practice of replacing logistics with SCM on various levels from books to curriculum titles. Even provided that the concepts would be understood as equal in theory, then in practice the more attractive concept of SCM would prevail and logistics would fade. Therefore the author argues that relabelling theory, again if applied to full extent, would lead to the demise of logistics paradigm. Such views are still present today, but more in practical applications and less by academic authors, where the idea is in decline.
2. As typical SCM treatments do not dedicate more attention to logistics than refer to it as a functional component area (the theory of unionism), the question is raised if logistics as a separate field of academic study is sustainable or perhaps redundant. It appears that lately, SCM has considerably matured and established own strong paradigm whereas the essence of logistics has obfuscated. A decade ago, similar confusion was in place in formulating SCM, but today, the burden of differentiation to survive is firmly the task for logistics.
3. However, there does not appear to be a realistic way to support traditionalism (logistics > SCM) and this perspective has completely vanished from literature in the last decade. The only logical way to keep logistics sustainable is therefore to formulate it with distinctly from SCM (this is the theory of intersectionism). This is indeed the view of many authors of logistics. The situation is, however, that everyone has their own opinion on how to facilitate the differentiation and so an abundance of niches are formed. Therefore "everyone is allowed to write about almost anything when the title is logistics".

This also implies that competence standards and curricula in logistics could have similarly varying content. In chapter 2, the author analysed logistics competence models and found that the field is scattered to various standards and certifications with no central and agreed view to what logistics education would need to comprise of that could be used by curricula boards for benchmarking.

To better understand the reach of various aspects in logistics that belong to more prominent logistician competency models, **the author constructed a merged model of logistics knowledge areas**. Analysing any logistics curriculum against this model offers insight into topical coverage and focal points and would help universities to better position their programmes.

The author carried out a cluster analysis of international undergraduate logistics curricula in Europe. **The results revealed a landscape with a four-way typology of logistics curricula**, described in the work, titled:

1. Logistics engineering;
2. Business administration and logistics;
3. Interdisciplinary logistics management;
4. Modern transport management.

Type 1 is the most distinct. Type 2 is close to traditional business curriculum. Type 3 is the most similar to SCM perspective. Types 1 and 4 could be seen as alternative means to differentiate from SCM with more focus to certain details. The author argues that the area of logistics education needs more standardisation by forming and applying multiple well-defined concepts.

In chapter 3, the author surveyed the view of educators in logistics and found that specialists understand logistics as transport-centric approach with some included interdisciplinary elements. Intersectionism prevailed as majority view.

The author concluded that efforts are required to formulate existing niches into more specifically formulated concepts and set a practical goal **to create a new profile for „logistics systems engineer“**, which is one notable gap in current competency profiles and which has potential to be applied in curriculum development. Engineering view needs reinforcement as logistics is leaning in some cases too much on business and too little on technology treatments.

The author would like to add the following to support the new model:

1. Logistics engineers are in notable demand and education landscape can benefit from a dedicated competence model. The current model in that area, SOLE, is quite vague, input-centric and aged.
2. Logistics systems and enabling technologies form the stage where the turbulence of business environments combines with rapidly progressing technologies, forming a "frontier" of modern logistics. Systemic view is a recognised traditional concept in logistics. The term „logistics systems engineer“ has been proposed before, but briefly and much superficially compared to approach suggested here.

3. *Systems engineering* as a non-domain-specific construct can be integrated with various technology fields. Integrating it with *logistics engineering* in education is reasonable and advantageous. The characteristics of logistics as a system is a fitting example of a complex area, where systems engineering would support interdisciplinary approaches and analytical views to processes, projects and to material and information flows.
4. The synthesised competence profile of “logistics systems engineer” is presented in appendix 3, covering over 200 competence elements and founded upon key areas of logistics future technologies. The profile is intended for integrated bachelor and master studies but can be also partially applied in either as curriculum development guideline. It forms a basis which could evolve into an occupational standard and, over time, a certification programme.
5. This treatment views logistics more narrowly than SCM but also more broadly than transport-centric view, including of an array of variables, trade-offs and complexities as key elements across logistics system and value generation, design and application of logistics technologies and inventory, information and network configurations.
6. The author’s model includes substantial technology trends in logistics as core elements. The author is determined that combining these areas with systems engineering approach is the primary characteristic that demonstrates both novelty and relevance of the created model.
7. The proposed profile forms a T-shaped view to logistics education, where broad systemic treatment of logistics and enterprise is complemented with focus on understanding and creating an array of technological solutions.

As directly related areas of further research, the author sees benefit in detailed observations of the dynamics in logistics education and theories; a clustering approach to analyse SCM curricula landscape; and demand-side analysis relating industry expectations to existing concepts and curricula. Furthermore, studies on how to include interdisciplinary systems engineering view not only as topic areas but as integrated with other learning methods in various courses, would provide valuable information for universities teaching logistics.

All in all, the push towards clarity in logistics has to come from academia on both conceptual and competency levels. It can be proposed that the dominating view to SCM in academia is a holistic and strategic concept, which in practice makes it “broad but thin”. This makes the intersectionist approach to logistics education feasible and relevant, as it would aim for more specific knowledge.

Logistics as an education concept is far from “a lost cause”. The nature of niche-based fragmentation along with continuing changes in technological and economic landscape make strong paradigm formulation challenging, but promoting integrated engineering view in the concept would bring about more clearly formulated variety and ensure that specialists with proper interdisciplinary skill set would populate logistics and supply chain related jobs to support business continuity and the needs of the society in an optimal way.

KOKKUVÕTE

Logistika kõrghariduse kaasajastamine rõhuasetusega insenerivaldkonna kompetentsidele

Tarvo Niine

Doktoritöö uurimisobjektiks oli logistika valdkonna kõrgharidus ja asjakohased kutsestandardid (kompetentsimudelid). Praktiline probleem seisnes õppekavade oluliselt erinevates rõhuasetustes, mille üheks põhjuseks on nende vähene rahvusvaheline standardiseeritus ja erisused olemasolevates logistiku kompetentsimudelites. Selle üheks tagajärjeks on õppekavade nimetuste ja sisu lahknevus, mis võib nii üliõpilastes kui ühiskonnas tekitada vääritimõistmist ning konflikte ootuste ja pakutava koolituse vahel. Teoreetiline tuumikprobleem seisnes vastuoludes logistika kui akadeemilise distsipliini määratlustes. Logistika on paradigmana suhteliselt nõrk ja oluliseks lahknevuste allikaks on logistika suhted tarneahela juhtimise valdkonnaga.

Töö eesmärgiks oli välja selgitada, kuidas positsioneerida logistikat kui akadeemilist distsipliini tarneahela juhtimise suhtes, kaardistada hetkeolukord nii teoreetiliste konstruktsioonide, kompetentsimudelite, õppekavade kui ekspertarvamuste vaates ning selle tulemusena hinnata logistika kui eraldiseisva uurimis- ja õpetamisvaldkonna jätkusuutlikkust ning arenguperspektiive.

Töö ülesehitus lähtus järgnevatest uurimisküsimustest.

1. **Kuidas sisustada logistikat kui akadeemilist distsipliini "tarneahela juhtimise" ajastul?**
2. Kuidas käsitatakse akadeemiliselt logistikat tarneahela juhtimise suhtes?
3. Millised on oleviku ja lähituleviku trendid logistikavaldkonna tehnoloogiates ja neile vastavates kompetentsides?
4. Mida on seni uuritud logistika kõrghariduses?
5. Kuidas on logistikult oodatavad teadmised ja oskused määratletud rahvusvahelistes kompetentsimudelites? Kuivõrd leiavad käsitamist logistika kaasaegsed tehnoloogiad? Millised on erinevused?
6. Millised mudelid sobivad logistika õppekavade võrdlevanalüüsiks?
7. Kas on võimalik luua tähenduslikku tüpoloogiat üle logistika õppekavade ning millised need lähenemised on? Milline tüüp vajab enim korrastamist ja kaasajastamist kompetentsimudeli tasemel?
8. Kuidas käsitatakse logistikajuhi teadmisi ja oskusi võrreldes tarneahela juhi kompetentsidega Eesti akadeemilisel maastikul?
9. **Milline peaks olema kaasajastatud logistiku teadmiste ja oskuste portfell insenerikompetentside vaatenurgast?**

Küsimused 2-8 selgitavad küsimuse nr 1 tausta. Vastus küsimusele nr 7 toetab otseselt küsimuse nr 9 asjakohasust. Küsimuse nr 9 vastus annab autori tõlgenduses ka vastuse küsimusele nr 1. Autor kasutas töös järgmisi meetodeid:

A. tekstianalüüs määratlemaks vaidlusküsimusi ning katmata valdkondi senistes uuringutes (küsimused 1, 2, 3, 4, 5 ja 7);
B. Larson-Halldorssoni maatriks logistika erinevate määratluste identifitseerimiseks, selle sisendiks on kirjanduse struktuurne analüüs (küsimus nr 2);
C. kompetentsimudelite võrdlevanalüüs (küsimus nr 5);
D. mudeli loomine õppekava analüüsiks (küsimused 6 ja 7);
E. logistika rahvusvaheliste õppekavade valimi hierarhiline klasteranalüüs (küsimus nr 7);
F. kvantitatiivne uuring (küsitlus), kus kasutati Larson-Halldorssoni meetodit (küsimus nr 8);
G. uue kompetentsimudeli koostamine koos kõigi vajalike õpiväljundite sõnastamisega (küsimus nr 9).

Töö tähtsamate tulemuste ja teoreetilise panusena tõstab autor esile järgmist.

1. Logistika valdkonna arengule on tulnud kahjuks n-ö „ümbernimetamise“ teooria, mille kohaselt „logistika = tarneahela juhtimine“. Selliseid käsitusi leidub ka täna, aga pigem praktikute kui akadeemikute poolt.
2. Et „tarneahela juhtimise“ käsitused ei pühenda üldjuhul logistikale rohkem tähelepanu kui tarneahela ühele funktsionaalsele komponendile (unionismi teooria), on üles kerkinud küsimus, kas logistika on üldse jätkusuutlik ainevaldkond. Käesolevas töös selgus, et viimasel aastakümnel on tarneahela juhtimine kui kontseptsioon oluliselt küpsenud ja kehtestanud „oma paradigma“, samas logistika määratlus on hägustunud. Veel kümmekond aastat tagasi kohtas tarneahela juhtimise valdkonnas palju konfliktseid arvamusi, kuid täna peab just logistika hääbumise vältimiseks suutma end piisavalt kehtestada.
3. Autor leidis, et tarneahela juhtimise teaduslik määratlus ei kata kõrghariduses piisavalt kõiki kavandamise, uute lahenduste loomise, optimeerimise ja arendamise aspekte, mis antud valdkonnas vajalikud on. Just süvendatud detailsus on logistika võimalus olla akadeemilise distsipliinina jätkusuutlik (intersektsionismi teooria).
4. Autor asus seisukohale, et intersektsionistlik lähenemine on ühiskonna seisukohalt eelistatuim. Selgelt läbimõeldud erinevad rõhuasetused tarneahela juhtimise ja logistika vahel toetavad kõrghariduses mõlema valdkonna arengut ja panustavad kogumina parimal viisil tööjõuturu erinevate vajaduste rahuldamisse.
5. Intersektsionism leiab põhimõttelist toetust ka paljude logistikaautorite poolt. Probleemiks on, et teemat käsitatakse erinevates, kohati vastukäivates niššides. Võimalusi logistika eriomaseks käsitamiseks on

mitmeid, näiteks transpordikorraldaja, logistikateenuse pakkuja või logistilise võrgu optimeerija vaatepunktist. Lisaks teoreetilistele seisukohtadele peegelduvad taolised vaatenurgad ka kompetentsimudelite rõhuasetustes. Autor leidis, et tuleb teha pingutusi saavutamaks logistika laiemas määratluses konsensust, ning et ka kitsamad käsitused areneksid detailsete kutsekvalifikatsioonideni. Üks ilmselgelt intersektsionistlik käsitus, mis on autori arvates teenimatult tahaplaanile jäänud, on logistika kui insenerivaldkond.

6. Uurimisküsimuste nr 5 ja 6 osas leidis autor, et tänased logistika kompetentsimudelid on niivõrd suurte erisustega, et ükski ei ole ideaalne kõrghariduse õppekavade väljatöötamisel. Mõned lähenevad logistiku kompetentsidele läbi tööprotsesside, teised läbi teadmisvaldkondade, aga kummalgi juhul ei ole mudelite detailsusaste ei piisavalt spetsiifiline ega ka ühtlane konkreetse mudeli sees. See omakorda eeldab õppekavaarendajatelt mudelite iseärasuste tundmist ja kas mitme mudeli paralleelset kasutamist või teadlikku valikut õppe suunitluse osas.
7. Autor viis läbi klasteranalüüsi, mis hõlmas kokku 42 rahvusvahelist logistika õppekava Euroopas. Analüüsi tulemusena eristas autor nelja logistika õppekavade põhitüüpi: 1) logistikainsener; 2) logistika kui ärijuhtimise peaeriala; 3) interdistsiplinaarne logistika juhtimine; 4) transpordikeskne logistika. Tüüp 2) on sisuliselt konventsionaalse äriõppe vastava mooduliga täiendatud versioon, tüüp 3) on kuni hägustumiseni lähedane tarneahela juhtimisele ning tüübid 1) ja 4) on katsed eristada logistikat teistest lähedastest valdkondadest.
8. Eesti logistika ja tarneahela juhtimise spetsialistide hulgas läbi viidud ankeetküsitluse tulemustel on logistika roll seotud transpordikeskse mõtteviisiga, kuid siiski nähakse logistiku kompetentse mõneti laiematena, sisaldades ka varude juhtimist, laondust, oste ja infosüsteeme. Autori tõlgenduses ei ole logistiku käsitamine ekspedeerijana sugugi paratamatu ega ainus võimalus logistika eristamiseks. Käsitus süsteemiinsenerina võimaldab leida eeltoodule sobiva alternatiivi.
9. Kontseptuaalsel tasandil näeb autor oma töö tulemust kui panust logistika paradigma tugevdamisse ning võimaluse andmist üli- ja kõrgkoolidele logistika teadlikumaks õpetamiseks, valides sobivate erinevaid praktilisi vajadusi katvate standardiseeritud lähenemiste vahel.

Töö tulemuste põhjal sõnastas autor spetsiifilise ülesande – luua uudne kompetentsimudel „logistikasüsteemi insenerile", mis toetaks logistika olemuselt interdistsiplinaarset käsitust süsteemiinseneri vaatenurgast. Viimane kujutab endast samuti valdkondadeülest mõttemalli, millel on mitmeid sarnasusi logistika põhivaldkondade ja -probleemidega. Autor esitas töö lisas mudeli koos rohkem kui kahesaja õpiväljundiga.

Autor soovitab loodud teadmiste ja oskuste mudelit rakendada nii õppekavaarenduses kui kutsestandardina ning tulevikus ka laiema rahvusvahelise sertifitseerimissüsteemina. Seonduvalt soovib autor rõhutada järgmist.

1. Logistika insenerikeskse lähenemise järgi on reaalne vajadus ja sellega haakuvad paljud õppekavad, mis saavad kasu põhjalikult defineeritud kompetentsimudelist, et paremini tunnetada valdkondade ühisosa.
2. Logistikainseneri kohta eksisteerib ka täna rahvusvaheline kompetentsimudel organisatsioonilt SOLE, mis on aga võrdlemisi halvasti piiritletud, sisendipõhine ning vananenud. Autor käsitab enda loodud mudelit kui tulevikku suunatud alternatiivi SOLE mudelile.
3. Süsteemne käsitus on logistikateooriast tuntud lähenemine. Terminit „logistikasüsteemi insener" on varem käsitatud, aga lühidalt ja idee tasandil, mida autori töö tulemus on mitmes suunas edasi arendanud.
4. Toodud käsitus läheneb logistikale kitsamalt kui tarneahela juhtimine, ent selgelt laiemalt kui transpordikeskne lähenemine, tuues võtmevaldkondadena välja materjalivoo ja infovoo juhtimise tehnoloogiad, laovarude ning logistikasüsteemide ja -võrkude optimeerimise, mida käsitatakse integreerituna süsteemiinseneri oskuste ja ettevõtte kui väärtustloova kompleksse süsteemiga.
5. Logistikasüsteemid ning seda toetavad tehnoloogiad on valdkond, kus majanduskeskkonna dünaamilisus kombineerub tehnoloogia kiire arenguga ning on seega logistika „rindejooneks". Autor järgis teadlikult põhimõtet, et loodav mudel sisaldaks oskusi sellel „rindejoonel" toimetulemiseks, lisades käsitluse peamistest tehnoloogiatrendidest logistikas.
6. Mudeli ulatusest ja detailsusest tulenevalt on selle sobivaimaks vasteks kõrgharidusraamistikus bakalaureuse- ja magistriõppe integreeritud õppekava.
7. Kokkuvõttes võib loodud kompetentsiprofiili käsitada kui n-ö T-kujulist lähenemist logistiku väljaõppele, kus laiapõhjalisele süsteemsele käsitusele logistikast lisandub selge suund tehnoloogiliste lahenduste mõistmisele ja loomisele. Standardiseeritud komponentide täiendamine lokaalsete erisustega on praktikas tervitatav ning see ei vähenda autori silmis ühisosa konsensusliku määratluse väärtust.

Tööst tulenevate edasiste uuringute peamiste valdkondadena näeb autor:

1) käsitusi logistika hariduse dünaamikast ja parimatest praktikatest;
2) klasteranalüüsi, et sarnaselt käesolevaga tööga segmenteerida ja lahti mõtestada tarneahela juhtimise akadeemilist õpet;
3) logistikahariduse nõudluse uuringuid, et seostatult vaadelda tööandjate ootusi ja haridusmaastikul õppekavu.

Detailsemalt on autori huviorbiidis uuringud, kuidas siduda õppekavadesse süsteemiinseneri alusteadmisi mitte ainult teemaplokkidena, vaid ka integreeritult õppemeetoditesse läbi erialaainete. Autor loodab, et tema töö tulemused annavad väärtuslikku teavet kõigile logistikat õpetavatele õppeasutustele.

ABSTRACT

New approach to logistics education with emphasis to engineering competences

Tarvo Niine

The research area of this work is logistics higher education. Practical problem lies in notable differences in curricula and little effective standardisation and mismatch in logistics competency models. The theoretical problem debates the nature of logistics and confusion in relation to supply chain management.

The goal of the work is to identify specific formulation of logistics, to chart current status in concepts, competency treatments, curricula and views of educators and finally to create a modern competence profile for logistics engineers that would include major advances in modern logistics technologies.

Along extensive literature review, the main methods applied by author are:

- Larson-Halldorsson matrix and survey for concept mapping,
- a comparative analysis of competency models,
- a hierarchical cluster analysis of international logistics curricula,
- a competence model synthesis for *logistics systems engineer.*

As theoretical contribution, the author opposes relabelling theory and observes the strengthening of intersectionism theory of logistics, which is advantageous and allows to formulate logistics and sub-concepts more clearly. As practical contribution, the author proposes a typology of logistics curricula with cluster analysis and presents a novel competency model titled “logistics systems engineer”, which reinforces logistics engineering with interdisciplinary field of systems engineering and updates engineering-focused profile with modern technology trends. The author promotes this perspective as an alternative to the more transport management centric approach and to supply chain management. The model can be used in developing combined bachelor- and master level curricula and implemented as an occupational standard.

As further research, the author suggests observations of dynamics in logistics and supply chain education and demand-side analysis relating industry expectations to existing concepts and curricula.

The work is based on six scientific publications by author from 2012-2015.

Keywords: competence models in logistics, logistics and supply chain management, logistics education, logistics engineering, technology trends in logistics

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APPENDICES

APPENDIX 1. Logistics knowledge areas across competency profiles

The elements in sections are truncated for brevity.

Level A: General business administration topics			
#1: Business strategy and marketing	**#2: Financial management, costs**	**#3: Organization and people**	**#4: Operations management**
Market research	Financial statements	Decision-making tools	Demand forecasting methods
Business environment	Investment analysis	Organisation behaviour	Available capacity analysis
Market positioning	Financial ratio analysis	Motivation theories	Supply-demand synchron.
Strategic management	Activity based costing	Incentive and reward systems	Operations performance
Competitive environment	Total supply chain cost	Training and development	Innovation and creativity
Portfolio planning	Customer-based profitability	Leadership and delegation	Waste analysis and reduction
International marketing	Strategic pricing	Project management	LEAN process improvement
New product development	Asset utilization analysis	Teamwork	Six sigma
Product promotion	Budget planning and control	Effective communication	Root cause analysis
Logistics strategy	Lifecycle costs	Organisation structure	TOC Theory of Constraints
Industry benchmarking	Cash flow management	Process analysis, job design	TQM Quality Management
Product lifecycle	Funding	Change management	JIT, pull system management
Level B: Logistics core topics			
#5: Supply chain management core	**#6: Logistics network and system**	**#7: Purchasing and supplies**	**#8: Inventory management**
Supply chain competitive advantage	Logistics performance objectives	Sourcing strategies	Inventory performance analysis
Value chain management	Key performance indicators	Supplier selection criteria	Inventory costs
Value creation analysis	Customer service standards	Contract negotiations	Inventory classification
Supply chain mapping	Lead time and order cycle time	Supplier performance evaluation	Inventory deficit impact analysis
Supply chain configurations	Logistics cost categories	Purchasing costs	Inventory valuation
SCOR model	Cost trade-off management	Purchasing arrangements	Economic order quantity
Agile supply chain	Facility location analysis	Supply chain collaboration	Safety stock calculations
Postponement	DRP	Supplier base rationalisation	Ordering systems
Mass customization	Transaction documents	Supplier relationship management	Bullwhip effect
QR / ECR	3PL and 4PL concepts	Crosscultural communication	ABC-categorization
S&OP Sales and Operations Planning	Make-or-buy analysis	CPFR-model	Vendor managed inventory
Level C: Viewpoints on transport			
#9: Operational transport	**#10: Transport: society and system**	**#11: Field-specific transport**	**#12: Transport technology**
Transport performance objectives	Global cargo flows	Freight forwarding	Road transport technologies
Carrier types and service conditions	Transport infrastructure	Road transport	Rail transport technologies
Carrier selection and contracting	History of transport	Rail transport	Maritime transport technologies
Transport mode selection	Supply and demand in transport	Airfreight transport	Aviation technologies

Appendix 1 (continued)

Level C: Viewpoints on transport (continued)			
#9: Operational transport	**#10: Transport: society and system**	**#11: Field-specific transport**	**#12: Transport technology**
Load and route planning	Transport policy design	Sea and waterway transport	Pipeline technologies
Transport of hazardous materials	Socio-economic investment analysis	Public transport	Passenger transport technologies
Transport of oversized cargo	Full costs of transport	Airlines and air travel	Support infrastructure
Vehicle and cargo tracking	Transport external costs	Intermodal terminal management	Intermodal terminal technologies
Load fastening and protection	Transport market regulation	Port management	Intelligent transport systems
Road tolls, local regulations	Taxes and charges		

Level D: Other technology, process and systems engineering viewpoints			
#13: Systems engineering	**#14: Warehousing**	**#15: IT and information systems**	**#16: Manufacturing**
Supply chain process modelling	Warehouse performance objectives	Data warehousing	Manufacturing performance analysis
Logistics systems engineering	Warehouse capacity planning	E-commerce	Manufacturing capacity planning
Information system engineering	Storage condition requirements	ERP systems	Manufacturing process analysis
Product development	Handling of hazardous materials	Information system modelling	Master production schedule
Infrastructure engineering	Cross-docking operations	EDI electronic data interchange	MRP Material requirement planning
Traffic engineering	Conventional warehouse equipment	Data security and privacy	Kanban system
Facility layout engineering	Automated storage and retrieval	Automated identification standards	Manufacturing technologies
Reliability engineering	Packaging materials and technologies	RFID-technology applications	Advanced materials
Maintainability engineering	Unitization optimization	Warehouse management systems	CAD-CAM systems
Safety engineering	Inventory control techniques	Management information systems	Quality assurance and control

Level E: Cross-functional supporting viewpoints			
#17: Legal environment	**#18: Sustainability in logistics**	**#19: Risk analysis**	**#20: Natural and social sciences**
Basics of law	Climate change impact and risks	Risk management process	Calculus
Commercial law	Alternative fuels	Physical cargo risks	Statistics
Competition law	Modern vehicle technologies	Ergonomics, human safety	Physics
Labor law	Air quality and standards	Environmental risks	Chemistry
Intellectual property law	Congestion charging	Economic risks	Logic
Customs regulations	Travel demand management	Financial transaction risks	Environmental science
Taxes and taxation	Carbon footprint of business	Technological disruptions	Philosophy
International trade arrangem.	Triple bottom line concept	Regulatory compliance risks	Ethics
Documents and licenses in logistics	Renewable resources and energy	Supply chain security	Micro-economics
International transport conventions	Regulations on waste and recycling	Risk mitigation strategies	Human geography
Incoterms regulations	Reverse logistics	Contingency planning	Sociology

APPENDIX 2. Survey "Supply chain manager and logistics manager competency profile" form

Dear Sir/Madam,

We are asking for your contribution in this survey because you belong to the target group as a teacher/lecturer of topics of logistics, supply chain management or general management on undergraduate or graduate levels in Estonian universities.

The following questionnaire opens the fields of logistics and supply chain management in a list of topics, knowledge, skills and processes to determine the common ground for logistics manager and supply chain manager and inherent differences. The scope of the following list represents a broad approach to decisions fields in the area across operational, tactical and strategic levels, although not all of the listed competencies might be relevant for a supply chain manager nor logistics manager.

The survey is asking you to describe competency profiles of "ought to be" supply chain manager and „ought to be" logistics manager in your personal view. This means, whenever you feel there is a contradiction in what a trained professional logistics manager should be able to do and what actually logistics managers are doing or are trained to do in practice, please present your ideas based on the first viewpoint.

The survey has 3 questions and asks around 20 minutes of your time. Thank you in advance.

Question 1: in theory, the relations between the field of "supply chain management" and the field of "logistics" has been described through four schools of thought, as briefly summarised below. Which of the four approaches is the closest to your personal understanding?

1. Traditionalism – supply chain management is essentially a part of logistics management. Logistics is a wider concept dealing with all forms of material and information flow management whereas supply chain management deals with links between companies.
2. Relabelling – supply chain management is another name for modern logistics management. During the development of terminology and the evolution of business processes and success factors, logistics has evolved into a strategic concept named supply chain management. There is nothing essentially in the scope of supply chain management, that is not also understand under „logistics"
3. Unionism – logistics management is a subsystem of supply chain management. Supply chain management has a wider scope, including also aspects of purchasing, supplier selection and relationship management and supply chain cooperation development, which might or might not be related strictly to the field of logistics.
4. Intersectionism – Logistics management and supply chain management share a common „core", but they also have specific focal points and problems which do not fall under the scope of the other term. Thus, it could be said the jobs for logistics manager and supply chain manager are quite different. It could be interpreted as one being more on a tactical level and functionally proficient in specific whereas the other is more strategic and based more on a generalist holistic view of management.
5. None/other, please explain:

Appendix 2 (continued)

Question 2: Please determine the importance of the following 100 items in a „ought to be“ competence profile of a supply chain manager and logistics manager, using a Likert scale 0-5, where 0 = not necessary at all and 5 = is very important.

Distribution and transport

1. Distribution system planning
2. Cargo consolidation for transport
3. Vehicle capabilities
4. Choice of mode
5. Load securing
6. Cargo space utilization
7. Road tolls
8. Vehicle usage analysis
9. Transport cost analysis
10. Driver work time regulations
11. Route optimisation
12. Incoterms
13. Reverse logistics
14. Transport market overview

Warehousing

1. Warehousing and picking systems
2. Warehouse management systems
3. Barcodes and RFID-tags
4. Packaging technologies and -materials
5. Warehouse technology
6. Automated warehousing systems
7. Inventory control methods
8. Warehouse layout optimisation
9. Warehousing cost analysis

Information flow and IS

1. MRP/ERP systems
2. EDI
3. IT-system design and ordering
4. Information flow analysis and optimisation
5. Automatic replenishment systems
6. e-business
7. Track&trace

General management, strategy

1. Defining general company strategy
2. Defining and implementing functional strategies
3. Analysis of competitive advantages
4. Motivation
5. Competitor process benchmarking
6. KPI-based management
7. SCOR-model
8. Product lifecycle analysis
9. ISO9000/14000 standards
10. Project management skills
11. Change management

Process and supply chain optimisation

1. Waste management and LEAN
2. Kaizen
3. Kanban and JIT systems
4. Value stream mapping
5. 6 sigma and DMAIC cycle
6. TQM
7. Optimal location models
8. Supply chain flexibility analysis
9. Lead time and production volume
10. Theory of Constraints
11. Production planning
12. Postponement
13. Push/pull systems
14. Eliminating non-value-adding processes
15. Supply and demand management
16. Reducing bullwhip effect
17. Supply chain synchronisation
18. Supply chain risk analysis
19. Supply chain risk management strategy

Sales and customer relations

1. Customer requirements mapping
2. Customer service standards
3. Order cycle analysis
4. Customer-based process design
5. B2B marketing
6. Customer satisfaction analysis

Financial perspective

1. *Cash-to-cash* cycle time
2. ABC costing
3. Total cost of ownership
4. Calculating economic value added
5. Supply costs optimisation
6. Transport cost optimisation
7. Warehousing cost optimisation
8. Holistic supply chain cost optimisation

International environment

1. Custom regulations
2. Local business environment specifics
3. International transport regulation
4. International trade regulation
5. Cultural differences in business
6. Currency risks analysis
7. Analysis of environmental effects

Appendix 2 (continued)

Purchasing, supplier relations

1. Supplier choice criteria
2. Supplier performance analysis
3. Supply costs analysis
4. Cooperation forms in supply chain
5. Supplier relationship management
6. Negotiations
7. Contracts
8. Collaborative forecasting
9. Outsourcing

Inventory management

1. Inventory value analysis
2. ABC- and XYZ analysis
3. Identifying dead stock
4. Optimising inventory turnover
5. Vendor Managed Inventory
6. Demand forecasting techniques
7. Inventory mapping in supply chain
8. Inventory cost analysis
9. Forecast accuracy analysis
10. Reorder point calculations

Question 3: Please explain your view on similarities and differences of a competence profile of a logistics manager and of a supply chain manager.

Source: The author based the topics enquired in the study on selection of elements from APICS competency models for supply chain managers [5] and logistics managers [4].

APPENDIX 3. Competency profile "logistics systems engineer"

Application clauses

The competency profile "logistics systems engineer" is designed to be implemented on the level of combined bachelor and master studies, corresponding to level 7 in European Qualification Network [50], on which the targeted competence is defined as "manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches; take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams".

The profile can partially be applied for bachelor level studies but is designed to function fully (and as an appropriate level for basis of certification) through integrated BSc + MSc studies.

To comply with requirements from local Standard of Higher Education [178], the study programme also would need to take into account the following:

1. The nominal duration of combined Bachelor's and Master's study is at least five years and the study load determined in the study programme shall be 300 credit points.
2. Master's study ends with the defence of a Master's thesis or the taking of a Master's examination.
3. In Master's study, a Master's examination or Master's thesis shall constitute at least 15 credit points of the study load
4. In Master's study, practical training is foreseen for achieving learning outcomes

The profile reflects the expectations of workplace performance in case of a position, which requires managing logistics, supply and distribution networks systematically in a complex environment which includes advanced technological element and various development and implementation projects, which would require the viewpoints of "systems engineering".

In the profile, logistics is viewed as a system across the functions of purchasing, transport, handling, storage and sales, in which the two key focus areas are inventory (which represents material flow configuration and environment) and information systems and solutions (which represents information flow configuration and environment). In broad context, logistics is seen as a part of a wider value system. The profile aims to be rather more interdisciplinary than traditional logistics treatments and such notion should also be accounted for in course design.

Learning outputs

The competency profile lists learning outputs across the following sections:

A. Systems engineering fundamental competencies
B. Material flow technology competencies
C. Logistics system and supply network design and configuration competencies
D. Inventory system configuration competencies
E. Information system and flow configuration competencies
F. Operations, process and workflow development competencies
G. General performance, costs, control and sustainability competencies
H. Value system design and management competencies
I. Individual meta-competencies

A: Systems engineering fundamental competencies

The key concepts of systems engineering (as described in MITRE Competency Model)

The **Systems Engineering Life Cycle** consists of the fundamental competencies that systems engineers need to be competent in regardless of the life cycle methodology used. They conceptually define systems, specify and create architectures, and define alternative approaches. They monitor and assess design, development, integration, and test. They help the sponsor/customer with deployment, operations, and maintenance issues.

Systems Engineering Planning and Management describes fundamental competencies that the systems engineer needs to be capable of in the planning and managing the systems engineering activities for projects, programs, and enterprises throughout the life cycle. Some competencies, for example, risk management, may be used in every part of the life cycle, while others are only called for during specific life cycle phases.

System Engineering Technical Specialties are "call as needed" competencies that describe how the systems engineer works with a range of specialty engineering disciplines in one or more phases of the systems engineering life cycle.

1. Defines problems and opportunities from a comprehensive, integrated perspective and applies systems thinking to create strategies, anticipate problems, and provide short- and long-term solutions
2. Adapts to change and uncertainty in the project and program environment and assist other stakeholders
3. Proposes comprehensive solutions that contribute to general vision and mission statements, address interoperability and integration challenges across organizations and shape enterprise evolution through innovation
4. Synergizes own and others’ expertise to provide sound, objective evidence and advice for projects and solutions
5. Integrates business/mission and operational needs and transform these needs into system requirements. They analyze, manage, and trace systems requirements, facilitate stakeholder agreement about changes to and management of the systems requirements, and recommend critical performance measures
6. Describes the current architecture and underlying technologies for future architectures, performs an analysis of alternatives to frame future architectures, and recommends solutions.
7. Prepares design and milestone review criteria, develops and gains agreement on design review and milestone-decision approaches, evaluates development effort, makes performance assessments and leads design review teams
8. Assists with the development of an integration approach and the identification of integration and interoperability challenges, creates and advocates integration strategies that meet business/mission needs, uses domain knowledge to evaluate integration and interoperability options for evolving systems and observes and assesses integration testing
9. Assists with developing and defining test and evaluation plans and procedures, creates and guides test and evaluation strategies to field effective and interoperable systems, participates in developmental and operational testing, observes and communicates test results, influences re-test and mitigation strategy, and assists in system acceptance decision
10. Prepares transition plans for delivering systems, gains agreement on the transitional approach, and support system deployment, including simultaneous systems operation, develops, evaluate and recommend system operations, maintenance, and disposal plans
11. Collects and assesses data related to changes in current operations, processes, and procedures, formulates and recommends plans for transforming the organization, structure, and processes, and recommends systems interfaces and related interactions with other organizations

12. Performs project evaluations and milestone reviews, monitors performance, and recommends changes
13. Proposes and influences the risk management approach, identifies, analyzes, and prioritizes risks with respect to impact, probabilities, dependencies, timeframes, and unknowns, prepares and monitors risk mitigation plans and strategies
14. Prepares configuration management approaches, processes, and plans, analyzes changes to the baseline, evaluate the impacts from the proposed changes, facilitates decisions on these changes, and ensures that approved changes are implemented
15. Develops an integrated life-cycle logistics support approach and recommends alternatives during all life cycle phases to minimize risk and costs
16. Supports continuous process improvement by drafting policy, developing plans and conducting maturity assessments and to implement, assess, and improve shared systems engineering processes
17. Defines the approach, scope, key parameters, and trade-offs of the cost-benefit analysis
18. Collaborates with the specialist to support human centered engineering activities, defines the human centered engineering approach and recommends design and trade-off decisions
19. Collaborates with the specialist to identify approaches to modeling and simulation, create and validate models, interpret results, and recommend changes to operational capabilities
20. Collaborates with the specialist to identify security engineering approaches and constraints, plan for certification and accreditation, and recommend security-related trade-offs
21. Collaborates with the specialist to identify reliability, maintainability and availability approaches, interpret dedicated modelling results and sensitivities, suggest design changes, and prioritize corrective actions to improve operational systems
22. Collaborates with the specialist to identify safety engineering approaches and activities, conduct safety-related analyses, examine study or modeling results and their sensitivities, and provide recommendations on design trade-offs
23. Collaborates with the specialist to analyze user needs, develop software requirements, define performance measures, and prioritize risks; facilitates interaction among the customers, end-users, and specialists to clarify expectations, problems, and potential solutions; identifies critical areas for software testing, communicate risks, and develop mitigation strategies based on the testing results.
24. Collaborates with the specialist to develop approaches to data and network management, define end-to-end network/communications requirements, define system performance parameters, and determine architecture solutions
25. Identifies the need, defines the scope, and estimates the cost of studies and special engineering efforts outside existing competencies

B: Material flow technology competencies

1. Understands the characteristic, design, applications and limitations of traditional and modern technology solutions in transport, warehousing, tracking and handling
2. Is knowledgeable about state-of-the-art in following logistics technology areas:
    - Electric vehicles, alternative fuels and clean technologies
    - Telematics, real-time tracking and intelligent transport systems
    - Auto-pilot and autonomous vehicles: UAV, self-driving cars, ships etc.
    - Vehicle design, materials and systems for safety, costs and performance
    - Robotics, sensors and ID-solutions in cargo handling and security
    - Mobile and cloud computing applications and wireless communications
    - Logistics process and network simulation and optimisation software
    - Electronic marketplaces, e-commerce and smart networking
    - Big data, augmented reality, automatic data analysis and integration
    - Additive manufacturing (3D printing) applications

3. Analyses modern technologies and application environments in terms of capabilities, costs, implementation requirements, constraints and risks
4. Analyses current organisation processes and workflow in logistics and supply chains and identifies suitable technology solutions for current environment
5. Envisions potentially applicable solutions in organisation in the near future, relating to technological trends and evolving industry practices
6. Analyses the impact of various material flow technologies to logistics system and supply chain performance
7. Understands the synergetic relations between material flow technologies, information system and information flow configurations and utilises it in systems development
8. Matches technological capabilities with organizational value system needs
9. Carries out holistic risk analysis of implementation projects, including aspects of safety, security and environmental impact
10. Defines human, information system and technology interfaces and integrates physical technologies with information systems and workflow in an optimal way
11. Plans, coordinates, manages and controls new logistics technology implementation projects throughout the life cycle
12. Initiates and carries out feasibility and impact studies and cost-benefit analysis of all types of material- and information-flow technology improvement projects
13. Defines feasible testing environments for new solutions
14. Cooperates and consults with experts in the field
15. Cooperates with specialists in partner and supply chain companies to create systems reaching across organizational boundaries
16. Analysis the level and extent of technology- and innovation-related competencies in organization and assists in forming training plans as well as employment plans
17. Serves as a technological expert and supports organisational learning and innovation
18. Applies the concept of human-centred engineering in design and implementation
19. Is aware of the current and future boundary between human and machine-based operations and understands the required conditions when human labour can be replaced with machines
20. Understands the delicate relation between lengthy technology implementation projects and changing environments which might impose unexpected risks regardless of initial plans

C: Logistics system and supply network design and configuration competencies

1. Understands that supply network and logistics is a system of organizations, people, technology, activities, information, and resources
2. Forecasts demand for products and services with various methods and techniques and implements procedures for forecasting
3. Converts and communicate demand requirements for products and service into detailed plans and purchasing schedules
4. Synchronizes supply with demand by determining the need for material and operational capacity to address expected demand and executing the resulting plans
5. Designs and controls supply chain network and material flow in alignment with general priorities of the value systems
6. Defines specific customer service standards and develops objectives, indicators and performance metrics across the value system in terms of quality, cost, flexibility, adaptability, responsiveness, productivity, efficiency and customer satisfaction
7. Defines the role of logistics in company strategy and defines tactical plans and priorities
8. Outlines potential alternative development scenarios in logistics and supply chain network and their impact to general performance and value generation
9. Applies various theoretical constructs, models, analytical methods and tools from the traditional fields of operations management, purchasing, logistics and supply chain management to improve general logistics system performance

10. Analyses the supply chain by using value stream mapping
11. Analyses and optimizes the location of physical supply chain facilities (warehouses, hubs, factories, stores), taking into account the effects on lead times, availability, inventory and transport related costs, risks and other supply chain performance areas
12. Utilises quantitative models to analyse and improve route planning, load planning and shipment scheduling and arranges transport in optimal manner also accounting for service standards
13. Carries out lead time and order cycle time analysis and identifies potential improvements
14. Is proficient in modelling tools and methods to explore the impact of alternative configurations in the material and information flows in supply and distribution networks
15. Applies MRP and DRP systems to facilitate distribution, production, inventory and sourcing planning
16. Analyses the feasibility and impacts of various supply chain configurations (make to stock, assemble-, make, engineer-to-order) and optimizes current planning process configuration
17. Analyses the applicability and implements various supply chain improvement concepts (such as just-in-time, quick response, efficient consumer response, agile)
18. Coordinates logistics flows and planning systems with purchasing, manufacturing and other related stakeholders in an optimal manner
19. Understands, analyses and optimizes the total supply network capability and applies DMAIC cycle to processes, identifying and alleviating bottlenecks, managing trade-offs and coordinating decisions across functional areas
20. Negotiates contracts with suppliers and service providers to improve both company-centric logistics system as well as the general value system
21. Appreciates the impact of supply chain operations to environment, analyses the applicability of renewable raw materials, reverse logistics, recycling, paperless operations and green transport and optimises load factors and vehicle use efficiency.
22. Selects and negotiates with various logistics-related service providers, evaluates service provider performance and sets respective KPIs and goals
23. Defines supplier selection criteria and process and evaluates supplier performance
24. Effectively communicates and collaborates and with supply chain partners and supports information visibility by integrating activities across organizations in the supply chain
25. Analyses the impact of suppliers and service providers to logistics processes and company performance
26. Analyses the total cost associated with procuring an item or service, relating to total cost of ownership iceberg model, and uses this information in supplier evaluation and selection process
27. Defines standardized ways of communicating with suppliers, customers and partners
28. Analyses the reasons of stock outs and ways to increase availability
29. Develops and optimizes transport, handling, storage and distribution systems, including respective technologies and equipment, facilities, layouts and handling operations
30. Analyses and improves efficiency of utilised resources in transport, handling, storage and distribution systems
31. Analyses physical characteristics of products, packaging and handling systems, is aware of special requirements in transport and handling of hazardous cargo and designs solutions for efficient and effective handling, inspection and storage
32. Understands and designs processes to meet legal requirements of transport and logistics
33. Understands and complies with international regulations and requirements in international trade, including customs, tariffs and duties, taxes, security regulations, trade zones etc.
34. Define processes and job descriptions, competence requirements and performance metrics
35. Identifies, analyses and accounts for risks that affect supply, transport, delivery and demand

D: Inventory system configuration competencies

1. Defines inventory management strategy and improves balance between demand and supply
2. Calculates and develops action plans to improve key inventory performance metrics
3. Understands the impacts of strategic initiatives (such as LEAN, Quick Response), market changes, company strategy changes and changes in suppliers and supply patterns to inventory management
4. Converts demand information and forecasts into operations and purchasing schedules and designs systems to facilitate such planning
5. Applies forecasting techniques (quantitative, qualitative and causal), analyses forecast errors and strives to improve forecasting accuracy
6. Monitors inventory and related process performance to identify trending changes in internal processes and external impacts that require reconfigurations in inventory systems
7. Ensures that applied data systems would provide relevant inventory data to relevant decision makers with minimal downtime and discrepancies and offer information with quality and quantity to support control and human decision-making
8. Understands the extent to which inventory-related analysis and decisions can be automatic and designs purchasing, inventory and sales-related systems to offer optimal balance between manual and automatic decisions
9. Defines, implements and develops inventory control procedures and systems
10. Coordinates physical storage related decisions with inventory control requirements
11. Optimizes inventory levels and holding costs while simultaneously improving availability
12. Designs systems and processes to monitor the level of inventory, inventory value and estimated days-of-supply
13. Designs processes to effectively identify excess and obsolete inventories and communicate this information to respective decision-makers (such as sales and marketing personnel)
14. Calculates and applies various inventory costing and valuation methods
15. Understands various concepts of categorizing inventory, analyses and categorizes inventory systematically and defines dedicated inventory management principles and objectives to categories
16. Understands the concepts of dependent and independent demand and what it implies to inventory planning systems and information systems
17. Understands the concepts of periodic and continuous review systems, principles of visual review, two-bin systems, kanban systems etc, determines optimal ordering systems and designs process requirements to facilitate it
18. Applies economic order quantity principles and reorder point calculations in inventory optimisation and designs systems for automatic calculation and resulting notifications
19. Defines optimal inventory turnover targets per categories and analysis all the resulting impacts from changing inventory turnover rate
20. Determines required levels of safety stocks
21. Analyses the relations between distribution network design and required safety stock levels to suggest improvements to networks
22. Understands, calculates and analyses inventory holding and ordering costs
23. Understands, designs and applies means to counter the bullwhip effect
24. Understands and manages the trade-offs in inventory management between availability, costs, risks and control as well as between inventory costs, manufacturing costs, purchasing costs and other departmental costs
25. Analyses the on-shelf availability of products and ways to increase it
26. Analyses the amount of purchases lost during out-of-stock situations through direct and indirect means, including web analytics
27. Analyses customer reaction to stock outs on category and item level, relating it to aspects of out-of-stock rates, available substitutes, product variety, customer loyalty, perceived risk of substituting, purchase urgency and other factors influencing customer reaction

28. Analyses the total cost of stock outs, including lost sales, loss of customers, loyalty and reputation
29. Defines, implements and develops the configuration of material and distribution requirements planning (MRP/DRP) systems
30. Analyses the possibilities and implications of running vendor managed inventory and collaborative forecasting methods and designs suitable processes

E: Information system and flow configuration

1. Analyses various information flow configurations and selects suitable solutions to facilitate key processes in an optimal way
2. Understands various types of information systems and their roles, such as transaction processing, process control, office automation, information reporting, decision support and executive information systems
3. Relates information system capabilities to process definitions, workflow and job responsibilities and understands that both sides might need to be altered to reach optimal information system and information flow
4. Understands and implements various relevant IT and planning systems and concepts, such as APS, MRP, DRP, ERP, CRM
5. Integrates various sub-systems to allow information exchange in an optimal way given current technological and economic realities
6. Carries out cost and benefit analysis in terms of various IT-system related investments both in terms of hardware and software from small-scale modular updates to complete design and implementation of standardized or tailor-made systems
7. Analyses and measures the IT-system performance from user point of view
8. Compiles and models the user requirements of information systems and defines interface, performance and other requirements as inputs to IT-system reconfigurations, updates, design and implementation
9. Manages IT system transition and integration processes and communicates with personnel with technical competence to deal with problems and manage changes and updates in optimal manner so that the impact to running processes would be minimal
10. Is knowledgeable about modern software and IT-related concepts and applies IT-system benchmarking analysis against best practices in the field
11. Considers various viewpoints and trade-offs in information system analysis, including reliability, features, security, capacity, flexibility, workplace ergonomics etc
12. Understands both the "big picture" of IT systems as well as appreciates the issues relevant to local users and can explain the required changes in processes and workflow to facilitate easier transition to changing ways of carrying out daily work
13. Accounts for security and privacy issues in information system design and software applications
14. Defines the requirements, analytic procedures and reporting for data mining and various analytic systems
15. Is proactively surveying existing software solutions on the market and communicating with potential service providers
16. Ensures the external customers of information are catered for, such as by facilitating the generation of various reports and sharing statistics
17. Understands the concept of information visibility in supply chains and ensures that data obtained from sales, customers, suppliers and business partners is optimally utilized, transferred to the right people and presented in an optimal manner for optimal decisions
18. Facilitates data sharing with suppliers and customers, integrates activities across organizations on the supply chain and participates in projects realizing the initiatives such as vandor managed inventory, collaborative planning, forecasting and replenishment etc

19. Applies EDI and other modern solutions in B2B communication and analyses the impact on workflow, planning accuracy, process control and general logistics performance
20. Designs e-commerce solutions understanding the target group's information needs, expectations, behaviour and technological reality and preferences; evaluates the performance of current solutions as well as the impact of e-channel to general business model
21. Designs tracking solutions (such as GPS, barcodes, RFID) and integrates the solutions with information systems and workflow
22. Analyses the impact of tracking to costs, efficiency, asset utilisation, process control, delivery speed, flexibility and customer satisfaction
23. Develops systems for optimal balance between automatic and manual components in terms of forecasting, inventory level and reorder point monitoring and ordering
24. Identifies feasible ways how IT systems and information flow could be advanced towards reducing the amount of paper required in operations
25. Defines the requirements of warehouse management systems, accounting for warehouse workflow, regular operations and needed exceptions
26. Designs and develops systems for monitoring general logistics performance, including interfaces with 3rd party participants such as delivery services and integrates it into management information systems
27. Designs and develops systems for monitoring general supplier performance and integrates it into management information systems
28. Designs systems for storing customer-related data and allowing specific data analysis for marketing and strategic purposes
29. Is proactive towards development and understands that while no information system is perfect, every information system can be improved
30. Has an overview of upcoming technologies in 5-10 years and understands how these solutions can be applied for business success both in tactical (more information, better analytics, new channels of communication) and strategic sense (new services and personalised customisation of current services)

F: Operations, process and workflow development competencies

1. Assists in developing a culture and organizational behaviour where departmental sub-optimisation is minimised and cooperation is supported and understood as a central value that would encourage visibility of company performance and understanding "the big picture"
2. Understands the trade-offs between system priorities and coordinates processes accordingly
3. Supports the culture where changes in priorities, processes and workflow are accepted and communicated to keep the workforce agile and the products and processes adaptable
4. Understands that every part of main process in a company needs to create value and develops processes accordingly
5. Identifies and eliminates causes of quality problems, analyses and reduces process variation and strives to remove non-value-adding components in processes and workflow
6. Analyses and improves procedural standards, structures, responsibilities, job and task descriptions and coordination and control mechanisms
7. Applies systematic approach to increasing system performance through streamlining, coordination and cycle time reduction
8. Controls and manages complexity in products, processes and communication interfaces
9. Analyses and improves the performance of processes and workflow in terms of flexibility, predictability, control and standards
10. Applies process analysis and improvement methods and operations management techniques, models and concepts in analysing, controlling and optimizing in-house and supply and distribution network processes
11. Analyses the applicability and applies methods and techniques involved in lean thinking and JIT management

12. Defines and enables internal feedback systems for process improvements
13. Analyses near-term future process improvement possibilities that are enabled and supported by new emerging technologies
14. Appreciates the human component in operations, processes, job design, performance evaluation, motivation, rewarding and teamwork and plans accordingly
15. Analyses recent changes in operations (in terms of priorities, processes, workflow, job descriptions, capacities, schedules, manpower, planning, coordination, control etc.) and initiates reverse action or further changes if the results are unsatisfactory
16. Facilitates training and development to support motivation, performance and flexibility
17. Applies classic data-based DMAIC cycle in all improvement actions
18. Applies systematic decision-making tools, collects objective data to support decisions, defines key performance measurements and benchmark targets, identifies symptoms of problems in processes, performs root cause analysis and facilitates continuous improvement
19. Understands and implements improvement concepts such as business process reengineering, total quality management, six sigma, sales and operations planning, theory of constraints, lean and agile
20. Facilitates innovation to gain new competitive advantages

G: General performance, costs, control and sustainability competencies

1. Evaluates general financial performance of an organization, the performance and the success or failure rate of projects, products and services and their value systems, understands and calculates financial performance indicators and related concepts and understands how changes in logistics system can affect financial performance
2. Defines strategic and tactical key performance indicators for the company and defines measurement systems of performance indicators
3. Develops strategic objectives of logistics and value system relating to SCOR model metrics: reliability, responsiveness, adaptability, costs and asset utilisation
4. Defines quality standards and plans and analyses quality inspection and improvement
5. Defines, plans, analyses and controls financial and project management aspects of development projects and investments
6. Employs the technique of break-even analysis and determines optimal operating level
7. Calculates project and company cash flow forecasts, present value investment comparisons and risk-adjusted return calculations
8. Understands basic principles of sustainability and evaluates internal sustainability of the logistics systems
9. Evaluates external impact of the systems on environment and society, applies the triple-bottom-line concept and analyses and improves carbon footprint, understands current government regulations governing sustainability and related industry standards and strives company processes towards sustainability
10. Defines and develops cost accounting systems that would keep track and facilitate the analysis of all types of costs and activity-based costing
11. Plans and analyses the total costs of products and services and projects and analyses total life cycle cost
12. Carries out customer-based and product-based profitability analysis and communicates the findings as inputs to tactical and strategic planning
13. Performs systematic risk analysis across all risk categories and develops strategies for risk avoidance, minimization, avoidance as well as contingency plans
14. Analyses and optimizes efficiency, productivity, asset utilisation and communicates the results to decision-makers
15. Performs benchmarking analysis across various performance and cost categories against industry leaders and utilizes the results as input to defining potential improvement projects and initiatives

H: Value system design and management competencies

1. Views the organization as a system that converts inputs to outputs
2. Understands the role of management activities and different organisation structures and applies fundamental management theories and concepts in practice
3. Participates in strategic planning, including long-term strategic goals, and relates strategic priorities to market and business environment trends, current status of the company and to goals of functional strategies and tactical plans
4. Analyses market and customer requirements and expectations, needs and desires, order qualifying and order winning factors and how the value generated by company is perceived in the mind of customer as a primary input to defining value system priorities
5. Analyses short- and long-term trends in the industry, region and micro-, macro- and global environment
6. Applies various analytical techniques to evaluate and improve company and main products position on the competitive landscape
7. Defines the system and component processes of value generation and the role of supporting activities in a company
8. Defines value offer to customers, applies differentiation and positioning concepts based on marketing data and assists in outlining marketing strategies as means to communicate the value offer to target customer segments
9. Analyses comparatively competitive forces and pressure on market
10. Defines goals and principles of the value systems, key success factors and product and service standards in value systems
11. Performs value stream mapping and outlines value system improvement plan accordingly
12. Understands the role of suppliers, customers and business partners in the supply chain, how it influences the total value perceived by end customer and how to coordinate actions, priorities and management principles to increase total value generation
13. Carries out make-or-buy analysis and impact of outsourcing to value generation
14. Performs gap analysis and defines improvement priorities to value systems accordingly
15. Assists in defining and developing external feedback systems and uses the data in planning and improvement actions
16. Manages company portfolio, optimal product and service profile and personalised customization options
17. Initiates and coordinates planning process of new products and services
18. Plans and manages research and development initiatives and actions and includes business partners in joint planning where applicable
19. Focuses on developing and maintaining long-term relationships with trading partners in order to improve value systems and understands the role of trust and mutual commitment in creating synergy and competitive success
20. Analyses the life-cycle of products and services and communicates the information to relevant decision-makers

I: Individual meta-competencies

Ability to communicate and collaborate

- Ability to manage the collaboration process in local and global setting
- Ability to create new knowledge collaboratively in a diverse team
- Competence in negotiation
- Persuasiveness and influence
- Teamwork competence
- Ability to critically evaluate and formulate opinions in debate
- Ability to utilize modern technologies in communication and collaboration
- Ability to utilize brainstorming and other creative collaborative methods

Ability to learn and manage information
- Ability to identify the competencies and meta-competencies needed to create value in a culturally diverse, distributed engineering world
- Ability to self-instruct and self-monitor
- Ability to interact with multiple modes of learning
- Ability to gather, interpret, validate, and use information
- Ability to understand and use quantitative and qualitative information
- Ability to discard useless information
- Ability to define gaps in existing information
- Ability to cope with data-intensive situations and maintain focus

Ability to manage thinking
- Ability to identify and manage dilemmas associated with the realization of complex, sustainable, societal-technological-economic systems
- Holistic thinking across disciplines
- Conceptual and critical thinking
- Thinking in a local and global context
- Ability to speculate and to identify research topics worthy of investigation
- Ability to use both divergent and convergent thinking
- Ability to engage in critical discussion
- Ability to identify opportunities
- Ability to think strategically by using both theory and methods
- Ability to apply problem-solving focus and result-oriented attitude in decision-making

Ability to manage attitude
- Ability to self-motivate
- Ability to cope with chaos
- Ability to cope with risks and manage risk taking
- Ability to cope with changes
- Attitude towards life-long learning
- Ability to apply positive and supportive attitude
- Focus towards building trust
- Self-criticism
- Ability to identify and acknowledge mistakes and unproductive paths

Supporting foundational personal characteristics
- Accountability
- Adaptability
- Creativity
- Empathy
- Integrity

PUBLICATIONS

I	Logistics Management in the Era of Supply Chain Management: A Gap in Academic Literature.
II	Designing a Meta-Model of Logistics Knowledge Areas.
III	Findings from Cluster Analysis of Logistics Undergraduate Curricula in Europe.
IV	Logistics Systems Engineer – Interdisciplinary Competence Model for Modern Education.
V	Logistics Management versus Supply Chain Management – the Crystallization of Debate for Academic Clarity.
VI	The Impact of Technology Trends on Skills of Logistics Engineers – A Novel Competence Approach.

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PUBLICATION I

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Logistics Management in the Era of Supply Chain Management – A Gap in Academic Literature

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This paper aims to contribute to the decades-long debate about the relationships between logistics and supply chain management. Although the terminology has developed over time to achieve much higher level of clarity, the authors of this paper would argue that some of this evolution has also introduced new problems in reaching a unified understanding of the concepts in academia.

When supply chain management (SCM) was first introduced, it proved to be a successful concept in a short time and was picked up by numerous authors from the fields of logistics, management and business administration. When it became apparent that SCM is here to stay, a number of authors described it as a new form of logistics, some as a subset of the latter, some as a much wider concept and some couldn't decide at all. Over the timespan of 30 years, the academic community has reached a well-developed and refined understanding of SCM as a research field, whereas logistics management as a distinct concept has, it could be argued, grown slightly out of fashion.

This paper studies the question if separate treatment of logistics management is needed and how is the possible distinction formulated by various authors. Alternatively, is logistics seen fitting mostly well enough inside SCM? The specific focus of this paper is to observe and analyse the viewpoint of modern literature in the field of logistics and SCM. The paper presents a literature review of historical development and modern understanding of the concepts. In the empirical part, authors present a detailed analysis across 35 modern textbooks to evaluate the presence of various schools of thought in the debate using the typology first suggested by Larson and Halldorsson (2004).

Our findings point out that even though SCM is commonly understood as a maturing and broader cross-functionally over-arching concept in recent academic treatments, the specific role of logistics management in relation to it is much less clear as authors have rather varying viewpoints. Authors of some SCM textbooks don't emphasize or even define logistics, suggesting that the concept of logistics might be in the risk of fading, should such trend continue. It appears many authors that have previously written on logistics are now writing about supply chain management. Considering typical book of both types, this entails the switch from more specific treatment to much broader but also more generalised treatment of topics, thinning the segment of textbooks that would be more oriented towards specific tactical level tools and skills instead of strategic management issues.

In practice, both logistics managers and supply chain managers are in demand, and only a part of their competence profile is shared (this is called "intersectionism"). For that purpose, further distinguishing between supply chain management and logistics management is required. In authors' interpretation, if logistics management is to thrive as a concept, it needs to more clearly differentiate itself from SCM and embrace intersectionist view. More specifically defined and agreed logistics management is needed as a concept, competence field and university curriculum, existing side-by-side with supply chain management, to overcome general vagueness on the nature of logistics that can be observed by viewing both SCM textbooks as well as various SCM and logistics programmes across universities in the world.

Keywords: *logistics management, supply chain management, logistics competencies, evolution of logistics, unionism, intersectionism.*

Introduction

The concepts of logistics management (LM) and supply chain management (SCM) certainly have a lot in common: people working on and researching the fields, institutions and even many books. However, depending on the viewpoint of management level involved, functional or cross-functional approach, organisational or business network angle there can be differences – some of them perhaps more to do with academic semantics, some of them substantial practical differences.

One viewpoint is that there is enough room for jobs, logistics manager and supply chain manager, even though the job descriptions and competence requirements met in practice are greatly varying from firm to firm, sometimes overlapping or even completely matching. Some logistics managers work next door to supply chain managers of the same company. While inside a company it is very much up to top management to define the structure, positions, responsibilities and workflow, the question of terms is more pressing for professional training and university programs. In such mess, one input to define the terms should come from academia, which would need to consider all practical needs. The main input and output factors in question are presented on figure 1.

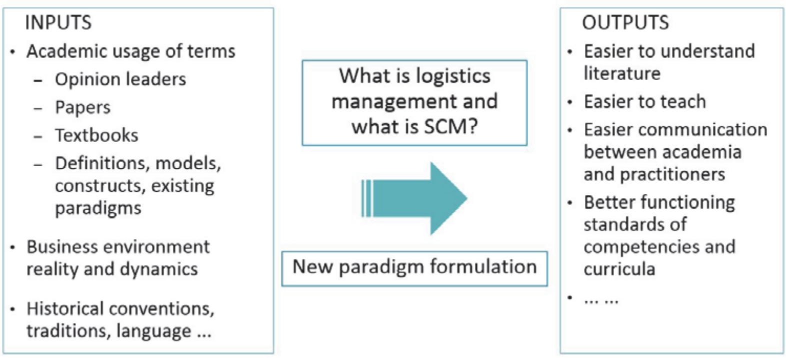

Figure 1: Main aspects involved in the process of developing common terminology in authors' view

Alternative view could be that LM and SCM are essentially the same so that there is no need for distinction for most purposes (other than perhaps marketing reasons). While this is certainly in coherence with many practical observations of the last decades, such as renaming of textbooks, curricula, institutions, job titles etc., it does impose a set of problems. First and foremost it could be that SCM in its entirety of over-arching competencies is too broad to form a good basis for teaching the concept in professional training. This could result in SCM programmes varying substantially in content from university to university (according to authors' observations this is the situation in many cases today) and could create confusion if such programmes are suitable for all kinds of labour market needs concerning management of logistics processes. (Niine, Koppel, 2011)

One possible scenario arising from this mismatch is where the market demands calls for various specialists with narrower skill-sets along the general SCM approach, but the universities offer only SCM assuming that all-in-one approach is possible, even if no-one is able to truly meet that promise. Of course the question would remain, whether LM would be a suitable package for a more specific approach to training, perhaps one with more focus on operational and tactical rather than strategic management level, or should these emerging niches just be filled with programs on a totally another level of narrowed-down detail, such as "warehouse management", "maritime shipping economics" etc. It could also be that if SCM manages to cover the entirety of general training and niches are covered by more specific concepts, logistics as an in-between concept is indeed no longer required.

Still, there are a great number of "logistics management" programs in existence today, even though randomly picked pairs of them might lack strong common core. However, shouldn't it be more agreed upon and standardized? This brings us back to our main question: if separate treatment of LM is needed or is it all fitting mostly well enough into SCM (and is therefore not needed as a separate concept from career development and curriculum point of view).

The general aims of this paper are 1) to contribute to terminology development to reduce misunderstandings between teachers, students and their future employers, 2) to help identify, which relationship between LM and SCM is currently dominating and 3) to suggest ideas for paradigm development, should it turn out that "Laissez-faire" approach is not efficiently leading academia towards meeting the challenges of the 21st century business environment.

This paper observes the situation from broad academic point of view and then, more specifically, turns focus towards recent textbooks discussing LM and SCM. The research problem is to find out the level of coherence of how logistics and SCM are defined and interrelated according to textbook authors. The main goal of such research is to understand the current state of logistics management as a concept, which could, on one extreme, prove that the concept is rather sustainable and clearly differentiated from SCM, or, on the other extreme, that the concept is fading in the background of SCM. Another goal would be to test the scope and strength of LM against SCM – it could also be, though the instincts might suggest otherwise, that logistics is a stronger concept and it is SCM that has to evolve and differentiate to survive instead. As a methodological tool, the typology first suggested by Larson and Halldorsson in 2004, which could be called Larson-Halldorsson matrix, is used in this paper to map the relationship between the two concepts.

Literature review – the essence of logistics and supply chain management

Early approaches

The history of logistics as a business concept has evolved substantially throughout the last 100 years of being used in business vocabulary. A good starting point emphasizing the relevance of the topic comes from Arch Shaw from Harvard Business School (1915): "The relations between the activities of demand creation and physical supply … illustrate the existence of two principles of interdependence and balance. Failure to co-ordinate any of these activities with its group fellows and also with those in the other group, or undue emphasis or outlay put upon any of these activities, is certain to upset the equilibrium of forces which means efficient distribution." It is interesting to note that even though Shaw neither used the words logistics nor supply chain, the idea itself is often quoted even today in various treatments – so there is undoubtedly a lot of common ground in the concepts.

Alongside such general framework of thought existed the understanding of logistics, or, as it was still mostly called up until 1950s and 1960s, physical distribution, as an operational area without much strategic importance. For example, Drucker (1962) is often quoted in pointing out that distribution was commonly perceived as "low-grade nuisance" more than anything else and the entire field had great unutilized potential, which he called economy's dark continent and noted to be "one of the sadly neglected, most promising areas of American Business". Managing distribution was seen in that era more as a necessary evil than a source of business success. In the words of Ballou, "logistics was not considered the function of strategy makers" (Ballou, 1978). However, that was about to change.

Snyder has suggested four elements that contributed the most to the development of logistics in the 1950s: 1) changes in customer demand patterns towards more dispersed nature and higher variety, 2) economic pressures as logistics costs were increasing in share and threatening profits, 3) technological change relating to electronic data processing and using computer as a business tool, which put emphasis on systematic business process design and allowed purchasing, production, inventory and sales to be better linked, 4) military experience with managing huge levels of inventory, which served as a best practice and extensive information base. (Snyder, 1963).

In the 1960s and 1970s, numerous trends and the changes in the general economic climate contributed to the rise of importance of logistics both in practice and in theory. On one hand, the oil crisis and the rise of interest rates contributed to companies dedicating more focus on all forms of cost control and increasing efficiency. (Soni, Kodali, 2008). Suddenly, distribution costs had become much more important. Secondly, the competition on many markets had grown considerably, inducing the need for larger product varieties and more extensive distribution networks (Bowersox et al, 1968). However, when industries started to reach the point of supply exceeding the demand, the risks of dead stock came more apparent. This started the long trend to alter supply chains towards greater responsiveness and shorter lead times. In other words, the role of logistics was starting to be seen as a source for competitive advantage, or indeed various types of competitive advantages.

Concept evolution since the 1980s

Following into the 1980s, the environment for logistics continued to be dynamic and pushed the understanding of logistics forward on various fronts with increasing international competition, emergence of Japanese economy and their management principles, trend towards higher specialization and outsourcing, technologies such as EDI and MRP-II, new concepts such as quality management, greater means of information sharing, changes in organisation structures, productivity improvements, emphasis on lower inventory etc. being some of the leading keywords. (New, Westbrook, 2004, Mangan et al, 2008)

This had an effect both on the performance expectations and priorities of logistics in companies as well as how logistics was treated academically. As Rushton et al (2010) have put it: “Logistics is a function made up of many sub-functions and many sub-systems, each of which has been, and may still be, treated as a distinct management operation. Both the academic and the business world now accept that there is a need to adopt a more holistic view of these different operations in order to take into account how they interrelate and interact with one another.” While it is nothing new in today’s context, such statement would have probably sounded much more innovative 40 years ago, similarly to this one by Hesket et al (1973): “Logistics is the management of all activities which facilitate movement and the coordination of supply and demand in the creation of time and place utility.”

Along rapid changes in logistics environment, the term “supply chain management” (SCM) emerged. The first authors to use the term SCM, Oliver and Webber (1982), noted: “Supply chain management covers the flow of goods from supplier through manufacturing and distribution chains to end-user. … 1) SCM views the supply chain as a single entity; 2) It demands strategic decision making and system integration 3) It views balancing inventories as the last resort” Since then, there has been some dispute over what SCM is and what it is not, while in some approaches SCM is viewed as a functional area and in others as broader management concept. In recent years, however, SCM is mostly treated clearly as foremost a strategic concept. As Melnyk et al (2009) put it: “over time, the theory and practice of SCM has experienced a transition from a tactical to a strategic focus. SCM involves more than simply making a ‘better’ buy; it affects the ability of the firm to make and maintain a sustainable competitive advantage.”

One approach, which in hindsight might have contributed to constraining the evolution of logistics from functional to holistic cross-functional competitive advantage level, was introduced in 1984 by Porter – the ideas of value chain and value system. According to Porter (1991): "Discrete activities are part of an interdependent system in which the cost or effectiveness of one activity can be affected by the way others are performed. I term these linkages. The cost of after-sale service, for example, is influenced how product design, inspection and installation are performed. Such linkages can extend outside the firm to encompass the activities of suppliers, channels and buyers." Such understanding has over time become the core of modern SCM. In Porter's view, logistics is a functional area contributing to the value system, rather than the system itself.

The debate over boundaries of terminology is normal for any young concept and probably never stops to be fuelled by continuous changes in practical environment. The long-term growth in importance of SCM can be, similarly to logistics growth earlier and also in parallel, attributed to a variety of factors such as globalization, liberalization of international trade, outsourcing and increasing competitive pressure in industries to offer higher quality with not only better price, but with superior speed, flexibility and value-added services. It is essential to realize that regardless of specifics of a given product and it's positioning on the market, all the aforementioned competitive advantages can be influenced not only by logistics performance but more generally the performance of supply chains. In that sense, while there is much in supply chains, that can be either directly or indirectly linked to logistics, such formulation also leaves room for issues not related to logistics in managing a supply chain strategically.

Perhaps one of the most important keywords in SCM development, in parallel to evolution of logistics, has been integration. Ellram and Cooper (1990) defined SCM as "an integrative philosophy to manage the total flow of distribution channel from supplier to ultimate user". Another example of a cross-functional definition is offered by Ayers and Odegaard (2008): "SCM is design, maintenance and operation of supply chain processes, including those for base and extended products, for satisfaction of end-user needs." In another wording by Lyons et al (2012): „The consequence is that supply chains are increasingly looked upon from an holistic, multi-business, yet integrated perspective and it is from such vantage point that makes feasible the development of a supply chain strategy that can be meaningful and coherent across a series of both loose and tight network alliances."

The idea of integration and holistic view in the supply chains can be dated back to the ideas of systems theory from the 1950s. The key point can be summarized as the observation that the behavior of a complex system cannot be understood completely by the segregated analysis of its constituent parts (Quayle, 2006). It is notable that in recent decades, while modern technology has facilitated ways to achieve much better integration via data sharing and quick information transfer, it has lowered the pressure on technology and instead pointed out that willingness to cooperate within the supply chain, understanding the available gains from it and reaching common ground in negotiations is the real bottleneck towards higher integration levels.

The need for developing integration has, similarly to logistics, also been widely accepted by authors in the field of operations management, which, not surprisingly have also started to turn more attention towards supply chain topics. In a recent edition of "Operations Management – Creating Value along the Supply Chain", Russell and Taylor (2011) emphasize: "Supply chains require close communication, cooperation and collaboration among members to be effective. Suppliers and their customers must share information. It is the rapid flow of information that characterizes today's supply chain management. Suppliers and customers must have the same goals. They need to be able to trust each other. Suppliers and customers must participate together in a design of a supply chain to achieve their shared goals."

Supply chain collaboration has been described as a process that promotes inter-organisational cooperation, openness, the creation of inter-company decision-making routines, knowledge sharing and customer-supplier intimacy (Mentzer et al, 2000).

Integrated logistics vs integrated supply chains

It can be said there is a difference between integrated logistics and integrated supply chains. Soni and Kodali (2008) have emphasized it as SCM "introducing the idea of external integration in addition to internal integration". Inside a firm, integration means that everything is working systematically and problems are holistically dealt with proper managerial actions. This applies to SCM only partially, as most supply chains are not fully vertically integrated. Due to different business environments, competitive situations, negotiating power and priorities of various chain participants, who is to determine the ideal characteristics of a supply chain in question? However, potential benefits from integration should not be discarded: „The biggest challenge facing companies today is not the internet, or globalization but integration of supply chains from vendors through manufacturers and distributors to satisfy end customers and obtain value. The goal of SC integration is to synchronize the requirements of customers with the flow of materials in order to achieve a balance between high customer service, low inventory investment and low unit costs. (Sadler, 2011)

It is logically less complex to manage any single company compared to attempting to manage the optimal output and cost balance over the entire supply chain. Furthermore, the more dynamic the market, the higher performance is expected from a supply chain on delivery speed and flexibility front – which itself is continuously questioning the status quo in many industries on a daily basis and makes SCM a truly strategic topic. As Janvier-James has put it, market uncertainty necessitates supply chains to be easily flexible to changes in the situation of trade" (Janvier-James, 2012). This requires increasingly more effort and cooperation in the supply chains. Paradoxically, the more dynamic a market is, the more probable it is that supply chains are less stable in terms of participants, making it increasingly more difficult to develop competitive advantages that require long-term commitment to coordination and collaboration between partners. In short, the challenges of SCM are never-ending. In comparison, integration inside an enterprise, which it could be said forms the scope of logistics management, is relatively more easily achievable.

To add support to such distinction, a recently emerged and evolving concept in the field is supply chain alignment. Gattorna (1998) has noted: "alignment with both external and internal partners in a supply chain should be a priority topic in defining any supply chain strategy." Alignment could be viewed as a more feasible goal in SCM compared to integration. Aligning with supply chain partners is both a strategic and managerial task: strategic, because it brings in long-term decisions about how operations will be structured and managerial because it encompasses decisions within an overall „game plan" (Harrison et al 2008). To better understand the nature of alignment, the „management" part of the phrase SCM should be interpreted in a widest possible context, in our wording as an act of assembling people to accomplish goals using available resources efficiently and effectively. In our context it means that supply chains can be managed via initiating cooperation even though no single entity usually fully controls the entire supply chain. Indeed often no single person even has a thorough overview about every aspect of the supply chain of their product.

Shouldn't alignment with suppliers belong to logistics manager's scope of responsibilities? Probably not according to authors such as Rushton et al (2010) with a view "supply chain = suppliers + logistics + customers". It seems that in contrast to pre-SCM era, when logistics was about to evolve into such holistic concept, numerous authors nowadays treat LM as subset of SCM. For example Wisner et al (2012) have expressed that SCM should be viewed balanced upon three pillars: purchasing, operations and logistics. In this view, logistics is a key part of SCM, as is any other function that contributes to perceived value and/or cost to the product, whereas purchasing, including issues of supplier selection and relationships, cover the inter-organizational aspects not covered by logistics.

Logistics management vs supply chain management

There might be more aspects in which SCM is broader or different compared to LM. Desphande has recently suggested that current methodologies for analyzing supply chains are not sufficiently comprehensive, particularly when it comes to understanding the complexities in SCM and organization performance. Based on extensive literature review, Desphande has identified three crucial SCM dimensions: long-term relationships, concurrent engineering and strategic purchasing (Desphande, 2012). Long-term relationships give businesses a multitude of benefits: higher level of trust advances in knowledge and ease of information sharing. (Griffith et al, 2006)

Strategic purchasing means that supplier selection decisions are not only based on best product offering with optimal balance in the quality-speed-cost triangle, but more strategic aspects are considered, such as long-term financial status, strategic positioning and willingness to collaborate and coordinate actions. According to Chen and Paulraj (2004), the construct of strategic purchasing requires supplier selection to be aligned with firm's strategic orientation, with a long-term relationship focus and asks if supplier has adequate understanding of firm's strategic goals and vice versa. Finally, concurrent engineering is focused on involving supply chain partners in product design phases. The goal of it is to better manage cross-functional and inter-organizational trade-offs and include a supply chain plan already in a preliminary business plan. From customer feedback perspective, it helps to obtain information from the earliest possible stage (Desphande, 2012).

In some interpretations, SCM and logistics are more roughly split into, respectively, external and internal domains. According to Christopher (2011): "SCM is the management of upstream and downstream relationships with suppliers and customers in order to deliver superior customer value at less cost to the supply chain as a whole." In such context, internal logistics would not even properly fit the scope of SCM.

Probably the most widely known definitions for SCM and LM are provided by Council of Supply Chain Management Professionals (CSCMP, 2013) as follows:

- Logistics management is that part of SCM that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements. Logistics management activities typically include inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfilment, logistics network design, inventory management, supply/demand planning, and management of third party logistics services providers.
- SCM encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. It includes all of the logistics management activities noted above, as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales, product design, and finance and information technology.

A substantial contribution to understanding the components of SCM was suggested by Lambert et al, (1997), according to which supply chains encompass eight general management processes that are applicable for every firm in a supply chain: customer relationship management, supplier relationship management, customer service management, demand management, order fulfilment, manufacturing flow management, product development and commercialization and returns management. In this view, the eight sub-processes are cross-functional and cross-firm by nature, forming a foundational framework of process integration. According to Lambert, a clear distinction was needed between SCM and logistics to emphasize that even the strategic meaning of logistics is only a part of SCM (ibid.)

In functional sense, Rushton et al (2010) have suggested a simple model of five components as composition of logistics: transport, inventory, warehousing, packaging and information. The authors have also specifically emphasized four areas in which SCM is different from of logistics:

1. The supply chain is viewed as a single entity rather than a series of fragmented elements such as procurement, manufacturing, distribution, etc. This is also how logistics is viewed in most forward-looking companies. The real change is that both the suppliers and the end users are included in the planning process, thus going outside the boundaries of a single organization in an attempt to plan for the supply chain as a whole.
2. SCM is very much a strategic planning process, with a particular emphasis on strategic decision making rather than on the operational systems.
3. SCM provides for a very different approach to dealing with inventory. Traditionally, inventory has been used as a safety valve between the separate components within the pipeline – thus leading to large and expensive stocks of products. Supply chain management aims to alter this perspective so that inventory is used as a last resort to balance the integrated flow of product through the pipeline.
4. Central to the success of effective SCM is the use of integrated information systems that are a part of the whole supply chain rather than merely acting in isolation for each of the separate components. These enable visibility of product demand and stock levels through the full length of the pipeline. This has only become a possibility with the recent advances in information systems technology. (ibid.)

Regardless differences in scope, the goal of logistics management and of SCM are usually stated very similarly. According to a classic approach: “Logistics involves getting, in the right way, the right product, in the right quantity and right quality, in the right place at the right time, for the right customer at the right cost” (Mangan et al, 2008).

Likewise, Chartered Institute of Logistics and Transport has defined logistics as “the positioning of resource at the right time, in the right place, at the right cost, at the right quality” (Rushton et al, 2010). This is not too different from the wording suggested by Simchi-Levi (2004): “SCM is a set of approaches used to efficiently integrate suppliers, manufacturers, warehouses and stores so that merchandise is produced and distributed at the right quantities to the right locations at the right time in order to minimize system wide costs while satisfying service-level requirements”.

In brief conclusion, it appears there is less confusion over terminology in recent approaches of front-line research as it is mostly agreed that SCM and logistics are in close view distinct, though similar, concepts. The latter is usually seen to entail a plan for material and information flow through an organization, whereas SCM is directed to expanding that plan to include suppliers and other business network participants to create synergies that are not achievable through actions inside one company alone. After 30 years, the concept of SCM, at least in terms of scope and definitions, is finally just reaching maturity. However, precisely defining logistics in relation to SCM remains a challenge and a source of misunderstandings in practice. We now turn our focus to how the same aspects of terminology are explained to students across broad range of modern textbooks.

Methodology

The aim of this research is to analyze how modern literature of SCM and logistics treat the relationship between the two terms. There are two main hypotheses:

1. The definitions of SCM in modern day textbooks of the field are coherent to suggest relative maturity of the concept;
2. The nature of logistics is defined clearly and similarly among modern textbook authors and similarly in relation to SCM.

The question on the relationship between two concepts has been discussed for more than two decades. Not only is it of importance on academic conceptual level but also for universities for curriculum development and for practitioners to reach common understandings in the terminology. Almost 20 years ago, Lambert et al (1997) noted: "Practitioners and educators have addressed the idea of SCM as an extension of logistics, the same as logistics, or as an all-encompassing approach to business integration" A strong foundation to understanding the existing parties in the debate was laid out by Larson and Halldorsson (2004), who pointed out: "the unclear conceptual borders of SCM make it difficult to design educational programs in SCM without large overlap with other fields such as logistics, marketing, operations management and purchasing" In their view, there are four possible relationships between the two terms (depicted on figure 2), namely:

- Traditionalism – logistics is a broad "mother" concept of which SCM has emerged as a part
- Relabeling – due to concept evolution, logistics has come a long way and finally transformed into supply chain management, which essentially is the modern viewpoint of logistics
- Unionism – SCM is a wider concept than logistics and encompasses logistics in its entirety, however, adding other challenges and decision areas into the scope that are not subcomponents of the field of logistics
- Intersectionism – SCM shares a common core with logistics. However, the field of logistics has aspects which don't belong under the scope of SCM and similarly the other way around – there are aspects of SCM that don't belong under what logistics is (or should be, according to the representatives of this school of thought)
- It should be noted that even though fifth approach is also imaginable – that the two fields are entirely separate – it did not appear practical for the authors and was cast aside.

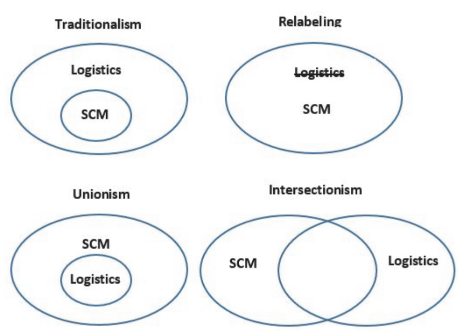

Figure 2: Possible relations between the terms according to Larson and Halldorsson (2004)

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What Larson and Halldorsson (2004) did was to ask the opinion of various educators of the two topics around the world by designing and carrying out a survey that could mathematically divide the respondents' detailed answers between the four understandings. The questions used were specific enough to remove bias – the respondents evaluated the relevance of a long list of topics to the fields of logistics and SCM without being directly asked their opinion. The result of the survey showed that all four schools of thought do exist, each having a strong level of support by some educators in the world.

Based on the literature reviewed, we could speculate before-hand that hypothesis 1 is a reasonable expectation due to recent trends. However, we did consider our hypothesis 2 as a rather bold assumption, as the four-way typology is only a decade old.

The literature for the analysis was chosen for the study by using two criteria. First it had to be less than 10 years old and secondly it had to be a textbook with a general aim towards either "supply chain management" or "logistics management". Many books in our sample are used by universities, have been successful in internet sales such as on amazon.com and are ranking high in Google Books database. We hope the final selection of 35 books surveyed forms an adequate unbiased sample of the existing textbooks, the grand total of which would probably reach a few hundred (and would still only include authors writing in English).

We analyzed 20 books from the first and 15 from the second category. This appears to reflect the situation on the current textbook landscape in the field of study mostly adequately – indeed there appear to be more books published in general about SCM than focusing on LM and sometimes the terms are merged. The first 20 were evaluated for the first hypothesis and to obtain the first viewpoint of SCM-focused authors' treatments towards logistics to then compare to the more specific logistics treatments. For analyses of the terms, the presented definitions in text were used as well as analytical explanations and context of terminology use. Even though in some cases the authors' views were not directly stated on the matter of our research interest, we could still most of the time makes reasonable interpretations according to Larson-Halldorsson matrix.

Findings from supply chain management textbooks

In this section the summary of findings from pure SCM textbooks are presented, followed afterwards by attention towards books that dedicate more detailed focus on logistics. Table 1 below presents a concise overview about the SCM literature studied. In the column "logistics", the coding used means:

- "-" – does not provide any specific explanation of the term logistics;
- "+" – explains partially the nature of logistics or the meaning can be deduced from context, without a proper definition being present;
- "++" – presents specific explanation on what is the authors' view on logistics.

The column "approach" refers to our interpretation on which of the four possible relationships of the terms in the Larson-Halldorsson matrix fits best the treatment in the textbook in question, where "U" represents unionism, "I" intersectionism, "T" traditionalism and "R" relabeling school.

The treatments of logistics by some authors reviewed here is firstly surprisingly shallow and secondly dismissive as a clearly inferior concept. It appears that some of the authors focusing on SCM oppose the idea of logistics having a greatly more augmented meaning today than compared to 30 years ago or indeed even aim to reverse the trend to define logistics again with a smaller, company-based or even only transport-based focus.

Table 1: 20 books of SCM involved in the study

Author(s)	Title	Year	Logistics	Approach
An, Fromm	Supply Chain Management on Demand	2005	-	n/a
Arlbjorn *et al*	Supply Chain Management. Sources for competitive advantages	2010	+	U
Ayers, Odegaard	Retail Supply Chain Management	2008	+	U/I
Basu, Wright	Total Supply Chain Management	2008	+	U
Blanchard	Supply Chain Management – Best Practices	2010	+	U
Bozarth, Handfield	Introductions to Operations and Supply Chain Management	2008	+	U
Chopra, Meindl	Supply Chain Management	2007	+	U
Cohen, Roussel	Strategic Supply Chain Management	2005	+	U
Emmett, Crocker	Relationship-driven Supply Chain. Creating a Culture of Collaboration	2006	+	U
Haksever, Render	Service Management. An Integrated Approach to Supply Chain Management	2013	++	U/I
Hugos	Essentials of Supply Chain Management	2006	++	U
Ivanov, Sokolov	Adaptive Supply Chain Management	2010	++	U/I
Monczka *et al*	Purchasing and Supply Chain Management	2009	+	U
Morris, Pinto	The Wiley Guide to Project Technology and Supply Chain Management	2007	+	U
Quayle	Purchasing and Supply Chain Management	2006	+	U
Scott *et al*	Guide to Supply Chain Management	2011	-	U
Sehgal	Enterprise Supply Chain Management	2009	-	U
Stadtler, Kilger	Supply Chain Management and Advanced Planning	2008	+	U/I
Wisner *et al*	Principles of Supply Chain Management: a Balanced Approach	2012	+	U
Yücesan	Competitive Supply Chains. A Value-Based Management Perspective	2007	+	U

It is clear that if the main headline is "supply chain management", then on the one hand authors need to promote their concept and reasonably differentiate it in terminology too. On the other hand, SCM was indeed born in the age of growing understanding of logistics and the part that is shared by the two concepts is essential. The real question still up for debate is how big this common ground is. The more logistics is narrowed down to, i.e. the more substantially greater the authors present SCM to be, the less there would be reason to treat logistics as a separate academic concept. On the other hand, it could be said that if logistics would be defined and agreed upon with more breadth and precision, it would stand its ground much better. In our view (reflected in table 1), the former is the view of unionists whereas the latter leaves more room for intersectionism. Such difference brings us to conclude that only 4 of the studied books were more open to or supportive of intersectionism, whereas the rest supported unionism. As expected from pure SCM-focused treatments, there were none "traditionalists" and only seldom could one spot the idea the fields "logistics" and "SCM" can be / have historically been seen as synonyms.

We have therefore divided our SCM textbooks into two categories based on their approach – there are authors which more clearly support unionism approach and authors whose opinion on the matter based on the book is less clear.

Unionist treatments

Arlbjorn et al (2010) define SCM as "… concerned with transformation of demand information to physical delivery of goods and services. /…/ The management ideal is to provide a differentiated management of intra- and inter-organisational activities and processes with the purpose to fulfill customers' requirements." Additionally, the authors explain the components of SCM in six component issues: product, technology-based, organisation, competition, relation-ship-based and global issues. The authors don't define logistics per se, but include an overview of concept development, which shows logistics as an intermediary form of integration, later surpassed by the integration offered by SCM, which is the viewpoint of unionism.

According to Basu and Wright (2008), supply chain should not be treated purely as a series of separate operations and organizations but as a complete end-to-end product-based cradle-to-grave process. The authors emphasize that "the objective is to be cost-effective across the whole supply chain, which requires a system-wide approach to optimization." Concerning LM, the authors seem to be unsure and inconsistent. On one hand, they promote the 2007 definition by Council of Supply Chain Management Professionals (CSCMP), but according to their interpretation, this makes the two concepts more or less synonymous (at least when manufacturing and supply organizations are concerned). However, on another occasion, the term logistics is used in context to mean nothing more than an operational field of cargo transport. In summary, they do explicitly state to support the unionist viewpoint.

Blanchard is building his approach both on SCOR process model by Supply Chain Council and on CSCMP definitions (which supports unionism) without further going into details on the scope of definition or logistics role in relation to it. In his view, the key components of SCM are identifying supply chain process reality and overcoming flow bottlenecks, designing proper processes to meet the set needs and empowering people. The term logistics is used heavily in the book representing mostly management of physical and information flows. (Blanchard, 2010)

Bozarth and Handfield (2008) approach SCM through operations management viewpoint. The chapter of logistics was only added in the 2nd edition of the book, which is probably already more proof than needed to suggest in their view SCM is wider than logistics. They have also based their approach on unionist CSCMP definitions of SCM and LM. However, in contrast it should be mentioned that according to authors' view, logistics is treated with much more narrow focus. Judging from chapter structure, even though logistics has a separate chapter, the topics of forecasting and even inventory management stand separately rather than under logistics section. This, it could be said, is a more extreme treatment of logistics, close to just being another name for transport.

In one of the more widely known books of the field, Chopra and Meindl (2007) start with emphasizing that SCM consists of strategy design elements, supply chain planning and operational elements. Their approach is rather remarkably unionistic, as the term logistics is used sparingly and is explained as the strictly functional aspects of facilities, inventory and transportation.

The textbook by Cohen and Roussel (2005) stands out by not including any specific definition of SCM, even though the book is titled „Strategic Supply Chain Management". It could be speculated if they reckoned the existing definitions to be too vague or contradictory to prove of specific value. The book does explain SCOR model as one approach to the problem scope. In content, authors leave no doubt that logistics is only one function in supply chain framework ("End-to-end supply chain management is not just about logistics"). As logistics is not specifically defined, the approach of the authors is more probably unionism than intersectionism.

Emmett and Crocker (2006) make it clear from the start that "SCM is a philosophy and a way of looking at how to better manage across functions. If we try to make supply chain management a functional department, then we will run the risk of subordinating the benefits of the approach and getting locked into power plays and the playing of serious schoolyard politics; such matters being commonly found in and between existing organizational functional silos/departments. Supply chain management by definition is all about integrating, coordinating and control, across internal and external functions." Interestingly, the authors point out that "logistics, which originally encompassed the whole supply chain, is now being understood by many companies as a new name for transport or for warehousing/stores or for distribution. Logistics can therefore be a confusing word. Additionally, some people use the term logistics to describe their own internal company process, and use the supply chain term, when they are dealing with external suppliers/customers." The authors don't really specify their own normative understanding of logistics.

In "Essentials of Supply Chain Management", Hugos (2006) describes SCM as significant evolution of the fields of logistics and operations management and presents a personal definition for SCM as "the coordination of production, inventory, location, and transportation among the participants in a supply chain to achieve the best mix of responsiveness and efficiency for the market being served." Hugos represents pure unionism in stating: "logistics focuses its attention on activities such as procurement, distribution, maintenance, and inventory management. SCM acknowledges all of traditional logistics and also includes activities such as marketing, new product development, finance, and customer service. In the wider view of supply chain thinking, these additional activities are now seen as part of the work needed to fulfill customer requests."

Monczka et al (2009) are approaching SCM through defining supply chain orientation. "A supply chain orientation is a higher-level recognition of the strategic value of managing operational activities and flows within and across a supply chain. / ... / Supply chain management, then, endorses a supply chain orientation and involves proactively managing the two-way movement and coordination of goods, services, information, and funds from raw material through end user. According to this definition, supply chain management requires the coordination of activities and flows that extend across boundaries." The authors are describing logistics as: "logistics managers are responsible for the actual movement of materials between locations. One major part of logistics is transportation management, involving the selection and management of external carriers (trucking companies, airlines, railroads, shipping companies) or the management of internal private fleets of carriers." This leaves little room for interpreting it otherwise than strict unionism with logistics viewed only on operational and tactical management levels.

According to Morris and Pinto (2007), "SCM is a set of approaches utilized to efficiently and fully integrate the network of all organizations and their related activities in producing, completing and delivering a product, a service, or a project. SCM approaches such as partnering, information, and risk sharing can greatly reduce the impact of these uncertainties." The role of logistics in this picture is only briefly mentioned: "New opportunities for businesses to improve operations even further now rest largely in the supply chain areas of purchasing, distribution, and logistics" With no more specifics on the nature of logistics given, this could be classified as yet another pure unionist.

Quayle (2006) argues that "SCM is the management of all activities in order to satisfy the ultimate consumer, covering almost all business activity, including marketing, manufacturing, purchasing, logistics, and, more generally, such activities as finance and personnel" and that "supply chain must reach beyond traditional logistics boundaries, to form partnerships with the aim of creating a seamless flow of goods and information".

"A Guide to Supply Chain Management" by Scott et al (2011) is yet another book basing its approach on SCOR process model and approaching logistics as not much else than a functional area to arrange physical flows. Quite similarly, according to Sehgal (2009), „SCM consists of managing the flow of resources across the enterprise for efficient business operation." Sehgal goes on to present a list of core supply chain functions, which does not contain the term logistics, although including many traditional subtopics of logistics. However, according to Sehgal's „supply chain planning functions", logistics is only viewed as a sum of transport and warehousing planning. Again, even inventory management has been left separate from logistics.

In addition to the popular SCM definition by CSCMP, Wisner et al present a formulation by Singapore-based Logistics & Supply Chain Management Society: "The coordinated set of techniques to plan and execute all steps in the global network used to acquire raw materials from vendors, transform them into finished goods, and deliver both goods and services to customers." The authors add: "In theory, supply chains work as a cohesive, singularly competitive unit, accomplishing what many large, vertically integrated firms have tried and failed to accomplish." Logistics is mentioned by authors as a functional area but no specific definition of LM given. (Wisner et al, 2012)

Yücesan models supply chain as a platform to coordinate physical, information and financial flows on three pillars: processes of value-adding activities; organizational structures encompassing not only a range of relationships from total vertical integration to networked companies, but also performance measurement and incentive schemes to make relationships sustainable; and enabling technologies. The book does not go any deeper on explaining the scope of logistics. (Yücesan, 2007)

Other treatments

An and Fromm have compiled their book without actually defined SCM or logistics. (An, Fromm, 2005) The term "logistics" is used sparingly in the book, to say the least, so the viewpoint on the Larson-Halldorsson matrix can't be determined from the text.

Ayers and Odegaard (2008) have compared various viewpoints in the debate between two terms, some of which are more broad, planning-oriented definitions, some more operational focused. The decidedly take a wider look across functional boundaries and compare 11 SCM definitions before presenting their own. The authors feel a broad view of SCM is required that emphasizes the strategic role of SCM and hence their preferred definition relies on the phrase "(management of) product life-cycle processes". In this view, the flows of materials, information and money belong to the scope, as well as their own addition, the flow of knowledge, to support supply chain processes and lead to growth through innovation. The authors have not defined logistics. Their approach to a multitude of SCM definitions indicates that their interpretation is either unionism or intersectionism. They point out that each definition has to be understood in its practical context, therefore suggesting that part of this debate will never be fully settled.

Haksever and Render (2013) note that "SCM as a field of study and practice can be considered as an outgrowth or expansion of logistics management. To a certain extent this is true; some of its tools and techniques are borrowed from logistics management, some from operations management and operations research. / … / LM activities typically include inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfillment, logistics network design, inventory management, supply/demand planning and management of third-party logistics services providers. / … / However, SCM is broader in scope and takes more strategic approach to supply chain operations including the traditional logistics activities." For our methodological purposes, such view gives enough specific credit to logistics so that it could be treated closer to intersectionism than to unionism.

A substantially more systematic and elaborate approach has been presented by Ivanov and Sokolov in "Adaptive Supply Chain Management" (2010). According to authors' view, "SCM studies human decisions in relation to cross-enterprise collaboration processes to transform and use the SC resources in the most rational way along the entire value chain, from raw material suppliers to customers, based on functional and structural integration, cooperation, and coordination throughout." The authors present a thorough explanation to their intersectionist viewpoint by stating: "logistics deals mostly with local functions for implementing the physical transition of material flows and SCM deals with the value-adding chain as a whole and concentrates on the managerial links between the local functions for implementing the physical transition of inbound and outbound material flows. /.../ In other words, logistics takes care of providing the right goods, in the right place, at the right time, in the right volume, in the right package, in the right quality, with the right costs, and SCM takes care of balancing the supplies along the entire value-adding chain subject to the full customer satisfaction. / .../ As examples of logistics problems, warehouse management, transportation optimization, procurement quantity optimization, local inventory management, cross-docking design, inter-modal terminals design, etc. can be named. Accordingly, manufacturing deals with optimizations in assembly lines, production cells, etc. As examples of SCM problems, distribution network design, demand forecasting, collaborative inventory management, supply coordination, supply monitoring, and controlling can be identified. In practice, the logistics and SCM problems interact and are tightly interlinked. This is impossible to consider logistics and SCM in isolation from each other. SCM and logistics mutually enriches themselves. SCM is a very important part of logistics. In its turn, logistics is a very important part of SCM."

Another detailed overview of the nature of SCM is presented by Stadtler and Kilger (2008), in which the main keywords are integration and cooperation: "the task of integrating organizational units along a supply chain and coordinating material, information and financial flows in order to fulfill (ultimate) customer demands with the aim of improving the competitiveness of a supply chain." Although logistics is treated as a functional "building block" that forms the foundation of SCM next to marketing, operations research, purchasing etc., credit is also given to a wider more philosophical understanding of logistics through presenting the five principles of logistics thinking (originally described by Pfohl in 2004), which are: thinking in values and benefits, systems thinking, total cost thinking, service orientation and striving for efficiency. Such approach makes logistics as an area stand relatively higher compared with many authors but differentiating between unionism and intersectionism is again difficult.

To sum up the 20 textbooks, the common theme is presenting SCM as a holistic concept that reaches across companies and functions and strives for success through cooperation and integration. On the level of definitions, hypothesis #1 could be considered as proven. There are, however, some differences in the structure and content of the books, which is understandable due to huge scope, offered by the very definition, but still makes the entire topic appear slightly vague. This is partially remedied by a number of authors that have found support structure for their approach from SCOR model, which does serve as a relatively good backbone. Another problem for SCM textbooks, however, is that the wide definitions of SCM demand inclusion of so many topics, it is challenging, to say the least, to treat every aspect with appropriate level of detail.

Findings from logistics textbooks

Now moving onto the textbooks focusing on logistics, the reason for research has become clearer – if there would be substantial common ground and distinct difference from SCM treatments, and then it would demonstrate logistics undoubtedly as a sustainable paradigm itself. However, our results across 15 logistics textbooks reveal a much more colorful picture, as can be seen in the final column of table 2 below.

It must be firstly noted that when the main term studied in the book relates to "logistics", the terminology debate meets notably more attention than in the first part of our research. Such multitude of opinions can be interpreted logically in two ways. Either some of them are in the wrong or mostly everyone is right in a sense as only specific viewpoints are treated by respected authors instead of broader nature of logistics. We would personally lean mostly towards the latter. Still, this means that the scope of logistics remains vague.

Table 2: 15 books on logistics involved in the study

Author(s)	Title	Year	SCM*	Approach
Branch	Global Supply Chain Management and International Logistics	2009	+	R
Christopher	Logistics and Supply Chain Management	2011	++	I
Dinitzen, Bohlbro	Value-Added Logistics in Supply Chain Management	2010	++	U/I
Simchi-Levi *et al*	The Logic of Logistics. Theory, Algorithms, and Applications for Logistics and Supply Chain Management	2005	+	R
Waters	Supply Chain Risk Management. Vulnerability and Resilience in Logistics	2007	++	R
David, Stewart	**International Logistics: The Management of International Trade Operations**	2010	++	U/I
Farahani *et al*	Logistics Operations and Management. Concepts and Models	2011	-	n/a or I
Fernie, Sparks	Logistics & Retail Management	2009	-	n/a or I
Ghiani *et al*	Introduction to Logistics Systems Management	2013	-	n/a or I
Gudehus, Kotzab	Comprehensive Logistics	2009	-	R/I
Harrison, van Hoek	Logistics Management and Strategy	2008	++	U/I
Langevin, Riopel	Logistics Systems Design and Implementation	2005	-	U/I
Lun et al	Shipping and Logistics Management	2010	-	n/a or I
Rushton *et al*	Handbook of Logistics and Distribution Management	2010	++	U/I
Schönsleben	Integral Logistics Management	2007	++	I

*The marking system here is similar to table 1 turned towards the treatment of the nature of SCM.

Branch (2009) defines logistics as “the time-related positioning of resources ensuring that material, people, operational capacity and information are in the right place at the right time in the right quantity and at the right quality and cost. He continues: “This embraces the ultimate objective of global supply management, which is to link the marketplace, the distribution network, the manufacturing and assembly process and the procurement activity…” The author does not define SCM per se, but from context it is rather clear that the author uses it interchangeably with logistics management. Therefore we have identified our first case of relabeled. This is not to say that there are not detailed differences in the context of how the author uses the terms at all, just that these are not evident enough and the author does not emphasize them.

Christopher (2011) starts his latest edition of his renowned textbook by stating: “SCM is not just an extension of LM, but rather that it is about managing relationships across the complex networks that today's supply chains have become.” It is worth emphasizing that Christopher treats logistics as a strategic discipline: “Logistics is the process of strategically managing the procurement, movement and storage of materials, parts and finished inventory (and the related information flows) through the organization and its marketing channels in such a way that current and future profitability are maximized through the cost-effective fulfilment of orders.” The question whether Christopher’s approach is of that of a unionist or rather intersectionist is not perfectly clear, however, the definitions are distinct enough to lean towards intersectionism.

Dinitzen and Bohlbro (2010) set out with making sure the terms are well defined: “LM is the process of managing and coordinating the flow of materials and information within the company and between the company and its partners. A distinction is made between that part of the task that lies within an individual company and that part that involves coordination and collaboration between several companies. The former is logistics while the latter is SCM. SCM consists of the planning and control processes from raw materials to end user through the coordination and linking of partners in a supply chain." Therefore the responsibilities of logistics are of similar expected outcome but of narrower scope and dealing with partly different tasks. The authors stress that one key difference is the management level. "In contrast to the logistics strategy, SCM involves several companies and their ability to coordinate their individual logistics strategies."

Simchi-Levi et al (2005) present mathematical optimization models for logistics, which is only one specific perspective on the enormous field of SCM. The authors note that the perceived difference of terminology much depends on the author but in their own approach they do not distinguish between logistics and SCM.

Similarly in "Supply Chain Risk Management. Vulnerability and Resilience in Logistics", Waters (2007) deals with logistics from a specific angle, risk management. From such focus, it makes more sense not to deal extensively with solving indirect terminology debates and so from risks point of view, the two terms are interchangeable. In authors' own words: "In reality, SCM might emphasize the importance of integrating activities, but this has been a developing theme of logistics for decades. The choice of terms is largely a matter of semantics, and here we stick to the convention that the two terms refer to exactly the same function."

David and Stewart (2010) follow the definitions of CSCMP. "The scope of SCM is much broader than the scope of logistics. Not only does it include all the tactical and managerial decisions, on which logistics and operations managers tend to focus, but it also includes strategic issues that are traditionally the domain of top management positions. /…/ International logistics professionals focus on the tactical aspects of a global supply chain, activities which are inherent to the movement of goods and paperwork, activities that constitute basis for import and export activities".

Farahani et al (2011) present a detailed view on different aspects of logistics without much analyzing SCM. In such view, evidently, there are distinct differences in the concepts and similarly to many others, the authors have built the book around the definition of CSCMP. The content of the book also includes detailed and more technical aspects of logistics not usually treated in typical SCM books, such as vehicle routing problem, warehouse design and optimization of uncertain logistics networks. Therefore it appears the authors' would agree that for conceptual purposes logistics is a sustainable field in itself.

Fernie and Sparks (2009) have further focused their view of logistics on retail operations only. The authors don't aim to deal with the entirety of SCM and therefore don't define it, but instead they build on five stated components of "logistics mix" - storage facilities, inventory, transportation, unitization and communication. The book presents detailed aspects of managing operations in all mentioned fields to support strategy of a given retail environment.

In the foreword to "Introduction to Logistics Systems Management" by Ghiani et al (2013), Marc Goetschalckx notes: "while logistics management requires an integrated, holistic approach, its treatment in courses and textbooks tends to be either integrated and qualitative or mathematical and very specific. This book bridges the gap between those two approaches by providing a comprehensive and modelling-based treatment of the logistics processes". The approach to logistics by Ghiani et al is comprehensive indeed, treating LM from both operational, flow network as well as integrated system management point of view. It is, peculiar, how the book avoids dealing with the term SCM almost entirely. However, intersectionism is the most likely interpretation.

Gudehus and Kotzab (2009) aim to present respectable range of topics one would expect from comprehensive treatment of logistics, and end up with near 900 pages. In their view, "… logistics has to design, set up, operate and optimize systems, which generate physical goods and immaterial services. These tasks overlap with production planning, process technology, industrial engineering, operations research, informatics and other fields of technology and economics. Logistics in the broadest sense includes also purchase and sales." The authors discuss supply chains mostly from network optimization point of view and the book doesn't touch some topics treated in an average SCM book. While it therefore appears to us that their approach classifies as clear intersectionism, the authors declare something more along the lines of relabeling: "In daily business, SCM is confined to the selection of cost-optimal logistic chains for current orders. To remain competitive, the company, which pays the delivery costs, must permanently optimize its supply chains. When demand changes, the supply chains have to be adapted or new logistic structures have to be designed and implemented." The authors don't expand on the long-term horizon or perspective business aspect of SCM in contrast to the "daily business" viewpoint they have based their book around.

Harrison and van Hoek (2008) are on the opinion that „logistics and SCM are sufficiently different for separate definitions to be needed", and also that „SCM is wider than logistics". The authors define SCM as "planning and controlling all of the business processes – from end-customer to raw material suppliers – that link together partners in a supply chain in order to serve the needs of the end-customer." The viewpoint appears to be between unionism and intersectionism but it is definitely a different form of unionism compared to some SCM authors that would rather marginalize the meaning of logistics.

Langevin and Riopel (2005) have defined altogether 48 aspects of logistics decisions across three categories: strategic planning level (such as customer service objectives and standards, outsourcing), network level decisions (such as physical network design and communications network design) and operational decisions (demand forecasting, inventory management, order processing, warehousing etc.). The authors are declaring support for the CSCMP definitions.

Lun et al treat LM with shipping industry and transport process context. (Lun et al, 2010) The book presents another set of examples of specific logistics issues which are only seldom discussed under SCM label and such approach is in our interpretation intersectionistic.

Rushton et al take a rather philosophical view in the debate by stating: "There is, realistically, no 'true' definition that should be pedantically applied, because products, companies and systems differ. Logistics is a diverse and dynamic function that has to be flexible and has to change according to the various constraints and demands imposed upon it and with respect to the environment in which it works. These many terms are used, often interchangeably, in literature and in the business world. One quite widely accepted definition that uses some of these terms also helps to describe one of the key relationships: Logistics = Materials management + Distribution. An extension to this idea helps to illustrate that the supply chain covers an even broader scope of the business area including supply of raw materials and components as well as the delivery of products to the final customer. Thus: Supply Chain = Suppliers + Logistics + Customers." While this appears as unionism, it is again evident that the depths of which some of the distribution-related topics are treated in this book are rarely dealt with that level of detail in a typical SCM textbook. For practical purposes, then, it might as well be labelled intersectionism. By authors' own words: "The scope of logistics has continued to grow rapidly, and this is reflected in the content of the book. We have included key aspects of supply chain philosophy and practice, but have tried to retain the focus on distribution and logistics." (Rushton et al, 2010)

Finally, Schönsleben (2007) offers somewhat different definitions for logistics and SCM. "Logistics in and among companies is the organization, planning, and realization of the total flow of goods, data, and control along the entire product life cycle", whereas "SCM is the coordination of strategic and long-term cooperation among co-makers in the total supply chain, both in production and procurement and in product and process innovation". This is the only textbook we could identify as pure intersectionist just from definitions without further interpretations required.

In summary, the real indicator of intersectionism in our view is the depth with which the topics are approached. This would mean that the sum of all reviewed textbooks quite clearly lend support intersectionism. Let's take another look. Four books supported relabeling. In case of Simchi-Levi et al (2005) and Waters (2007), this is due to specific viewpoints to the topic matter, which does not absolutely demand distinct differentiation between LM and SCM. In case of Branch (2009), this could be due to more practical handbook-style approach that does not attempt to theoretically cover everything the terms used might imply. Probably both arguments would apply for Gudehus and Kotzab (2009) and this was the case of stated relabeling, whereas by content, the book appears substantially more detailed than any generic SCM textbook (not that we'd want to marginalize or be dismissive towards books that aim for higher coverage of aspects over specific detailed treatments).

Briefly put, there appears to be a distinct difference between typical SCM textbook and the book that puts more emphasis on the details of logistics in a specific context or from a specific viewpoint. This is how intersectionism should reflect the matter. It appears authors writing on logistics are mostly searching suitable niches to differentiate from SCM. It could be paraphrased that in defining logistics management, "bigger is not better" anymore as it can't compete with the scope of SCM.

It could also be said that if viewed from far enough, the concepts most evidently appear similar and differences are only revealed when specific aspects are taken into focus. Hence it is encouraging that there is an ongoing search for these niches, although there are, on average, nowadays less books on logistics than there are books on supply chain management. The substantial issue, however, is that the nature of logistics in relation to SCM is not as clear as it could be and authors have sometimes substantially varying ideas of how this differentiation should be best formulated.

Conclusions

First of all, it appears evident that the understanding of SCM has harmonized and is rather coherent among modern textbook authors. References to international definitions such as ones by CSCMP and SCOR are widespread. These treatments leave no doubt that traditionalism and relabeling are out of the picture and unionism is, from the SCM "flagship" point of view, the dominant approach. The field of SCM appears much more mature than still in 2004 when Larson and Halldorsson published their research. The range of topics covered under SCM title, however, varies to some extent and this is mostly due to the wide range of topics involved by definition. If a perfect SCM textbook exists then it can be perfect in the sense of "nothing to take away" rather than "nothing more to add", which would be impossible to reach.

Secondly, SCM authors treat logistics as a functional component of SCM with varying degrees of breadth ranging from pure transport arrangement (extreme unionism) to integrated management of material and information flows through the supply chain (which could be determined as soft unionism or also intersectionism). More specified understanding of logistics is often lacking in SCM books both in content as well as even in definition.

The textbooks discussing logistics entail more terminological disagreement and have less of a common denominator. Some authors still support relabelling, while others are unionists or intersectionists and in some cases no attention is turned towards the nature of SCM at all. We could not identify any case of traditionalism, i.e. the view that SCM would form a subset of logistics management. It could also be said that the relabelling cases we noted were more related to specific practical viewpoint to the topic matter rather than being theoretical declarations. Still, such approaches contribute to the remaining confusion.

The treatments of logistics vary to notable extent and while this demonstrates logistics as similarly rather broad concept, it is another factor of confusion. On one hand there are authors who attempt to grasp the full scope of the term in the textbook, on the other hand there are books that treat only certain viewpoints to logistics (such as optimization models or practical trade handbooks or operations management tools) with the content not being too clear just judging by the title. So the problem of logistics having many faces is similar in textbooks as it is in curricula over the world. At any rate, a typical book on logistics covers a set of more specific issues with much greater detail compared to typical SCM book. In other words, when details are concerned, many authors still prefer to discuss it as "logistics" rather than SCM. Considering this, the practical conclusion is that the books on logistics fill a multitude of different niches which are not filled by most SCM books and therefore the actual textbook field is best to be described as intersectionistic, but not in a clearly defined sense how Larson and Halldorsson described, as shown on figure 3.

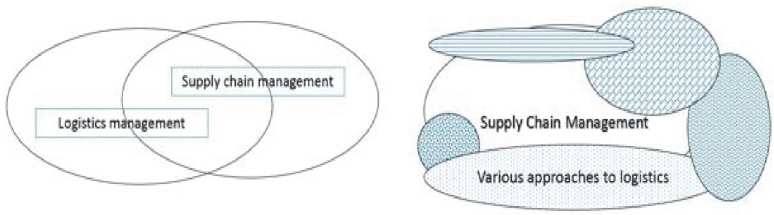

Figure 3: Clear intersectionism (left) and currently observed intersectionism (right)

When purely definitions are concerned, it is difficult to argue with unionists. In our view it is mostly established today that SCM entails some topics that fall outside the scope of logistics management. The debate continues on whether there is some bit of logistics management that would not belong under SCM. Judging by the textbooks, it could be argued that there is rather a lot of room there and so intersectionism appears a feasible and preferable approach for the future, combining the typical generalized SCM treatment (more topics, less depth) with specific studies of component issues treated as "logistics" and focused more on operations analysis and tactical management rather than strategic management. This would further distinguish between the roles of supply chain manager and logistics manager and we feel that it is needed – currently both roles are still rather vaguely understood in practice. The economy requires both people to analyze supply chains, manage supplier and customer relationships and search for ways of value chain cooperation (supply chain managers) as well as people who directly manage physical and information flows and know the technical details, specific technologies and have other specific competencies that the general supply chain manager would not have (logistics managers). This can be a task for the same person only in a small company. As for university curriculum, such merger into a single competence profile it is not practical.

Therefore, logistics shouldn't be dismissed and even though SCM is by definition greater than logistics, it does not mean that there is no need to teach logistics in universities (often right next to supply chain managers) nor that there is no need to write books about logistics (again side-by-side with books on SCM). For some, this might sound as a trivial point, but when we look around, we see many authors becoming obsessed with SCM and too many books on basically the very same thing while there is a relative shortage of books presenting logistics in a holistic manner. This is, by the end of the day, counterproductive due to the risk of logistics fading to the background, as some SCM proponents are still using belittling of logistics (not the actual practical field, as details are always important for the true professional, but the term as a theoretical concept) as a marketing point for their own concept. This might as one extreme consequence lead us to the situation where the academia is preparing too many generalist-type managers (because SCM covers everything, right?) but too few specialist-type logistics managers.

All in all our conclusion is that logistics treatments do bring more details to the table, but the scope should be more clearly formulated and agreed upon for future development next to supply chain management to help refine competence models, develop international standards and offer better input to universities for curriculum development. In practice, moving towards more clear intersectionism should be the priority and in the long term it would benefit all the stakeholders.

As a final thought, we'd like to agree with Ivanov and Sokolov (2010) when they wrote: "Actually, the elaboration of a unique viewpoint on this aspect should not be counted on. Sometimes, these discussions appear very similar to discussions on interrelations of theatre and cinema in the 1940–1950s. Nevertheless, both the theatre and the cinema exist now. So both the logistics and SCM will exist in the future."

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PUBLICATION II

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COMPETENCE IN LOGISTICS – DESIGNING A META-MODEL OF LOGISTICS KNOWLEDGE AREAS

NIINE, T. & KOPPEL, O.

Abstract: *Logistics is an extensive interdisciplinary field across industries and jobs, merging the viewpoints of engineering, manufacturing, operations and business administration. In higher education of logistics, various curricula approaches exist from "one-size-fits-all" style to narrow specific focus. However, even when the broad scope is applied in title, the content can vary substantially, often misrepresenting technology topics. This presents a terminological and a practical problem for academia. Competence standards and certifications in logistics differ as well and are not sufficient to drive curricula harmonisation. Our research studies the gaps between models of expected competences from professional logistician. The paper analyses six international standards and presents an augmented structural model of logistics knowledge areas. Such meta-model can be used for effective quantitative curricula evaluation and development and contributes towards refinement of standards.*

Key words: *logistics competences, logistics knowledge areas, curricula development, competence models, interdisciplinary learning*

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1. Introduction

Logistics is an extensive field reaching across sectors, industries and widely varying responsibilities and job descriptions. Over decades, logistics has evolved into an interdisciplinary concept across the fields of natural and social sciences, merging the viewpoints of engineering and business administration. In both domains, the scope of topics covered by logistics has expanded in time. Recently, integrated treatments of manufacturing, technology design and logistics have seen major developments, further reinforcing the engineering aspect of logistics.

Among such variety and complexity, the core concept of "logistics" remains at the heart of research, monographs, university curricula and competence models. However, the more detailed explanation about the component areas of logistics one would research, the more there are disagreements and mismatches in approaches. This is to some extent taking place already on the definition level, but much more so when detailed models of competences and knowledge areas of logistics professionals are concerned.

In terms of function-specific niches inside logistics, there is relatively less debate. Areas such as warehouse operations or transport planning have their own standards and certification options and universities, if they desire, can build their curricula with more detailed and clear focus. The more interdisciplinary the approach aims to get, the more difficulties for scope it presents. For example, manufacturing logistics support merges production with inventory management, but is also intertwined with purchasing, material handling and ICT topics.

In terms of undergraduate programs, the approach applied by the majority is still generic "logistics" without more specific focus. In all these cases the competence that should be acquired is less clear due to two main factors. One is the wide range of topics that modern logistics entails *per se*, forcing difficult choices upon curricula designers. Secondly, various international certification and competence model approaches disagree to certain extent among themselves, which means curricula boards are getting mixed messages. In our view, the problem lies in the lack of clarity and harmony across competence standards, which is required for effective curricula development. This paper aims to contribute to reducing the problem by presenting a synthesised meta-model of logistics professional's knowledge areas. The goals of our paper are twofold:

- to identify gaps between standards of logistics competences and fill them;
- to create an integrated tool for "short-cut knowledge-area analysis" of existing curricula as well as developing and positioning new ones.

The structure of this chapter is the following. We start out briefly presenting some relevant points from the literature. Then we focus on the area of competence models in logistics and present a comparison of selected renowned models. The creation and configuration process of our own model is then explained. We also present initial results from pilot-testing our model against a selection of curricula which gave feedback to the model. We conclude with brief discussion of implications and outlining further actions.

2. Literature review

Globalisation and changes in the society keep labour market situation ever evolving (Jirincova & Leicherova, 2012). Knowledge is a limited resource and importance of knowledge as a driving force of innovation and economic growth worldwide is increasing significantly (Tekic et al, 2013; Sorak & Dragic, 2013). This prioritises distinguishing between average and excellent employees and the development of performance (Krajcovicova et al, 2012) which in turn effects the competences required from students (Pupavac, 2011). The exact responsibilities of logisticians has been much discussed (Gudehus & Kotzab, 2009; Schönsleben, 2007). The definition often offered explains logistics via activities that facilitate the coordination of supply and demand in creating time and place utility, which leaves room for various professional interpretations (Simchi-Levy et al 2005, Dinitzen & Bohlbro, 2010; Erturgut & Soysekerci, 2011)

Modern logistics is understood as interdisciplinary concept and as such, interfaces with other business functions, as well as to other areas of engineering are abundant. Most textbooks of logistics present some form of a model of the components (David & Stewart, 2010; Farahani et al, 2011). Perhaps one of the most structured approaches to logistics decision areas has been put forward by Langevin and Riopel (2005) in presenting a structure of 48 decision areas across the levels of strategic planning, physical facility network and operations.

While such approaches offer insight, they are not specific enough to use as direct input for curricula. Furthermore, specific treatments are not internationally agreed upon. Therefore this paper directs attention towards logistics competence standards of wider recognition in hopes that such platforms offer more feasible harmonisation. As far as we know, specific and detailed analysis of various logistician competence models with curriculum development focus has not been carried out before.

3. Methodology

3.1. Input selection criteria

The criteria for selecting logistician competence models and occupational standards to be included in our study were the following:

1. The model has to focus on “logistics” with a relatively broad view. This means that a model of “distribution and logistics management” would fall into selection as distribution is an integral part of logistics, whereas a model of purely “warehouse management” (such as certification offered by International Warehouse Logistics Association) was not included as logistics is in many dimensions broader than warehousing operations. Another model left out was Certified Logistics Technician (CLT) certification, as it focuses exclusively on technical competencies of front-line material handling and distribution workers.
2. Models focusing purely on “supply chain management” would be excluded stemming from the conceptual understanding that logistics is, though similar, a

distinct concept, at least in terms of academic treatments of professional competences. In our view contrasting logistician and supply chain manager competence models is worthy of separate study and including this dimension here would obfuscate focus. The topic is controversial. There are examples of logistics organisations that certify supply chain managers, such as SCM-PRO certification by Confederation of Indian Industry Institute of Logistics.
3. The model has to describe logistician knowledge areas on professional level suitable for comparison against university or college curricula. Some certification programs strictly require college diploma or degree while others are more flexible, suggesting a combination of work life experience and additional modular training. Some models reference European Qualifications Framework (at least level 5 was required to be included) yet others don't reference the related education level at all. Models clearly focusing on lower positions were left aside.
4. The model must have significant international recognition. Qualification standards of seemingly national reach only were excluded.
5. The model must have clear structure in detailing applicable skills and knowledge areas. For that reason, we did not include Certified Logistics Professional CLP certification by The Logistics and Supply Chain Management Society, among others, as their certification process is built around a scoring calculator of various career-related achievements, but not on specific competences. Their understanding of the reach of logistics is represented by a single sentence, which leaves the system flexible, but extremely subjective. Information on models to study was readily available on the internet.

3.2. Selected input - relevant competence models

All considered, it appeared adequate to limit this research with 6 models, which was deemed sufficient to give plentiful ingredients to our meta-model:

- Distribution and logistics managers' competency model by The Association for Operations Management (APICS, 2014);
- Certified in transport and logistics (CTL) by American Society of Transportation and Logistics (AST&L, 2014);
- Demonstrated master logistician (DML) and Certified master logistician (CML) by The International Society of Logistics (SOLE, 2005);
- International Diploma in Logistics and Transport by Chartered Institute of Logistics and Transport (CILT, 2006);
- Logistics professional by European Logistics Association (ELA, 2014);
- Certified International Trade Logistics Specialist (CITLS) by International Trade Certification (IIEI, 2014).

The Association for Operations Management APICS is one of the more widely known international bodies in logistics. Their model consists of two classes of competencies: foundational and profession-related. While the latter expands into a tree of knowledge areas in "operations management" and "distribution and logistics", the former is mostly structured around personality traits, general skills and attitudes.

In the view of using APICS model as benchmark for curricula, mostly only profession-related topics would be directly applicable. While it is, of course, relevant to develop traits such as integrity, continuous learning and problem solving ability in any industry-focused training program, the presence of such aspects are largely not identifiable from curricula explicitly. Such aspects are essential for curriculum self-evaluation, but difficult to evaluate from outsider's perspective and this is the reason why our model describes "knowledge areas" not competence, which is a wider concept. Our focus is specific topics which are directly comparable against curricula content and measurable on the level of course titles and descriptions. Keeping that in mind, some items under "academic foundational competencies" in APICS model, such as sections "enterprise economics" and "materials management" were applicable for our research purposes.

American Society of Transportation and Logistics offers multiple levels of certification options: an entry-level oriented "global logistics associate" (GLA), a central and probably most popular "certified in transport and logistics" (CTL) and more exclusive senior-level "distinguished logistics professional" (DLP). CTL presents a flexible framework of three compulsory modules (transport economics, logistics management, international transport and logistics) and three required elective modules of seven (general management principles, lean logistics, logistics analysis, supply chain strategy, logistics finance, supply chain management and creative component). To qualify as CTL, an individual must have earned an undergraduate degree or have at least three years of industry experience. It is worth noting that different to some certification programs, AST&L also lists universities, the coursework of which is directly counted towards certification.

The International Society of Logistics, with presence in over 50 countries, approaches the topic with more emphasis towards technologies, (being originally The Society of Logistics Engineers) and promotes a balance between logistics management business methods on one side and engineering and industrial processes on the other. SOLE recognition system has five steps: demonstrated logistician, demonstrated senior logistician, demonstrated master logistician, certified master logistician (CML) and certified professional logistician (CPL). Each step on the career path imposes logistics job performance and continuing education requirements as well as additional lists of related functional skills and enabler skills training areas. Workplace experience and education degree and coursework requirements are interrelated and flexible – a defined amount of courses needs to be passed for every recognition level from a large list of electives. According to SOLE, applicants with master's degree are invited to CML levels directly. SOLE suggest a model of typical educational areas appropriate to logistics designation programs, which is built around four pillars: systems management, systems development and design, acquisition and product support and distribution and customer support.

The UK-based Chartered Institute of Logistics and Transport (CILT), with members in 30 countries, offers three levels of certification: International Certificate in Logistics and Transport (level 3 in EQF), International Diploma in Logistics and Transport (level 5 in EQF) and International Advanced Diploma in Logistics and Transport (level 6 in EQF i.e. "degree level"). According to the diploma guide: "The

Diploma is aimed at those already working in the industry/sector at a middle management level and who wish to develop a strategic view of logistics and transport operations". The course content is divided into six modules: logistics operations, resources, transport economics and finance, logistics and supply chain, inventory and warehouse, and finally passenger transport. Advanced diploma adds a layer of five knowledge areas relating to strategic performance management. The range of topics is extensive on both levels, but are intended to be completed in only 360 hours.

A similar structure of three levels is suggested by European Logistics Association: supervisory and operational management of logistics (EQF level 4), senior management of logistics (level 6), and strategic management of logistics (level 7). ELA is a federation of 30 national organizations, situated in Central and Western Europe. The mission of ELA is to offer certification that follows industry trends and is suitable for international evaluation, training and recruitment. Both level 4 and level 6 ELA standards consist of four key skill areas: business principles, logistics design, supply chain and logistics planning and execution, with latter further expanding into transport, warehousing, customer service and sourcing topics.

IIEI International Trade Certification has defined altogether 10 standards for various positions concerning international trade operations. While some of them are clearly too narrow to be used in this research, such as Certified International Freight Forwarder, the Certified International Trade Logistics Specialists (CITLS) suggests a broad range of knowledge areas, which IIEI calls "an in-depth synopsis of Supply Chain Management concentrating on the exporting/importing environment". The CITLS model is essentially a long list of over 30 topics as specific knowledge areas expected from logistics specialist operating in international trade.

3.3. Logistics knowledge areas - model configuration

Our process of research steps undertaken along with results from each steps are presented on Fig. 1 below.

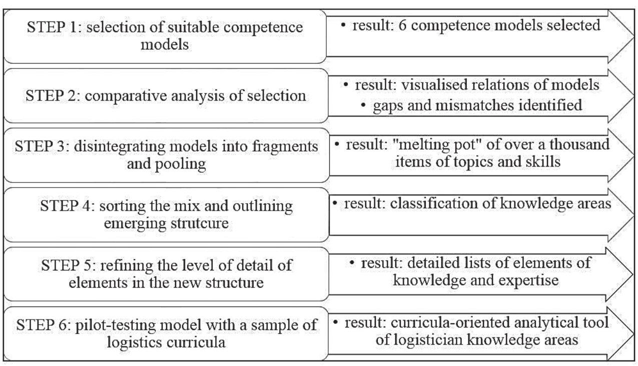

Fig. 1. Implemented research process and outcomes.
Source: authors' compilation.

Even without delving deep into our selection, it was clear that models were far from describing the same scope. Being perfectly competent to be certified by any one of these models would not automatically assume certification success according to others. The models differ in scope, in structure, in the level of detail described and in the approach used to describe the details, whether from the viewpoint of knowledge areas (i.e. *understands*, *is knowledgeable about....)* or skills (i.e. *skilled in performing, evaluates, identifies, manages, demonstrates* etc.). The extent of differences referred in step 2 are in more detail demonstrated in the following section.

To merge the knowledge areas of all the models, it would be possible to use any one structure as a basis and "fill in the gaps". However, we felt that none of the structures were perfect in terms of classifying knowledge areas directly from teaching viewpoint rather than performance-in-workplace view that most standards are based on. Hence heavy restructuring of topic divisions appeared unavoidable. Careful to avoid bias, we split models into component fragments, merged the fragment pools and sorted the elements into reasonable structure for curricula analysis. The initial pool was a notable mess which further demonstrated substantially different ways to present the mind of a logistician.

While step 3 was purely mechanical, steps 4 and 5 required thoughtful considerations, keeping in mind both the integrity as well as practical usability of the emerging model. To demonstrate the application of our model, pilot-testing was done and the findings from step 6 were used as feedback to further refine it.

The principle of the model is simple. It consists of 20 knowledge areas, with each section containing 9-12 elements that should belong to logistician's training. The model is sizeable and presented in the appendix. For example, section "manufacturing process and technologies" includes 11 elements, items such as "*manufacturing capacity planning*", "*CAD-CAM systems*" and "*quality assurance*". While they do not belong to the heart of logistics, the interfaces are still relevant. For each item, the evaluation can have three outcomes: 1) it is explicitly embedded in the curriculum; 2) inclusion of the topic in the curriculum appears indirect, with more distant wording, as a possible component under a more general heading or if a wider topic field forms only a small part in one course (this mitigates the case when publicly available data is less than perfect); 3) there is no indication that the topic is included in the curriculum. Mathematically it is just 1.0, 0.5 or 0 and the average rating across each of the 20 sections is finally what is measured. This means, for each curriculum analysed, we can identify to what extent is the program able to fill each section. In percentage values, each curriculum is represented by a vector CUR_i.

$$CUR_i = (a_1, a_2 \dots a_{20}) \quad (1)$$

In (1), a_x is identified coverage of analysed curriculum on given section. Done across sections, this would give insight into the actual profile of the curriculum regardless of titles and marketing. With adequate specific data of a large pool of curricula, this would allow to run a 20-dimensional cluster analysis for better understanding how general logistics curricula are actually built up and what are the most common types of approaches.

We note that our analytical tool is more suitable for comparing the scope and focal issues of content of any curricula against another rather than giving the said curriculum a "quality level" as the quality of education is on many levels a higher concept than just declarative curriculum content. Still an approximate quantitative indication of a level of coverage of a curriculum against our benchmark model offers meaningful interpretations. Therefore the model can be used as a basis for simple gap-analysis. Whilst actually identifying quality level of all the courses requires specific customer satisfaction input, at least the scope of the program can be measured quickly, which is why we call it "the short-cut knowledge-area analysis".

In the following section, we first turn attention towards findings from step 2, then describe the process in steps 4 and 5 and conclude with findings from step 6.

4. Data

4.1. The gaps between component models

In terms of scope and structure, the differences between models can best be visualised on a diagram. For the sake of brevity, we'll present graphically only the comparison of two models here: between APICS and ELA in Fig. 2. Fig. 2 represents the simplified model of ELA in the middle, composed of nine sections, and the model of APICS laid around it in two core pillars: "logistics and distribution" and "operations management" knowledge areas. The idea of such comparison is to focus on all subcomponents of APICS (16 and 8 on sides) and evaluate their relation to ELA model. Continuous lines represent close to full coverage of that APICS element by ELA, cut lines demonstrate partial coverage and links to the question mark point that either a small proportion (dashed line) or a significant amount (continuous line) of elements are not specifically included by ELA.

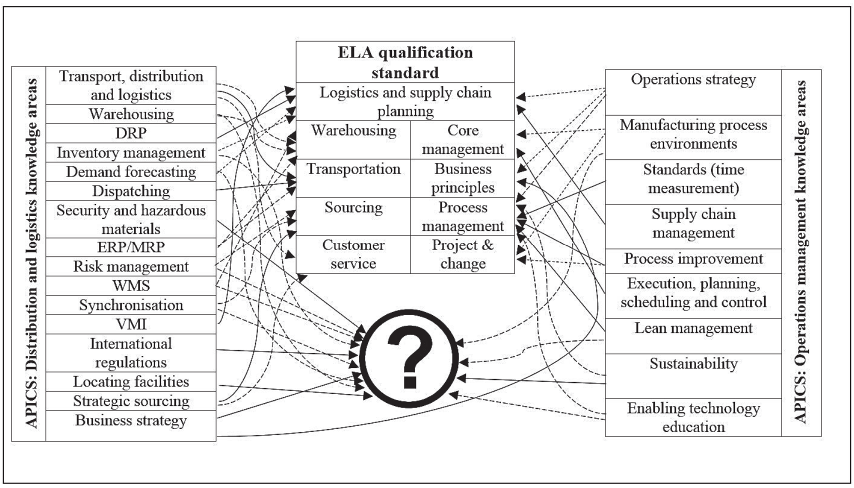

Fig. 2. Relations between ELA and APICS models of logistics competences.
Source: authors' compilation.

We would like to point out both the abundance of connectors on the figure, representing differences in structure, as well as a notable proportion left uncovered.

While figure 2 could be mistaken as a direct criticism of ELA competence model, it is not our intent as all the models we've reviewed have their gaps. Other models, for instance CITLS, can point out further gaps in both ELA and APICS and yet in contrast, both of them are about ten times bigger and much richer in details compared to CITLS. We have noted that both ELA and APICS have also some overlap between the categories of the very same model. In short, modelling the content in logistics is not an easy task. One lesson to be learned, on both the levels of competence models as well as curricula, is that the more there are category divisions, the more there are interfaces between them and these relationships need to be carefully managed to guarantee essentials are covered with as little overlap as possible.

4.2. Emerging classification of knowledge areas

In terms of process-oriented versus knowledge-oriented learning outcomes, we knowingly leaned towards latter, as that suited the main goal, to develop a tool for curricula analysis, better. Essentially, some task-based viewpoints were altered to be knowledge-based. This often meant merges and simplifications – a process-oriented model might suggest "*assists manufacturing management in the development of meaningful productivity and performance measurements*" and "*ensures the alignment of the materials management strategy with the business strategy*". In our approach, it became "*manufacturing performance analysis*", because this is the level of detail met in curriculum and it would make sense various aspects of it together. Such transfer from detailed operational aspects to broader knowledge areas meant that our model would consist of roughly few hundred elements, while the former would have been many times larger even after removing the duplicates.

Before the final level of detail was in focus, the question of structure had to be decided. In this regard, a problem similar to organising logistics in practice was met – reaching strictly functional division of aspects is almost impossible due to interlinking viewpoints. It initially appeared rational to postulate three levels of knowledge areas: a level of *general business administration* topics, one for issues that we felt formed the *core of business logistics management* in a broad sense (in terms of service, network and flow management) and one for all kinds of issues in managing typical functions in logistics (transport, warehousing, ICT etc.).

As the third level was still the most abundant in information (after all, logistician must know the details, not only "the big picture"), it was decided to separate transport-related topics. Such division allowed for placing the elements of manufacturing and systems engineering next to warehousing and ICT technologies and the entire section was labelled "*supporting technologies, processes and systems engineering*". We note that while inventory management is conventionally treated as a functional area, we'd argue that from the practical business point of view inventory issues form a core of logistics even more than transport so we treated inventory management with a spot in the section of core issues. For all practical purposes of this model, the relative position of subsections matters less than actual scope and content.

Finally some viewpoints remained on the table that reached across other levels, specifically various legal, sustainability and risk management issues. On one hand, separating these aspects means introducing overlap into sections (such as transport law belonging both other transport and legal issues). However, another consideration is that including these aspects separately would give the model better functionality in evaluating the strengths and weaknesses of any given curriculum from more viewpoints and would allow to observe more dimensions. We decided to favour the latter approach. For practical purposes the loss in measurement accuracy because of few similar topics existing twice in the model, is minimal.

This left us with 19 subsections with fragments still needing substantial consolidation. In addition, there were some topics left which formed foundational knowledge in various fields of sciences, both natural and social: statistics, physics, ethics etc. These aspects are seldom included in competence models but they can sometimes account for notable curriculum space. Therefore, as seen on Fig. 3, we added final section titled “basics of natural and social sciences”.

Level A: General business administration			
#1: Business strategy and marketing	#2: Financial management and costs	#3: Organization, people and workflow	#4: Operations management and process improvement
Level B: Broad logistics core			
#5: Supply chain management core concepts	#6: Logistics operations, network and system	#7: Purchasing and supply management	#8: Inventory management
Level C: Viewpoints on transport			
#9: Operational transport	#10: Transport: society and systems view	#11: Field-specific transport economics	#12: Transport technology
Level D: Other technology, process and systems engineering viewpoints			
#13: Systems engineering and development	#14: Warehousing process and technologies	#15: Information and communication technologies	#16: Manufacturing process and technologies
Level E: Cross-functional supporting viewpoints			
#17: Legal environment in logistics	#18: Sustainability in logistics	#19: Risk analysis	#20: Basics of natural and social sciences

Fig. 3. Consolidated and refined model of knowledge areas of logistics professionals.
Source: authors’ compilation.

Structurally, this section appeared to fit along other interdisciplinary aspects, so the final section of the model was renamed to “cross-functional supporting viewpoints”. This also simplified the structural framework of the model, which appears to reflect the extent to which modern understanding of logistics has grown. The components of each section are listed in appendix.

4.3. Pilot-testing with curricula

The model was tested by comparing it against five undergraduate logistics curricula. We list them here but present the data as anonymous lines on figure 4 not to be blamed for malevolent intent in case either the input data was outdated, lacking or the measurement came out slightly incorrect. The curricula evaluated were:

- “International logistics management” – Upper Austria University of Applied Sciences, Steyr, Austria;
- “Business logistics and transport management” – University of Greenwich, UK;
- “Logistics” – Tallinn University of Technology, Estonia;
- “Business logistics” – Riga Technical University, Latvia;
- “Logistics engineering” – JAMK University of Applied Sciences, Finland.

We note that some curricula cannot be studied objectively because of a lack of publicly available data. While most universities list the courses (yet some list only modules and are protective of details), the description of course content can range from a few lines to about a full page. The model will not work accurately if there is more taught in classroom than shown on paper. These are considerations when attempting to gather data on large pool of curricula. However, when the curriculum input is detailed, the analysis takes only around 45-60 minutes.

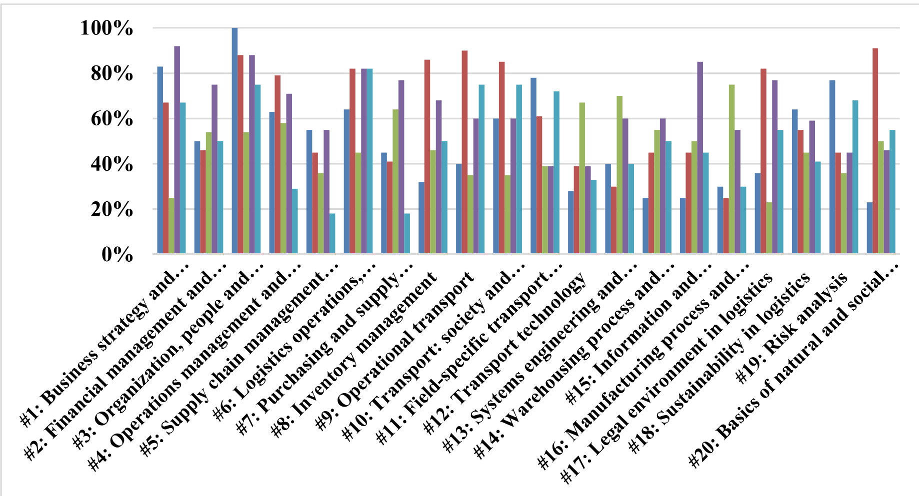

Fig. 4. Five logistics curricula benchmarked against our knowledge-area model. Source: authors’ compilation.

In evaluating the curricula, minor additions to model components and tweaks to formulation were made. In some cases, the components inside each section do not cover the section completely, which would be practically impossible, but still present enough variety so that the evaluation results in a meaningful rate of relative coverage.

Our limited testing confirmed our expectations – we have not yet observed a close-to-complete treatment of topic areas in any curriculum. The contrasts and gaps in our small sample were larger than anticipated. The argument of intended curricula differentiation might be a partial explanation, but it is still strange, for example, when a curriculum is stronger on engineering side in general and yet falls unexpectedly short in some technology area that would logically belong to such profile.

One can easily argue that completeness is essentially unachievable due to program capacity constraints. Fig. 4 reveals average coverage rates only around 50-

60%. Still some manage notably better than others and all five curricula have their weaknesses where coverage rate falls below 40%. We suspect the issue lies at least partially in lack of benchmarking in logistics education. What the data on figure 4 indicates is that there is room for improvement in any logistics curriculum.

5. Conclusion

The paper studied the problem of discrepancies in competence models and undergraduate curricula in the field of logistics. We approached the issue by synthesising a meta-model of knowledge areas of logistics professionals, with an intent of utilising it as a tool for existing curricula benchmarking analysis.

The first conclusion based on limited testing of our model is that the differences between logistics curricula can be substantial. Partially this can be seen as the result of universities knowingly attempting to differentiate, due to physical constraints and lack of strong unified vision of the reach of logistics, yet partially because logistics as a field has grown too big to cover. One could exaggerate and say "there is no logistics", just selections of topics in various combinations. Of course the heart of logistics, namely transport planning, inventory, material handling and IT technologies, is mostly present everywhere, but with much varying flavours.

For broader conclusions our future plan is to analyse more curricula. While data availability is still a relevant constraint, it is our observation that a trend exists to publish more detailed course information in university websites. Our quantitative approach could be used to carry out statistical cluster analysis of curricula to group similar programs and identify the variety of approaches in teaching logistics. This would allow curricula to be better positioned and refined.

For us, the findings are not just a theoretical curiosity but the model can be applied in curriculum development. Firstly it would help curricula boards to understand "how big is the big picture". Secondly, should the board knowingly decide to offer more differentiated niche program, the model offers the dimensions to consider and also allows to chart closest competing programs so that differentiation would be more effective. Of course, in all these cases, it should be really important to stress that such programs would need to be called something more specific than just "logistics" (or "supply chain management"). Our conclusion is – if full coverage of logistics is attempted by curriculum, it demands careful attention to avoid gaps and also overlap which is also easy to happen without integrated course development. We hope our model contributes to more efficient development of new curricula.

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APPENDIX. A meta-model of logistics knowledge areas

Level A: General business administration topics			
#1: Business strategy and marketing	**#2: Financial management and costs**	**#3: Organization and people**	**#4: Operations management**
Market research	Financial statements	Decision-making tools	Demand forecasting methods
Business environment analysis	Investment analysis	Organisation behaviour	Available capacity analysis
Market positioning	Financial ratio analysis	Motivation theories	Supply and demand synchronisation
Strategic management	Activity based costing	Incentive and reward systems	Operations performance analysis
Competitive environment	Total supply chain cost analysis	Training and development	Innovation and creativity
Portfolio planning	Customer-based profitability	Leadership and delegation	Waste analysis and reduction
International marketing	Strategic pricing	Project management	LEAN process improvement
New product development	Asset utilization analysis	Teamwork	Six sigma
Product promotion	Budget planning and control	Effective communication	Root cause analysis
Logistics strategy	Lifecycle costs	Organisation structure	TOC Theory of Constraints
Industry benchmarking	Cash flow management	Process analysis and job design	TQM Total Quality Management
Product lifecycle management	Funding	Change management	JIT and pull system management
Level B: Logistics "big picture" core topics			
#5: Supply chain management core	**#6: Logistics network and system**	**#7: Purchasing and supplies**	**#8: Inventory management**
Supply chain competitive advantage	Logistics performance objectives	Sourcing strategies	Inventory performance analysis
Value chain management	Key performance indicators	Supplier selection criteria analysis	Inventory costs
Value creation analysis	Customer service standards	Contract negotiations	Inventory classification
Supply chain mapping	Lead time and order cycle time	Supplier performance evaluation	Inventory deficit impact analysis
Supply chain configurations	Logistics cost categories	Purchasing costs	Methods of inventory valuation
SCOR model	Cost trade-off management	Types of purchasing arrangements	Economic order quantity
Agile supply chain	Facility location analysis	Supply chain collaboration	Safety stock calculations
Postponement	DRP	Supplier base rationalisation	Ordering systems
Mass customization	Transaction documents	Supplier relationship management	Bullwhip effect
QR / ECR	3PL and 4PL concepts	Cross-cultural communication	ABC-categorization
S&OP Sales and Operations Planning	Make-or-buy analysis	CPFR-model	Vendor managed inventory
Level C: Viewpoints on transport			
#9: Operational transport	**#10: Transport: society and system**	**#11: Field-specific transport**	**#12: Transport technology**
Transport performance objectives	Global cargo flows	Freight forwarding	Road transport technologies
Carrier types and service conditions	Transport infrastructure	Road transport	Rail transport technologies
Carrier selection and contracting	History of transport	Rail transport	Maritime transport technologies
Transport mode selection	Supply and demand in transport	Airfreight transport	Aviation technologies
Load and route planning	Transport policy design and goals	Sea and waterway transport	Pipeline transport technologies
Transport of hazardous materials	Socio-economic investment analysis	Public transport	Passenger transport technologies
Transport of oversized cargo	Full costs of transport	Airlines and air travel	Support infrastructure technologies
Vehicle and cargo tracking	Transport external costs	Intermodal terminal management	Intermodal terminal technologies
Load fastening and protection	Transport market regulation	Port management	Intelligent transport systems
Road tolls, local regulations	Taxes and charges in transport		
Level D: Other technology, process and systems engineering viewpoints			
#13: Systems engineering	**#14: Warehousing**	**#15: IT and information systems**	**#16: Manufacturing**
Supply chain process modelling	Warehouse performance objectives	Data warehousing	Manufacturing performance analysis
Logistics systems engineering	Warehouse capacity planning	E-commerce	Manufacturing capacity planning
Information system engineering	Storage condition requirements	ERP systems	Manufacturing process analysis
Product development	Handling of hazardous materials	Information system modelling	Master production schedule
Infrastructure engineering	Cross-docking operations	EDI electronic data interchange	MRP Material requirement planning
Traffic engineering	Conventional warehouse equipment	Data security and privacy	Kanban system
Facility layout engineering	Automated storage and retrieval	Automated identification standards	Manufacturing technologies
Reliability engineering	Packaging materials and technologies	RFID-technology applications	Advanced materials
Maintainability engineering	Unitization optimization	Warehouse management systems	CAD-CAM systems
Safety engineering	Inventory control techniques	Management information systems	Quality assurance and control
Level E: Cross-functional supporting viewpoints			
#17: Legal environment	**#18: Sustainability in logistics**	**#19: Risk analysis**	**#20: Natural and social sciences**
Basics of law	Climate change impact and risks	Risk management process	Calculus
Commercial law	Alternative fuels	Physical cargo risks	Statistics
Competition law	Modern vehicle technologies	Ergonomics and human safety	Physics
Labor law	Air quality and emission standards	Environmental risks	Chemistry
Intellectual property law	Congestion charging	Economic risks	Logic
Customs regulations	Travel demand management	Financial transaction risks	Environmental science
Taxes and taxation	Carbon footprint of business	Technological disruptions	Philosophy
International trade agreements	Triple bottom line concept	Regulatory and compliance risks	Ethics
Documents and licenses in logistics	Renewable resources and energy	Supply chain security	Micro-economics
International transport conventions	Regulations on waste and recycling	Risk mitigation strategies	Human geography
Incoterms regulations	Reverse logistics	Contingency planning	Sociology

PUBLICATION III

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Findings from Cluster Analysis of Logistics Undergraduate Curricula in Europe

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***Abstract*—The field of logistics education is rather colorful. The range of possible topics is huge and so each curriculum has unique approach towards which topic areas to emphasize and which to treat briefly or even omit. There is only little effective standardization in logistics education. This study examines the content of 42 undergraduate logistics curricula in Europe via cluster analysis, with a goal to propose a typology of logistics curricula. The findings define the spectrum of logistics education in four clusters, ranging from „business administration“ with little focus on most specific logistics topics, through „interdisciplinary logistics management“ and „modern transport management“ to „logistics engineering“ with a strong quantitative and technology approach. However, a problem remains that curriculum title does not always reflect actual profile. A typical title "logistics management" might in one case contain various engineering elements, but in another none at all. Such findings point out the need for curricula boards to decide, if trying to cover the entire scope by „one-size-fits-all“ program is the best option or if more distinct focus is needed. In both cases this decision needs to be intentional, agreed and clearly communicated to avoid confusing students and society. Furthermore, the study points out the need to refine standards of competences in logistics, especially for logistics engineering.**

Keywords—logistics education; logistics competence models; curriculum development; logistics knowledge areas; cluster analysis; interdisciplinary education

I. Introduction

It is challenging to present an agreed definition of logistics. When formulation is limited to a sentence, various approaches exist and most of them can co-exist without much practical implications and debate. However, the more into details one would delve, the more confused the researcher might get – where does logistics start and where does it end? This paper studies higher education in logistics with primary focus on undergraduate studies to reach better understanding on how logistics unfolds and what is the extent of disagreement and actually applied approaches on that level. The main questions asked in this paper concern the size of agreed core in logistics that would be reflected by common denominators across curricula as well as specific ways to differentiate a logistics curriculum. Could a typology of logistics curricula be created through clustering and what would the clusters look like?

The goal of this study is to quantitatively evaluate the coverage of topics in a sample of logistics curricula and attempt to cluster logistics programs into a typology to better understand the current landscape of logistics higher education. The literature review presents an overview of what has been written on logistics education and how the scope of logistics and logistician competences has been formulated. In methodology, a structural model is introduced which is then used as a tool for logistics curricula evaluation. The paper concludes with findings from the clustering, interpretations and outlining future research.

II. Background

On the level of curricula in the general field of logistics, there are multiple ways to combine education programs with different focus to cater for various interests and different needs on the labour market. Some curricula relate to local, regional or even to some international standard, others do not. Some try to cover a wider variety of topics, others go into more detail in chosen aspects, be it technologies or business viewpoints, or leave certain topic matters even untouched. Constructs "logistics and X" (where X is most often transport) or "Y-type logistics" are common (where Y would stand for transport mode, terminal, distribution, manufacturing, retail, trade etc.).

In some cases, one could observe the title "logistics" being used without additions or specifications and then discover that such title is not the most appropriate choice judging by the content. One of the starting points of this research were comments made by students in the authors' faculty on the semester spent studying abroad – the curricula and module titles can often be vague with the most popular title being just "logistics management" and one can be misled without specifically checking the course details. In some cases, this is pure business management view. In other cases, a strong engineering and quantitative optimization element is included. The more general the title, the more chances of false assumptions and "logistics" is a rather general title. For example, a student might expect that "manufacturing logistics" course deals with designing conveyor lines and AS/RS technologies and in some cases that expectation is indeed met. In other cases, the approach can be more centred on the impact of process improvement on business metrics and target goals, such as inventory levels and lead times, rather than on how to actually design the processes or the underlying technologies.

While this explains the interdisciplinary nature of logistics, it also leaves room to suggest that titles can be used for other goals than direct content reflection, perhaps for marketing purposes. It could also be that for some universities, the ability to differentiate curriculum from the competition is rather more important than attempting to harmonize and standardize the education. Additionally, there are some perfectly "typical", more balanced logistics programs, which are called supply chain management (or "logistics and supply chain management" for even more marketing visibility, regardless if the authors actually distinguish between the two concepts or not). This is not an easy question, which has been discussed by Dinitzen and Bohlbro [1] and Christopher [2]. The conclusion appears to lean towards the concepts being different in terms of expected skill profiles. However, they are intertwined enough to be merged or even replaced on the level of course titles.

It is interesting to attempt to generalize the factors that serve as main inputs to curriculum design. In authors' view, at least five factors should be treated together on that question:

- broad concept level – what do key terms actually imply;
- own brand level – what kind of curriculum and positioning is desired by the administration;
- feasibility – background of the current teaching staff, availability of new specialists and cost implications of teaching topics with more expensive procedural or facility requirements;
- society and labour market needs – what knowledge and skills are the most valuable for the society;
- student view – what are the most desirable study topics.

This means that there are at least four important considerations which all might cause gaps between curriculum headings and content. The picture gets more complicated when other possible considerations, such as local or international standards and certifications or perhaps modern academic "buzz-words" are included in the mix.

In this paper, attention is on the first two elements of the above list. While all this can explain and justify contrasts between terminology, curricula titles and classroom reality, there is also a question of when is the offered study profile distinct enough to change the title to something more specific. Certainly, some universities do it today and this supports visibility. Possible titles might be strategic management of logistics or information logistics. Such differentiation is not usually standardized though, so everyone is free to introduce their own concepts, for better or worse. But what about those that do not? Is there really as substantial mismatch between logistics curricula as selected observations would indicate? This paper offers an analytical tool for curricula analysis and applies it to data of a sample of curricula.

III. Literature Review

To begin with, logistics is a field driven by both rapidly evolving technologies as well as dynamic and turbulent markets. These issues combined indicate that it is by nature challenging for logistics education to stay ahead of the curve and this is a common theme in logics education literature [3, 4].

A much telling viewpoint was presented by Myers *et al* [5] in a study focused on mid-entry level employees of logistics positions in 2004. In that study, it was found that direct job-related skills such as decision-making and time management, are primary factors contributing to success and both experience and education factors were left in the distance. In authors' view, this called for a switch in logistics education towards including more soft skills and problem-solving.

A comprehensive overview of logistics education from the 1970s up until 2005 identified three main areas of logistics education research: curriculum content, skills and competences, teaching methods [6]. The dominant approaches in literature are case studies of curriculum and competence development and teaching excellence, followed by surveys [7, 8]. A recurring theme is a push for more interdisciplinary approaches. Lancioni *et al* [9] have pointed out the need of logistics faculties to develop cross-departmental partnerships to facilitate the creation of interdisciplinary logistics courses.

An insightful study on the content in logistics programs through the viewpoint of educators was carried out by Larson and Halldorsson in 2004 [10]. The study identified four schools of thought on how logistics relates to the area of supply chain management and surveyed the relevance of 88 topics in respective courses across 98 educators. In one identified viewpoint, logistics and supply chain management are equal terms, covering the range of topics from forecasting to suppliers and from process re-engineering to warehousing and even to e-commerce and conflict management. Similarly, Murhpy and Poist [11] researched senior positions in logistics in 2007 and found that over 16 years, logistics had become much more business management focused as many executive search firms pointed out the supply chain orientation as a primary skill of logistics managers.

One of the few even broader studies aimed at mapping a landscape of logistics education was carried out by Wu *et al* in 2007 [12]. One of the findings across courses in logistics was that the three biggest categories were "logistics", "transportation" and "information technology", accounting for 48% of entire credit hours. Interestingly, when analyzing the background of US-based logistics curricula, it was also found that 33% of logistics departments belong under marketing or business administration faculties. The paper also pointed out notable variations in curriculum content by analyzing the extent of operations management topics in logistics curricula in various areas. The study effectively reiterated the wide variety of topics directly connected to logistics, as many departments studied were found not only to research logistics but also areas like statistics, finance and law.

Most recently, Lutz and Birou [13] have analysed the topics taught and methods applied in logistics classes on graduate and undergraduate levels, mostly based on data from US. The authors identified 95 topics covered in different courses in logistics on undergraduate level and noted high variance in both topics covered as well as their perceived importance.

Another recent paper identified 50 skills in nine categories that logistics experts regard as essential competences. Right next to more conventional topics, noteworthy elements were crisis management, social responsibility, production integration and independent decision-making. The paper concluded with a philosophical statement: "*An effective logistician should combine global business expertise with functional and technical skills, rather than being primarily a functional/technical or a logistics specialist* [14]."

The term "logistics potentials" has been used to describe logistics-related competences and capabilities utilized for successful competitive performance. Sennheiser and Schnetzler have defined potentials as specific resources and capabilities, merging the approaches of resource-based view with the theory of dynamic capabilities and competence-based management and suggesting the most common bottleneck does not lie in resources but in the capabilities to adaptively and flexibly acquire and exploit them [15]. Matwiejczuk [16] has expanded this idea to explain how competences are a synergized sum of resources and human capabilities. In his view, there are ten key competence areas of logistics potentials that emphasize the integration of processes and stakeholders in a supply chain.

It appears from the literature on logistics education and competences that there is a research gap in contrasting various curricula and identifying the focal points of curricula along with shortcomings. This is at least partly due to there not being a central well-defined model to compare against.

To deal with all the variety of topics, modern textbook authors merge the more hands-on aspects of physical logistics operations with systems optimization elements and strategic management, such as recently Rushton *et al* [17] and Farahani *et al* [18]. Rushton *et al* define the core of logistics through five areas: storage and warehousing, transport, inventory, packing and unitization and information and control. The authors acknowledge that through applying ideas of integration and total cost trade-offs into the scheme, the scope extends into other areas such as manufacturing, purchasing and marketing. According to Farahani *et al* [18] the key to successful strategies lies in managing both physical network of facilities as well as information network.

A more detailed approach of 48 decision areas of logistics extending across the levels of strategic planning, physical facility network and operations has been suggested by Langevin and Riopel [19]. Still, while such approaches all offer their insight, these models don't specifically treat how to approach these elements in education for curriculum analysis and course design.

Traditionally, the most detailed input for curriculum development is expected from competence models and certification programs. In logistics, there are many to choose from, with the most widely known being:

- European Qualification Standard for Logistics Professionals by European Logistics Association (ELA) [20];
- International Diploma in Logistics and Transport by Chartered Institute of Logistics and Transport (CILT) [21];
- Distribution and logistics managers' competency model by The Association for Operations Management (APICS) [22];
- Certified Master Logistician CML program by The International Society of Logistics (SOLE) [23];
- Certified in transport and logistics CTL by American Society of Transportation and Logistics (AST&L) [24];
- Certified International Trade Logistics Specialist CITLS by International Trade Certification (IIEI) [25].

The most important characteristics of these models are comparatively summarized below in Table I. Approach in this context means if the model is built around topic fields as study input or knowledge or competences as learning outputs.

TABLE I. COMPARISON OF LOGISTICS COMPETENCE MODELS

Viewpoint	**Logistics competence models**					
	ELA	***CILT***	***SOLE***	***AST&L***	***APICS***	***CITLS***
Categories	13	6	6	10	6	3
Elements	195	92	148	56	276	30
Approach	outputs	both	inputs	outputs	outputs	both
Recently updated	yes	no	no	yes	yes	yes
Scope	broad	average	broad	average	broad	average
Usability	good	good	average	good	good	average

Source: authors' compilation.

As depicted, all the models appear essentially usable for curriculum analysis. The "average" scope should be understood in relation not only to more extensive ones but to other models that were left out from this study due to being too narrow in their scope. Nevertheless, the models cover various functional areas as well as some interdisciplinary viewpoints.

IV. METHODOLOGY

A. *Concerning the suitability of existing models*

For successful quantitative analysis of curricula content, three components are needed:

- A structured model to provide quantitative curriculum evaluation data, with a method to categorize topics, which presence can be expected in a logistics program;
- Statistical approach to analyze the data so that the output could be meaningfully interpreted;
- A sample of suitable curricula to be analyzed.

In terms for an objective point of reference, one could use a model of logistics decision areas or a structure of skills defined by an appropriate occupational standard, professional certificate system or competency model. However, more detailed analysis of the models summarized in Table I reveal that there is no model that would be extensive and still detailed enough to cover the rest. To visualize it, Table II presents a comparison of the most concise model, CITLS, against others.

What table II demonstrates is that there are significant gaps between models. Even though all deal with logistics, they approach various aspects, dedicate careful attention towards selected areas and leaving others only vaguely mentioned or even left aside. SOLE model is missing from Table II because the comparison failed to give specific results on most aspects. Vagueness made it impossible to tell which of the here formulated elements was actually envisioned by SOLE authors.

TABLE II. CITLS TOPICS IN OTHER COMPETENCE MODELS

CITLS elements	Presence in competing models			
	ELA	*CILT*	*AST&L*	*APICS*
Air freight shipments	-	+	-	-
Ocean freight practices	-	+	-	-
Intermodal shipments	-	+	-	-
Trade regulations	+	+/-	-	+
International distribution	+	+	+	+
Insurance issues in trade	-	+	-	-
Incoterms	-	+	-	-
Packaging requirements	-	+	-	+
Customs warehouses, free trade zones		-	-	+
Logistics monitoring & control	+	+/-	+	+
International trade terminology	-	+	-	+
International trade documentation	-	+	-	-
Expansion to international markets	+/-	+	+/-	+/-
Import/export potential analysis	+/-	-	-	-
International market research	+	+	+	+/-
Establishing pricing for international markets	+/-	-	-	-
International finance tools	-	+	+/-	+
International business resources	+/-	+	+	+
Warehousing overview	+	+	+	+
Traditional warehousing	+	+	-	+
Principles of warehousing	+	+	-	+
Third-party warehousing	-		-	-
Warehousing operations	+	+	+	+
Warehousing as a integrated system	-	+/-	-	-
Mechanics of warehousing	+	-	-	-
Warehouse processes and practices	+	+	+	+
Warehouse layout and design	+	+	-	+
Automation and computerization technologies	+	+	-	-
Warehouse utilization and design	+	-	-	-
Integrated warehouse modeling	-	+	+/-	+

Source: authors' compilation.

Given such mismatches, it can be assumed that the area of logistics curricula would reflect a similar picture. None of the models are ideal for curricula comparison purposes. Because of the gaps, the options would be to either use most extensive model, carry out curricula evaluation against multiple models or design a new model of logistician knowledge areas.

B. Applying a dedicated analytical tool

In previous research directly leading to this paper, the authors have constructed a model of logistics professional knowledge areas by merging various approaches analyzed in Table I. The result was recently published [26]. While the original intent of the model was topic coverage benchmarking in curriculum development, for this paper's purposes, the model is adjusted and put to comparative quantitative use.

The implemented approach consisted of breaking models down to fragments and creating a new structure of topics. The resulting structure, depicted on Fig. 1, consists of five layers of topics, with sections representing various knowledge areas in logistics. In extended form, each section includes a list of specific subtopics that outline the areas, aiming to broadly cover the topics that could be taught to logistics students in each section. One peculiarity of this model is that it is based on learning inputs rather than outputs. This is unfortunate, given all the recent efforts to push universities towards outcome-focused approach. However, it was necessary, given that a large share of curricula are today still only defined by input.

Level I: General business administration		
Section #1: Business strategy, marketing and environment	Section #2: Accounting and financial management	Section #3: Organization, people and process management
Level II: Broad logistics core		
Section #4: Supply chain management concepts	Section #5: Logistics management and trade	Section #6: Purchasing and inventory management
Level III: Viewpoints on transport		
Section #7: Transport operations	Section #8: Transport - society and systems view	Section #9: Engineering and transport technology
Level IV: Supporting functional areas		
Section #10: Warehousing processes and technologies	Section #11: Information and communication technologies	Section #12: Manufacturing processes and technologies
Level V: Foundational topics		
Section #13: Laws and legal environment	Section #14: Basics of natural sciences	Section #15: Basics of social sciences

Fig. 1. Integrated model of logistics knowledge areas.

Source: Modified based on Niine and Koppel [26].

A few models of logistics competences that the authors have come across include foundational competences and individual traits in addition to specific topics of professional knowledge. Sometimes such factors are called graduate abilities or capabilities. These include aspects such as team working, leadership, interpersonal skills, cultural awareness and creativity. It has been suggested that managing such capabilities explicitly and dedicatedly in a curriculum has the greatest impact on the learning outcome [27]. However, such traits are in practice only rarely taught explicitly and their implicit existence in an average curriculum is difficult if not impossible to identify. Therefore, the model proposed here focuses in a more narrow fashion on specific knowledge areas.

The idea of the following analysis is that each of these sections can form a potential area of focal expertise in a curriculum. The extent to which any given curricula covers the sections, measured manually and proportionally weighed by the amount of work in credit hours, can be interpreted as the actual attention profile of the program. The analysis takes place on the level of courses, relating each course to a suitable section or, in rare cases, splitting between sections. The model is large so full balanced coverage of all sections by most curricula is not expected. Something has to be left out and perhaps the data on "what is missing" is more telling than "what is present" in terms of actual focus of the curriculum. The landscape across curricula can then be described by exploratory cluster analysis.

The main bottleneck in quantitative curricula analysis is that the result of the evaluation can only be as good as the input data from the curriculum. In that sense, errors on both directions are possible. Sometimes the plan on paper is greater than treated in the classroom or in other methods. Still in other cases the official course titles might not go into enough details compared to the reality of studies. However, there is no realistic way of getting around imperfections when quantitative approach is applied across a large pool of curricula.

It has to be said that such model analyses comparatively course content stated in curriculum not specifically the precise amount of attention on topics or the actual quality of input, nor least the quality of study output. So this analysis can point out that curriculum A has different focal points from B and indicate that C has an overall broader coverage than D, but this is only potentially a criticism towards the applied scope and perhaps also naming of D, but not directly the quality of education of D.

C. *Gathering a sample of curricula*

A noteworthy constraint in detailed curricula analysis is public curricula availability. While international systematic efforts have been recently made to ensure clarity and comparability of curricula, it still happens that some universities are protective of fine details and in some cases the data is presented deep in the university information systems, which is challenging to reach.

The selection of curricula for this analysis was defined with following criteria:

- Curriculum title approaches logistics with appropriately broad focus towards the subject. For example, the titles "logistics management", or "logistics and supply chain engineering" were included whereas programs with more narrow functional focus, such as "reverse logistics" or "maritime logistics" were excluded.
- The curriculum belongs to the first level of higher education with at least three year nominal full-time study duration. In most cases the graduates are awarded a bachelor degree, but in some situations, vocational diploma is awarded instead.
- The curriculum has to be international, i.e. taught in English. This constrained the sample intentionally. Arguably with local programs, more specific regional focus can be an issue. An idea of this paper is to identify the variety in programs in English, which could be assumed to be more universal to a certain degree.
- Finally, the sample only focused on European curricula. Valid continental differences have already been suggested in other studies. The aim here is to "zoom in" and identify variety inside a region.

The initial list of suitable curricula was identified through databases available at http://www.university-directory.eu/ and www.bachelorsportal.eu/. This netted altogether 71 curricula: 18 from UK, 10 from Germany, 9 from Netherlands, six from Poland, three from Finland and Austria and 22 from various other countries. The list is not presented here due to length but the authors are willing to share details on demand.

The next step was considering specific data availability. This was partially a consideration why the research was constrained to Europe – in some areas, the information about curriculum made publicly available tends to be on average less specific. The data was deemed suitably specific in 42 cases and these were then measured against the model.

The measuring of each curriculum results in a 15-dimensional vector, which then can be treated as a specimen for conventional hierarchical cluster analysis. The goal of this approach is to obtain information on meaningful groupings of curricula. The objective of cluster analysis is to classify a sample of entities into a small number of exclusive groups based on the similarities among the entities [28]. The cluster analyses allows to interpret data in exploratory fashion. The number of groups is not determined beforehand. Instead, the most appropriate interpretation of clusters is decided after the statistical analysis. Hierarchical classifications may be presented in a two-dimensional dendrogram, which illustrates the divisions made throughout the analysis [29].

The data was analyzed with cluster analysis tools in Statistica10.0 software package. As all the data elements in this case are represented by percentages, the analysis treated the variables equally so there was no need for data normalization.

V. FINDINGS

The evaluation data was first transformed into a dendrogram, which is depicted on Fig. 2.

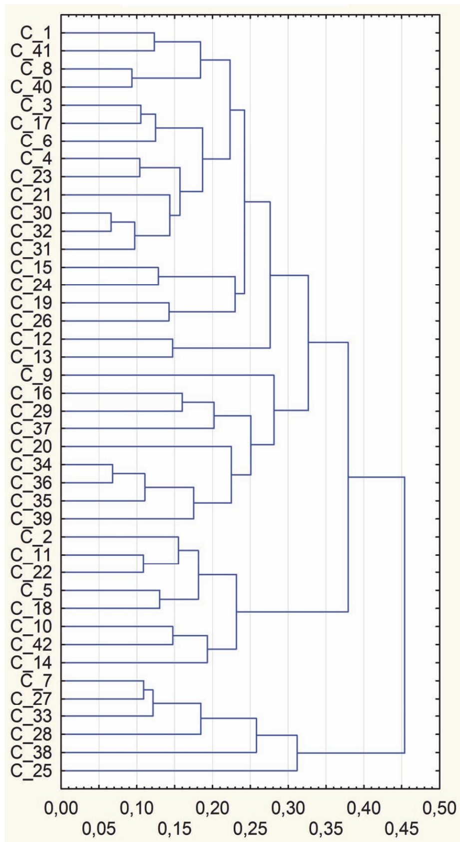

Fig. 2. Formation of 42 curricula into clusters.

Source: Statistica 10 cluster model output based on authors' data.

The first set of curricula that differentiates and forms a cluster is located in the bottom part of Fig. 2 with six curricula. Closer inspection reveals that these curricula stand out by emphasizing various engineering topics: transport, handling and IT technology. The curricula also emphasize basic natural sciences: mathematics, physics, chemistry etc. All specimen carry different titles, only one actually being labelled engineering. However, due to their content profile, it is most suitable to call this cluster "#1: logistics engineering".

The next cluster forms from 8 curricula, which much differ from the first set. On Fig. 2, these form the second large segment from the bottom. These curricula include heavy emphasis on general business topics, such as marketing, business environment, operations and human resources management. Therefore it seems most fitting to label this cluster "#2: business administration and logistics". The element of logistics here comes in a form of general introductory courses to logistics operations and management. While some representatives in this cluster have indeed formulated their curriculum as traditional business administration with major in logistics, others have not. Some have titled their program "business logistics", some "logistics and supply chain management", although this cluster does not differentiate by including more courses relating to supply chain management.

The differences between clusters #1 and #2 are stark and they are visualized on Fig. 3 below. The chart demonstrates the relative focal points and topic areas of secondary attention of both types of logistics curricula.

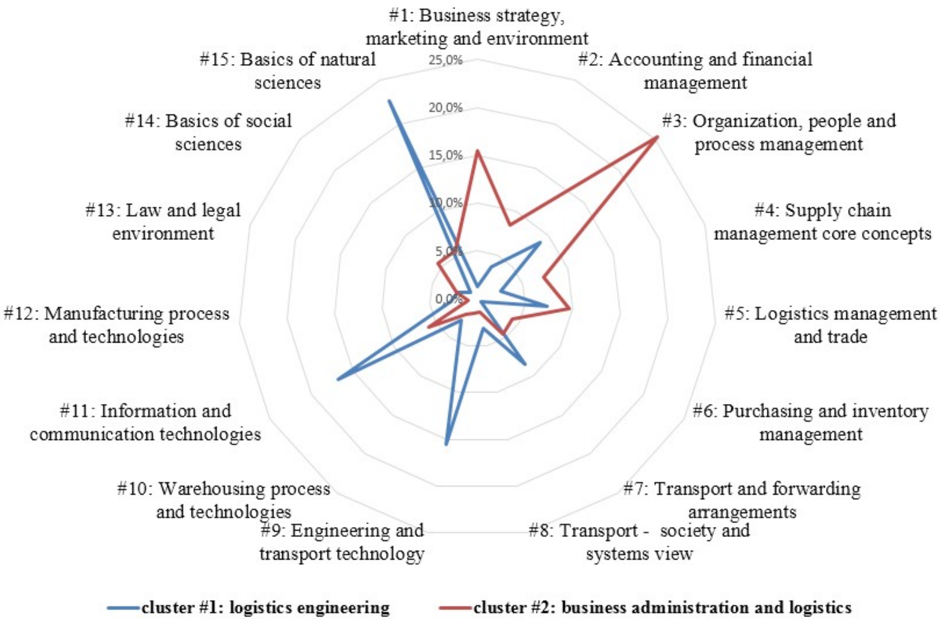

Fig. 3. The contrasted curricula profiles of two extreme clusters in logistics undergraduate education: logistics engineering and business administration view.

Source: Authors' compilation.

This leaves 2/3 of curricula that could be further categorized. The 17 curricula on the top part of Fig. 2 are on average quite similar to the previous cluster, with two clear differences. Firstly, the focus of previous cluster on general management topics has been replaced by general courses of logistics and distribution management. Secondly, this cluster dedicates roughly twice as much attention towards teaching the foundations of natural sciences – but then, not nearly as much as specimen of engineering cluster. It is perhaps not too misleading to label this cluster "#3: interdisciplinary logistics management". The focus of this type of curriculum is still on management, but specifically on management of various logistics processes and logistics network. While it could be also argued that true interdisciplinary approach can be never reached inside the boundaries of single undergraduate program, more efforts towards it have at least been made by representatives of this cluster.

While Fig. 2 suggests that the curricula from the top part of the chart form two distinctly separate clusters, the actual differences in the two profiles are not too great, as demonstrated on Fig. 4. The nine curricula from the center part of Fig. 2 have one key difference from cluster #3, which is that they dedicate much more focus on transport topics. In practical terms, this means dedicated courses on transport modes and cargo forwarding operations. To achieve greater focus on these topics, lesser focus is dedicated to foundational knowledge, while in other areas there are almost no differences. This final cluster is more focused on transport than any other so it would be appropriate to label it "#4: modern transport management".

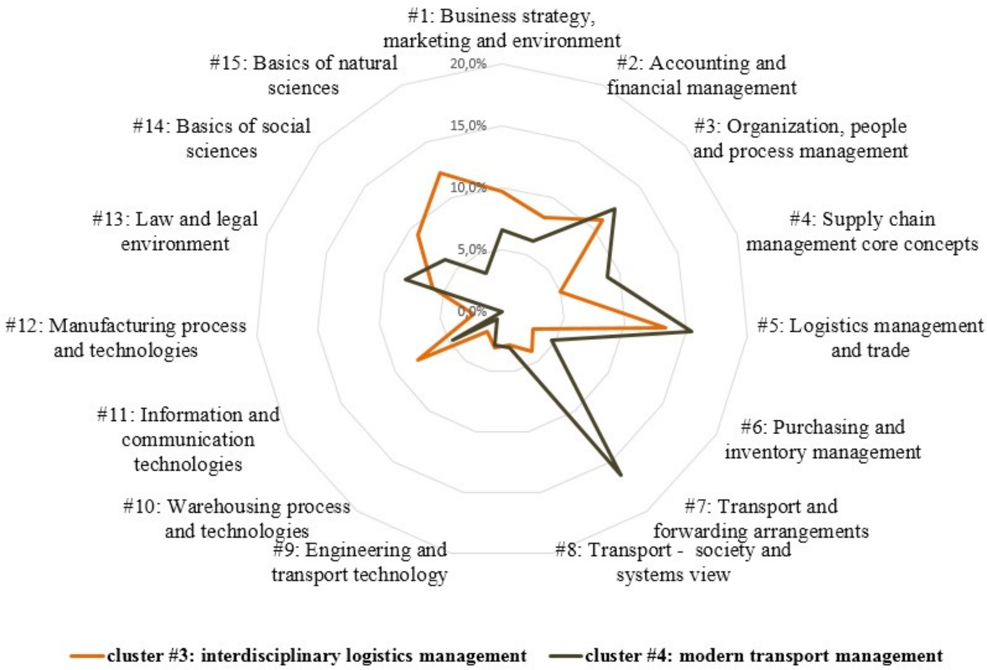

Fig. 4. The contrasted curricula profiles of interdisciplinary logistics management and modern transport management.

Source: Authors' compilation.

Across the four clusters, there are still common similarities. In by far the most cases, logistics program includes one course for warehouse operations and management and inventory management. In some cases, purchasing is treated as a separate course, in other cases it is omitted or merged with inventory management. The study also identified aspects which vary across curricula more but still not substantially so – such as legal viewpoints and linkages to manufacturing topics.

VI. Conclusions

The authors would like to conclude with following statements and comments.

1. This study identified four main approaches to logistics curricula on undergraduate level in Europe. The results reflect the variety present on the field of modern logistics curricula. While all approaches maintain some form of common core to be worthy of the title "logistics", the actual profiling differences from curriculum to curriculum are substantial. This is in many respects also a good thing – if the basics are covered sufficiently, it is most welcome if universities also focus in niches not typically covered elsewhere.

2. In terms of differentiating logistics education, rather more than these four approaches can be applied in principle. The wide range of options comes from the very nature of logistics, which covers such an extensive range of topics that creating a carefully balanced "something for everyone" curriculum is really challenging if not impossible.

3. The downside of such variety is that it does obfuscate the central understanding of logistics. The diversity in curricula is partially both cause and effect of different views and a lack of strong agreement on conceptual issues among academic authors and organizations managing certificate programs. Current competence standards in logistics appear also to be more focused on competition and differentiating from the rest rather than moving towards harmonization. Therefore, if logistics can be extensively "flavored" in so many ways, it can reach the point which raises the question if it is still in principle even the same dish.

4. The field of logistics education would be clearer if the titles would reflect a similar pattern to the clusters. Alas it is in many cases not so. An informed logistician or academic has little trouble looking up the course content and making appropriate conclusions. However, it is likely that in some current cases, a high school graduate or potential exchange student is left confused. When it appears the actual content does not meet initial expectations, it is only partially student's own fault but also the responsibility of academia to communicate the educational offering more clearly.

5. The level of competence standards in logistics is in need of both harmonization as well as development of modern niche profiles. The same applies for curricula – certain basics need to be covered regardless of profiling and currently some curricula included in the analysis did raise some questions on that matter. As it is often noted, the modern required education profile needs to be T-shaped combining sturdy foundations with strong specialty.

6. One distinct profile in the area is logistics engineering. It is encouraging that this segment appears to be growing. The relevance of such profile can't be understated. If the current logistics education is somehow "tilted" away from the needs of society, it is that there is too much emphasis on "supply chain management" in logistics, which can in some cases mean that traditional business administration curriculum is only slightly refurbished and rebranded. A couple of logistics courses built on top of business programme is also relevant in some respects as it makes sure firms are supplied with people who understand the cross-functional aspect of business better. However, it is not good enough in terms of developing specialists who will need to create the solutions for tomorrow's supply chains. The aspect of logistics engineering is the cluster which is in relatively more pressing need for dedicated competence model development.

7. Further research areas directly stemming from this study are threefold: 1) extending this approach outside Europe to better grasp the scope of logistics education; 2) updating models of competences and vocational standards to better reflect the conceptual diversity of logistics in both international and local levels; 3) studying best practices of yet different and emerging unique approaches to logistics curricula as case studies.

The authors are hopeful that this study reiterates the need for constant monitoring of the directions in logistics education. The future of education is moving towards higher integration of various platforms and more cooperation between universities in delivering content. In that context, developing world class core competences in a niche is a major success factor, as is knowing which other specific competencies exist elsewhere and being able to cooperate rather than compete.

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PUBLICATION IV

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Logistics Systems Engineer – Interdisciplinary Competence Model for Modern Education

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Abstract—**Logistics is an interdisciplinary field of study. Modern logisticians need to integrate business management and administration skills with technology design, IT systems and other engineering fields. However, based on research of university curricula and competence standards in logistics, the engineering aspect is not represented to full potential. There are some treatments of logistician competences which relate to engineering, but not a modernized one with wide-spread recognition. This paper aims to explain the situation from the conceptual development point of view and suggests a competence profile for "logistics system engineer", which introduces the viewpoint of systems engineering into logistics. For that purpose, the paper analyses requirements of various topical competence models and merges the introductory competences of systems engineering into logistics. In current interpretation, logistics systems engineering view integrates networks, technologies and ICT, process and service design and offers broader interdisciplinary approach. Another term suitable for this field would be intelligent logistics. The practical implication of such a competence profile is to utilize it in curriculum development and also present it as an occupational standard. The academic relevance of such concept is to offer a specific way to differentiate education in logistics.**

***Index Terms*—competence models, curriculum development, logistics engineering, systems engineering.**

I. INTRODUCTION

Logistics is by nature an interdisciplinary field of study. In terms of engineering, logistics topics range from optimization of order delivery, inventory and distribution networks to dealing with inherent physical properties of cargo and designing transit, warehousing, handling and supporting IT-systems. From the traditional viewpoint of business administration, logistics is viewed as a function in service of company strategy that aims to provide the right products at the right time in the right place as consistently as possible. There is of course substantial common ground in these approaches, but also differences, which means the most suitable approach in logistics is interdisciplinary education. The aspects of both natural and social sciences are heavily linked in logistics also in studying the broad view of transport economics, such as in analyzing cargo flows, travel patterns and regulatory systems, and in logistics network design.

More specifically, modern logistics needs to be treated as a cross-functional integration concept that is aimed at coordinating business functions priorities, analyzing supply and demand realities and outlooks, developing processes that would better match existing demand with available supply and cooperating with suppliers for improvements to material and information flows. However, based on research of university curricula, it is observed that the field of logistics education does not include engineering aspects to enough extent. This is both in terms of technologies as well as the systematic nature of engineering thinking. Large proportion of logistics curricula are focused on business administration with only selected engineering topics touched, usually focusing on case studies of implementation benefits rather than how to specifically design, develop such technologies and to re-engineer processes to accommodate with the changes. In terms of logistics system design and underlying thought processes, the approach could often benefit from being more systematic.

Similar gap can be observed on the level of competence models in logistics. There are numerous treatments relating to engineering elements but not a modern central and recognized one. This paper observes the problem closely, aims to explain the situation from concept development viewpoint and suggests a competence profile for a position "logistics system engineer", which introduces viewpoints of "systems engineering" (SE) into logistics, fills one gap in modern logistics education and is recommended to be applied by academia in practice.

This paper reviews literature on logistics engineering, followed by what has been found in terms of competences in SE. The methodology of this study is founded on analyzing a selection of models of logistics competences from SE models viewpoint in order to identify the gaps and then design a profile of logistics systems engineer to fill these gaps. Once the model is introduced and commented upon, the authors' conclude with brief discussion of limitations and outlining future research. But before going into details of competence models, some explanations of background setting are in order.

II. BACKGROUND – LOGISTICS EVOLUTION

A selection of prominent keywords of logistics development over the last half century are integration, total cost optimization, responsiveness and general increase in relevance. Nevertheless, it is not only practical environment that alters the understanding of logistics, but also theoretical reflection about how concepts support practice and what aspects should be covered by existing constructs. A point often quoted was made by P. Drucker in 1962, which described logistics as "economy's dark continent" and a "low-grade nuisance" [1]. The society has gone a long way since - the "continent" today is far from being dark and logistics is seen as major value generator rather than tedious cost element. It could be paraphrased that through the decades, logistics has grown from garage level into office and onwards to the level of executive directors. Along that growth, little has been lost, but conceptual complexity has increased. The field of logistics today is more complex in both technology and management components than ever before.

This has much changed the way logistics is taught and what competences are expected from a specialist. The traditional concept still 50 years ago was "physical distribution management". The focus was on process capabilities and control, optimal routes and schedules, all topics of engineering flavor. In the 1970s, the term "logistics" became popular aiming to deal with a larger set of topics than the father-concept. The "systems view" integrated more and more topics and functions into physical distribution treatments. The ideas of total system cost and cost trade-off management were born and remain at the core of logistics ever since.

In the next step it, inbound and outbound logistics became integrated and it was clear the old concept "physical distribution management" was redundant and misleading. The evolution of logistics continued, being much influenced in the 1980s by the value chain concept of M. Porter [2]. As a result, similarly to past, yet a new concept emerged – supply chain management (SCM). This new idea drew more attention towards value creation across conventional business functions – such as purchasing, logistics, manufacturing and sales – and towards managing business relationships in a supply chain in more dimensions than previously implied by logistics.

Today, the practical relations between the fields of logistics and SCM are unclear in workplace, in classrooms and in academic debate. Having previously researched these conceptual relations, it appears logistics is in relatively higher need of more specific and agreed formulation than SCM [3]. While SCM is understood without substantial contradictions, the academia has not reached an agreement on the content and scope of logistics and the situation is vaguer than in the 1980's. Some authors have stepped on the SCM "gravy train" and have ceased to emphasize logistics *per se*, while others attempt to define distinct difference. Therefore it is not surprising that there is effectively only little standardization in logistics education and the existing models of competences, certifications and university curricula are in disarray.

It has been noted that human factor is the main bottleneck in developing supply chains, hindering the potential of modern technologies [4]. The lack of ontological clarity in logistics results in the viewpoints of academic authors and curricula boards ranging from narrowest views of transport arrangements, suggesting that SCM is a much higher level concept [5], to treating logistics and SCM as the same [6]. Some views suggest there is no need for logistics similarly as there is no physical distribution as a concept anymore – that SCM would offer a roof for all possible approaches. Others define distinct differences [7], and more contrasts are revealed when the concepts are modelled [8]. Such understanding appears more appropriate for education. Provided that generic SCM could not feasibly cover all niches (this paper argues that it possibly could not) and that there is a lack of other well-defined intermediary concepts (instead everyone has their own idea of differentiation), retaining and refining logistician profiles from multiple viewpoints would allow for conceptual clarity and diversity of specialists needed by the society.

It has been observed that there is a dominance of programs with business focus over technology design and engineering focus in logistics [9]. Even though typical programs of business logistics include some technology aspects, such approach is usually superficial and selective. There is of course a separate layer of curricula with more specific engineering approaches, such as warehousing systems, manufacturing logistics etc. But these are designed for narrow specialists. Under business logistics and SCM curriculum titles, the theme can be similar to traditional business curriculum and quite far from the forefront of technology. Although the idea "supply chain engineering" has been discussed in books by Dolgui and Proth [10] and Goetschalckx [11], the field has not yet developed into paradigm in its own right.

The field of higher education in logistics has been criticized in terms of gaps between academia and market relevance, such as by van Hoek [12] and Myers et al [13], as well as terminological mismatches [14]. A major meta-study of articles on logistics education was carried out by Gravier and Farris [15]. It observed 81 articles spanning over four decades on three main topics: curricula content, skills and competences, and teaching methods. However, from all articles on logistics curricula and competences, none were found to specifically treat the engineering aspect, although many included mentioning some engineering topics without specific emphasis.

A major area of debate in logistics education is the balance between theory and practice, vocational and academic training. This paper carries the viewpoint that given the complex environment of modern logistics, purely vocational training falls short without understanding conceptual issues and development, whereas the degree education has to be much aware of the changing vocational landscape. Essentially, in logistics, the two viewpoints are closer today than ever before.

One trend in terms of the future of engineering education is the growth of interdisciplinary approaches. In their vision for 2020, the National Academy of Engineering states: "*the future economy will be influenced by the global marketplace for engineering services, evidenced by the outsourcing of engineering jobs, a growing need for interdisciplinary and system-based approaches and demands for new paradigms of customization*" [16]. In our view, the field of logistics is facing many of these challenges and this paper contributes to meeting them, keeping in mind that engineering education is not solely a topic of higher education, but also much depends on earlier education and student perceptions [17, 18].

It is difficult to reach integration in the field that "exists as a fragmented discipline, housed in university departments as diverse as production management, marketing, supply management, industrial engineering and management science" [15]. It is noteworthy that: "*while logistics management requires an integrated, holistic approach, its treatment in courses and textbooks tends to be either integrated and qualitative or mathematical and very specific.*[19]" Both sides are of course required, but in between lies a gap, which is not sufficiently filled today by any competence standard. Therefore this paper focuses on refining "logistics engineering" and proposes a competence profile for logistics systems engineer, which the authors see as suitable approach to fill the gap so that the education in logistics could offer specialists of interdisciplinary engineering skillset for all needs that are not met by "one-size-fits-all" SCM style programs.

It must be pointed out that differentiation of curriculum is very important to universities that are competing for best students both regionally and globally. Caution is therefore needed to ensure that standardization wouldn't go too far where it would hinder the growth of practically relevant niches and profiles. The field of logistics is, after all, rather dynamic. As it stands today, however, more focus towards standards development is needed to ensure that the engineering aspect of logistics is reinforced and that various specialization niches could be built on top of these foundations. In terms of a well-known concept in education, the ideal profile for modern logistician is indeed T-shaped.

III. LITERATURE REVIEW

A. On the Nature of Logistics Engineering

This section focuses on both logistics and supply chain engineering for two reasons. Firstly, logistics engineering is an area of relatively modest literature, for which the modern supply chain viewpoints help to fill the gaps. Secondly, the aspects of supply chain engineering represent the modern version and evolutionary result of logistics engineering similarly to how logistics management has evolved and transformed into SCM. It is not our intent to contrast logistics engineering to supply chain engineering. Instead, the latter keeps the former up-to-date with forefront of technology and business realities.

Surprisingly little has been recently written on logistics engineering. Browsing through logistics journals resulted in findings that mostly dated to 1980s and 1990s. This can be interpreted as a lack of broad logistics-centered focus to engineering. Of course all the practically relevant areas such as electronic data interchange (EDI), enterprise resource planning (ERP) systems, warehousing, identification and tracking technologies (AS/RS, RFID) etc. are developing both in practice (improving in functionality) and in theory, research is active and publications are abundant. In the last 15 years, logistics engineering has been exposed to intense impacts from the development of ICT, especially computer networks, mobile and wireless applications, and electronic commerce [20]. An expansive area is engineering autonomous logistics systems, such as described by [21], which reaches across all the aforementioned fields. What is mostly lacking, however, is the systematic and integrated approach to these topics as a field of engineering in its own right and as a competence profile.

There are two international organizations relating logistics to engineering: International Society of Logistics SOLE and Council of Logistics Engineering Professionals CLEP. SOLE was originally founded as Society of Logistics Engineers. Whatever reasons triggered the name change, SOLE is still focusing on uniting "individuals organized to enhance the art and science of logistics technology and education" [22]. SOLE has lead long-time extensive competence recognition programs of professional logisticians (called demonstrated master logistician and Certified Master Logistician CML). These profiles include more various engineering aspects than present in most other models of logistics competences, however, with not much conceptual backing. SOLE competence profile is later on analyzed in detail.

CLEP defines detailed understanding of the field: "*Logistics Engineering is the professional engineering discipline responsible for the integration of support considerations in the design and development; test and evaluation; production and/or construction; operation; maintenance; and the ultimate disposal/recycling of systems and equipment. Additionally, this discipline defines and influences the supporting infrastructure for these systems. The practice of logistics engineering is exercised throughout the system life-cycle by trade-off studies to optimize costs and system, logistics, and performance requirements*" [23]. However, last time CLEP webpage was updated was in 2012, which points out the body is no longer actively functioning.

There are few books specifically on logistics engineering and therefore it is unfortunate that the most prominent of them, combining chapters from over 40 authors, does not properly define the area [24]. Furthermore, Joel Sutherland from Lehigh University has pointed out a controversial understanding that there are only selected few differences between business and engineering logistics, which can be summarized with logistics engineers being more focused on quantitative approaches [25]. It is relevant to note that this view much differs from approach suggested in this paper. The problem in such use of terminology, is that it does disservice to both logistics engineering and supply chain management fields, as the engineering element tends to suffer in logistics and supply chain education without explicit and broad conceptual focus.

Perhaps a more appropriate approach would be to treat logistics as a sum of "managing current logistics environments" and "designing and (re)engineering new logistics systems and subsystems". In such construct, the former is business management view (i.e. SCM) and the latter would be the view of engineering, which would incorporate and facilitate thorough approaches to processes, networks and systems design. That being said, it must be acknowledged it is misleading to overly contrast logistics engineering to business as both serve to improve processes, organizational performance and contribute to competitive advantages of supply chains.

Recently, the term logistics engineering has seen attention in the military. The American consultancy Booz Allen Hamilton has issued a report on logistics engineering as a foundation to ensure availability, life-cycle management and cost optimization. The core idea can be directly translated to business context: "*Logistics engineering brings science to the art of logistics and optimizes difficult programmatic decisions in a recourse-constrained environment. /.../ Logistics engineering is a technical discipline that applies analytics and tools to facilitate knowledge-based decision-making through-out a system's life-cycle. Logistics engineering addresses all facets of systems acquisition*" [26]. It is also noteworthy to point out that in their view, logistics engineering does not refer only to technology design and life-cycle analysis, but also process engineering, incorporating approaches such as lean six sigma and theory of constraints.

As for what details logistics engineering should entail in the military, D. Sanford has reflected on a study carried out across 101 air force logistics-related officers, which emphasized five key areas of competences: material management, distribution, air transport, fuels and contingency operations. The study pointed out that the current training of logisticians is too vague, which ends up with personnel "jack-of-all-trades, expert at none" [27].

To strengthen engineering side of logistics, supply chain engineering is an emerging concept with good potential. One recognized supporter of this concept is M. Goetschalckx from Georgia Institute of Technology, an author of the book with the same name, which preface notes: "*A supply chain system can be loosely described as a system that – through procurement, production, and distribution – delivers goods to satisfy the demands of customers. As a consequence, there exists a very large variety of supply chain system types with different goals, constraints, and decisions. But a systematic approach to the design and planning of any supply chain can be based on the principles and methods of system engineering.* [11]" The book promotes various process modelling viewpoints and practical solutions algorithms ranging across engineering design, forecasting, transport routing and scheduling, inventory optimization, supply chain systems and models.

J. Miebach is considered to be one of the first authors using the term supply chain engineering. The core of such view is similar – an optimal supply chain can perform according to objectives and deliver success if its structure is holistically designed merging technical and economical viewpoints [28]. To end this section, we'd like to emphasize that engineering treatments in logistics are not only about technological innovations but also process innovations, relating to the concepts of systems engineering [29], concurrent engineering and business process engineering [30]. This means that an interdisciplinary engineering view of logistics reaches into process and project management.

B. On the Nature of Systems Engineering

SE is a more established field compared to logistics engineering. Even though multiple definitions for SE exist and the field itself is dynamic and evolving, for our purposes a simple formulation – a field responsible of designing, enabling and managing complex engineering systems over their life cycle – is a suitable starting point.

The lifecycle is explained in a V-shaped model, which presents seven main components of systems engineering (which may happen concurrently and iteratively): concept development, requirements engineering, system architecture, design, development, integration, testing, evaluation, operation and maintenance [31]. The underlying idea of SE is to be customer-oriented so that required functionality of the system drives the entire engineering process [32] A more specific concept, enterprise engineering, aims for a comprehensive view of engineering activities at the customer enterprise [31].

A systems engineer serves to translate customer needs into specifications that can be realized by system development. In order to realize successful systems, systems engineer supports a set of life cycle processes beginning early in conceptual design and continuing throughout the life cycle. The systems engineer must analyze, specify, design, and verify the system to ensure that functional, interface, performance, and other quality characteristics, and cost are balanced to meet the needs of the system stakeholders [33].

There are various models of competencies in the field of SE, comparatively analyzed by Ferris [34]. Competence in this context is meant in a broad sense reaching across skills, knowledge, abilities, behaviors and other characteristics that need to be performed in work roles and that are observable and measurable. The models with wider recognition that were reviewed for our study are:

a) "INCOSE Systems Engineer Competency Model" by International Council of Systems Engineering, first developed in 2005 [35]

b) "MITRE Systems Engineering Competency Model" by MITRE Corporation from 2007 [36]

c) "NASAs Systems Engineering competencies" by Academy of Program/Project and Engineering Leadership APPEL [37]

The INCOSE framework is divided into three theme areas - systems thinking, holistic life cycle view and systems management – and further expanding into 20 specific areas. It has been noted that "*the INCOSE framework is simple and easy to understand and focuses on specific aspects of competency rather than trying to be a master of all disciplines*" [38].

The MITRE model consists of 36 competencies organized into five sections: enterprise perspectives, systems engineering life cycle, systems engineering management, engineering technical specialties and collaboration and individual characteristics. The model then expands into over 100 items of tasks or behaviors, which are described on three levels: foundational, intermediate and expert, noting that a systems engineer is likely to be expert only in some competencies, intermediate in others, and foundational in others [36].

The APPEL model consists of ten competency areas. In contrast to previously described, the model explicitly includes areas of project management, human capital management and knowledge management. All areas expand into 37 competencies, which further consist of 114 elements. The model is aimed primarily for use in NASA, as one of the ten areas is "NASA internal and external environments" [37]. However, the entire scope of the model is, one could say, even more comprehensive compared to aforementioned ones.

The field of engineering education has not been without criticism. Patil and Codner note: "*There is increasing evidence of a mismatch between graduate student's skills developed during their studies and those needed by gradate engineers in the workplace*" [39]. Davidz and Nightingale have pointed out "*the adequacy of certification programs remains controversial, primarily due to their newness for widespread certification*" [40].

Recently, developing the competence in systems engineering in the profile of any engineer has been advocated by field C. Wasson. Wasson focuses on filling the void in general engineering education to include a course dedicated to SE fundamentals, which in this view is a minimum set of topics required from every engineer: *"... understand the difference in SE as a professional career discipline versus a domain engineers such as electrical, mechanical, etc. that apply SE methods, processes and tools to solve domain specific problems. Both contextual roles are crucial to meeting the interdisciplinary team needs to develop complex systems*" [41]. All in all, Wasson lists 43 elements of SE topics that should be included in any domain engineer profile.

IV. METHODOLOGY – THE ROAD TO NEW MODEL

This paper aims at synthesizing an integrated and interdisciplinary model of competence areas in logistics as seen from the viewpoint of systems engineering. The first empirical research task was to evaluate and demonstrate the extent to which modern logistician competence models treat the topics of SE. It is not expected that any model positioned centrally across the wide spectrum of logistics would cover the entire scope of SE, as one is a field-specific concept, the other is not.

Still the two fields share common characteristics such as hugely varying application environments, the need for inter-disciplinary approach, and rapid development of technologies and business environment dynamics, which pushes solutions towards concurrent engineering. Therefore linkages on various viewpoints could be assumed. Logistics is an area of domain engineering, which ought to include the systems viewpoints to facilitate proper development of interdisciplinary skillsets. After all, logistics in service of company goals and strategies is nothing but a large-scale complex system itself. This implies that the underlying engineering element in logistics is strong enough so that integrating system engineering view wouldn't be something that would meet opposition in principle.

As the field of logistics is relatively little standardized, there are many competing certifications and competence profiles, a selection of which is covered here. The selection was influenced by including viewpoints of European and American origin describing the broad reach of logistics. On the question of the level of education, the focus is on university-level, though it is nigh impossible to draw the line between undergraduate and graduate levels in competence standards. The models usually solve this by flexibly defining various proficiency levels, as understandably a working model must retain some adaptability. Our analyzed selection consists of:

a) Designated logistician profile by SOLE [42],

b) Logistics professional by European Logistics Association (ELA) [43]

c) International Diploma in Logistics by Chartered Institute of Logistics and Transport (CILT) [44]

d) Distribution and logistics managers' competency model by The Association for Operations Management (APICS) [45]

On the question of which model of systems engineering competence to utilize as initial basis for comparison, we selected the model by MITRE, taking into account that:

1) the model appeared to have the best balance across a variety of factors;
2) it is much detailed;
3) it had the best structure of the models reviewed, which considerably simplified the analysis.

The methodological approach is visualized on Fig. 1.

The results of initial comparative analysis are summarized in Table I. We note that comparing two competence models is not overly precise process and it is difficult to quantify the outcome, but general evaluations can still be made. For visual clarity, a blank square means that no aspect of given competence was identified in the model and the stronger the filling, the closer linkage was perceived.

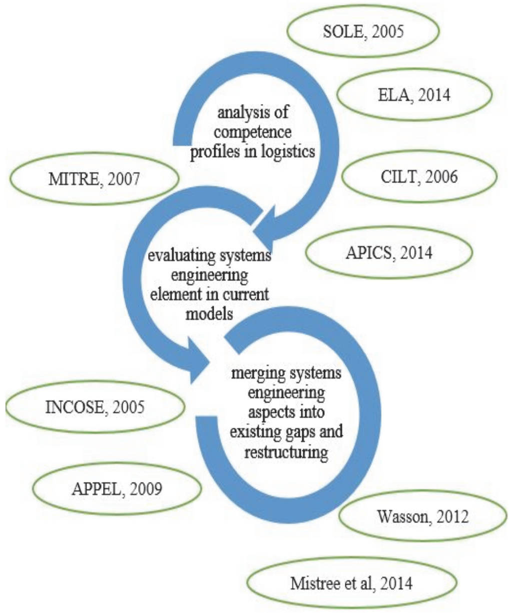

Figure 1. Applied methodology and main inputs in new model design.

Source: authors' compilation

As Table I demonstrates, there are notable differences across models in including the elements of SE. Some aspects are more strongly present due to nature of the field, such as quality and risk management aspects. Others are only occasionally mentioned here and there. For example, one might assume that human factor is relevant in designing warehouse workflow and processes, and of course it is, only that the models have not seen it important enough to explicitly point out. All in all, this demonstrates how various models in logistics competencies differ and send mixed signals to universities and to society.

Comments have to be made about SOLE model. Whereas the typical way of a competence model or a certification program is to set obligatory and clearly defined limited optional components, then the approach applied by SOLE presents lengthy list of "suggested study areas" in terms of "functional training" and "enabler training", which means that the model is able to cover wider scope but in itself it does not guarantee that a certified specialist would know all or even most of the areas. Taking that into account it is still somewhat noteworthy that the model built originally with engineering focus in mind does not reference many aspects of SE, at least not according to comparing the formulations with MITRE components. It is therefore important to note that while SOLE model does treat various SE topics right next to more conventional logistics topics, the areas are only represented as keywords so one really can't treat SOLE as a competence model but just a compiled list of topics relating to logistics.

TABLE I. PRESENCE OF SYSTEMS ENGINEERING ASPECTS IN LOGISTICS COMPETENCE MODELS AND CERTIFICATION PROGRAMMES

MITRE competency fields	**Presence in logistics models**			
	SOLE	***ELA***	***CILT***	***APICS***
1. Enterprise Perspectives				
1.1 Comprehensive viewpoints to system context and modeling				
1.2 Innovative approaches				
1.3 Foster stakeholder relationships				
2. Systems Engineering Life Cycle				
2.1 Concept definition				
2.2 Requirements engineering				
2.3 Architecture				
2.4 Systems design and development				
2.5 Systems integration				
2.6 Test and evaluation				
2.7 Implementation and maintenance				
3. Systems Engineering Planning and Management				
3.1 Transformational planning				
3.2 Acquisition support				
3.3 Contractor evaluation				
3.4 Risk management				
3.5 Configuration management				
3.6 Integrated logistics support				
3.7 Quality assurance and measurement				
3.8 Continuous process improvement				
4. System Engineer Technical Specialties				
4.1 Cost/benefit analysis				
4.2 Human centered engineering				
4.3 Modeling and simulation				
4.4 Security engineering				
4.5 Reliability, maintainability and availability				
4.6 Safety engineering				
4.7 Software and information engineering				
4.8 Communications and network engineering				
4.9 Collaborating with technical specialties				
5. Collaboration and individual characteristics				
5.1 Building trust				
5.2 Building a successful team				
5.3 Communicating with impact				
5.4 Persuasiveness and influence				
5.5 Facilitating and managing change				
5.6 High quality standards				
5.7 Result orientation				
5.8 Adaptability				
5.9 Integrity				

[a] Darker shade of grey represents more direct relationship

The three other models are more traditional competence models by their structure and formulations, but, alas, they don't dedicate too much attention to SE specifically. Perhaps such outcome could have also been assumed beforehand. The result in Table I confirms the expectation that SE component in logistics competence models can be, at best, labelled "could be improved".

Such result could reasonably be interpreted as a gap which should be overcome. Such integration between systems engineering and logistics wouldn't in our view be just a curiosity, but would reinforce engineering element in logistics, which, if applied in practice, would help universities to present students with a stronger interdisciplinary skill profile. Currently, although mostly everyone in the field would agree that interdisciplinary approach is a requirement in logistics, the profiles actually developed in many universities are not that interdisciplinary as they could be, if there also would be a standards pushing for such change.

Therefore we set out to formulate our view of what should logistics system engineer's competence profile consist of. The process of model creation required at first to differentiate various competence areas, which was not overly difficult. The more challenging part was going through the existing logistician models once more to make sure that our approach would not leave any essential viewpoints aside. The task was complex as all models have their own inner structure.

The next step was to define the extent to which systems engineering topics would fit into the new model. As the primary goal of our model is to use it as a tool for curriculum design, the extent of systems engineering topics from INCOSE, MITRE and APPEL models was consolidated and shortened, taking into account approach suggested by Wasson about the content of minimal systems engineering module for domain engineering fields [41]. In the vision of our model, systems engineering material would need to cover around 20% of curriculum, keeping the profile still field-specific with additional strong systematic foundation.

Additional effort was made to map required individual foundational competencies right next to field-specific task competencies. There is, of course, an abundance of personal traits and attitudes that are foundational for a field covering such a variety of jobs as logistics. As Table I showed, the models include some and leave out others, so we attempted to consolidate the most essential across all the models. Additionally, just this year, a group of authors published their approach to foundational aspects expected from any engineer [46], so we made sure to integrate their approach as a double check for quality.

V. RESULT – A COMPETENCE PROFILE FOR LOGISTICS SYSTEM ENGINEERS

First of all, the structure of our proposed model is shown on Fig. 2. It consists of six layers, starting from foundational engineering competences. In the presented view, systems engineering treatments form the conceptual foundation to the model, so that all the layers are built upon it. On top of that lies the layer of specific technologies that need to be engineered and maintained in logistics, followed by a core layer of more conventional logistics topic areas. It is difficult to offer non-overlapping categorization to logistics technologies. In current perspective, three technology areas are parts of material flow whereas the last component suggests the dimension of automation and intelligent technologies is applicable about almost all aspects of modern logistics technologies.

The core includes all operational and tactical elements of logistics and supply chain related decisions. At the very center lies a lost list of issues grouped as "logistics and supply chain network design and configurations", which in this context foremost includes the areas of supply chain design, supplier selection and evaluation, physical material flow characteristics configuration, transport and material handling arrangements and optimization.

Figure 2. The building blocks of logistics systems engineer's profile

Source: authors' compilation

The core is supported by two pillars, which represent two main variables in logistics networks: inventory and information. Changes made in these configurations require careful management and understanding the trade-offs across entire logistics system.

Information systems and information flow configurations belong into the "core" rather than form just one technology pillar because information is the "glue", which keeps all the systems running and facilitates both planning and control across variety of dimensions. All technology implementation areas include information flow aspects one way or another anyway, so there is no distinct line, but then, everything is related to everything else in the picture of logistics systems. Information technology section is intentionally separated from physical technologies to demonstrate the importance and applicability in almost any logistics environment, whereas other technologies are much more context related.

The goal of presenting these three aspects together points out that the core reaches across the initial requirements for logistics system (understanding customer demand) to arranging the optimal supply network (suppliers, cost and time implications of deliveries, inventory costs and risks) and keeping the system flexible by optimal management of information and inventories. This layer also involves network optimization.

The following layer adds the view of operations and processes and stresses that improvements to logistics system do not only come from technologies, network configuration and better information management but also from optimized workflow and processes – or indeed, that proper optimization of all types of processes is what facilitates the more hands-on improvements in logistics quality and stakeholder satisfaction. This layer also includes all forms of performance measurement in both financial and non-financial aspects in order to provide direct input to all other areas and drive continuous improvement.

The top of the model, "value creation system design and management" is the strategic capstone of entire logistics system that must explain the driving force why everything is running in the first place. The simple reason is the customer. The more general reason lies in the outputs that the system is designed to generate that are valued by the stakeholders. This aspect is on top because of importance but also that it is mostly the only aspect what is directly perceived of the system from the outside.

Understanding the value creation system gives meaning to all activities in scope of logistics. Principle changes on this level need to trickle down across the layers to accommodate accordingly: to streamline processes, create new and reconfigure existing supply networks, identify system current and future priorities, define investments and bring about innovation. However, to make it happen, the roots, i.e. the foundational competences, must all serve as enablers. Also, sometimes systems develop and evolve from bottom to top and the more dynamic the environment, the more crucial is to take advantage of the emerging options.

Initially, the capstone was titled just "value system", which would be sufficient, if it would not already have been used in the context of ethical and cultural values in stakeholder theory. Therefore, the aim here was to avoid confusion. In this paper, value is in principle the sum of utility that a system provides for the stakeholders.

The competence model in its full form is rather extensive. The entirety of topics treated under various programs of logistics is still notably wider [47], so the model presented here implies dedicated differentiation. Though, even if limited to competence elements at the level of listing required learning outputs, the model is longer than the constraints presented by this paper. Therefore on most competence layers in the following tables II and III, only an abbreviated form of competences is presented. This consolidated the size of tables to around 60% of its original form. The authors are glad to distribute the complete version to anyone interested on contact. The meta-competences referenced in table III are integrated mostly in their original form according to Mistree et al [46].

Due to extensive reach of the created competence profile, it is not realistic that such training would be achieved in the typical three years of undergraduate studies. The authors are therefore on a position that the programs for logistics systems engineers would have to be full five year study programs similar in length to other fields of engineering.

One difficulty in implementing such profile in universities would be cost. The field of logistics covers an abundance of technologies, which requires universities to invest into a variety of simulation, testing and other lab equipment. Another requirement is tight cooperation with industry to ensure the problems research by students would be as realistic as possible and that quality internships would be facilitated. In summary, this is a complex problem for universities with lesser resources and this is, in authors' view, one of the reasons why pure business-focused logistics programs are so abundant – they are substantially cheaper and easier to manage.

TABLE II. SELECTED COMPETENCIES IN THE PROFILE OF "LOGISTICS SYSTEMS ENGINEER", LAYERS I-III

A. Value creation system design and management (shortened)
A.1 Views the organization as a system that converts inputs to outputs
A.2 Understands the role of management activities and different organisation structures and applies fundamental management theories and concepts in practice
A.3 Participates in strategic planning, including long-term strategic goals, and relates strategic priorities to market and business environment trends, current status of the company and to goals of functional strategies and tactical plans
A.4 Analyses market and customer requirements and expectations, needs and desires, order qualifying and order winning factors and how the value generated by company is perceived in the mind of customer as a primary input to defining value system priorities
A.5 Analyses short- and long-term trends in the industry, region and micro-, macro- and global environment
A.6 Applies various analytical techniques to evaluate and improve company and main products position on the competitive landscape
A.7 Defines the system and component processes of value generation and the role of supporting activities in a company
A.8 Defines value offer to customers, applies differentiation and positioning concepts based on marketing data and assists in outlining marketing strategies as means to communicate the value offer to target customer segments
A.9 Analyses comparatively competitive forces and pressure on market
A.10 Defines goals and principles of the value systems, key success factors and product and service standards in value systems
A.11 Performs value stream mapping and outlines value system improvement plan accordingly
A.12 Understands the role of suppliers, customers and business partners in the supply chain, how it influences the total value perceived by end customer and how to coordinate actions, priorities and management principles to increase total value generation

B. Performance, costs, control and sustainability (shortened)
B.1 Evaluates general financial performance of an organization, the performance and the success or failure rate of projects, products and services and their value systems, understands and calculates financial performance indicators and related concepts and understands how changes in logistics system can affect financial performance
B.2 Defines strategic and tactical key performance indicators for the company and defines measurement systems of performance indicators
B.3 Develops strategic objectives of logistics and value system relating to SCOR model metrics: reliability, responsiveness, adaptability, costs and asset utilisation
B.4 Defines quality standards and plans and analyses quality inspection and improvement
B.5 Defines, plans, analyses and controls financial and project management aspects of development projects and investments
B.6 Employs the technique of break-even analysis and determines optimal operating level
B.7 Calculates project and company cash flow forecasts, present value investment comparisons and risk-adjusted return calculations
B.8 Understands basic principles of sustainability and evaluates internal sustainability of the logistics systems

C. Operations, process and workflow development (shortened)
C.1 Assists in developing a culture and organizational behaviour where departmental sub-optimisation is minimised and cooperation is supported and understood as a central value that would encourage visibility of company performance and understanding "the big picture"
C.2 Understands the trade-offs between system priorities and coordinates processes accordingly
C.3 Supports the culture where changes in priorities, processes and workflow are accepted and communicated to keep the workforce agile and the products and processes adaptable
C.4 Understands that every part of main process in a company needs to create value and develops processes accordingly
C.5 Identifies and eliminates causes of quality problems, analyses and reduces process variation and strives to remove non-value-adding components in processes and workflow
C.6 Analyses and improves procedural standards, structures, responsibilities, job and task descriptions and coordination and control mechanisms
C.7 Applies systematic approach to increasing system performance through streamlining, coordination and cycle time reduction

D. Logistics network design and configuration (shortened)
D.1 Forecasts demand for products and services with various methods and techniques
D.2 Synchronizes supply with demand by determining the need for material and operational capacity to address expected demand and executing the resulting plans
D.3 Designs supply chain network and logistical flow in alignment with general priorities of the value systems
D.4 Defines specific customer service standards and develops objectives and indicators across the supply network in terms of quality, cost, flexibility, adaptability, responsiveness, productivity, efficiency and customer satisfaction
D.5 Analyses and optimizes the location of physical supplies chain facilities (warehouses, hubs, factories, stores), taking into account the effects on lead times, availability, inventory and transport related costs, risks and other supply chain performance areas
D.6 Carries out lead time and order cycle time analysis and identifies potential improvements
D.7 Optimizes material and information flow between supply chain participants and improves process control
D.8 Analyses the applicability and implements various supply chain management concepts such as just-in-time, QR, CPFR, VMI, etc.
D.9 Coordinates manufacturing and logistics flows and planning systems
D.10 Understands, analyses and optimizes the total supply network capability by controlling processes, identifying and removing bottlenecks, managing trade-offs and coordinating decisions across functional areas
D.11 Applies various operations management techniques in controlling and optimizing logistics activities
D.12 Analyses the applicability of technologies in the field of logistics and process control to improve performance
D.13 Appreciates the impact of supply chain operations to environment and applies principles such as renewable raw materials, reverse logistics, recycling, paperless operations and green transport
D.14 Analyses the feasibility and impacts of various supply chain configurations (MTS, ATO, MTO) and optimizes current configuration
D.15 Carries out make-or-buy analysis, negotiates contracts with suppliers and service providers

E. Inventory system configuration (shortened)
E.1 Defines inventory management strategies and objectives and balances demand with supply
E.2 Calculates and develops actions to improve key inventory performance metrics
E.3 Converts demand information and forecasts into operations and purchasing schedules
E.4 Defines, implements and develops inventory control procedures
E.5 Analyses and categorizes inventory with various techniques and defines dedicated inventory management principles to categories
E.6 Determines optimal ordering systems, order quantity, safety stock and availability control parameters
E.7 Understands and calculates inventory holding and ordering costs
E.8 Understands and counters the bullwhip effect
E.9 Understands the trade-offs in inventory management between availability, costs, risks and control
E.10 Analyses the availability of products and ways to increase it
E.11 Optimizes inventory levels and holding costs while simultaneously improving availability

F. Information system and flow configuration (shortened)
F.1 Understands fundamentals and defines role of MRP/ERP software
F.2 Applies EDI and other modern solutions in B2B communication and analyses the impact on logistics performance
F.3 Designs e-commerce solutions and evaluates impact on customers
F.4 Compiles and models the user requirements of information systems
F.5 Integrates activities across organizations on the supply chain by ensuring information visibility
F.6 Analyses the relations how IT systems affect processes and vice versa
F.7 Accounts for security and privacy issues in IS design
F.8 Defines and implements data mining and various analytic systems
F.9 Manages IT system transition and integration processes
F.10 Facilitates visibility by designing suitable tracking systems
F.11 Considers various viewpoints and trade-offs in information system analysis, including reliability, features, security, capacity, flexibility, workplace ergonomics etc

TABLE III. FOUNDATIONAL COMPETENCE LAYERS IN THE PROFILE

G. Logistics technology layer (shortened)
G.1 Understands modern technologies and future trends in the areas of transport, tracking, warehousing, handling, and autonomous solutions in terms of capabilities, costs, requirements, constraints and risks G.2 Analyses current and future need for logistics technology innovation and the impact of solutions to supply chain performance G.3 Initiates and carries out feasibility and impact studies of technology innovation projects in logistics G.4 Matches value system needs with technological capabilities G.5 Cooperates and consults with experts in the field G.6 Manages new logistics technology implementation projects throughout the life cycle G.7 Carries out thorough risk analysis of implementation projects, including aspects of safety and security G.8 Defines human, information system and technology interfaces and integrates physical technologies with IS and workflow G.9 Applies human-centered engineering in design and implementation G.10 Cooperates with external experts to create systems reaching across organizational boundaries G.11 Specifically, is knowledgeable about current state, trends and applications of alternative fuels, vehicle designs, self-driving vehicles, cargo room characteristics, alternative energy sources, warehousing and racking solution, AS/RS, automatic handling and packaging, sensors and automatic identification, monitoring and inspection and information system designs and concepts G.12 Is aware of the current and future boundary between human and machine-based operations and understands the required conditions when human labour can be replaced with machines G.13 Envisions potentially applicable solutions in organization in the near future, relating to technological trends and evolving industry practices G.14 Understands the synergetic relations between material flow technologies, information system and information flow configurations and utilises it in systems development G.15 Analysis the level and extent of technology- and innovation-related competencies in organization and assists in forming training plans as well as employment plans
H. Systems engineering layer (shortened)
H.1 Understands SE terminology, foundational process and planning, design and control concepts H.2 Defines system strategies, mission statements and specifications H.3 Researches, assesses and manages system stakeholder requirements H.4 Analyses system complexity and decomposition H.5 Understands and formulates system element architecture H.6 Defines system interfaces and manages phases, modes and states H.7 Performs analysis of alternatives H.8 Understands the system life cycle analysis, dynamics and planning and implementing of various functions through-out the life cycle H.9 Plans and analyses reliability, availability, and maintainability H.10 Applies tools and methods of system performance measurement, modeling and optimization H.11 Estimates system life-cycle costs H.12 Analyses and manages safety aspects H.13 Is able to perform configuration and data management, technical reviews and audits H.14 Identifies, assesses and mitigates risks H.15 Is proficient in fundamental tools of project management
I. Generalized individual meta-competences
I.1 Ability to learn and manage information I.2 Ability to manage thinking I.3 Ability to communicate and collaborate I.4 Ability to manage attitude
M. Supporting foundational characteristics
M.1 Accountability M.2 Adaptability M.3 Creativity M.4 Empathy M.5 Integrity

VI. CONCLUSIONS

This paper synthesized the competences of systems engineering with modern logistics engineering, creating a profile "logistics systems engineering", which fills a gap in logistics education by reinforcing the engineering aspect and aims to counter the present bias in logistics education towards traditional business management.

In the process of model creation, the two prominent questions were of conceptual reach: to what extent should SE aspect be included and what should be the proper balance between engineering and management aspects in the resulting model. The applied approach aimed for wider coverage of topics so that engineering focus would be covered by both foundational systems engineering concepts as well as domain-specific technologies and they would all still be related with wider organizational and business network context that the authors called "value creation system". In a sense, the resulting model is even more interdisciplinary than many existing treatments of professional logistician profiles and that was intentional. The competences for logistics systems engineer integrate the aspects of systems, networks, physical technologies, ICT, product and process engineering.

The primary theoretical contribution of this paper is to offer a means for academia to treat logistics topics differently from the dominating SCM concept, which does not dedicate enough systematic attention towards engineering aspects (although a smaller set of universities do, regardless). In terms of the name for such concept, both logistics and supply chain engineering are almost suitable. The latter is more common in literature, while the former would offer a new face for logistics along with sustainable longevity. Regardless of which name prevails, the authors expect that the content of the suggested profile will stand the test of time and be applied by universities.

It must be acknowledged that the result, as any competence model, is never "final" but open to interpretations and accommodations in any specific curriculum case and changes on educational landscape. Still, the result appears complete enough to be used as curriculum development input in the case of authors' own *alma mater*. The profile is directed at integrated bachelor- and master-level studies. Further, the profile could be implemented as occupational standard and a certification system. The areas of directly related future research would be case studies of implementing such programs, studies aimed at identifying the view of industry stakeholders towards the concept and developing optimal teaching methods that would merge systems and domain-specific views in the context of modern ways of learning.

There is another term suitable for the field – intelligent logistics. The concept is barrowed from intelligent transport systems and extended across the cross-functional nature of logistics. We are living in an age where there is less and less physical human labour in logistics and more automation and autonomous systems in in-house operations. Furthermore, we may see autonomous solutions in logistics on the streets in a future that is not too far away that educators wouldn't need to think about it today. All the current and projected developments require people with proper educational profiles and this forms the frontier of modern logistics engineering.

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Logistics Management versus Supply Chain Management – the Crystallization of Debate for Academic and Practical Clarity

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***Abstract*—Research objective and methodology. The relation of terms *logistics* and *supply chain management* (SCM) has been debated since the first use of the latter in the 1980s. In the beginning of 2000s, four distinct schools of thought were observed to exist in the treatments by the academic world, called *traditionalism*, *relabelling*, *unionism* and *intersectionism*. This paper focuses on the current state of the debate, drawing on recent treatments in literature as well as findings from a survey carried out among academic specialists in the field – much similar by design to the survey used a decade ago that originally identified the four viewpoints.**

Results and interpretations. The results are pointing out that the understanding of scope of the two disciplines has harmonised in time and, more specifically, two approaches, traditionalism and relabelling, have, by the beginning of 2010's, marginalised close to the point of extinction. In our interpretation this demonstrates the only recent switch of generations. Additionally, it could be concluded that the pressure to clearly differentiate from the historical sister-concept now lies on logistics at least by as much as on supply chain management, whereas traditionally the SCM scope has clearly seen comparatively much more debate.

The findings do not only have conceptual relevance but also allow for more clarity in the terminology use. For academia, this gives valuable input for building university curricula for both disciplines and also encourages, in situations when both demand and supply allows, both curricula to exist side-by-side. Similarly on business relevance, companies deal with logistics and SCM in different scope - local and global scope. The role of this paper is to provide input for theoretical treatment of epistemology and ontology of the field and it is our hope that it contributes guidelines for how logistics should be viewed and conceptually developed.

***Key words*—intersectionism, logistics, logistics curriculum design, unionism, supply chain management.**

I. Introduction

Since the first formulation of the supply chain management (SCM) idea in early 1980s, the field has grown considerably in practical relevance, causing the theoretical treatment and research of it to evolve in time as well. This evolution has not been without conflicting debates on the theoretical level of the scope, focus and essential attributes of SCM as well as relation to logistics. First treated as a subtopic in the field of logistics, for example by Oliver and Webber in 1982 [1], numerous authors have later observed that SCM has grown much larger from its original form. It is sometimes said the scope of SCM is „the big picture" of value creation. This raises the question about the outer boundary of the term. Does SCM involve all the aspects of management and business functions, such as marketing, workforce issues, product design, research and so on? If it does, then it means SCM cannot be explained as a functional area at all and then the question arises if SCM is just another name for process and operations management or perhaps a subset of it. Where would it leave logistics?

For optimal management of logistics and supply chains, competent managers are required to develop process integration and manage the inherent complexities and this is the starting point of this paper. To educate future specialists, there has to be a clear conceptual understanding of SCM and logistics, what they consists of and how they relate to other business administration and management topics. Metaphorically, the vocabulary and grammar should be commonly understood before composing sentences and stories. One problem for the academia has been a lack of clear paradigm and understanding of SCM as a field of study. This has resulted in various curricula, some with a wider approach, and some with direct focus on some components. In many cases „logistics management" and SCM curricula are taught side by side, sometimes one being opened next to the other, sometimes the former replacing the latter. Sometimes a randomly selected "logistics" programme can be almost identical to another randomly selected "supply chain management" programme. This article is aimed at mapping the current situation of the scope of SCM. In literature review, we first present various treatments on the nature of supply chain management and then review how it relates to logistics. In the empirical part, we present results of a survey ran among specialists of logistics and supply chain management with a goal to identify the existence of various schools of thought in the debate concerning the ontological debate. Briefly put, we are aiming at identifying the change in the understanding of the relationship of the concepts that has taken place over the last decade.

II. The Nature of Supply Chain Management

Before defining SCM, let us briefly focus on defining a supply chain. Although the product-oriented network nature forms the core of a supply chain, there are interesting details in approaches to even such a simple idea.

For example, Ayers has worded that „supply chain is a life cycle process involving physical goods, information and financial flows to satisfy end consumer requisites with goods and services from diverse connected suppliers [2]." Perhaps notable here is the distinct inclusion of financial flows. Modern understanding seems to be in favour of including financial flows to the supply chain vantage point [3]. It can even be said that it is one of the leading differences between SCM and the distinct „father concept" logistics. One such example is given by Harrison and van Hoek – „logistics is the task of coordinating material flow and information flow inside a supply chain" [4] - although proponents of the augmented meaning of logistics might disagree.

An important trend in supply chains is searching for ways of better integration and this has also been included into numerous definitions. Pienaar and Vogt have defined the supply chain as „a general description of the process integration involving organizations to transform raw materials into finished goods and to transport them to end-user [5]."

One topic of debate in defining a supply chain is determining a beginning and an end-point. The modern view has much turned against the traditional slogan „*everything starts with mining*" with at least two counter arguments. Firstly, the supply chain as a business process should start with any form of demand planning, be it forecasting or operating on-demand. Secondly, this demand planning itself should start by determining the needs of end-customers in the physical „end" of the supply chain rather than forecasting at the first node (which is still taking place in parallel). Harrison and van Hoek have defined the starting point of a supply chain cycle: „(SCM is) planning and controlling all of the business processes – from end customer to raw material suppliers – that link together partners in a supply chain in order to serve the needs of an end customer. /…/ In effect, the end customer starts the whole process by buying finished products. It is this behaviour that causes materials to move through the supply chain [4]." In other words, demand planning and management is the initiating process of supply chain management. Sometimes the term *demand chain* is used instead of a supply chain to point out the relevance of a pull-based business model. Similar idea is carried by the concept of a value chain, developed by M. Porter [6].

The end of a supply chain has also been debated. Originally, fulfilling the customer demand with a product with all the required quality and service dimensions was seen as the end of a supply chain. This has been later augmented by the following ideas. Firstly, customers are often expecting support or additional services after the sale has taken place. Secondly, reverse flows have been added to the scope of a supply chain, meaning not only that entirely new processes have to be designed in the framework of SCM, but also that the real end of a supply chain is reached when all the resources left over from consumption have been reused, recycled or otherwise utilised. Harrison and van Hoek have similarly defined a supply chain as „a network of partners who collectively convert a basic commodity into a finished product that is valued by the end customers, and who manage returns at each stage [4]."

Another question in supply chain is the real composition of entities and their pattern. A supply chain is of course only „a chain" as an illustration, whereas in practice the companies form an interlinked network. Supply chain and supply network are in literature usually used interchangeably and both the global and network aspect is acknowledged in various definitions, for instance one by Gunasekaran: „a worldwide network of suppliers, factories, warehouses, distribution centres and retailers through which raw materials are acquired, transformed and delivered to customers [7]." It has been argued by Stephen New that a supply chain has three distinct meanings. First is from the perspective of an individual firm, second is a life cycle of a particular product and thirdly a synonym for processes encompassing purchasing, materials management and distribution [8].

Aforementioned aspects aside, it appears from the literature that supply chain view is more or less settled to include the flows of materials, information, finances and returns, forming the essential playground of SCM. Across more detailed overview of SCM definitions, the following keywords appear to emerge most often: business relationships, cooperation, holistic optimisation, process integration, communication and aligned supply chain strategy. To start analysing SCM, the first question might be – what are the expectations placed on SCM, i.e. why talk about SCM at all? A good phrasing has been put forward by Langley et al: „SCM is aimed at examining and managing supply chain networks. The rationale for the concept is the opportunity for cost savings and better customer service. An important objective is to improve corporate competitiveness in a global marketplace in spite of hard competitive forces and promptly changing customers' needs. [9]"

The debate over the meaning of SCM includes various understandings of scope, content, most relevant management level and relation to other fields of business operations and research [10]. However, on the level of aims and objectives, SCM and logistics are often treated quite similarly. The goal of logistics is often explained through the 7R model – the right product, in the right place, at the right time, in the right condition and quantity, to the right customer with the right cost. It is logical to assume that the goal of logistics must also be at least partially a goal for supply chain management. According to a classic textbook „The Supply Chain – the Definite Guide", the authors state much similar objectives: „SCM is a set of approaches used to efficiently integrate suppliers, manufacturers, warehouses and stores so that merchandise is produced and distributed at the right quantities to the right locations at the right time in order to minimize system wide costs while satisfying service-level requirements [11]."

According to the latest edition of a textbook by one of the leading authors in the field of supply chains, Martin Christopher: „SCM is the management of upstream and downstream relationships with suppliers and customers in order to deliver superior customer value at less cost to the supply chain as a whole [12]." The goal of SCM here is similar to [11], but Christopher also suggests that the main focus of SCM is essentially supplier and business partner relationships and benefits to competitiveness achieved via these relationships. A contrast of such phrasing is that it appears to leave logistics decisions taking place inside any given company somewhat out of SCM scope.

Ayers and Odegaard have cited various definitions for SCM across industry professionals, ranging from more operations-focused to broader, strategic planning oriented approaches. According to the definition offered by the authors themselves: „SCM is design, maintenance and operation of supply chain processes, including those for base and extended products, for satisfaction of end-user needs. [13]" It must be emphasised, however, that reaching these goals through integration of various firms, strategies, market positioning, business models, visions and cost-control policies is far from an easy task and is much more challenging than coordinating business functions inside a company. According to Sadler, „The biggest challenge facing companies today is not the internet, or globalisation, or stakeholder needs but integration of supply chains from vendors through manufacturers and distributors to satisfy end customers and obtain value for those companies. /…/ The objective of supply chain integration is to synchronise the requirements of the customer with the flow of materials from the suppliers in order to achieve a balance between the goals of high customer service, low inventory investment and low unit costs. [14]"

The integration aspect of SCM is also emphasised by the idea of „supply chain alignment", which aims to find the best strategic match between the balance points of various supply chain performance goals of two companies operating as links in the same supply chain (or indeed that such alignment could reach across multiple entities in a chain). Among other authors expanding on that idea, it is Gattorna who has pointed out that alignment with both external and internal partners in a supply chain should be a priority topic in defining any supply chain strategy [15]. According to Baier et al [16], achieving the alignment is a taunting and quite possibly a never-ending task as is the task of understanding what factors enable alignment the most and by how much. In a recent study [17], a group of British authors identified six enablers of alignment: organisational structure, internal relational behaviour, customer relational behaviour, top management support, information sharing and business performance measurement system. Additionally, one interesting detail emerged from that study that fits this article's purpose the best - the discussion on supply chain alignment has, it appears, grown significantly in the last decade. This supports the notion of SCM growing „more strategic" in time, in contrast of just „managing all operations in a chain" on a tactical level. It can be argued that strategic alignment is the most important step towards supply chain integration. This is essentially what is meant by the slogan „supply chains compete with supply chains" – that supply chains become recognised more as more as units of competition in itself. Eloquently put by Lyons et al: „The consequence is that supply chains are increasingly looked upon from an holistic, multi-business, yet integrated perspective and it is from such vantage point that makes feasible the development of a supply chain strategy that can be meaningful and coherent across a series of both loose and tight network alliances." [3]

Douglas Lambert has likewise argued that successful SCM requires cross-functional integration within the firm and across the network with main challenge being how to achieve this integration. Lambert emphasises that integration starts with „defining and managing processes for customer relationship management and supplier relationship management [18]" Lambert does justice to Peter Drucker, who stated back in 1998 that „the ultimate success of business will depend on management's ability to integrate the companies intricate network of business relationships"[19]. Supply chain integration has been defined in greater detail by Näslund and Hulthen: „SCM integration is the coordination and management of the upstream and downstream product, service, financial and information flows of the core business processes between a focal company and its key supplier and its key customer [20]." According to Fabbe-Costes and Jahre, supply chain integration should be viewed in four elements: flows, processes, technologies and structures [21]. However, it is a vague topic when it comes to specifics. Näslund and Hulthen have found little empirical evidence to suggest that integration provides concrete benefits usually associated with the idea. The authors point out that the lack of agreed distinct concepts in approaching supply chain integration and supply chain collaboration „prevents the development of normative recommendation to practitioners of why, how, when and what to integrate [20]."

It could be argued that logistics is similarly aimed at achieving long-term benefits through integration and alignment. However, it is mostly agreed that logistics is only one functional part in the scheme, whereas supply chain management also encompasses matters which exceed the functional boundaries of logistics. A detailed and systematic overview of SCM subsystems was presented by Lambert et al already in 1997 [10]. According to authors' view, supply chains encompass 8 general management processes that are applicable for every firm in a supply chain, noting that a supply network cannot run on fewer processes than are needed for running a single company. These are, specifically, customer relationship management, supplier relationship management, customer service management, demand management, order fulfilment, manufacturing flow management, product development and commercialisation and returns management. In this view, the eight sub-processes are cross-functional and cross-firm by nature, forming a foundational framework of process integration. [10] Furthermore, Lambert treats corporate and functional silos as main barriers of process integration. For example, function-based measuring and rewarding constitutes a major bottleneck for achieving supply chain success, because it tends to favour functional cost and revenue targets and asset utilisation higher than customer or shareholder value [18]. Lambert also points out that not every supply chain link should be closely coordinated and integrated. Instead only the ones that are most critical for organisations success are worth pursuing [ibid].

To reduce the confusion over identifying the nature of SCM, Lambert has also expressed clear points on what is not SCM. Lambert argues that until the mid-1990s, SCM was viewed as logistics that was integrated with customers and suppliers, which created confusion as logistics had two different meanings: one as a functional area, one as a concept analysing information and material flows. A similar situation had been observed before in marketing (reflected in a popular statement „marketing is too important to be left to the marketing department"). A modern idea about SCM is similar: „supply chain manager is everybody's job". According to Lambert, a clear distinction was needed between SCM and logistics to emphasise that even the strategic meaning of logistics is only a part of SCM, with the other parts being all the other areas of customer and supplier relationships, where cooperation and coordination can result in benefits for both parties, which don't have to be related to logistics (i.e. time and place of material and information) [18]. Relating to the confusion between logistics and SCM, Lambert has expressed also a clear need to differentiate traditional operations management and purchasing management from SCM, the former being only its components. Despite that, Lambert points out, often operations management is relabelled to supply chain management similarly to some authors researching logistics. [18]

In a recent textbook by Wisner, Tan and Leon, the authors present the idea that SCM should be viewed as balanced upon three pillars: purchasing, operations and logistics [22] In such framework, logistics is a crucial part of supply chain management, as is any other operation that adds value and/or cost to the product, whereas purchasing, including the aspects of supplier selection and relationships, cover the inter-organisational aspects not covered by logistics. The authors view for the best SCM definition is: SCM is the design and management of seamless, value-added processes across organisational boundaries to meet the real needs of the end customers [22]. From another recent textbook „Supply Chain Risk Management" , Sodhi and Tang have defined SCM as „the management of material, information and financial flows through the supply chain, including the coordination of processes and activities across functions such as marketing, sales, production, product design, procurement, logistics, finance and information technology within the supply chain. [23]" This is yet another supporting viewpoint to understanding that logistics is viewed on a business function level, whereas SCM aims to coordinate across functions to facilitate meeting customer expectations and holistically manage strategy and value creation processes.

To sum up, it is interesting to note that for 30 years most authors have supported the view that the abundance of SCM definitions creates confusion and misunderstanding. However, it could be argued that some of the similarities among all the aforementioned definitions were already suggested by Oliver and Webber in the very beginning, more specifically as: „1) SCM views the supply chain as a single entity; 2) It demands strategic decision making and system integration 3) It views balancing inventories as the last resort [1]." Most of the aspects presented here so far have been to a large extent merged in the phrasing by The Council of Supply Chain Management Professionals: „SCM encompasses the planning and management of all activities involved in sourcing and procurement, conversion and all logistics management activities. Importantly, it also includes coordination and collaboration between channel partners, which can be suppliers, intermediaries, third-party service providers and customers. SCM integrates supply and demand management within and across companies. SCM is an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model. It includes all the logistics management activities as well as manufacturing operations and it drives coordination of processes and activities with and across marketing, sales, product design, finance and information technology [24]."

In conclusion, although the concept of SCM keeps evolving, the authors today are mostly in agreement over the core elements and issues of SCM. It could be said that SCM has established itself as a holistic business concept in its own right, integrating functional areas of logistics, purchasing, operations and sales and emphasising the potential benefits from cross-functional and cross-enterprise cooperation and collaboration. Similarly to modern understanding of marketing management, the concept is wider than a functional area. Supply chain managers are described mostly working in cross-functional teams and rotating between departments, still spending 30-40% of their time with external partners and usually dealing more with strategic relationships rather than transactional ones. This requires an extensive amount and level of interdisciplinary competences from a supply chain manager [25]. The field has also in recent years been better described through standards, certification programmes and competence models, such as [26], [27] and [28] to reference a few. We expect the standardisation of SCM to continue developing, but in purely mapping out the scope of SCM, notable progress has taken place during the last decade and there is less confusion and debate about the nature, scope and core of SCM.

III. Relationship Between Logistics and Supply Chain Management

The topic concerning relationship between SCM and logistics has been debated in academic world since 1990s. Practitioners and educators have addressed the idea of SCM as an extension of logistics, the same as logistics, or as an all-encompassing approach to business integration [10]. It has been pointed out that „without clear and agreed definition of supply chain management, the idea will not hold academic merit and will instead only be a short-lived hot buzzword for industry practitioners [29]." Such controversy was also reflected in one author's personal university studies in logistics in the beginning of 2000s, as it soon became clear some teachings were, in principle, contradicting each other. To bring clarity into the matter, logistics relation to SCM needs to be defined and agreed upon.

A landmark paper comparing the relationships between the concepts of SCM and logistics was published by Larson and Halldorsson in 2004. As authors note, „the unclear conceptual borders of SCM make it difficult to design educational programmes in SCM without large overlap with other fields such as logistics, marketing, operations management and purchasing [30]." The problem here is not only about fitting SCM with the already existing study fields but also about how the existing fields would need to accommodate for the possible overlap with SCM and how this would affect the studies in these fields. After careful review of numerous classical and modern definitions, authors reached the conclusion that there are four conceptual perspectives, which are essentially emerging clusters of interpretation. These perspectives were named and are also today known as: traditionalism, re-labelling, unionism and intersectionism [30]. As our research described in this paper is much based on that classification, the approaches are described here in more detail.

The traditionalist positions SCM within logistics, meaning that SCM forms a subset of logistics. As name suggests, this reflects the historical perspective as the term SCM first came into use in logistics literature, referring to a logistics „outside a company". In such interpretation, supply chain analysts would also broaden the scope of logistics analysis. In the perspective of a traditionalist, a supply chain analyst would probably belong to a logistics department and deal with conventional logistics issues with time and place management of all material flows. The practical point for teaching, in the view of a traditionalist, would be that SCM does not need to become separate discipline but is more suitable as a course inside a logistics or operations management programme instead [30].

Re-labelling refers to large similarities between concepts. In this view, logistics has evolved over decades to include coordinated and integrated management of material and information flows and has been labelled SCM to stress that the frontier of improving logistics nowadays lies in optimising supply chain, i.e. inter-organisational operations [31]. This has resulted in many authors using the terms supply chains and logistics networks interchangeably. In practice, this would mean that the logistics analyst from last decade would now be called a supply chain analyst [30]. Such approach has been also backed by observations from business practice, for example by Gammelgaard in 2001. When industry specialists were queried on „what is expected from a supply chain manager", many answers were worded much similarly to the popular understandings of logistics - the aforementioned 7R model [32].

From a unionist perspective, however, SCM is wider than logistics and the latter is a complete subset of the former. In this view, noted to be extreme by Larson and Halldorsson [30], SCM meaning for academia is much similar to the scope of conventional business administration curriculum. One of the influential early supporters of such view have been Mentzer et al [41]. According to unionism, there is more to SCM than just logistics. This could be rephrased as – even if logistics is treated with reasonably wide scope, it should not reach the scope of SCM. This can be explained by asking, what benefit can be received from optimising supply chains that are not related to the field of logistics. In unionism, SCM includes understanding the market, the dynamics, strategic planning and positioning, whereas logistics much more serves the plan in the framework of defined service level requirements. Perhaps the following three examples are suitable to support the view of an unionist: 1) when companies include the aspects of strategic alignment and corporate vision into their supplier selection criteria, there is a greater chance of developing mutual trust and helps to ensure the communication between supply chain partners is functioning on all levels of management; 2) via cooperation with supply chain partners, the future competitiveness can increase due to common product and service development efforts, resulting in better flexibility in turbulent marketplaces; 3) supplier relationship management can help dealing with various ethical issues – as in addition to the flows of materials, information and capital, there is also reputation that can transfer along the supply chain. According to unionism, a supply chain manager would not be a yesterday's logistics manager but would more probably be "the boss" of a logistics manager – a position in the upper management to oversee not only supply chain operations and performance from the „big picture" view, but also business relationships and benefits achieved and yet achievable through cooperation. Such perspective was also presented in the study by Gammelgaard and Larson [32].

To open evolutionary background, SCM has been described as „logical progression of developments in logistics management" [34]. Such evolution has been described through four stages. The first, physical distribution, involved integrating the transportation and warehousing functions. Logistics, the second stage, added procurement, manufacturing and order management to the "big picture". The third stage, integrated SCM, positions both suppliers and customers in the supply chain. The fourth and final stage, „super" SCM, includes additional functions, e.g. marketing, product development and customer service [34], and [35]. The views of unionists can indeed vary in respect to how far the boundaries of SCM are pushed. Tan et al have expressed the opinion that SCM is an integrated approach to purchasing and logistics management [36]. According to Hult, SCM should be viewed as consisting of four traditional areas: marketing, logistics, supply management and operations management [37]. In contrast, to quote Halldorsson et al, "under a broad unionist regime, responsibilities of the top supply chain manager would approach those of the CEO [35]".

The last of the four approaches, intersectionism, sees logistics as only partially belonging under SCM. In one sense, this can be described as an approach to merge most of perceptive points made by other approaches. The key point to differentiate logistics from SCM here is the management level – logistics deals with issues on the operational and tactical level, whereas supply chain management is about most strategic aspects in a supply chain. According to authors' own phrasing: „The intersection concept suggests SCM is not the union of logistics, marketing, operations management, purchasing and other functional areas. Rather it includes strategic, integrative elements from all these disciplines. /…/ SCM coordinates cross-functional efforts across multiple teams. /…/ Logistics, marketing and operations do not report to SCM, instead they draw on the SCM group for research, intelligence and consulting support [30]." Similarly, Pilkington and Fitzgerald have viewed SCM as „cross-functional activity" [38]. Halldorsson et al explain it the following way: „In logistics, negotiating a long-term 3PL deal is a strategic element, while warehouse order picking and packing is a tactical element within the function. A decision to use discreet versus batch picking is a tactical decision rather than a strategic one. The intersectionist supply chain manager would be involved in the 3PL negotiations, but not the pick-and-pack decision [35]." However, intersectionist view still manifests a degree of vagueness. If a separate logistics manager exists in this hypothetical company, then is he/she only dealing with tactical decisions (which would be favoured by an unionist), is he/she involved in some strategic decisions about logistics (but still reporting to supply chain manager, which would be somewhere between unionism and intersectionism) or could the logistics manager carry sole responsibility on some strategic logistics issues and not report to supply chain manager, who would more serve as a management consultant for CEO? The latter viewpoint is „true" intersectionism according to [35].

For academia, intersectionist approach means that although logistics and SCM share a lot of knowledge areas and competences, a supply chain specialist would be focused on strategic business management view whereas logistician would be focused on arranging the flows optimally, more focused on tactical level decisions. This would mean that the idea of a supply chain curriculum would lie somewhere between logistics management and general business administration – more focused on strategy than logistics, yet more focused on supply chain flows and relationships than general business administration profile.

Having postulated the four approaches, Larson and Halldorsson conducted a survey to test if all the ideas were actually supported by various educators across the world. The aim of the survey was to compare topics the respondents would see added to the courses of logistics management and supply chain management. The authors used 88 keywords and asked the respondents to rate the importance of these topics to both courses. Keywords were related to operations (such as cross-docking or barcoding), to concepts and models (e.g. SCOR, VMI), various decision areas (e.g. facility location, purchasing and channel management), general skills (conflict management, teamwork) and background knowledge (e.g. globalisation, foreign trade zones) [30].

Out of 88 keywords, the results identified 34 items that were significantly more relevant to SCM, most of them dealing with cross-functional and inter-organisational relationships. To contrast, 16 items rated significantly more important for SCM compared to logistics. This list included mostly classic functions dealing with material flow as well as tactical and operational aspects of flows (reorder point, cross-docking, packing, FOB). Finally, 38 survey items showed similar relevance to both SCM and logistics, pointing out the overlap in topics and quantitatively supporting the intersectionist view. The significance of the overlap was also supported by the data showing that out of ten most important keywords for both groups, seven were shared between SCM and logistics. Cluster analysis of the data showed that regardless of the average view, which supported the intersectionist approach, the 88 respondents' answers in details were classified into 50 relabellers, 16 traditionalists, 22 unionists and only 7 true intersectionists. This essentially demonstrated the diversity of SCM, where, on one end, a traditionalist would only include SCM as a lecture or a course in a logistics programme, whereas a true unionist would be tempted to rename the whole business administration programme to SCM. The authors concluded with stating that if the academia cannot reach a common understanding, it will confuse practitioners, create a communication barrier and be a major obstacle in managing real supply chains optimally. [30]

IV. Methodology – in the Footsteps of Giants

The literature review pointed out that while the definitions of SCM still have a degree of variability, the understanding is more harmonised than a decade ago. Our aim is to give empiric support to this statement by studying how the ontological issue is seen locally among educators in Estonia. A survey was run in the beginning of 2013, in essence much similar to that of Larson and Halldorsson from 2004, with Estonian logistics, SCM and general management educators. We felt that while the mathematical approach by Larson and Halldorsson was elegant and methodologically sound, the list of topics presented in the survey could use a more modern and specific treatment. To achieve that, we partly based our survey items on the APICS supply chain manager competence model [35] which is an acclaimed system ranging from foundational competences to specific profession-related competence fields. In our approach, only the latter (i.e. tiers 4-6 of APICS model) appeared relevant. APICS approach to SCM, judging by its content, is similar to „unionist" understanding, meaning that the topics would cover various potential SCM issues quite well and still be usable to identify competing approaches.

To simplify the structure, we identified ten key areas of competence and filled them with 100 keywords, which included various knowledge areas, skills and participation and management of different processes. In comparison, it is still generally similar to that of Larson and Halldorsson, as it includes topics from all management levels and we aimed to maintain a balance between strategic, tactical and operational issues. We also made sure the list included some topics not directly spelled out in APICS but relevant to technical, operational and tactical management of logistics and also from logistical service provider rather than customer point of view. Furthermore, the survey also asked the respondents directly to state their view in the ontological debate. This gave us the opportunity to test whether, for example, someone claiming to be „unionist“ is actually a unionist according to their detailed answers.

An important matter to clarify is why we used the wording „*evaluate the importance of the following 100 items in a „ought to be" competence profile of a supply chain manager and logistics manager*" instead of „*indicate how important you believe it is to cover each of the following topics, tools and techniques in a Logistics Management course and a Supply Chain Management (SCM) course*", which was used in the original study. First of all, we felt that „academic course" approach is not too practical, as the studies are becoming more and more modular and when we are dealing with educating logistics and SCM master-level specialists, one course is not nearly enough to even try to cover the requirements in an integrated way. Instead, we focused on what can be expected from a manager of the field. The job descriptions and responsibilities of course vary in business practice, but still a view of a „perfect manager" in the field can be imagined: perfect not in „know-everything" but instead in „focus most energy on most important issues". Another problem with „course" approach would have been that some educators could have had their personal view different from their actual job at a university. We believe „competence profile" approach is more objective and allows for more conclusions for practical purposes as well.

In the original survey, Larson and Halldorsson defined two indices, by which to divide the responses into different schools of thought. The same approach was used in our study.

„The first index, abs, is the sum of the absolute value of differences between importance for SCM and importance for logistics, across all survey items.

$$abs = sum\ |SCM_i - logistics_i|, \text{ where } i = 1 \text{ to } 100.$$

The second index, raw, is the sum of raw differences between importance for SCM and importance for logistics, across all survey items.

$$raw = sum\ (SCM_i - logistics_i), \text{ where } i = 1 \text{ to } 100. [38]."$$

The interpretation is that high raw scores identify unionists, as they perceive a large difference between the importance of issues to SCM compared to logistics, favouring SCM. Secondly, the group with lower raw scores but still relatively high abs scores are intersectionists. In their view, the differences between concepts are notable but there are also topics more relevant to logistics manager than to supply chain manager, hence diminishing the raw score – differences exist, but both concepts hold their ground. Thirdly, in contrast to the previous groups, relabellers perceive relatively little difference between concepts. This would logically make their abs score (and thereby also their raw score) relatively low. Finally, the traditionalist view would be to point out differences in concepts but perceiving logistics issues to be wider and of more general importance than SCM issues. This could be identified by respondents medium-to-high abs scores and negative raw scores.

Our survey was sent out to 80 educators at Estonian universities. We included general management circle to better understand not only the educated specialist view but also that of people who might not know the details of modern SCM scope but are still affecting the students by explaining their views in secondary context. The survey needed about 20-25 minutes to be filled.

V. Findings from the Survey – against Traditionalism and Relabelling

Our survey gathered 29 full responses. The respondents initially identified themselves as: 14 intersectionists (48,2%), 8 unionists (27,6%), 4 traditionalists (13,8%) and 3 relabellers (10,3%). Their answers to the main question, however, produced slightly different picture as shown below on fig. 1. The personal identification of the respondent on fig. 1 is given in different colours, whereas the classification of viewpoints based on detailed survey data is marked as clusters.

Dividing the gathered responses into four groups is problematic in border areas, but generally the analytical thought process is the following. First and foremost, the view of traditionalism is, according to our data, completely marginal. Of four respondents identifying themselves as traditionalists, one is clearly a relabeller, one an intersectionist and one difficult to identify. This is in stark contrast to the original study. Our results indicate similarly to reviewed literature that the view of traditionalism is no longer adequate – a logistics manager is either seen as same as a supply chain manager (relabeller view), working under a supply chain manager (unionist view) or with distinct difference from SCM, but not wholly grasping the entirety of SCM. This demonstrates the understanding of SCM concept development.

Secondly, relabellers still exist, but are in clear minority. The boundary between relabelling and intersectionism can never be too clear but both views are present and so some confusion still remains. In theory context this might be interpreted as "a zoomed-out view" – when you generalise enough, it is easier to see the similarities than the differences. However, this could also be viewed in practical context – Estonian economy is small with a substantial share of micro and small enterprises. In a smaller company, it is much more probable that the person managing logistics is also responsible for supply chain issues therefore the terminology is fused with a higher probability.

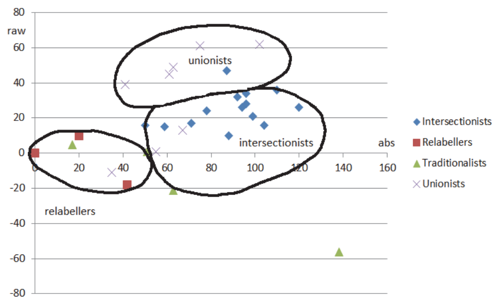

Figure 1: Survey respondent's views divided into predefined schools of thought

Thirdly, intersectionism appears to be dominating view through the eyes of local specialists. Logistics management has its niche and in our view that niche is not expected to grow out of fashion. It seems the intersectionist view of logistics management has withstood on one front the attacks from relabellers, which are pointing out there is no specific need for logistics managers anymore, and on the other front from unionists, which would rather claim that a logistics manager is somewhere between 1/3 and 2/3 of a proper supply chain manager. Finally, unionism exists as a strong school, although perhaps some of it is connected to SCM being „the fashionable topic" of the last decade or more. Similarly, the comment about the relative simplicity of local entrepreneurship applies here as well.

A closer look at the data reveals a higher level of differences between SCM and logistics than in the original study. Table 1 demonstrates, in our view, the heart of intersectionism, with 10 highest and 7 lowest rated topics for both supply chain managers and logistics managers. In TOP10, only one element is shared: information flow analysis and optimisation.

Table 1: Most and least important competences of a supply chain manager and logistics manager

Topic/Competence field	SCM score	Topic/Competence field	logistics score
Holistic supply chain cost optimisation	4,86	Transport cost optimisation	4,62
Analysis of competitive advantages	4,76	Transport prices and market overview	4,59
Information flow analysis and optimisation	4,66	Choice of mode	4,52
Supply costs analysis	4,62	Transport cost analysis	4,52
Negotiations	4,62	Track & trace	4,48
Participation in defining general company strategy	4,59	Warehousing and picking systems	4,45
Change management	4,59	Incoterms	4,41
Cash-to-cash cycle time	4,55	Information flow analysis and optimisation	4,41
Supplier performance analysis	4,55	International transport regulation	4,41
Supply chain synchronisation	4,55	Warehousing cost analysis	4,38
Distribution system planning	4,52	Defining and implementing functional strategies	4,34
Supply chain risk analysis	4,52	Project management skills	4,34
...	...	...	...
Inventory control methods	3,14	Calculating economic value added	3,10
Cargo consolidation for transport	3,10	B2B marketing	3,10

Road tolls	2,97	Product lifecycle analysis	3,10
Cargo space utilization	2,83	Supplier choice criteria	3,07
Drivers work time regulations	2,83	Collaborative forecasting	3,03
Vehicle capabilities	2,79	E-business	2,86
Load securing	2,38	Currency rate risk analysis	2,76

Source: authors' survey results

On methodology, we can conclude that APICS is a useful model and our data support its relevance. Interestingly, only a few topics in APICS standard turned out to be of lower relevance than expected: namely the importance of TQM, ISO standards and analysing environmental effects (with relevance scores all around 3.5-3.6 for supply chain manager competence profile).

Table 2 presents 5 elements with highest perceived differences from both ends of the spectrum, which further demonstrates intersectionism – more transport-focused aspects are seen as less relevant to SCM whereas purchasing and supply issues are of lesser importance to logistics. It is worth pointing out that we only augmented the APICS competence model with a handful of „hands-on" level logistics competencies. As two respondents pointed out in their comments, the selection of keywords involved in the study do give a good overview of a supply chain manager but are missing some essentials of a logistics manager. Therefore, it could be argued that the differences are more substantial than our survey could demonstrate, given the full specifics of a logistics managers' skillset.

Table 3. Notable gaps between profiles of a supply chain manager and a logistics manager

Topic/Competence field	SCM score	LOG score	SCM - LOG
Supplier performance analysis	4,55	3,17	1,38
Supplier choice criteria	4,41	3,07	1,34
Supply costs analysis	4,62	3,45	1,17
Supplier relationship management	4,48	3,34	1,14
Collaborative forecasting	4,07	3,03	1,03
...			
Driver work time regulations	2,83	3,97	-1,14
Vehicle usage analysis	3,21	4,38	-1,17
Cargo space utilization	2,83	4,21	-1,38
Vehicle capabilities	2,79	4,21	-1,41
Load securing	2,38	3,83	-1,45

Source: authors' survey results

Finally, we present the aggregated numbers of ten subcategories in Table 3. Throughout as well as inside the categories we found that common ground was shared in topics of inventory management and information flow. Both distribution, transport and warehousing topics were seen as more important to logistics than supply chains. This means that although a supply chain manager should not discard those issues completely, it is not his/her focus either and the questions asked are different. Such difference is even larger in financial issues, process management and supply chain optimisation. Perhaps the summarised distance of a logistics manager to supply chain manager in the viewpoint of our respondents even came as a little surprise to us.

Table 3: Perceived competence profile mix of a supply chain manager and a logistics manager

Competence category	SCM average	LOG average
Distribution and transport	3,44	4,24
Warehousing	3,74	4,01
Information flow and information systems	4,08	3,79
Finance specifics	4,24	3,78
International environment	3,85	3,65
Purchasing and supplier relations	4,43	3,58
Sales and customer relations	4,23	3,90
Inventory management	4,13	3,82
Process management and supply chain optimisation	4,13	3,71

General management and strategy	4,26	3,88

Source: authors' survey results

CONCLUSION

In 2004, Larson and Halldorsson asked if one implication of SCM was the downgrade of strategic role of logistics [30]. Our research suggests that this is partially true. We feel the concept of SCM has evolved quickly, has developed its own core of implications and has, in a sense, taken over topics that were previously discussed as the essentials of strategic logistics management. In the debate on relating the two concepts, traditionalism appears to be a forgotten idea today and relabelling seems to be growing out of fashion as well. Unionism and intersectionism have stood the test of time. In theory, this is an important topic for paradigm formation purposes. In practice, it is relevant to understanding the role of both managers. As is with the SCM theory, the supply chain manager competence profile has become clearer and more agreed over time. The role of a logistics manager, however, is comparatively not as clear, even though both heavily depend on practical context. Our survey showed intersectionism to be the approach of choice for understanding the responsibilities of a logistics manager. In a large company, a logistics manager is seen on average to be a mid-level manager, whereas a supply chain manager is dealing with more strategic issues. Such difference means that the entire concept of logistics management is still relevant and we feel it would be beneficial for the future of logistics management concept to adapt the intersectionist view rather than trying to surf the rising wave of SCM by using relabelling claims.

The main viewpoint of unionists, specifically that SCM entails more than logistics management, is supported both by theory and practice and in that sense SCM is indeed the new evolutionary form that is the result of rising importance of logistics issues in general business environment. However, in such extended scope, there is little hope that a person trained and qualified in all strategic issues of SCM could also serve as a top quality logistics manager. Therefore we conclude that the burden of differentiation is not on SCM any longer but instead on logistics management and it would be beneficial if the differences would be more universally agreed upon. The aim should be clearer understanding of different focuses of the two concepts, but still making sure that the "shared part" is also important. The "big picture" view of operations and processes should still remain essential for logistics managers as well.

In conclusion, we feel there is more clarity today in the relationship between supply chain managers' and logistics managers' responsibilities. For academia, it allows to define curricula more precisely and support supply chain and logistics education quality. The dominating intersectionist approach in the survey results could be viewed as a foundation that suggests there is a need to train both logistics managers and supply chain managers with specific programmes.

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THE IMPACT OF TECHNOLOGY TRENDS ON SKILLS OF LOGISTICS ENGINEERS – A NOVEL COMPETENCE APPROACH

Niine, T. & Koppel, O.

Abstract: *Logistics is heavily influenced by technologies and engineered solutions. Identification, tracking, process control, automation and sustainability-oriented technologies are advancing rapidly. These areas should be studied in classroom by all future logisticians and in-depth by logisticians with engineering focus.*

The paper summarizes relevant technologies in modern-day and near-future logistics and analyses the presence of these elements in current competence models in logistics (by APICS, AST&L, ELA and SOLE). A novel competence model titled "logistics systems engineer" is presented as research outcome. The paper explains model structure and promotes it as significantly modernized way to integrate crucial technological viewpoints into logistics engineer's competence profile to overcome gaps present in current models. The model can be used as curriculum development guideline.

Key words: logistics technologies, logistics engineering, logistics skill areas, logistics competence models.

1. INTRODUCTION

The environment of logistics education is swiftly evolving due to technological progress and economic advancement. In many areas, capability of rapid innovation and technological modernization is a key success factor. Often this is coupled by emphasised role of logistics in the mix of competitive advantages to ensure agile and reliable global deliveries.

Universities need to thoroughly understand essential competences of future logistics professionals today [1, 2, 3]. Logistics education has to be interdisciplinary, as society needs broad knowledge and know-how to manage interrelated functions of logistics systems [4, 5].

This paper argues that the technological element is not represented to sufficient extent and depth in some renowned competence models of logistics professionals. It has been suggested that logistics has over time turned more business management focused [6] and that there is a lack of engineering students in logistics because of it [7].

Firstly, the paper reviews literature on major technology trends in logistics and identifies ten key technology areas. In the next section, five international models of logistics competence, which are often used as standards for curriculum development, are reviewed in terms of references to these technologies. As gaps are notable, the authors present a novel competence model titled „*logistics systems engineer*" designed in Tallinn University of Technology as a modern interdisciplinary and systemic view to logistics engineering education.

2. TECHNOLOGY TRENDS IN LOGISTICS

Three major studies of technology advancements with biggest impact for future logistics systems, all from 2014, are summarized in table 1 [8-10].

Notable driving force of logistics technologies are "green" sustainability oriented solutions, pushing towards lower environmental impact, improved services, lower costs and greater efficiency and also resulting in increased reliability, service innovation and increases in revenue and reputation [11]. A study on the evolution of supply chains by SMI [1212] has concluded that cutting carbon emissions will be the greatest challenge, followed by fuel supply in the future of oil scarcity.

Logistics Trends 2020 [8]	**Logistics Trend radar [9]**	**Material hand-ling and logistics: US roadmap [10]**
application of telematics	big open data	e-commerce
deeper penetration of logistics systems with ICT	cloud logistics	mass personalisation
implementation of GPS systems	autonomous logistics	mobile, wearable computing
traffic information, real time routing	3D printing	robotics, automation and driverless vehicles
e-marketplaces for logistics services	robotics and automation	sensors and the internet of things
networking and integration in IT	internet of things	big data and predictive analysis
real time transport information systems	localization and local intelligence	new methods of distribution
application of mobile computing	wearable technology	tracking integration
traffic information systems	augmented reality	cloud-based visibility
logistics simulation models	low-cost sensor technology	sensor data standards
	crypto-currencies and -payment	process optimisation tools

Table 1. Notable technology trends in logistics

Innovative tools make logistics operations cleaner and resource-efficient through advances in vehicle emissions, energy efficiency and technologies for smart cities [13]. The smart city concept includes vehicle sensors and intelligent transport systems (ITS) for controlled traffic, but indirectly also integrated information solutions for businesses and online marketplaces. Promising trends in ITS are collision avoiding systems, lane keeping systems, RFID tracking, driving monitoring systems and real time travel data analysis [14].

As an underlying trend, the SMI study [12] foresees that the customers of the future "*continue to demand greater control over the logistics process, and will more actively intervene in the delivery process of the goods they do order. This will increase the complexity of logistics processes, making necessary a highly sophisticated technical infrastructure.*" To provide control, advances in both information as well as physical delivery capabilities are required, which are the main pillars of progress in logistics.

McKinnon *et al* [15] have treated the impact of modern vehicle technologies through three pillars: *carrying capacity, energy efficiency* and *externalities*. Improving truck aerodynamics can notably improve fuel efficiency [16]. Another efficiency gain comes from lightweight materials, which reduce fuel consumption, increase capacity and as a result requires less road space.

In another study, the fields of smart cities, e-mobility and zero emission technologies belong to the top of global economic mega-trends [17]. Wide-scale implementation of automatic technologies in cargo handling, packaging and robotic transport in industry applications is also forecasted. Similarly, the SMI study [12] proposes considerable growth in autonomous systems and increases in capacities across modes, ultra-large container vessels, aircraft and LHVs.

Driverless transportation systems can provide cognitivity, safe navigation and notably altered cost patterns, which may become a reality by 2030: "*Autonomous vehicles with radar, navigation and ultra-sonic sensors can steer themselves and enable dynamic real-time traffic-dependent routing*" [9]. Another area of autonomous logistics is UAVs (unmanned aerial vehicles, drones), which is in first phases of testing commercial applications across courier express parcel sector.

Advanced cognitivity is also impacting warehouse systems where processes can be facilitated by magnetic or optical guidance. The solutions are supported by advances in software, such as swarm intelligence platforms. Intermec [18] has listed voice recognition, RFID, digital imaging and resulting remote management among their top technology trends.

In a Delphi study of logistics realities in 2050 [19], one possible scenario, "mega-efficiency in megacities", is described as "transition to the automation age" and embraces green paradigm shift, smart urban logistics to deal with externalities, high efficiency traffic concepts, robotics-based logistics, underground networks, global grid of large-scale transport, information logistics, open trade, and global governance.

Another scenario, "customized lifestyles", predicts the emergence of 3D printing and localized production – only raw materials and data would flow globally and managing "last mile" transport would become critical, while global flows decline. The study identified 14 key trends, of which three are technological: ICT and robotics, materials and urban development solutions.

The potential of RFID-tracking is also strong in retail, improving efficiency and saving costs. Four key impacts of RFID are meeting demand, sharing real-time data, creating delivery value and error reduction [20]. Additional outcomes are transparency, improved availability and labour savings.

Logistics is innovative application industry for IT. Cloud computing has been promoted as a means for fundamental redesign of logistics systems [21]. As the real-time aspect of logistics information grows, the future constraint is not obtaining the data but rather distributing data along supply chain, which requires inter-company integration and efforts in analysing the data.

In another vision for next decade supply chain advances [22], improved supply chain infrastructure and affordable technologies and big data are prominent. The key elements of infrastructure relate to faster deliveries across modes, unitization technologies, continuing modal shift to intermodal solutions and semi-automatic handling. The report suggests "information explosion is a certainty" with widespread internet and mobile coverage and huge increases in data generation and storage. The report foresees internal data from ERP systems complemented with external such as geospatial data and point-of-sale terminals. As data storage costs dropping, partly due to cloud computing, more data fuels growth in flexible, reliable and affordable data analytics architectures [22].

The authors of this paper have consolidated a list of ten major technology areas, which should be essential for future logistics engineering specialists:

1. Electric vehicles, alternative fuels and clean technologies;
2. Telematics, real-time tracking and intelligent transport systems;
3. Auto-pilot and autonomous vehicles: UAV, self-driving cars, ships etc.;
4. Vehicle design, materials and systems of safety, costs and performance;
5. Robotics, sensors and ID-solutions in cargo handling and security;
6. Mobile and cloud computing applications, wireless communication;
7. Logistics process and network simulation and optimisation software;
8. Electronic marketplaces, e-commerce and smart networking;
9. Big data, augmented reality, automatic data analysis and integration;
10. Additive manufacturing (3D printing) applications.

In conclusion, the authors agree with Zelewski *et al* [8] who remarked that no particular trend stand out, which suggests the fields synergize to realize the concept of continuous shipment tracking including corresponding added value services.

3. TECHNOLOGIES IN LOGISTICS COMPETENCE MODELS

The authors have carried out a comparison of four internationally recognised models of logistics professional competences in an ongoing curriculum development process:

- Distribution and logistics managers' competency model by APICS [23];
- Certified in transport and logistics (CTL) by AST&L [24];
- Certified master logistician (CML) by SOLE[25];
- Logistics professional by European Logistics Association ELA [26].

All the models are aimed at describing logistician competences on the level of higher education and suggest a relatively broad scope in their title. The study goal was to identify to what extent are the models in line with the envisioned ten technology areas and would these models then prove suitable for logistics engineering curriculum benchmarking. The results, however, demonstrated notable gaps and mismatches across board.

APICS model assumes students to "*demonstrate an understanding of the factors that are considered important to the branch of knowledge or technology*" and "*to implement new technology*" [23] with no *ad hoc* list of technologies. However in various sections, the following technology elements are mentioned: materials and distribution requirements planning, ERP-systems, advanced planning systems, renewable materials, energy reduction, warehouse management systems and electronic data interchange (EDI).

AST&L model [24] is approaching logistics, and more specifically transport, more in terms of exploitation and management rather than design and development, by requiring the competence of "*how the operating and service characteristics of each mode affect cost, performance, and the products moved*". The only time innovation is mentioned in the model is under "creative component".

SOLE [25] lists some educational areas connected to technologies and to related design and implementation life-cycle aspects: conceptual system design, civil engineering, safety and reliability engineering and user tests. However, no technology area is treated in detail.

ELA model [26] states: "*Due to the constant progress in ICT, specific technologies are not defined in the modules. It is a prerequisite, though, that current technologies must be applied in all relevant fields. ICT competences are implicit in every module.*" The model mentions vendor managed inventory, e-procurement, APS, WMS, transport management system, customer relationship management (CRM) systems and software testing. No reference is made to other technologies, except: "*Understands the impact of technological innovation on supply chain design*".

In summary it appears that while the models are mostly capable of describing soft skills and business workplace process-oriented competences, the models are poor guidelines in terms of developing a logistics curriculum that would be founded on natural sciences and technologies.

AST&L perspective to logistics is mostly that of transport management. ELA and APICS are more interdisciplinary but not in terms of technologies. Even SOLE, originally named Society of Logistics Engineers, does not draw dedicated focus to the building blocks of modern logistics engineering.

4. LOGISTICS SYSTEMS ENGINEER COMPETENCE MODEL

To reinforce technology element in logistics competences, the authors have created a novel competency approach titled "logistics systems engineer". The guiding idea has been to infuse the modern understanding of logistics with dedicated focus to technologies and to the design and implementation process (the focus of systems engineering).

The model structure is shown on Figure 1. It consists of six layers, starting from foundational engineering competences. In this view, systems engineering treatments form the conceptual basis. This is followed by a layer for specific technologies that need to be engineered and maintained in logistics, and a core layer of more conventional logistics topic areas. The technology layer is essentially an abbreviated version of the ten technology areas. However, all business information system related topics are intentionally not included on this layer – rather they form a separate segment on the next layer, as they integrate all logistics data aspects.

Fig. 1. Competency areas and structure in "logistics systems engineer" training profile

The core layer views logistics as a system with inventory and information as key variables. All technology solutions in logistics essentially imbue information and physical inventory handling and related operations. The top two layers add logistics management elements to the technology foundation and point out that all applied solutions should be viewed as parts in a value creation system of an enterprise.

In brief, the key technological competences in the model are the following.

1. Understands the characteristic, design, applications and limitations of technology solutions in transport, warehousing, tracking and handling.
2. Analyses modern technologies and application environments in terms of capabilities, costs, implementation requirements, constraints and risks.
3. Analyses current organisation processes and workflow and identifies suitable technology solutions.
4. Analyses the impact of various material flow technologies to logistics system and supply chain performance.
5. Understands synergetic relations of material flow technologies, IS and information flow configurations and utilises it in systems development.
6. Plans, manages and controls new technology implementation projects throughout the life cycle.
7. Defines human, IS and technology interfaces and integrates physical technologies with information systems and workflow in an optimal way.
8. Initiates and carries out feasibility, risk and impact studies and cost-benefit analysis, including aspects of safety, security and environmental impact.
9. Cooperates with specialists in partner companies to create systems reaching across organizational boundaries.
10. Analysis technological competencies in company and assists in defining training, serves as a technological expert and supports innovation.
11. Is aware of the boundary of human and machine-based operations and the conditions when human labour can be replaced with machines.
12. Understands delicate relation between lengthy implementation projects and changing environments which can impose risks regardless of initial plans.

The entire competence model includes over 250 defined competency elements and is far too extensive to present here. The details are available from corresponding author on contact.

5. CONCLUSIONS

In conclusion, some competence models in logistics do not emphasise technologies from modern logistics frontier. The authors have designed a new competency approach more fitting for future logistics engineers.

The new model serves as a curriculum development guideline for all universities wanting to develop logistics programs with technology orientation. The entirety of the model is suitable for 5-year integrated masters' studies, but it can be partially applied also on bachelor level.

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2009 –	Tallinna Tehnikaülikool	Doktoriõpingud logistikas TTÜ ehitusteaduskonnas
2007	Tallinna Tehnikaülikool	Logistika magistriõpe, *cum laude*
2005	Tallinna Tehnikaülikool	Logistika bakalaureuseõpe, *cum laude*
2002	Gustav Adolfi Gümnaasium	keskharidus

3. Keelteoskus

Eesti keel	emakeel
Inglise keel	väga hea

4. Töökäik

2007 –	Tallinna Tehnikaülikool	Majandusteaduskonna, Ärikorralduse instituudi lektor, ärinduse bakalaureuse-õppe õppekavajuht Peamised ainekursused: ärilogistika, tarneahela juhtimine, varude juhtimine Tänaseni 30 bakalaureuse- ja 5 magistritöö juhendaja.
2007 – 2012	Tallinna Tehnikakõrgkool	Lektor osakoormusega “Logistikaseminari” projekti juhendaja
2005 – 2008	TTG Tallinna Tehnikagümnaasium	Osakoormusega keskkooliõpetaja aines “sissejuhatus logistikasse”

5. Eelretsenseeritud teaduspublikatsioonid ja raamatu peatükid

Niine, T.; Koppel, O. (2011). Searching for the perfect SCM curriculum – comparative study of SCOR and APICS competence models and renowned SCM master's programs. *Journal of International Scientific Publications: Educational Alternatives*, 9, 34 - 53.

Kolbre, E.; Niine, T.; Miksa, W.; Dziugiel, M.; Dziugiel, B. (2013). Service Location and Site Quality Analysis in Support of Air Cargo Development: Case Studies of Tallinn and Katowice Airports. *Journal of Business Management and Applied Economics*, II(6), 1 - 15.

Niine, T.; Lend, E. (2013). Logistics Management versus Supply Chain Management – the Crystallization of Debate for Academic Clarity. *Journal of Logistics & Sustainable Transport*, 4(1), 39 - 50.

Niine, T.; Prause, G.; Kolbre, E.; Dziugiel, B. (2013). Air cargo outlooks of regional airports in the Baltic Sea Region: cases of Tallinn and Katowice. G. Prause, U. Venesaar and W. Kersten (Eds.). Business Development in Baltic Sea Region (49 - 71). Berlin: Peter Lang Verlag

Niine, T.; Koppel, O. (2014). Competence in Logistics – Designing a Meta-Model of Logistics Knowledge Areas. B. Katalinic (Toim.). DAAAM International Scientific Book 2014 (543 - 556).DAAAM International Vienna

Niine, T.; Koppel, O. (2014). Logistics Management in the Era of Supply Chain Management – A Gap in Academic Literature. *Journal of Business Management and Applied Economics*, III(3), 1 - 23.

Niine, T., Koppel, O. (2015) Logistics Systems Engineer – Interdisciplinary Competence Model for Modern Education. – *International Journal of Engineering Pedagogy,* 2015, 5, 2, 54-63.

Niine, T., Koppel, O. (2015) Typology of logistics curricula – four categories of logistics undergraduate education in Europe. – *International Journal of Engineering Pedagogy,* 2015, 5, 2, 4-11.

6. Kuulumine erialaorganisatsioonidesse

Eesti Ostu- ja Tarneahelate Juhtimise Ühingu (ProLog) liige

Tarvo Niine
25.05.2015

DISSERTATIONS DEFENDED AT TALLINN UNIVERSITY OF TECHNOLOGY ON *CIVIL ENGINEERING*

1. **Heino Mölder**. Cycle of Investigations to Improve the Efficiency and Reliability of Activated Sludge Process in Sewage Treatment Plants. 1992.

2. **Stellian Grabko**. Structure and Properties of Oil-Shale Portland Cement Concrete. 1993.

3. **Kent Arvidsson**. Analysis of Interacting Systems of Shear Walls, Coupled Shear Walls and Frames in Multi-Storey Buildings. 1996.

4. **Andrus Aavik**. Methodical Basis for the Evaluation of Pavement Structural Strength in Estonian Pavement Management System (EPMS). 2003.

5. **Priit Vilba**. Unstiffened Welded Thin-Walled Metal Girder under Uniform Loading. 2003.

6. **Irene Lill.** Evaluation of Labour Management Strategies in Construction. 2004.

7. **Juhan Idnurm**. Discrete Analysis of Cable-Supported Bridges. 2004.

8. **Arvo Iital**. Monitoring of Surface Water Quality in Small Agricultural Watersheds. Methodology and Optimization of monitoring Network. 2005.

9. **Liis Sipelgas**. Application of Satellite Data for Monitoring the Marine Environment. 2006.

10. **Ott Koppel**. Infrastruktuuri arvestus vertikaalselt integreeritud raudtee-ettevõtja korral: hinnakujunduse aspekt (Eesti peamise raudtee-ettevõtja näitel). 2006.

11. **Targo Kalamees**. Hygrothermal Criteria for Design and Simulation of Buildings. 2006.

12. **Raido Puust**. Probabilistic Leak Detection in Pipe Networks Using the SCEM-UA Algorithm. 2007.

13. **Sergei Zub**. Combined Treatment of Sulfate-Rich Molasses Wastewater from Yeast Industry. Technology Optimization. 2007.

14. **Alvina Reihan**. Analysis of Long-Term River Runoff Trends and Climate Change Impact on Water Resources in Estonia. 2008.

15. **Ain Valdmann**. On the Coastal Zone Management of the City of Tallinn under Natural and Anthropogenic Pressure. 2008.

16. **Ira Didenkulova**. Long Wave Dynamics in the Coastal Zone. 2008.

17. **Alvar Toode**. DHW Consumption, Consumption Profiles and Their Influence on Dimensioning of a District Heating Network. 2008.

18. **Annely Kuu**. Biological Diversity of Agricultural Soils in Estonia. 2008.

19. **Andres Tolli**. Hiina konteinerveod läbi Eesti Venemaale ja Hiinasse tagasisaadetavate tühjade konteinerite arvu vähendamise võimalused. 2008.

20. **Heiki Onton**. Investigation of the Causes of Deterioration of Old Reinforced Concrete Constructions and Possibilities of Their Restoration. 2008.

21. **Harri Moora**. Life Cycle Assessment as a Decision Support Tool for System optimisation – the Case of Waste Management in Estonia. 2009.

22. **Andres Kask**. Lithohydrodynamic Processes in the Tallinn Bay Area. 2009.

23. **Loreta Kelpšaitė**. Changing Properties of Wind Waves and Vessel Wakes on the Eastern Coast of the Baltic Sea. 2009.

24. **Dmitry Kurennoy.** Analysis of the Properties of Fast Ferry Wakes in the Context of Coastal Management. 2009.

25. **Egon Kivi**. Structural Behavior of Cable-Stayed Suspension Bridge Structure. 2009.

26. **Madis Ratassepp**. Wave Scattering at Discontinuities in Plates and Pipes. 2010.

27. **Tiia Pedusaar**. Management of Lake Ülemiste, a Drinking Water Reservoir. 2010.

28. **Karin Pachel**. Water Resources, Sustainable Use and Integrated Management in Estonia. 2010.

29. **Andrus Räämet**. Spatio-Temporal Variability of the Baltic Sea Wave Fields. 2010.

30. **Alar Just**. Structural Fire Design of Timber Frame Assemblies Insulated by Glass Wool and Covered by Gypsum Plasterboards. 2010.

31. **Toomas Liiv**. Experimental Analysis of Boundary Layer Dynamics in Plunging Breaking Wave. 2011.

32. **Martti Kiisa**. Discrete Analysis of Single-Pylon Suspension Bridges. 2011.

33. **Ivar Annus**. Development of Accelerating Pipe Flow Starting from Rest. 2011.

34. **Emlyn D. Q. Witt**. Risk Transfer and Construction Project Delivery Efficiency – Implications for Public Private Partnerships. 2012.

35. **Oxana Kurkina**. Nonlinear Dynamics of Internal Gravity Waves in Shallow Seas. 2012.

36. **Allan Hani**. Investigation of Energy Efficiency in Buildings and HVAC Systems. 2012.

37. **Tiina Hain**. Characteristics of Portland Cements for Sulfate and Weather Resistant Concrete. 2012.

38. **Dmitri Loginov**. Autonomous Design Systems (ADS) in HVAC Field. Synergetics-Based Approach. 2012.

39. **Kati Kõrbe Kaare**. Performance Measurement for the Road Network: Conceptual Approach and Technologies for Estonia. 2013.

40. **Viktoria Voronova**. Assessment of Environmental Impacts of Landfilling and Alternatives for Management of Municipal Solid Waste. 2013.

41. **Joonas Vaabel**. Hydraulic Power Capacity of Water Supply Systems. 2013.

42. **Inga Zaitseva-Pärnaste**. Wave Climate and its Decadal Changes in the Baltic Sea Derived from Visual Observations. 2013.

43. **Bert Viikmäe**. Optimising Fairways in the Gulf of Finland Using Patterns of Surface Currents. 2014.

44. **Raili Niine**. Population Equivalence Based Discharge Criteria of Wastewater Treatment Plants in Estonia. 2014.

45. **Marika Eik**. Orientation of Short Steel Fibers in Cocrete. Measuring and Modelling. 2014.

46. **Maija Viška**. Sediment Transport Patterns Along the Eastern Coasts of the Baltic Sea. 2014.

47. **Jana Põldnurk**. Integrated Economic and Environmental Impact Assessment and Optimisation of the Municipal Waste Management Model in Rural Area by Case of Harju County Municipalities in Estonia. 2014.

48. **Nicole Delpeche-Ellmann**. Circulation Patterns in the Gulf of Finland Applied to Environmental Management of Marine Protected Areas. 2014.

49. **Andrea Giudici**. Quantification of Spontaneous Current-Induced Patch Formation in the Marine Surface Layer. 2015.

50. **Tiina Nuuter**. Comparison of Housing Market Sustainability in European Countries Based on Multiple Criteria Assessment. 2015.

51. **Erkki Seinre**. Quantification of Environmental and Economic Impacts in Building Sustainability Assessment. 2015.

52. **Artem Rodin**. Propagation and Run-up of Nonlinear Solitary Surface Waves in Shallow Seas and Coastal Areas. 2015.

53. **Kaspar Lasn**. Evaluation of Stiffness and Damage of Laminar Composites. 2015.

54. **Margus Koor**. Water Distribution System Modelling and Pumping Optimization Based on Real Network of Tallinn. 2015.

55. **Mikk Maivel**. Heating System Efficiency Aspects in Low-Energy Residential Buildings. 2015.

56. **Kalle Kuusk**. Integrated Cost-Optimal Renovation of Apartment Buildings toward Nearly Zero-Energy Buildings. 2015.

57. **Endrik Arumägi**. Renovation of Historic Wooden Apartment Buildings. 2015.